PHYTOPHARMACOLOGY OF *MORINGA OLEIFERA* – AN EDIBLE PLANT

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Summary

Moringa oleifera (Moringaceae), commonly called the "drumstick ", is well-known for its multipurpose attributes, wide adaptability, and ease of establishment. It is distributed in many countries of the tropics and subtropics. It has an impressive range of medicinal uses with high nutritional value. Different parts of this plant contain a profile of important minerals, and are a good source of protein, vitamins, beta-carotene, amino acids and various phenolics. The Moringa plant provides a rich and rare combination of zeatin, quercetin, beta-sitosterol, caffeoylquinic acid and kaempferol. In addition to its compelling water purifying powers and high nutritional value, *M. oleifera* is very important for its medicinal value. Various parts of this plant such as the leaves, roots, seed, bark, fruit, flowers and immature pods act as cardiac and circulatory stimulants, possess antitumor, antipyretic, antiepileptic, antiinflammatory, antiulcer, antispasmodic, diuretic, antihypertensive, cholesterol lowering, antioxidant, antidiabetic, hepatoprotective, antibacterial and antifungal activities, and are being employed for the treatment of different ailments in the indigenous system of medicine.

Key words: *Moringa oleifera*, Phytochemistry, Pharmacology.

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Introduction

History: The Moringa plant is native to Northern India, where it was first described around 2000 B.C. as a medicinal herb. The oral tradition of Ayurvedic medicine in India declared that Moringa prevents 300 diseases.

Description: In India, the plant is propagated by planting limb cuttings 1-2 m long, from June to August, preferably. The plant starts bearing pods 6-8 months after planting but regular bearing commenced after the second year. The tree bears for several years.

Origin and Distribution: *Moringa oleifera* is believed to be native to sub-Himalayan tracts of northern India but is now found worldwide in the tropics and sub-tropics. It grows best in direct sunlight under 500 meters altitude.

Phytochemicals: Per 100 g, the pod is reported to contain 86.9 g H_2O, 2.5 g protein, 0.1 g fat, 8.5 g total carbohydrate, 4.8 g fiber, 2.0 g ash, 30 mg Ca, 110 mg P, 5.3 mg Fe, 184 IU vit. A, 0.2 mg niacin, and 120 mg ascorbic acid, 310 µg Cu, 1.8 µg I. Leaves contain 7.5 g H_2O, 6.7 g protein, 1.7 g fat, 14.3 g total carbohydrate, 0.9 g fiber, 2.3 g ash, 440 mg Ca, 70 mg P, 7 mg Fe, 110 µg Cu, 5.1 µg I, 11,300 IU vit. A, 120 µg vit. B, 0.8 mg nicotinic acid, 220 mg ascorbic acid, and 7.4 mg tocopherol per 100g.

Leaf amino acids include 6.0 g arginine/16 g N, 2.1 histidine, 4.3 lysine, 1.9 tryptophane, 6.4 phenylalanine, 2.0 methionine, 4.9 threonine, 9.3 lucine, 6.3 isoleucine, and 7.1 valine. Pod amino acids enclue 3.6 g arginine/16 g N, 1.1 g histidine, 1.5 g lysine, 0.8 g tryptophane, 4.3 g phenylalanine, 1.4 g methionine, 3.9 g threonine, 6.5 g leucine, 4.4 g isoleucine, and 5.4 valine.

Seed kernel (70-74% of seed) contains 4.08 H_2O, 38.4 g crude protein, 34.7% fatty oil, 16.4 g N free extract, 3.5 g fiber, and 3.2 g ash. The seed oil contains 9.3% palmitic, 7.4% stearic, 8.6% behenic, and 65.7% oleic acids among the fatty acids. Myristic and lignoceric acids have also been reported. The cake left after oil extraction contains 58.9% crude protein, 0.4% CaO, 1.1% P_2O_5 and 0.8%K_2O.

A water-soluble polysaccharide was isolated from the aqueous extract of pods of *Moringa olifera*.

The polysaccharide contains d-galactose, 6-O-Me-D-galactose, D-galacturonicacid, l-arabinose, and l-rhamnose in a molar ratio of 1:1:1:1:1. On the basis of total hydrolysis, methylation analysis, periodate oxidation, and NMR ((1)H, (13)C, TOCSY, DQF-COSY, NOESY, ROESY, HSQC, and HMBC) studies, the repeating unit of the polysaccharide is established.[1]

