

Review Article



Moringa olifera: constituents and protective effects on organ systems

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Abstract

Moringa olifera (MO) belongs to Moringaceae family commonly known as the Miracle Tree. It is a versatile tree useful for human beings and animals and also has industrial values. It is one among the richest plant sources of vitamins A, B, C, D, E and K. MO leaves and fruits are used as vegetables in various countries of the world. Earlier studies have found that MO to be nontoxic and recommended for therapeutic use in developing countries. It has been used in treatment of many diseases such as antimicrobial activity, antidiabetic, hepatoprotective, hypo cholesterolemic activity, cancer, high blood pressure and for cardiac stimulation. It is an antioxidant which is known to be more powerful and a free radical scavenger able to inhibit oxidant and stimulate antioxidant status.

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Introduction

Moringa oleifera (MO) belongs to Moringaceae family commonly known as the “Miracle Tree”, “Horseradish-tree” or “Ben oil tree” (Luqman et al., 2012). It is a multipurpose evergreen crop, widely cultivated in Africa and Southern Asia with medicinal and nutritional properties attributed to its roots, bark, leaves, flowers, fruits and seeds (Sanchez et al., 2006; Nouman et al., 2014). It is a versatile tree which is useful for human beings and animals and also has industrial values. It is one of the richest plant having sources of vitamins A, B, C, D, E and K. MO leaves and fruits are used as vegetables in various countries of the world. MO is known to be nontoxic and is recommended for its therapeutic effects in developing countries as it has been used for long time in treatment of many diseases such as antimicrobial activity, antidiabetic, hepatoprotective,

hypcholesterolemia activity, in cancer, high blood pressure and for cardiac stimulation.

Some of the previous studies have reported the antiulcer, diuretic, anti-inflammatory, antifertility, CNS depressant and wound healing properties of leaves of MO (Bais et al., 2014). This will provide useful forage in the form of leaves and seeds and can be used to supplement poor quality and low protein roughage. The importance of multipurpose plants as source of protein and energy to ruminants particularly during the dry season of the year can never be over emphasized. Some studies have shown that this tree can offer good alternate source of feed during the dry seasons. The rich nitrogen source of this tree can further be exploited to boost sustenance and production of West African Dwarf goats especially during periods of scarcity when fodder quality and quantity are low. Inclusion of MO in goat's feed would provide nourishable supplement all year round for

goats. This way more meat will be realized making animal protein available and affordable (Jiwuba et al., 2016). Leaves of the *MO* tree is noted for high crude protein, energy and appreciable levels of carotene, ascorbic acid, iron, methionine and cysteine with negligible amounts of tannins (Jiwuba et al., 2016).

The biological properties and medicinal functions of *MO* extracts have been mainly supported by *in vitro* assays based on their antioxidant capacity and bioactive profile (Anwar et al., 2007; Sultana et al., 2009; Atsukwei et al., 2014). *MO* leaf extracts exhibit antioxidant activity due to their abundance of phenolic acids and flavonoids (Vongsak et al., 2013).

History

MO, *Lam* syn. *M. pterygosperma*, Gaertn (Family – Moringaceae), is a small or medium-sized tree, attractive enough owing to its creamy white, sweetly scented flowers and light green tripinnately compound foliage. It is a native crop of India, occurring wild in the sub-Himalayan regions of Northern India and cultivated throughout the country. It is commonly known as Sajina (Bengali), Horseradish tree, drumstick tree (English), Sahinjan, mungna (Hindi), Murinna, muringa, tishnagandha (Malayalam), Sevaga, segata (Marathi), Sohanjana (Punjabi), Sobhanjana, sigru, murungi, dvishiguru (Sanskrit) and Sehjan (Urdu) in varied Indian languages and regions while in the Nile valley the name of the tree is 'Shagara al Rauwaq', which means 'tree for purifying'. In the Philippines, it is known as 'mother's best friend' because of its utilization to increase woman's milk production and is sometimes prescribed for anemia.

