

Review

Medicinal properties of *Moringa oleifera*: An overview of promising healer

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***Moringa oleifera* Lam. (MO) is a small size tree with approximately 5 to 10 m height. It is cultivated all over the world due to its multiple utilities. Every part of *Moringa* is used for certain nutritional and/or medicinal propose. Besides being a good source of protein, vitamins, oils, fatty acids, micro-macro minerals elements and various phenolics, it is also reported as anti-inflammatory, antimicrobial, antioxidant, anticancer, cardiovascular, hepatoprotective, anti-ulcer, diuretic, antiurolithiatic, and antihelmintic. Its multiple pharmaceutical effects are capitalized as therapeutic remedy for various diseases in traditional medicinal system. Further research on this charismatic healer may lead to the development of novel agents for various diseases. This study provides a brief overview about medicinal potential of *Moringa* and its future as a component of modern medicinal system. This study concludes that *Moringa* needs legitimate appraisal to establish its pharmaceutical knack in modern medicine.**

Key word: *Moringa oleifera*, medicinal plant, anti-inflammatory, anti-microbial, antioxidant, antiulcer, diuretic.

INTRODUCTION

Moringa oleifera (MO) is an aboriginal of Indian subcontinent and has become naturalized in the tropical and subtropical areas around the world. Nearly thirteen species of *Moringa* are included in the family Moringaceae (Nadkarni, 1976). Indians have been using it as a regular component of conventional eatables for nearly 5000 years (Anwar et al., 2005; Anwar and Bhangar, 2003; D'Souza and Kulkarni, 1993). *Moringa* tree can grow well in the humid tropic or hot dry land with average height that ranges from 5 to 10 m. It can survive in harsh climatic condition including destitute soil without being much affected by drought (Morton, 1991). It can tolerate wide range of rainfall requirements estimated at 250 mm and maximum at over 3000 mm and a pH of 5.0 to 9.0 (Palada and Chang, 2003). Its trunk is soft, white

corky and branches bearing a gummy bark. Each tripinnately compound leaves bear several small leaf legs. The flowers are white and the three wings seeds are scattered by the winds. The flowers, tenders leaves and pods are eaten as vegetables. The leaves are rich in iron and therefore highly recommended for expected mothers. In some part of the world, MO is referred to as the 'drum stick tree' or the 'horse radish tree', whereas in others, it is known as the kelor, marango, mlonge, moonga, mulangay, nebeday, saijhan, sajna or Ben oil tree (Anwar and Bhangar, 2003; Prabhu et al., 2011). In India and Pakistan, MO is locally known as Sohanjna and is grown and cultivated all over the country (Anwar et al., 2005; Qaisar, 1973). It has been reported by Bureau of plant industry that *Moringa* is an outstanding source nutritional components. Its leaves (weight per weight) have the calcium equivalent of four times that of milk, the vitamin C content is seven times that of oranges, while its potassium is three times that of bananas, three times the iron of spinach, four times the amount of vitamin A in carrots, and two times the protein in milk (Kamal, 2008). Besides, *Moringa* is also suggested as a viable

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Abbreviations: MO, *Moringa oleifera*; GK, Goto-Kakizaki; ISP, isoproterenol.

supplement of dietary minerals. The pods and leaves of *Moringa* contains high amount of Ca, Mg, K, Mn, P, Zn, Na, Cu, and Fe (Aslam et al., 2005). Although, minerals content of *Moringa* shows variation in composition with changes in location (Anjorin et al., 2010).

Ancient medicinal system relies on several plant products used by traditionally human communities in many parts of the world for different diseases. Among these plants, *MO* has its great contribution from ancient time. It is a plant with exceptional medicinal properties which can resolves the health care needs in several situations. Easy cultivation of *Moringa* within adverse environmental condition and wide availability attract attention for economic and health related potential in resource limited developing countries. This study discusses medicinal potential of this exceptional plant and its potential as a commercial medicinal and nutritional supplement.

MEDICINAL PROPERTIES OF MORINGA

MO has enormous medicinal potential, which has long been recognized in the Ayurvedic and Unani system (Mughal et al., 1999). Nearly every part of this plant, including root, bark, gum, leaf, fruit (pods), flowers, seed, and seed oil have been used for various ailments in the indigenous medicine (Odebiyi and Sofowora, 1999), but recent research is also indicating about several active constituents for accepting its applicability in modern medicine (Table 1). Few representatives of these are discussed in this article.