Five flavonol glycosides characterised as kaempferide 3-O-(2",3"-diacetylglucoside), kaempferide 3-O-(2"-O-galloylrhamnoside), kaempferide 3-O-(2"-O-galloylrutinoside)-7-O-alpha-rhamnoside, kaempferol 3-Q-[beta-glucosyl-(1→2)]-[aipha-rhamnosyl-(1→6)]-beta-glucoside-7-O-alpha-rhamnoside and kaempferol 3-O-[alpha-rhamnosyl-(1→2)]-[alpha-rhamnosyl-(1→4)]-beta-glucoside-7-O-alpha-rhamnoside
together with benzoic acid 4-O-beta-glucoside, benzoic acid 4-O-alpha-rhamnosyi-(1→2)-beta-glucoside and benzaldehyde 4-O-beta-glucoside have been isolated from methanolic extract of *Moringa oleifera* leaves. Also obtained from the same extract were known compounds, kaempferol 3-O-alpha-rhamnoside, kaempferoi, syringic acid, gallic acid, rutin and quercetin 3-O-beta-glucoside.[2] 4-Hydroxyme!lein, vanillin, beta -sitostenone, octacosanoic acid and beta -sitosterol were isolated from *M. oleifera* stems.[3]

Traditional Medicinal Uses: Decoction of dried leaves is taken orally for abortion. Externally for rheumatism[2] and for wound healing, leaves made into a paste with salt is used to treat edema. Dried fruit is taken orally for 20 days to produce sterility. A mixture of the fruits of *Clerodendrum indicum, Sesamum orientale, Moringa pterygosperma* and *Piper nigrum* is mixed with sugar. The mixture is also taken as a tonic. Hot water extract of the dried fruit is taken orally for headache and for giddiness. Dried gum is applied externally for headache. Dried seeds, after frying, are eaten. Dried stem bark is taken orally for backache. Flowers are taken orally as a stimulant and aphrodiastic. Hot water extract is taken orally as a tonic and cholagogue. Fresh flowers are used as a vegetable. Fresh seeds pods are used as a vegetable. Gum is administered intravaginally to produce abortion. Hot water extract of dried flowers is taken orally in Ayurvedic and Unani medicine as an aphrodiastic and stimulant. Hot water extract of dried fruit and leaves is taken orally for dysentery and diarrhoea. Hot water extract of dried root and stem bark is taken orally as an abortifacient and emmenagogue. Hot water extract of dried root, bark is taken orally in Ayruvedic medicine as an abortive, antipyretic and as a tonic. Hot water extract of the dried bark is used in Ayurvedic and Unani Medicine as an abortifacient, taken orally by pregnant women. Hot water extract of the dried root is taken orally in Ayurvedic and Unani medicine as an abortifacient. Juice of fresh bark is taken orally to relieve acute stomachaches. Also, for stomachache, juice of bark is mixed with Ferula asofoetida and salt, and given orally. Externally the juice is used as a treatment for mange in horses. Leaf juice, mixed with honey is used as an eye ointment for conjunctivitis. Leaves are taken orally as an aphrodiasic, and to treat wounds. Leaves are pounded with turmeric and buttermilk and applied to wounds. Powdered dried root and stem is used externally for rheumatism pains. For asthma, the cough, 50 mg of the powder in water is taken orally. Stem bark is taken orally to produce permanent sterility. Five gram of stem bark from an old tree is ground, into a paste by adding two seeds of *Piper nigrum*, one gram of *Cuminum cyminum* seeds and a few pieces of *Allium sativum*. This paste is swallowed after the third day of delivery. A bland diet is followed. This is repeated three times. After two to three months, the woman should not participate in coitus. Fresh stem bark is used to produce abortion. The gum is very tough, swells rapidly when moistened, and produces abortion by dilating the cervix.

PHARMACOLOGICAL ACTIVITIES AND CLINICAL TRIALS:

Anti-anaphylactic agents: In the study, the effects of the ethanolic extract of seeds of *Moringa oleifera* (MOEE-herbal remedy) on systemic and local anaphylaxis were investigated. The potential anti-anaphylactic effect of MOEE was studied in a mouse model of Compound 48/80-induced systemic anaphylactic shock. Passive cutaneous anaphylaxis activated by anti IgE-antibody was also used to assess the effect of MOEE. In addition, rat peritoneal mast cells (RPMC) were used to investigate the effect of MOEE on histamine release induced by compound 48/80. When administered 1 hr before 48/80 injection, MOEE at doses of 0.001-1.000 g/kg completely inhibited the inducible induced anaphylactic shock. MOEE significantly inhibited passive cutaneous anaphylaxis activated by anti-IgE antibody at a dose of 1 g/kg. When MOEE extract was given as pretreatment at concentrations ranging 0.1-100 mg/ml, the histamine release from the mast cells that was induced by the 48/80 was reduced in a dose-dependent manner. These results suggest a potential role for MOEE as a source of anti-anaphylactic agents for use in allergic disorders.[4]