It also thrives well in Pakistan, Bangladesh, Sri Lanka, tropical Africa, Arabia, Philippines, Cambodia and Central, North and South America. Described as "one of the most amazing trees God has created" because of its usefulness in every part. Almost every part of this highly esteemed tree have long been consumed by humans and used for various domestic purposes as for alley cropping, animal forage, biogas, domestic cleaning agent, blue dye, fertilizer, foliar nutrient, green manure, gum (from tree trunks), honey and sugar cane juice-clarifier (powdered seeds), ornamental plantings, biopesticide, pulp, rope, tannin for tanning hides, water purification, machine lubrication (oil), manufacture of perfume and hair care products. Leaves can be eaten fresh,

cooked or stored as dry powder for many months without refrigeration, without loss of nutritional value. Literature reports that *Moringa* to be an abortifacient, antidote, antirheumatic, bactericide, diuretic, ecboic, emetic, expectorant, purgative, rubefacient, stimulant, tonic, vermifuge and vesicant (Pandey et al., 2012). *MO* is incorporated in various marketed formulations, such as Rumalaya and Septilin (The Himalaya Drug Company, Bangalore India), Orthoherb (Walter Bushnell Ltd. Mumbai, India), Kupid Ford (Pharma Products Pvt Ltd, Thayavur, India) and Livospin (Herbals APS Pvt. Ltd., Patna, India), which are available for a variety of ailments. Ayurvedic preparations include Ratnagiri Rasa, Sarasvata Ghrta, Sudarsana churna, Sarsapadi Pralepa, Visatimduka Taila and etc (Sashidhara et al., 2009).

Planting of MO

It requires a temperature of 25–35°C, sandy or loamy soil with slightly acidic PH and a net rainfall of 250-3000mm is required for the growth of *MO* in any tropical and subtropical regions of the world. It has high germination rate so direct seedling is followed. This will also be cultivated by cuttings of 1m length and 4–5cm in diameter of the tree. They don't have a deep root system so that it is very much sensitive to wind and drought. Soil where *MO* grows is an important factor for growth, nutrient content and strength of the plant. Dania et al. (2014) showed that fertilizers applied singly or in combination with others resulted in different nutrient compositions on plant parts. NPK fertilizer, poultry manure and organic base fertilizer was supplemented to study the effect on the nutrient content. It was found that poultry manure gave the best results than phosphorous, potassium, sodium and manganese. Likewise the stem growth and vegetative growth of *Moringa* increased on application of poultry manure. The overall nutrient attributes of the plant remains same albeit nutrient variability. This makes *Moringa* viable as a potential nutraceutical anywhere in the world (Gopalakrishnan et al., 2016; Dania et al., 2014).

Chemical composition of leaves and seeds

Aja et al. (2014) investigated the chemical constituents of the methanolic extract of *MO* leaves and seeds using gas chromatography-mass spectrometry and identified sixteen chemical constituents in the leaf methanolic extract. They are

9-octadecenoic acid (20.89%), L-(+)-ascorbic acid-2,6-dihexadecanoate (19.66%), 14-methyl-8-hexadecenal (8.11%), 4-hydroxyl-4-methyl-2-pentanone (7.01%), 3-ethyl-2, 4-dimethyl-pentane (6.14%), phytol (4.24%), octadecamethyl-cyclononasiloxane (1.23%), 1, 2-benzene dicarboxylic acid (2.46%), 3, 4-epoxy-ethanone comprising (1.78%), N-(-1-methylethylidene)-benzene ethanamine (1.54%), 4,8,12,16-tetramethylheptadecan-4-olide (2.77%), 3-5-bis (1,1-dimethylethyl)-phenol (2.55%), 1-hexadecanol (1.23%), 3,7,11,15-tetramethyl-2 hexadecene-1-ol (1.17%), hexadecanoic acid (2.03%) and 1,2,3-propanetriyl ester-9 octadecenoic acid (1.23%). Also there are five chemical constituents in methanolic seed extract as oleic acid (84%), L-(+)- ascorbic acid 2,6-dihexadecanoate (9.80%), 9-octadecenoic acid (1.88%), methyl ester-hexadecanoic acid (1.31%) and 9-octadecenamide (0.78%). They concluded that the methanolic leaf extract of *MO* has more chemical constituents than the seed (Aja et al., 2014). There is a difference in nutritional components of a tree grown in India compared to the tree grown in Nigeria. Asante et al. (2014) studied the nutritional differences in the leaves from two ecological locations semi-deciduous and Savannah regions. It showed that the latter was less nutritious than the former and attributed this to high temperatures at the Savannah regions. At higher temperature, proteins and enzymes get denatured and this could be the cause for the difference in nutrient content.