Antimicrobial and antihelmintic effects

Antimicrobial components of *MO* have been validated after the discovery of inhibitory activity against several microorganisms. In a recent study, aqueous extracts of *MO* was found to be inhibitory against many pathogenic bacteria, including *Staphylococcus aureus*, *Bacillus subtilis*, *Escherichia coli*, and *Pseudomonas aeruginosa* in dose dependent manner (Saadabi and Abu Zaid, 2011). *MO* extracts was also found to be inhibitory against *Mycobacterium phlei* and *B. subtilis* (Eilert et al., 1981). Leaf extract of *MO* was found to be effective in checking growth of fungi *Basidiobolus haptosporus* and *Basidiobolus ranarums* (Nwosu and Okafor, 1995). Another study involving aqueous methanolic extract and fixed oil against microorganisms was performed using *Scenedesmus obliquus* (green algae), *E. coli* ATCC 13706, *P. aeruginosa* ATCC10145, *S. aureus* NAMRU 3 25923, *Bacillus stearothermophilus* (bacterial strains) and Herpes Simplex virus type 1 (HSV 1) and Polio virus type 1 (sabin vaccine). Varying degree of antimicrobial activity was observed ranging from sensitive for *B. stearothermophilus* to resistant for *P. aeruginosa* (Ali et

al., 2004). Beside antibacterial activity of *MO* oils, it also posses anti-fungal activity (Chuang et al., 2007). Study comparing relative antimicrobial activity of seed extracts against bacteria (*Pasturella multocida*, *E. coli*, *B. subtilis* and *S. aureus*) and fungi (*Fusarium solani* and *Rhizopus solani*) revealed that *P. multocida* and *B. subtilis* were the most sensitive strains, and their activity was influenced by cations (Na^+ , K^+ , Mg^{2+} and Ca^{2+}) (Jabeen et al., 2008). Another relative comparison of antibacterial and antifungal efficacy of *MO* steam distillate observed more inhibition for *E. coli* followed by *S. aureus*, *Klebsiella pneumoniae*, *P. aeruginosa* and *B. subtilis*. In case of fungi, *Aspergillus niger* was strongly inhibited followed by *Aspergillus oryzae*, *Aspergillus terreus* and *Aspergillus nidulans* (Prashith Kekuda et al., 2010). Contrary to resistance against *P. aeruginosa* and *Candida albicans* for *MO* in other studies, one study using ethanolic extract of leaves, seeds and flowers showed the antimicrobial activity against *E. coli*, *K. pneumoniae*, *Enterobacter* species, *Proteus mirabilis*, *P. aeruginosa*, *Salmonella typhi* A, *S. aureus*, *Streptococcus* and *Candida albicans* (Nepolean et al., 2009). *Moringa* contains pterygospermin (originally found in *Moringa pterygosperma*) which has powerful antibacterial and fungicidal effects (Rao et al., 1946). Several other specific components of *Moringa* have been reported with antibacterial activity, including 4-(4'-O-acetyl-a-L-rhamnopyranosyloxy) benzyl isothiocyanate, 4-(a-L-rhamnopyranosyloxy) benzyl isothiocyanate, niazimicin, benzyl isothiocyanate, and 4-(a-L-rhamnopyranosyloxy) benzyl glucosinolate (Fahey, 2005). Other bioactive compounds, such as Spirochin and Anthonine are found in root and are active against several bacteria. Anthonine has potent inhibitory activity against *Vibrio cholerae* (Nwosu and Okafor, 1995). *MO* flower and leaves are also capable of controlling parasitic worms, their antihelmintic activity has been demonstrated during several studies (Bhattacharya et al., 1982). Moreover, it has also been reported to inhibit Indian earthworm *Pheritima posthuma* with *MO* leaves ethanolic extracts (Rastogi et al., 2009).

Anti-inflammatory activity

Moringa plant parts have substantial anti-inflammatory activity. For instance, the root extract exhibits significant anti-inflammatory activity in carrageenan induced rat paw oedema (Ezeamuzie et al., 1996; Khare et al., 1997). The crude methanol extract of the root inhibits carrageenan-induced rat paw oedema in a dose dependent manner after oral administration (Anonymous, 2005). Moreover, n-butanol extract of the seeds of *MO* shows anti-inflammatory activity against ovalbumin-induced airway inflammation in guinea pigs (Mahajan et al., 2009). Amelioration of inflammation associated chronic diseases can be possible with the potent anti-inflammatory activity of *MO* bioactive compounds (Muangnoi et al., 2011).