Antiarthritic property: The investigation was carried out to study the anti-arthritic actiyjty of ethanolic extract of seeds of *Moringa oleifera* Lam. (MOEE) in adjuvant-induced arthritis in adult female Wistar rats. During the experimental period, body weight, paw edema volume (primary lesion) and arthritic index (secondary lesion) was observed. On the 21st day, serum from each animal was used for estimation of Rheumatoid Factor (RF) value and levels of selected cytokines (TNFatpha, 1L-1, and IL-6). Whole blood was used for measurement of erythrocyte sedimentation rate (ESR). Liver homogenate was utilized for assessment of oxidative stress and histopathology was performed to measure degree of inflammation in synovial joint. The results suggest that, percentage reduction in body weight was less, paw edema volume and arthritic index score was decreased significantly as compared to diseased control animals. Serum levels of RF, TNF-alpha, 1L-1, and IL-6 also showed decreased-levels as compared to those in the diseased control group. Treatment with MOEE also altered oxidative stress in relation to its anti-inflammatory activity. Histopathological observations showed mild or less infiltration of lymphocytes, angiogenesis and synovial lining thickening. From all above results and observations, it can be concluded that *Moringa oleifera* possesses promising antiarthritic property.[5]

Antiatherosclerotic activities: Investigated the antioxidant, hypolipidaemic and antiatherosclerotic activities of *Moringa oleifera* leaf extract. Scavenging activity of the extract on 1, 1-diphenyl-2- picrylhydrazyl radicals (DPPH), and the inhibitory effect on Cu (2+)-induced low-density lipoprotein (LDL) oxidation were determined in in vitro experiment. The effects of the extract on cholesterol levels, conjugated diene (CD) and thiobarbituric acid reactive substances (TBARS) and plaque formations in cholesterol-fed rabbits were investigated. It is found that in scavenging DPPH radicals the extract and Troiox had IC(50) of 78.15+/-0.92 and 2.14+/-0.12microg/ml, respectively. The extract significantly ($P<0.05$) prolonged the lag-time of CD formation and inhibited TBARS formation in both in vitro and ex vivo experiments in a dose-dependent manner. In hypercholesterol-fed rabbits, at 12 weeks of treatment, it significantly ($P<0.05$) lowered the cholesterol levels arid reduced the atherosclerotic plaque formation to about 50 and 86%, respectively. These effects were at degrees comparable to those of simvastatin. The results indicate that this plant possesses antioxidant, hypolipidaemic and antiatherosclerotic activities and has therapeutic potential for the prevention of cardiovascular diseases.[6]

Antibacterial activity: Crushed seeds of the *Moringa oieifera* tree have been used traditionally as natural flocculants to clarify drinking water. In this study, the conformational modeling of the peptide was coupled to a functional analysis of synthetic derivatives. This indicated that partly overlapping structural determinants mediate the sedimentation and antibacterial activities. Sedimentation requires a positively charged, glutamine-rich portion of the peptide that aggregates bacterial cells. The bactericidal activity was localized to a sequence prone to form a helix-loop-helix structural motif. Amino acid substitution showed that the bactericidal activity requires hydrophobic proline residues within the protruding loop. Vitai dye staining indicated that treatment with peptides containing this motif results in bacterial membrane damage. Assembly of multiple copies of this structural motif into a branched peptide enhanced antibacterial

activity, since low concentrations effectively kill bacteria such as Pseudomonas aeruginosa and Streptococcus pyogenes without displaying a toxic effect on human red blood cells. This study thus identifies a synthetic peptide with potent antibacterial activity against specific human pathogens. It also suggests partly distinct molecular mechanisms for each activity. Sedimentation may result from coupled flocculation and coagulation effects, while the bactericidal activity would require bacterial membrane destabilization by a hydrophobic loop.[7]

4(alpha-L-Rhamnosyloxy)benzyl isothiocyanate was identified as an active antimicrobial agent form seeds of *Moringa oleifera* and *M. stenopetala*. Roots of *M. oleifera* only contain this compound and benzyl isothiocyanate, but not pterygospermin as previously suggested. Defatted and shell free seeds of both species contain about 8-10% of 4(alpha-L-rhamnosyloxy)benzyl isothiocyanate, but this amount is produced from *M. oleifera* only when asorbic acid is added during water extraction. The compound acts on several bacteria and fungi. The minimal bactericidal concentration in vitro is 40 micromol/l for *Mycobacterium phlei* and 56 micromol/l for Bacillus subtilis.[8]

