Moringa olifera: constituents and protective effects on organ systems

Pravallika Pagadala*, Vinutha Shankar

Department of Physiology, Sri Devaraj Urs Academy of Higher Education & Research, Tamaka, Kolar Karnataka, India

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, hypocholesterolemic 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.

http://dx.doi.org/10.32598/ppj.24.2.40

Keywords:

- *M. olifera*
- Herbal medicine
- Therapeutic potential
- Protective effect

* Corresponding author: Pravallika Pagadala

Email: pravallika@sdumc.ac.in

Received 15 May 2019; Received in revised form 12 February 2020; Accepted 17 February 2020

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, hypocholesterolemic 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 (Malyalam), 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, ecobic, 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 Ghrita, 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 seeding 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-di-hexadecanoate (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%), octadecamethylene-cyclononasiloxane (1.23%), 1, 2-benzene dicarboxylic acid (2.46%), 3, 4-epoxy-ethaneone comprising (1.78%), N-(1-methyllylidene)-benzene ethanamine (1.54%), 4, 8, 12, 16-tetramethylethaptecan-4-oxide (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-di-hexadecanoate (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 isothiocynate and etc. The presence of isothiocynate (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
Ranjeet 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 hepatic cellular 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, niaiminin, 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.

Acknowledgments

We would like to acknowledge Dr. Karthiyanee kutty who helped us in writing the article.

Conflict of interest

Authors declares that they have no conflicts of interest.

References

Abbaspour N, Hurrell R, Kelishadi R. Review on iron and its importance for human health. J Res Med Sci 2014; 19: 164-74.

Aja PM, Nwachukwu N, Ibiarn UA, Igwenyi IO, Ofor CE, Orji UO. Chemical constituents of Moringa oleifera leaves and seeds from Abakaliki, Nigeria. Am J PhytoMed Clin Ther 2014; 2: 310-21.

Ajibade TO, Arowolo R, Olayemi FO. Phytochemical screening and toxicity studies on the methanol extract of the seeds of Moringa oleifera. J Complement Integr Med 2013; 10: 11-6. https://doi.org/10.1515/jcim-2012-0015

Ajugwo AO, Mounbégna PE, Kemajou TS, Ofokansi VC. Effects of Moringa oleifera leaves Extrait on haematological parameters of phenylhydrazine anaemia induced wistar rats. Int J Pub Health Safe 2017; 2: 139.

Al-Asmari AK, Albalawi SM, Athar MT, Khan AQ, Al-Shahrani H, Islam M. Moringa oleifera as an anticancer agent against breast and colorectal cancer cell lines. PLoS One 2015; 10: e0135814. https://doi.org/10.1371/journal.pone.0135814

Anwar F, Latif S, Ashraf M, Gilani AH. Moringa oleifera as an effective herbal remedy for the treatment of type 2 diabetes. J Ethnopharmacology 2015; 164: 100-7. https://doi.org/10.1016/j.jep.2015.04.001

Asante WJ, Nasare IL, Tom-Dery D. ochiré-Boadu K, Kentil KB. Nutrient composition of Moringa oleifera leaves from two agro ecological zones in Ghana. Afr J Plant Sci 2014; 8: 65-71. https://doi.org/10.5897/AJPS2012.0727

Asiedu-Gyekye IJ, Frimpong-Manso S, Awortwe C, Antwi DA, Nyarko AK, Nyarko AK. Micro and macronutrient composition and safety evaluation of the nutraceutical Moringa oleifera leaves. J Toxicol 2014; 2014: 786979. https://doi.org/10.1155/2014/786979

Atsukwei D, Eze ED, Adams MD, Adinoyi SS, Upkabi CN. Hypolipidaemic effect of ethanol leaf extract of Moringa oleifera Lam. in experimentally induced hypercholesterolemic wistar rats. Int J Nutr Food Sci 2014; 3: 355-60. https://doi.org/10.11648/j.ijnfs.20140304.28

Bais S, Singh GS, Sharma R. Antibesity and hypolipidemic activity of Moringa oleifera leaves against high fat diet-induced obesity in rats. Adv Bio 2014; 2014. https://doi.org/10.1155/2014/162914

Dania SO, Akpansubi P, Eghagare OO. Comparative effects of different fertilizer sources on the growth and nutrient content of Moringa (Moringa oleifera) seedlings in a greenhouse trial. Adv Agric 2014; 2014. https://doi.org/10.1155/2014/726313

Ekong MB, Ekpo MM, Akpanyung EO, Nwaokonko DU. Neuroprotective effect of Moringa oleifera leaf extract on aluminium-induced temporal cortical degeneration. Metab Brain Dis 2017; 32: 1437-47. https://doi.org/10.1007/s11011-017-0011-7

Gilani AH, Aftab K, Suria A, Siddiqui S, Salem R, Siddiqui BS, et al. Pharmacological studies on hypotensive and spasmylocic activities of pure compounds from Moringa oleifera. Phytother Res 1994; 8: 87-91. https://doi.org/10.1002/ptr.2650080207