Considering potent anti-inflammatory activity of *Moringa* plant, it can be surmised that this plant shows profound influence on inflammation associated diseases and resultant symptoms. As a consequence, this plant shows beneficial effects on asthma, pain, and other resultant symptoms.

Anti-asthmatic activity

It has been reported a long time ago that *Moringa* plant alkaloid closely resembles ephedrine in action and can be used for the treatment of asthma. Alkaloid moringine relaxes bronchioles (Kirtikar and Basu, 1975). The seed kernels of *MO* also showed promising effect in the treatment of bronchial asthma, during a study to analyze efficacy and safety of seed kernels for the management of asthmatic patients. The study showed significant decrease in the severity of asthma symptoms and also concurrent respiratory functions improvement (Agrawal and Mehta, 2008).

Analgesic activity

The analgesic activity of *Moringa* has been reported in several *Moringa* species. In a study using ethanolic extracts of *Moringa concanensis* tender pod-like fruits in experimental animals, a significant analgesic activity was observed (Rao et al., 2008). Furthermore, alcoholic extract of the leaves and seeds of *MO* also possess marked analgesic activity as evidenced through hot plate and tail immersion method (Sutar et al., 2008).

Antipyretic activity

As a result of anti-inflammatory action of *Moringa* bioactive constituents, the antipyretic activity can be hypothesized. A study was designed to assess antipyretic effect of ethanol, petroleum ether, solvent ether and ethyl acetate extracts of *MO* seeds using yeast induced hyperpyrexia method. Paracetamol was used as control during the study. Not surprisingly, ethanol and ethyl acetate extracts of seeds showed significant antipyretic activity in rats (Hukkeri et al., 2006).

Antihypertensive, diuretic and cholesterol lowering activities

Moringa leaves contain several bio active compounds, they exert direct effect on blood pressure, and thus these can be used for stabilizing blood pressure. *MO* compounds leading to blood pressure lowering effect includes nitrile, mustard oil glycosides and thiocarbamate glycosides present in *Moringa* leaves (Anwar et al.,

2007). In addition, diuretic activity of *Moringa* exists in its roots, leaves, flowers, gum and the aqueous infusion of seeds (Morton, 1991). Moreover, *Moringa* leaves also contain bioactive phytoconstituent, (that is, β -sitosterol) with cholesterol lowering effect. This compound is capable to reduce cholesterol level from the serum of high fat diet fed rats (Ghasi et al., 2000).

Antidiabetic activity

Several medicinal plants have been evaluated for their potential as therapeutic agent for diabetes. *MO* is also an important component in this category. *MO* leaves significantly decrease blood glucose concentration in Wistar rats and Goto-Kakizaki (GK) rats, modeled type 2 diabetes (Ndong et al., 2007). Another study indicated that the extract from *Moringa* leaf is effective in lowering blood sugar levels within 3 h after ingestion (Mittal et al., 2007). As a mechanistic model for antidiabetic activity of *MO*, it has been indicated that dark chocolate polyphenols (Grassi et al., 2005) and other polyphenols (Al-Awwadi et al., 2004; Moharram et al., 2003) are responsible for hypoglycemic activity. *Moringa* leaves are potent source of polyphenols, including quercetin-3-glycoside, rutin, kaempferol glycosides, and other polyphenols (Ndong et al., 2007). Thus, potential anti-diabetic activity of *MO* can be commercialized through the development of suitable technology with achieving anti-diabetic activity up to conventional drugs.

Antioxidant activity

MO is a rich source of antioxidant (Chumark et al., 2008). It has been reported that aqueous extracts of leaf, fruit and seed of *MO* act as an antioxidant (Singh et al., 2009). During a study reporting antioxidant property of freeze dried *Moringa* leaves from different extraction procedures, it was found that methanol and ethanol extracts of Indian origin *MO* have the highest antioxidant activity with 65.1 and 66.8%, respectively (Lalas and Tsaknis, 2002; Siddhuraju and Becker, 2003). It was also reported that the major bioactive compounds of phenolics, such as quercetin and kaempferol are responsible for antioxidant activity (Bajpai et al., 2005; Siddhuraju and Becker, 2003). During another study, quercetin and kaempferol have shown good antioxidant activity on hepatocyte growth factor (HGF) induced Met phosphorylation with IC_{50} value for 12 and ~ 6 μ M/L, respectively (Labbe et al., 2009). Another recent study comparing palm oil with *MO* seeds for their antioxidant potential found out that *MO* seed are superiors for radical scavenging (Ogbunugafor et al., 2011).