Anticancer activity: In studies of the anticancer potential of plants used in folk medicine of Bengal, extracts of plants such as *Oroxylum indicum, Moringa oleifera lam, Aegles marmelos* could be considered as potential sources of anticancer compounds. Amongst them only *Moringa oleifera* lam has unique anticancer as well as hormonal property, which may or may not be attributable to isothiocyanate.glucosinolate etc. that it contains. 5 adult female mice of swiss strain of 30 gm each 2-control, 3-treated kept on stock diet, pellet, having nutritional value of 7 days. An aqueous extract of the root was prepared according to a traditional method. 1 ml of extract was used orally daily for 45 days, results Attenuation of ovary and uterus was seen while mice tolerated the herb extract well. There was reversal to pre estrus phase of adult mice as was revealed by Pap smear from vagina. In histology there was absence of follicles in comparison to control ovary. There was lesser amount of fibrosis in treated ovary. Isothiocyanate etc. of Moringa may inhibit proliferation of ovarian granutosa and other cells as it induces apoptosis. There is strong possibilty of using this agent in epithelial ovarian cancer and, as such, a cell line experiment is urgently necessary.[9]

The study evaluated the anticancer potential of 11 plants used in Bangladeshi folk medicine. The extracts were tested for cytotoxicity using the brine shrimp lethality assay, sea urchin eggs assay, hemolysis assay and MTT assay using tumor cell lines. The extract of *Oroxylum indicum* showed the highest toxicity on all tumor cell lines tested, with an IC(50) of 19.6 microg/ml for GEM, 14.2 microg/ml for HL-60, 17.2 microg/ml for B-16 and 32.5 microg/ml for HCT-8. On the sea urchin eggs, it inhibited the progression of cell cycle since the frist cleavage (IC(50)=13.5 microg/ ml). The extract of *Aegle marmelos* exhibited toxicity on all used assays, but in a lower potency than *Oroxylum indicum*. In conclusion, among all tested extracts, only the extracts of *Oroxylum indicum*, Moringa oleifera and *Aegles marmelos* could be considered as potential sources of anticancer compounds. Further studies are necessary for chemical characterization of the active principles and more extensive biological evaluations.[10]

Anti-diabetic activity: Diabetes is the most common metabolic disorder worldwide and is a major public health problem. Its frequency increases every day in all countries. However, in developing African countries, few people have access to drugs. In addition,

in Africa, traditional beliefs induce people to use medicinal plants whenever they have health problems. Thus, many people in these developing countries use plants for the treatment of diabetes. Yet, few studies are focused on the knowledge and attitudes of the users on medicinal plants in Africa in general and in Senegal in particular. Hence undertook this survey on the use of medicinal plants for the treatment of diabetes in Senegal in order to make recommendations which could contribute to the increase of the value of herbal medicines in developing countries. Did a cross-sectional survey by direct interview at a university teaching hospital, in Dakar with a representative sample of 220 patients. Forty-one plants were used by the patients and the two most frequently cited were *Moringa oieifera* Lam (65.90%) and *Sclerocarya birrea* (A. Rich) Hochst (43.20%). Patients gave several reasons for using medicinal plants (traditional treatment: 40%, efficacy: 32%, low cost: 20%). The principal suppliers of plants were tradesmen in the market (66.8%) and traditional therapists (5%). Sixty-five per cent of patients think that medicinal plants are efficient for the treatment of diabetes and 20% have reported adverse effects which could be caused by medicinal plants. In conclusion, many people in the study think that medicinal plants are efficient for the treatment of diabetes, which requires research work by scientists in developing countries in this field in order to prove their efficacy and innocuousness.[11]

Antifertility activity: An aqueous extract of *Moringa oleifera* roots was investigated for its estrogenic, anti-estrogenic, progestational and antiprogestational activities. Oral administration of extract progressively increased the uterine wet weight of bilaterally ovariectomized rats. This estrogenic activity was supported by stimulation of uterine histo-architecture. When the extract was given conjointly with estradiol dipropionate (EDP), there was a successive reduction in the uterine wet weight when compared to the gain with EDP alone and uterine histological structures were also inhibited. In the deciduoma test, the highest dose of 600 mg/kg interfered with the formation of deciduoma in 50% of the rats, showing some antiprogestational activity. Doses up to 600 mg/ kg of the extract orally failed to induce a decidual response in the traumatized uterus of ovariectomized rats. The antifertility effect of the extract appears to be due to multiple attributes.[12]

The effect of aqueous extract of *Moringa oleifera* Lam. (roots) has been studied on histoarchitecture of the uterus during pre and post-implantation stages in rats so as to elucidate its antifertility mode of action. The histoarchitecture of the uterus of control pregnant rat had revealed a clear-cut close apposition of the uterine endometrium with reduced lumen and loose stroma. There was a prominent appearance of deciduoma and the uterine glands were enlarged. Glandular cells showed hypertrophy and in the endometrium the leucocytic infiltration was increased. When the aqueous extract of *M. oleifera* Lam. was administered, no deciduoma was observed on day 5th of pregnancy and the luminal epithelium remained unstimulated. The lumen was enlarged and the uterus was non-oedematous. It has been concluded that the administration of aqueous extract of *M. oleifera* Lam. to pregnant rats could not stimulate the uterus which remained non-receptive throughout the period of treatment, therefore, the fertilized eggs may not be welcomed by the unprepared uterus.[13]