Gopalakrishnan L, Doriya K, Kumar DS. Moringa oleifera: a review on nutritive importance and its medicinal application. Food Sci Hum Wellness 2016; 5: 49-56. https://doi.org/10.1016/j.fshw.2016.04.001

Jena CK, Gupta AR, Patra RC. Protective effect of Moringa oleifera on haematological and biochemical parameters of cattle from industrial fluoride polluted area. J Anim Res 2016; 6: 91-7. https://doi.org/10.5958/2277-940X.2016.00015.2

Jiwuba PD, Ahamefule FO, Okechukwu OS, Ikwunze K. Feed intake, body weight changes and haematology of West African dwarf goats fed dietary levels of Moringa oleifera leaf meal. Agriculture 2016; 13: 71-7. https://doi.org/10.1515/agriculture-2017-0009

Kou X, Li B, Olayanju JB, Drake JM, Chen N. Nutraceutical or pharmacological potential of Moringa oleifera Lam. Nutrients 2018; 10: 343. https://doi.org/10.3390/nu10030343

Lobo V, Patil A, Phatak A, Chandra N. Free radicals, antioxidants and functional foods: impact on human health. Pharmacogn Rev 2010; 4: 118. https://doi.org/10.4103/0973-7847.70902

Luqman S, Srivastava S, Kumar R, Maurya AK, Chanda D. Experimental assessment of Moringa oleifera leaf and fruit for its antistress, antioxidant, and scavenging potential using in vitro and in vivo assays. Evid Based Complement Alternat Med 2012; 2012: 519084. https://doi.org/10.1155/2012/519084

Maiti SK, Das PK. Biochemical changes in endometrial florosis in cattle. Indian J Anim Sci 2004; 74: 169-171.

Mandal KD, Das MR, Pati M, Pati PD, Gupta AR, Patra RC, et al. Effect of Moringa oleifera on hematological parameters of calves reared in industrial florotic area. Vet World 2015; 8: 1364-9. https://doi.org/10.14202/vetworld.2015.1364-1369

Nouman W, Basra SM, Siddiqui MT, Yasmeen A, Gull T, Alcayde MA. Potential of Moringa oleifera L. as...
Moringa olifera and its health benefits

Physiol Pharmacol 24 (2020) 82-88 |

livestock fodder crop: a review. Turk J Agric For 2014; 38: 1-4. https://doi.org/10.3906/tar-1211-66

Olajemi AT, Olanrewaju MJ, Oloruntoba AC. Toxicological evaluation of Moringa oleifera Lam seeds and leaves in wistar rats. Pharmacogn Commn 2016; 6: 100. https://doi.org/10.5530/pc.2016.2.8

Pandey A, Pandey RD, Tripathi P, Gupta PP, Haider J, Bhatt S, et al. Moringa oleifera Lam.(Sahijan)-A plant with a plethora of diverse therapeutic benefits: an updated retrospection. Med Aromat Plants 2012; 1:101. https://doi.org/10.4172/2167-0412.100101

Ranjan R, Swarup D, Patra RC, Chandra V. Tamarindus indica L. and Moringa oleifera M. extract administration ameliorates fluoride toxicity in rabbits. Indian J Exp Biol 2009; 47: 900-5.

Sanchez NR, Ledin S, Ledin I. Biomass production and chemical composition of Moringa oleifera under different management regimes in Nicaragua. Agroforestry Systems 2006; 66: 231-242. https://doi.org/10.1007/s10457-005-8847-y

Sashidhara KV, Rosaiah JN, Tyagi E, Shukla R, Raghubir R, Rajendran SM. Rare dipeptide and urea derivatives from roots of Moringa oleifera as potential anti-inflammatory and antinociceptive agents. Eur J Med Chem 2009; 44: 432-6. https://doi.org/10.1016/j.ejmech.2007.12.018

Siddhuraju P, Becker K. Antioxidant properties of various solvent extracts of total phenolic constituents from three different agroclimatic origins of drumstick tree (Moringa oleifera Lam.) leaves. J Agric Food Chem 2003; 15: 2144-55. https://doi.org/10.1021/jf020444+

Stohs SJ, Hartman MJ. Review of the safety and efficacy of Moringa oleifera. Phytother Res 2015; 29: 796-804. https://doi.org/10.1002/ptr.5325

Sultana B, Anwar F, Ashraf M. Effect of extraction solvent/technique on the antioxidant activity of selected medicinal plant extracts. Molecules 2009; 14: 2167-80. https://doi.org/10.3390/molecules14062167

Vongsak B, Sithisarn P, Mangmool S, Thongpraditchote S, Wongkrajang Y, Gritsanapan W. Maximizing total phenolics, total flavonoids contents and antioxidant activity of Moringa oleifera leaf extract by the appropriate extraction method. Ind Crops Prod 2013; 44: 566-71. https://doi.org/10.1016/j.indcrop.2012.09.021