Hepatoprotective activity

MO has shown significant hepatoprotective activity in

several studies. *MO* leaves ethanolic extracts showed significant protection against liver damage induced by antitubercular drugs [isoniazid (INH), rifampicin (RMP), and pyrazinamide (PZA)] in rats. It was found that hepatoprotective activity of *MO* is mediated 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 (Pari and Kumar, 2002). Moreover, methanolic and chloroform extracts of *MO* leaves also showed significant protection against CCl_4 induced liver damage in albino rats. Besides hepatoprotective activity of *MO* leaves, its root and flowers also possess strong hepatoprotective activity. *Moringa* flowers contain a well recognized flavonoid (Quercetin), which may be responsible for its potent hepatoprotective activity (Ruckmani et al., 1998; Selvakumar and Natarajan, 2008). In a recent study evaluating the effect of *MO* seed extract on liver fibrosis, it was found that *MO* seed extract has the ability to subside liver fibrosis. This study involved CCl_4 induced liver fibrosis and concurrent administration of *MO* seed extract. *MO* seed extract control the elevation of serum aminotransferase activities and globulin level induced by CCl_4 . Moreover, immunohistochemical studies also showed that *MO* reduces liver fibrosis (Hamza, 2010).

Antitumor activity

MO has been found as a potent anticancer plant and several bioactive compounds with significant antitumor activity have been discovered from *MO*. Among bioactive compounds from *MO*, niazimicin, a *MO* leaves thiocarbamate was found to have potent anticancer activity (Guevaraa et al., 1999). Furthermore, niazimicin also shows the inhibition of tumor promoter teleocidin B-4-induced Epstein-Barr virus (EBV) activation (Murakami et al., 1998). Another study involving 11 plants used in Bangladeshi folk medicine, *MO* was considered as potential source of anticancer compounds. During this study, the plant extract were analyzed for cytotoxicity through brine shrimp lethality assay, sea urchin eggs assay, hemolysis assay and MTT assay using tumor cell lines. The study also indicated the potential cytotoxic effects of *MO* leaf extract on human multiple myeloma cell lines (Costa-Lotufo et al., 2005; Parvathy and Umamaheshwari, 2007). Beside leaves, *MO* seed extracts also have anticancer activity through its effects on hepatic carcinogen metabolizing enzymes, and antioxidant property (Bharali et al., 2003).

Antifertility activity

MO plant also has pertinent antifertility activity. The aqueous extract obtained from root and bark of *MO*

showed post-coital antifertility effect in rat and also induced foetal resorption at late pregnancy (Prakash et al., 1987). Moreover, aqueous extract of *MO* roots was also evaluated for estrogenic, anti-estrogenic, progestational and antiproggestational activities. This extract induces several consequences for affecting its antifertility property (Shukla et al., 1988). During another study analyzing anti reproductive potential of folk medicine plants, *MO* leaf extracts were found to be 100% abortive with doses equivalent to 175 mg/kg of starting dry material (Nath et al., 1992).

Antispasmodic and antiulcer effects

Moringa root and leaves contain several compounds with spasmolytic activity. These compounds include 4-(alpha-L-rhamnosyloxybenzyl)-o-methyl thiocarbamate which is possibly affected through calcium channel blockade, niazinin A, niazinin B, niazimicin, etc., with hypotensive and bradycardiac effect. The spasmolytic activity of different constituents support for traditional uses of this plant in gastrointestinal motility disorder (Gilani et al., 1994). *MO* methanolic extract is also capable in protecting experimental rats from gastric lesions induced by acetylsalicylic acid, serotonin and indomethacin. In addition, it also enhances healing process of chronic gastric lesions induced by acetic acid in experimental animals (Pal et al., 1995). Another study have reported the antiulcer effect of *MO* leaves aqueous extract on adult Holtzman albino rats (Debnath and Guha, 2007).

Cardiac and circulatory stimulant

In addition to earlier mentioned bradycardiac effect of *MO* leaves, all parts of *MO* are reported with somewhat cardiac and circulatory stimulant activity. Root bark of *Moringa* contains alkaloid moringinine which acts as cardiac stimulant through its effect on sympathetic nervous system (Duke, 2001). The aforementioned effects can also result due to the prevention of hyperlipidemia. It has been demonstrated that *MO* prevent hyperlipidemia in male Wister rat due to iron deficiency (Ndong et al., 2007). During a study performing comparison of *MO* leaf extract with atenolol (a selective β_1 receptor antagonist drug, used for cardiovascular diseases) on serum cholesterol level, serum triglyceride level, blood glucose level, heart weight and body weight of adrenaline induced rats, it was found that *MO* leaf extract cause significant changes in cardiovascular parameters. This study reported *MO* leaf extract as hypolipidemic, lowering body weight, heart weight, serum triglyceride level and serum cholesterol level in experimental animals (Ara et al., 2008). In addition to the aforementioned studies, antiatherosclerotic and hypolipidaemic effect of *MO* leaves were also

Table 1. Major pharmaceutical components present in *Moringa* and their importance.