Anti-fungal activity: Investigations were carried out to evaluate the therapeutic properties of the seeds and leaves of *Moringa oleifera* Lam as herbal medicines. Ethanol

extracts showed anti-fungal activities in vitro against dermatophytes such as *Trichophyton rubrum, Trichophyton mentagrophytes, Epidermophyton floccosum,* and *Microsporum canis*. GC-MS analysis of the chemical composition of the essential oil from leaves showed a total of 44 compounds. Isolated extracts could be of use for the future development of anti-skin disease agents.[14]

Antimicrobial activities: Three fractions from the leaves of *Moringa oleifera* were obtained on Sephadex G-25 column chromatography. Single bands of these fractions were detected on Polyacrylamide SDS gel electrophoresis. An antibacterial action of small protein/peptide was tested against *E. coli Kl. aerogenes, Kl. pneumoniae, S. aureus,* and *B. subtilis*. Fraction P1, P2 and P3 showed strong inhibitory activity against *E. coli, S. aureus* and *B subtilis* but clear zone of inhibition was also noted against K1. aerogenes with peptide 1. Fraction P2 showed significant zone of inhibition against *Aspergillus niger*.[15]

Seed extracts of *Moringa oleifera* Lam., a tropical tree, have been proposed as an environment-friendly alternative, due to their traditional use for the clarification of drinking water. However, the precise nature of the active components of the extract and whether they may be produced in recombinant form are unknown. Here show that recombinant or synthetic forms of a cationic seed polypeptide mediate efficient sedimentation of suspended mineral particles and bacteria. Unexpectedly, the polypeptide was also found to possess a bactericidal activity capable of disinfecting heavily contaminated water. Furthermore, the polypeptide has been shown to efficiently kill several pathogenic bacteria, including antibiotic-resistant isolates of Staphylococccus, Streptococcus, and Legionella species. Thus, this polypeptide displays the unprecedented feature of combining water purification and disinfectant properties. Identification of an active principle derived from the seed extracts points to a range of potential for drinking water treatment or skin and mucosal disinfection in clinical settings.[16]

Antinociceptive agents: In the studies on the isolation of bioactive compounds from the roots of *Moringa oleifera*, a traditional herb in southeast Asia, rare aurantiamide acetate 4 and 1,3-dibenzyl urea 5 have been isolated and characterized. And also, this is the first report of isolation from this genus. Isolated compound inhibited the production of TNF-alpha and IL-2; further compound 5 showed significant analgesic activities in a dose dependant manner. These findings may help in understanding the mechanism of action of this traditional plant leading to control of activated mast cells on inflammatory conditions like arthritis, for which the crude extract has been used.[17]

Antioxidant activity: Water, aqueous methanol, and aqueous ethanol extracts of freeze-dried leaves of *Moringa oleifera* Lam. from different agroclimatic regions were examined for radical scavenging capacities and antioxidant activities. All leaf extracts were capable of scavenging peroxyl and superoxyl radicals. Similar scavenging activities for different solvent extracts of each collection were found for the stable 1, 1 -diphenyl 2-picrylhydrazyl (DPPH(*)) radical. Among the three different moringa samples, both methanol and ethanol extracts of Indian origins showed the highest antioxidant activities, 65.1 and 66.8%, respectively, in the beta-carotene-linoleic acid system. Nonetheless, increasing concentration of all the extracts had significantly ($P < 0.05$) increased reducing

power, which may in part be responsible for their antioxidant activity. The major bioactive compounds of phenolics were found to be flavonoid groups such as quercetin and kaempferol. On the basis of the results obtained, moringa leaves are found to be a potential source of natural antioxidants due to their marked antioxidant activity. This is the first report on the antioxidant properties of the extracts from freeze-dried moringa leaves. Overall, both methanol (80%) and ethanol (70%) were found to be the best solvents for the extraction of antioxidant compounds from moringa leaves.[18]

The protective effect of *Moringa oleifera* Lam. on hepatic marker enzymes, lipid peroxidation, and antioxidants was investigated during antitubercular drug (isoniazid, rifampicin, and pyrazinamide)-induced toxicity in rats. Enhanced hepatic marker enzymes and lipid peroxidation of antitubercular drug treatment was accompanied by a significant decrease in the levels of vitamin C, reduced glutathione, superoxide dismutase, catalase, glutathione peroxidase, and glutathione S-transferase. Administration of *Moringa oleifera* extract and silymarin significantly decreased hepatic marker enzymes and lipid peroxidation with a simultaneous increase in the level of antioxidants. Speculate that *Moringa oleifera* extract exerts its protective effects by decreasing liver lipid peroxides and enhancing antioxidants.[19]