Effects of *MO* on cure of Disease

It is a free radical antioxidant, which prevents oxidative damage. For hundreds of years, traditional healers have prescribed different parts of *MO* for treatment of skin diseases, respiratory illnesses, ear and dental infections, hypertension, diabetes, cancer treatment, and water purification, and they have promoted its use as a nutrient dense food source. The high concentrations of ascorbic acid, oestrogenic substances and sitosterol, iron, calcium, phosphorus, copper, vitamins A, B and C, tocopherol, riboflavin, nicotinic acid, folic acid, pyridoxine, carotene, protein and in particular essential amino acids such as methionine, cystine, tryptophan and lysine present in *MO* leaves and pods make it a virtually ideal dietary supplement (Lobo et al., 2010).

Hematology

The usage of *MO* is known to have positive effects on some hematological parameters. This could be due to the phytochemical constituents in the extract and also presence of minerals and vitamins (Mandal et al., 2015). These constituents are well-known haemopoietic factors that have direct influence on the production of blood cells in the bone marrow. The principal role of *MO* extract seems to facilitate iron absorption, as adequate amount of this element is necessary for hemoglobin synthesis and for the animal tissues such as the kidneys and bones to take part in manufacture of red blood cells. However, due to their ability to increase blood parameters, their polyherbal formulations have been used in several localities among housewives without any scientific investigation of their effect on hematological indices. It is therefore expedient to compare the blood boosting capacities of the individual extracts with their polyherbal formulation (Abbaspour et al., 2014).

Anticancer activity

MO leaves have been reported to have antitumor and anticancer activities and increases blood cell production (Ajugwo et al., 2017). *MO* exhibits anticancer potential by interfering with the signal transduction cascade that promotes cancer cell proliferation and progression. Cancer cell proliferation inhibition is majorly due to the presence of eugenol, a phenolic natural compound which targets E2F1/survivin in cancer cells, D-allose, isopropyl isothiocyanate and etc. The presence of isothiocyanate (organosulphur compound) in *MO* bark extract can be attributed to its anticancer property. It act as an anticancer agent by decreasing cell motility and colony formation in colorectal and breast cancer cell lines. In addition to that growth of cell survival will be reduced, high apoptosis is detected upon treatment with the extracts of *MO* leaves and bark. Al-Asmari et al. (2015) suggested that both the leaf and bark extracts of *Moringa* collected from the Saudi Arabian region possess anticancer activity that can be used to develop new drugs for treatment of breast and colorectal cancers.

On calcium

Ranjan et al. (2009) concluded that supplementation of dried fruit powder of *MO* in fluorotic cattle produced significant increase in calcium concentration which

might be due to its richness in calcium and reduced absorption or increased in elimination of fluoride from the body and also known to reduce alkaline phosphatase activity. Increase in alkaline phosphatase activity is related to abnormal bone formation and stimulated osteoblastic activity.