S/N	Compound	Method used for detection	Potential application	Reference
1	Pterygospermin	Solvent extraction followed by MIC analysis	Antibacterial and fungicidal effects	Rao et al. (1946)
2	4-(4'-O-acetyl-a-L-rhamnopyranosyloxy) benzyl isothiocyanate, 4-(a-L-rhamnopyranosyloxy) benzyl isothiocyanate, niazimicin, benzyl isothiocyanate, and 4-(a-L-rhamnopyranosyloxy) benzyl glucosinolate, Anthonine and Spirochin	Solvent extraction followed by MIC analysis (Busani et al., 2012)	Antibacterial	Fahey (2005) and Nwosu and Okafor (1995)
3	Alkaloid Moringine	Clinical study involving consumption of <i>Moringa</i> followed by antiasthmatic activity evaluation using spirometer	Antiasthmatic	Agrawal and Mehta (2008) and Kirtikar and Basu (1975)
4	Nitrile, mustard oil glycosides and thiocarbamate glycosides	Bioassay directed isolation	Hypotensive	Anwar et al. (2007) and Faizi et al. (1995)
5	b-sitosterol	Study involved consumption of <i>Moringa</i> leaves with cholesterol and subsequent measurement of cholesterol lowering activity (Ghasi et al., 2000).	Cholesterol lowering effects	Ghasi et al. (2000)
6	Dark chocolate polyphenols and other polyphenols	Administration of MO leaves in diabetic and control rats and hypoglycemic activity evaluation and characterization of polyphenols using HPLC (Ndong et al., 2007).	Hypoglycemic effects	Grassi et al. (2005), Al-Awwadi et al. (2004) and Moharram et al. (2003)
7	Quercetin and kaempferol	Solvent extraction followed by antioxidant activity analysis	Antioxidant, hepatoprotective	Bajpai et al. (2005), Siddhuraju and Becker (2003), Ruckmani et al. (1998) and Selvakumar and Natarajan (2008)
8	Niazimicin,	Solvent extraction followed by <i>in vitro</i> anticancer activity	Anticancer	Guevaraa et al. (1999)
9	4- (alpha- L-rhamnosyloxybenzyl)-o-methyl thiocarbamate, niazinin A, niazinin B, niazimicin etc.	Solvent extraction for purification of compounds followed by intravenous administration of each compound in anaesthetized rats and subsequent evaluation of their activity in experimental animals	Spasmolytic, hypotensive and bradycardiac	Gilani et al. (1994)

analyzed in another study using simvastatin as control (Chumark et al., 2008). *MO* also causes cardio protective effects in isoproterenol (ISP)-induced myocardial infarction in male Wistar albino rats. It was reported that *MO* treatment plays favorable modulation on biochemical

enzymatic parameters including, superoxide dismutase, catalase, glutathione peroxidase, lactate dehydrogenase, and creatine kinase-MB. Moreover, it also prevents histopathological damage and ultra-structure perturbation caused due to ISP induced myocardial infarction

(Nandave et al., 2009).

In ocular diseases

Vitamin A deficiency is a major cause of blindness, which ranges from impaired dark adaptation to night blindness. Consumption of *MO* leaves, and pods and leaf powder which contain high proportion of vitamin A can help to prevent night blindness and eye problems in children. Ingesting drumstick leaves with oils can improve vitamin A nutrition and can delay the development of cataract (Pullakhandam and Failla, 2007). In fact the use of *MO* as a supplementary food was highly accepted for integrated child development scheme supplementary food (ICDS-SFP) for its potential as vitamin A source (Nambiar et al., 2003).

Conclusion

Medicinal potential of *MO* is enormous and difficult to cover in a single article, despite this current article provided glimpses of *MO* applications for performing appraisal of this promising nutrition and medicinal plant. Although, many bioactive compounds have been discovered from *Moringa*, still the knowledge is in infancy, in term of its total reserve. Perhaps, future rigorous studies directed towards the detection, and commercialization of *MO* bioactive compounds can lead to the development of remedies for several ailments. Thus, it can also prove the validity of traditional utility of *MO* in various folklores.

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