Anti-ulcer activity: The study has been undertaken to observe the effect of aqueous extract of *M. oleifera* (MO) leaf (300mg/kg body weight) on mean ulcer index, enterochromaffin (EC) cells and serotonin (5-hydroxytryptamine; 5-HT) content of ulcerated gastric tissue. Ulceration was induced by using aspirin (500 mg/kg, po), cerebellar nodular lesion and applying cold stress. In all cases increased mean ulcer index in gastric tissue along with decreased EC cell count was observed with concomitant decrease of 5-HT content. Pretreatment with MO for 14 days decreased mean ulcer index, increased EC cell count and 5-HT content in all ulcerated group, but treatment with ondansetron, a 5-HT3 receptor antagonist, along with MO pretreatment increased mean ulcer index, decreased 5-HT content without any alteration in EC cell count. The results suggest that the protective effect of MO on ulceration is mediated by increased EC cell count and 5-HT levels which may act via 5-HT3 receptors on gastric tissue.[20]

Antiurolithiatic activity: In India, drumstick (*Moringa oleifera* Lam.) is commonly used as a phytotherapeutic agent. The effect of oral administration of aqueous and alcoholic extract of *Moringa oleifera* root-wood on calcium oxalate urolithiasis has been studied in male Wistar albino rats. Ethylene glycol feeding resulted in hyperoxaluria as well as increased renal excretion of calcium and phosphate. Supplementation with aqueous and alcoholic extract of *Moringa oleifera* root-wood significantly reduced the elevated urinary oxaiate, showing a regulatory action on endogenous oxalate synthesis. The increased deposition of stone forming constituents in the kidneys of calculogenic rats was also significantly lowered by curative and preventive treatment using aqueous and alcoholic extracts. The results indicate that the root-wood of *Moringa oleifera* is endowed with antiurolithiatic activity.[21]

Central inhibitory effect: Effect of chronic treatment of standardized aqueous extract of *Moringa oleifera* (MO) root (100, 200, 300, 350, 400, 450 mg/kg; po) on penicillin (PCN) induced convulsion, locomotor behaviour, brain serotonin (5-HTT), dopamine (DA) and norepinephrine (NE) level was studied in Holtzman strain adult albino rats. The

result revealed that pretreatment with MO inhibited PCN-induced seizure and markedly reduced locomotor activity. Chronic treatment with MO significantly increased the 5-HT and decreased the DA level in cerebral cortex (CC), midbrain (MB), caudate nucleus (CN) arid cerebellum (CB). NE level was significantly decreased in CC but no appreciable change was observed in MB, CB and CN. Thus the central inhibitory effect of MO is discussed in the light of the disturbed balance between 5-HT, DA and NE.[22]

Hepatoprotective activity: The aim of the study was to evaluate the hepatoprotective action of *Moringa oleifera* Lam (MO), an Asian plant of high medicinal value, against a single high dose of APAP. Groups of five male Sprague-Dawley rats were pre-administered with MO (200 and 800 mg/kg) prior to a single dose of APAP (3g/kg body weight; p.o). Silymarin was used as an established hepatoprotective drug against APAP induced liver injury. The hepatoprotective activity of MO extract was observed following significant histopathological analysis and reduction of the level of alanine aminotransferase (ALT), aspartate aminotransferase (AST) and alkaline phosphatase (ALP) in groups pretreated with MO compared to those treated with APAP alone. Meanwhile, the level of glutathione (GSH) was found to be restored in MO-treated animals compared to the groups treated with APAP alone. These observations were comparable to the group pretreated with silymarin prior to APAP administration. Group that was treated with APAP alone exhibited high level of transaminases and ALP activities besides reduction in the GSH level. The histoiogical hepatocellular deterioration was also evidenced. The results from the present study suggested that the leaves of MO can prevent hepatic injuries from APAP induced through preventing the decline of glutathione level.[23]

Evaluated the hepatoprotective effect of an ethanolic extract of *Moringa oleifera* leaves on liver damage induced by antitubercular drugs such as isoniazid (INH), rifampicin (RMP), and pyrazinamide (PZA) in rats. Oral administration of the extract showed a significant protective action made evident by its effect on the levels of glutamic oxaloacetic transaminase (aspartate aminotransferase), glutamic pyruvic transaminase (alanine aminotransferase), alkaline phosphatase, and bilirubin in the serum; lipids, and lipid peroxidation levels in liver. This observation was supplemented by histopathological examination of liver sections. The results of this study showed that treatment with M, oleifera extracts or silymarin (as a reference) appears to enhance the recovery from hepatic damage induced by antitubercular drugs.[24]