Hepatoprotection

Significant lower levels of serum protein in fluorotic cattle is indicator of hepatic dysfunction. It is reported that *MO* supplementation significantly increases serum protein levels by its constituents (monoterpenes, glycosides, organic acids, lipids, alkaloids, xanthenes, flavanoids [quercetin], β -carotenes and ascorbic acid) which have hepatoprotective effect owed to antioxidant property (Aja et al., 2014; Jena et al., 2016). The flowers show effective hepatoprotective effect due to the presence of quercetin. Seeds are used as biosorbent for the removal of cadmium from aqueous medium and are one of the best-known natural coagulants which is discovered so far (Luqman et al., 2012).

Renal function

There is a significant high level of urea and creatinine which is recorded in cattle reared in fluorotic zone (Maiti et al., 2004). Kidneys play an important role in regulation of total body fluoride burden and toxic doses of fluoride can result in renal dysfunction by inhibiting various enzyme systems in the kidneys. Consequent treatment with *MO* dried fruit powder showed a decrease in creatinine level which was significant at 60 days of treatment and there was decreased urea which was statistically not significant. This might be due to antioxidative property, reduced fluoride burden and higher calcium content of dried *MO* fruit powder which protects renal and muscular damage (Ranjan et al., 2009).

Obesity

The results of some studies suggested that leaves of *MO* supplementation at 200mg/kg and 400mg/kg are capable of preventing body weight gain and organ weight gain, concomitantly helping in maintaining normal body weight on rats which are fed with high fat diet and also they have shown that, significant increase in serum HDL levels with decreased LDL levels, total cholesterol and triglyceride levels.

Thus, in their study it is concluded that leaves of *MO*

possess cardioprotective potential. High fat diet fed rats were known to cause hepatocellular damage, as clearly seen by the marked elevation of serum enzymes (SGOT, SGPT and total bilirubin) activities and histopathological studies of liver exaggerated with hepatic steatosis; however, treatment with leaves of *MO* causes a momentary reduction in the enzyme levels.

It helps in preventing liver damage which is caused by having high-fat diet. It was also known to decrease blood glucose levels, body temperature and metabolic rate. The high concentrations of ascorbic acid, oestrogenic substances and sitosterol, iron, calcium, phosphorus, copper, vitamins A, B and C, α -tocopherol, riboflavin, nicotinic acid, folic acid, pyridoxine, β -carotene, protein, methionine, cysteine, tryptophan and lysine present in *MO* leaves and pods make it a virtually ideal dietary supplement (Bais et al., 2014).

Hormonal balance

Fruit and leaves of *MO* have been used to combat malnutrition, especially among infants and nursing mothers for enhancing milk production and also regulate thyroid hormone imbalance (Luqman et al., 2012).

Antimicrobial activity

It also possesses antimicrobial activity due to its principle component pterygospermin. The fresh leaf juice was found to inhibit the growth of human pathogens as *Staphylococcus aureus* and *Pseudomonas aeruginosa*. Phytoconstituents from different parts of the tree as niazimicin, niaininin, various carbamates and thiocarbamates have shown to exhibit antitumor activity in vitro. They are also considered to be antipyretic and bitter and reported to show antimicrobial activity. The roots have been reported to possess antispasmodic activity through calcium channel blockade which forms the basis for its traditional use in diarrhea (Luqman et al., 2012). Lectin present in seed extract of *MO* can inhibit growth, survival and cell permeability of multiple species of pathogenic bacteria. Leaves of *MO* have antibacterial properties, with strong inhibitory effects on Gram-positive species over Gram-negative species (Kou et al., 2018; Stohs et al., 2015).

Effects on Ocular Diseases

Major causes of blindness or ocular diseases by deficiency of vitamin A is cured by the leaves and pods of *MO* which has more concentrations of vitamin A which can improve vision by preventing night blindness and problems of eye. Also, consumption of leaves with oils improved vitamin A nutrition and delayed the development of cataracts (Anwar et al., 2007).