Hypoglycaemic activity: In experiments 30 hypoglycaemic medicinal plants have been selected for thorough studies from indigenous folk medicines, Ayurvedic, Unani and Siddha systems of medicines. In all the experiments with different herbal samples (vacuum dried 95% ethanolic extracts), definite blood glucose lowering effect within 2 weeks have been confirmed in alloxan diabetic albino rats. Blood glucose values are brought down close to normal fasting level using herbal samples at a dose of 250 mg/kg once, twice or thrice daily, as needed. While evaluating comparative hypoglycaemic activity of the experimental herbal samples, significant blood glucose lowering activities are observed in decreasing order in the following 24 sarnples-*Coccinia indica, Tragia involucrata, G. sylvestre, Pterocarpus marsupium, T. foenum-graecum, Moringa oleifera, Eugenia jambolana, Tinospora cordifolia, Swertia chirayita, Momordica charantia, Ficus glomerata, Ficus benghalensis, Vinca rosea, Premna integrifolia, Mucuna prurita,*

Terminalia bellirica, Sesbenia aegyptiaca, Azadirachta indica, Dendrocalamus hamiltonii, Zingiber officinale, Aegle marmelos, Cinnamomum tamala, Trichosanthes cucumerina and Ocimum sanctum. Present studies besides confirming hypoglycaemic activities of the experimental herbal samples, help identify more potent indigenous hypoglycaemic herbs (in crude ethanolic extract) from the comparative study of the reported experimental results.[25]

Hypolipidaemic effect: Rabbits were fed *Moringa oleifera* (200mg/kg/day, p.o.) or lovastatin (6mg/kg/day, p.o.) in banana pulp along with standard laboratory diet and hypercholesterolaemic diet for 120 days. *Moringa oleifera* and lovastatin were found to lower the serum cholesterol, phospholipid, triglyceride, VLDL, LDL, cholesterol to phospholipid ratio and atherogenic index, but were found to increase the HDL ratio (HDL/HDL-total cholesterol) as compared to the corresponding control groups. Treatment with *M. oleifera* or lovastatin in normal rabbits decreased the HDL levels. However, HDL levels were significantly increased or decreased in *M. oleifera* or lovastatin-treated hypercholesterolaemic rabbits, respectively. Lovastatin or *M. oleifera*-treated hypercholesterolaemic rabbits showed decrease in lipid profile of liver, heart and aorta while similar treatment of normal animals did not produce significant reduction in heart. *Moringa oleifera* was found to increase the excretion of faecal cholesterol. Thus, the study demonstrates that *M. oleifera* possesses a hypolipidaemic effect.[26]

Hypotensive activity: Hypotensive activity of the ethanolic and aqueous extracts of *Moringa oleifera* whole pods and their parts, namely, coat, pulp, and seed was investigated. The activity of the ethanolic extract of both the pods and the seeds was equivalent at the dose of 30 mg/kg. The ethyl acetate phase of the ethanolic extract of pods was found to be the most potent fraction at the same dose. Its bioassay-directed fractionation led to the isolation of thiocarbamate and isothiocyanate glycosides which were also the hypotensive principles of the pods as observed in case of Moringa leaves. Two new compounds, O-[2'-hydroxy-3'-(2"-heptenyloxy)]-propyl undecanoate (1) and O-ethyl-4-[(alpha-L-rhamnosyloxy)-benzyl] carbamate (2) along with the known substances methyl p-hydroxybenzoate (3) and beta-sitosterol have also been isolated in the present studies. The latter two compounds and p-hydroxybenzaldehyde showed promising hypotensive activity. Structures of all these compounds have been deduced by spectroscopy and chemical reactions.[27]

Six new and three synthetically known glycosides have been isolated from the leaves of *Moringa oleifera*, employing a bioassay-directed isolation method on the ethanolic extract. Most of these compounds, bearing thiocarbamate, carbamate or nitrile groups, are fully acetylated glycosides, which are very rare in nature. Elucidation of the structures was made using chemical and spectroscopic methods,, including 2D NMR techniques. Thiocarbamates showed hypotensive activity.[28]

Bioassay-guided analysis of an EtOH extract of *Moringa oleifera* leaves showing hypotensive activity led to the isolation of two nitrile glycosides, niazirin [1] and niazirinin [2], and three mustard oil glycosides, 4-[(4'-O-acetyl-alpha-L-rhamnosyloxy)benzyl]isothiocyanate [4], niaziminin A, and niaziminin B. Glycoside 2 is a new compound. Niaziminins A and B have previously been obtained from the left extract as a mixture, while compound 4 is new from this source. Structural determination

was accomplished by means of spectroscopic methods including appropriate 2D nmr experiments and chemical reactions. This is the first report of the isolation of nitrites, an isothiocyanate, and thiocarbamates from the same plant species. Isothiocyanate 4 and the thiocarbamate glycosides niaziminin A and B showed hypotensive activity while nitrile glycosides 1 and 2 were found to be inactive in this regard.[29]

Teratologic effects: A survey programme was organised in Lucknow and Farrukhabad, two towns of Uttar Pradesh, from March 1987 to July 1987. During the survey, the common folk medicine plants used by women were recorded and Ayurvedic and Unani drug encyclopedias were consulted for the antireproductive potential of these plants. Aqueous or 90% ethanol extracts of the plants of interest were studied in rats orally dosed for 10 days after insemination with special reference to effects on foetal development. Leaf extracts of *Moringa oleifera* and *Adhatoda vasica* were 100% abortive at doses equivalent to 175 mg/kg of starting dry material.[30]

Toxicity: In rural Sudan, powdered seeds of the tree *Moringa oleifera* are used to purify drinking water by coagulation. In trials, the powder was toxic to guppies *(Poecilia. reticulate},* protozoa *(Tetrahymena pyriformis)* and bacteria *(Escherichia coll)* and it inhibited acetylcholinesterase. It had no effect on coliphages, lactic dehydrogenase or invertase and the equivalent of cotyledon powder up to 1000 mg/litre had no mutagenic effect on *Salmonella.* Pericarp had no effect. Powdered cotyledon 5 mg/litre affected oxygen uptake of *T. pyriformis,* 30 to 40 mg/litre disturbed locomotion of guppies and the 96-h LC_{50} for guppies was 196 mg/litre. Toxic effects may have been due to 4(a-L-rhamnosyloxy) benzyl isothiocyanate, a glycosidic mustard oil. The toxin seemed not to be a danger to the health of man, at least not in the concentrations present during the use of the seeds for nutrition, medicine or water purification.[31]

Following oral administration, the extract inhibited carrageenan-induced rat paw edema in a dose-dependent manner, with 50% inhibitory concentration - IC_{50} (dose producing 50% inhibition) of 660 mg/kg. On the 6-day air pouch acute inflammation 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. Maximum inhibition obtained with 600 mg/kg were 83.8% and 80.0%, respectively. In contrast a moderate dose of indomethacin (5 mg/kg) inhibited the acute, but not the delayed form of air pouch inflammation. Acute toxicity tests in mice suggest very low toxicity.[32]

The cytotoxicity of extracts from a widely used species of plant, *Moringa stenopetala*, was assessed in HEPG2 cells, by measuring the leakage of lactate dehydrogenase (LDH) and cell viability. The functional integrity of extract-exposed cells was determined by measuring intracellular levels of ATP and glutathione (GSH). The ethanol extracts of leaves and seeds increased significantly ($p < 0.01$) LDH leakage in a dose- and time-dependent manner. The water extract of leaves and the ethanol extract of the root did not increase LDH leakage. A highly significant ($p < 0.001$) decrease in HEPG2 viability was found after incubating the cells with the highest concentration (500 microg/mL) of the ethanol leaf and seed extracts. At a concentration of 500 microg/mL, the water extract of leaves increased ($p < 0.01$), while the ethanol extract of the same plant part decreased ($p < 0.01$), ATP levels. The root and seed extracts had no significant

effect on ATP levels. The ethanol leaf extract decreased GSH levels at a concentration of 500 microg/mL ($p < 0.01$), as did the ethanol extract of the seeds at 250 microg/mL and 500 microg/mL ($p < 0.05$). The water extract of the leaves did not alter GSH or LDH levels or affect cell viability, suggesting that it may be non-toxic, and is consistent with its use as a vegetable. The data obtained from the studies with the ethanol extract of the leaves and seeds from Moringa stenopetala show that they contain toxic substances that are extractable with organic solvents or are formed during the process of extraction with these solvents. The significant depletion of ATP and GSH only occurred at concentrations of extract that caused leakage of LDH. Further investigation with this plant in order to identify the constituents extracted and their individual toxic effects both in vivo and in vitro is warranted. This study also illustrates the utility of cell culture for screening plant extracts for potential toxicity.[33]

Wound healing activity: Aqueous extract of leaves of *M. oleifera* was investigated and rationalised for its wound healing activity. The aqueous extract was studied at dose level of 300 mg/kg body weight using resutured incision; excision and dead space wound models in rats. Significant increase in wound closure rate, skin-breaking strength, granuloma breaking strength, hydroxyproline content, granuloma dry weight and decrease in scar area was observed. The prohealing actions seem to be due to increased collagen deposition as well as better alignment and maturation. From the results obtained, it may be concluded that the aqueous extract of *M. oleifera* has significant wound healing property.[34]

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