Cardiovascular effects

MO can be used in treatment of cardiovascular diseases as the roots, leaves, gum, flowers and infusion of seeds have nitrile, mustard oil glycosides and thiocarbamate glycosides as their chemical constituents which are suggested to be responsible for the cholesterol lowering, antiulcer, hepatoprotective and cardiovascular protective property of the tree (Anwar et al., 2007). Nitrile, mustard oil glycosides and thiocarbamate glycosides have been isolated from *MO* leaves, which were found to be responsible for the blood pressure lowering effect. Bioassay guided fractionation of the active ethanol extract of *MO* leaves led to the isolation of four pure compounds, niazinin A, niazinin B, niazimicin and niazinin AB which showed a blood pressure lowering effect in rats mediated possibly through a calcium antagonist effect (Stohs et al., 2015).

Neuronal damage

MO is a potential remedy for enhancing memory by treating neuronal disorders. It is known to stimulate neuronal outgrowth, increase the number and length of dendrites and axonal branches. In combination with fluoxetine it can act as an antidepressant by noradrenergic-serotonergic neurotransmission pathway (Gilani et al., 1994). The extract of *MO* exhibits both antioxidant activity and nootropic effects and can fight with oxidative stress by decreasing malondialdehyde levels and acetylcholinesterase activity, but can increase super oxide dismutase and catalase activity. At a dose of 300mg/kg of *MO* for 28days its able to decrease aluminum chloride-induced temporal cortical degeneration by decreasing the expression of neuron specific enolase and glial fibrillary acidic protein (Ekong et al., 2017).

On fluorosis

Studies shows that supplementation of *MO* is able to

reduce the plasma fluoride levels in affected calves. Interference with fluoride absorption from the gut might have played a role in reducing plasma fluoride concentrations. The lower molecular weight water soluble proteins in *Moringa* have a strong positive charge that attracts highly electronegative fluoride ions resulting the formation of flocculants. Furthermore, the presence of tannins, fibers and high concentration of minerals in *Moringa* like calcium, aluminum, phosphorus, manganese, potassium, copper and iron which are reported to form insoluble complexes with fluoride in the gut which justifies the enhanced fluoride elimination in faeces leads to reduced absorption from intestine, thereby reduction in urinary and serum fluoride concentration. It not only has chelating property but also have other constituents that protect oxidative damage to the hematopoietic system as well as reduce cytotoxic effect of fluoride intoxication (Mandal et al., 2015).

Medicinal uses of different parts of MO

Roots can be used for antifertility, anti-inflammatory, back pains, kidney pains and constipation. Leaves can be used for piles, head ache, bronchitis, fever, eye and ear infection. Flower can be used for muscle diseases, enlargement of spleen, lowers cholesterol levels and decreases lipid profile in liver, heart and aorta. Seed extracts can be used for protective effect by decreasing liver peroxides. Gum of *MO* can be used for asthma, intestinal complaints, rheumatism, which relives headaches, fever and dental caries. Stem bark can be used to heal ulcers, tumors, to cure eye diseases and prevents enlargement of spleen (Siddhuraju et al., 2003).

Hazardous effects

Ajibade et al. (2013) concluded that no adverse effects are seen in *MO* at concentrations lower than 3000mg/kg safe for both for medicinal and nutritional uses. Overdoses of 4000mg/kg *MO* leads to acute toxicity (agitation, confusion, disorientation) and mortality was observed at 5000mg/kg *MO* in wistar rats (Ajibade et al., 2013; Olayemi et al., 2016). An overdose of *MO* may cause high accumulation of iron. High iron can cause gastrointestinal distress and hemochromatosis. Hence, a daily dose of 70g of *Moringa* is suggested to be good and prevents over accumulation of nutrients (Asiedu-Gyekye et al., 2014).

Conclusion

Moringa is a local, natural, cheap and abundantly available, multipurpose crop. It has been praised for its health benefits for thousands of years. Each part of it is known to cure different types of diseases. It is very much rich in antioxidants and anti-inflammatory effects.

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Conflict of interest

Authors declares that they have no conflicts of interest.

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