



An Environment Friendly Natural Gift-*Moringa oleifera*

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Abstract

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. *Moringa* has been used since 150B.C. by ancient kings and queens in their diet for mental alertness and healthy skin. The leaves, pods, seeds, gums, bark and flowers of *Moringa* are used in more than 80 countries to relieve mineral and vitamin deficiencies. It has an impressive range of medicinal uses with high nutritional value. Apart from medicinal benefits it is deployed in re-forestation program used as fodder for livestock. *Moringa* is an edible extremely safe plant. Its tree could easily and cheaply be cultivated and grown. New uses of *Moringa oleifera* leaves have been found by many researchers for the last two decades which introduced new material in pharmaceutical and water treatment industry. In addition, it was found that it can work as a biosorbent for heavy metals in water treatment. Therefore, it can be considered as a natural product and environmentally friendly material.

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Introduction

In this modern era of research and technology this futile search still continues to discover novel herbal drugs and alternate source of nutritional supplements. One such promising tree which has successfully cleared all the tests of nutritional benefits, medicinal properties, environmental and consumption safety is the perennial, multipurpose, softwood-tree '*Moringa oleifera*' of the monogeneric family Moringaceae. *M.oleifera* is reputedly known as 'horseradish tree', 'drumstick tree', 'ben-oil tree' or 'benzoic tree', 'cabbage tree', 'mother's best friend' and 'miracle tree'. It is a native of Indian sub-continent and is cultivated worldwide owing to its numerous utilities. A single *Moringa* tree can provide leaf as a source of nutrition for human and livestock, seed-oil for cooking and biodiesel, seed-cake for water purification and wood to build shelter.

Moringa oleifera 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.

Moringa oleifera is an important food commodity which has had enormous attention as the 'natural nutrition of the tropics'. The leaves, fruit, flowers and immature pods of this tree are used as a highly nutritive vegetable in many countries, particularly in India, Pakistan, Philippines, Hawaii and many parts of Africa (D'souza and Kulkarni, 1993; Anwar and Bhangar, 2003; Anwar *et al.*, 2005).

Moringa leaves have been reported to be a rich source of β -carotene, protein, vitamin C, calcium and potassium and act as a good source of natural antioxidants; and thus enhance the shelf-life of containing foods due to the presence of various types of antioxidant compounds such as ascorbic acid, flavo-noids, phenolics and carotenoids (Dillard and German, 2000; Siddhuraju and Becker, 2003). 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 (Estrella *et al.*, 2000; Siddhuraju and Becker, 2003).

A number of medicinal properties have been ascribed to various parts of this highly esteemed tree. Almost all the parts of this plant: root, bark, gum, leaf, fruit (pods), flowers, seed and seed oil have been used for various ailments in the indigenous medicine of South Asia, including the treatment of inflammation and infectious diseases along with cardiovascular, gastro-intestinal, hematological and hepatorenal disorders (The Wealth of India, 1962; Singh and Kumar, 1999; Morimitsu *et al.*, 2000; Siddhuraju and Becker, 2003). The seeds of *Moringa* are considered to be anti-pyretic, acrid, bitter (Oliveira *et al.*, 1999) and reported to show antimicrobial activity (The Wealth of India, 1962).

This plant is variously used as water purifier, hand wash, cosmetics, cattle's fodder, plant growth enhancer and biogas. Since last one decade, more than hundreds of research papers, articles, thesis, reports and patents have been published on this tree. *Moringa* has its great contribution from ancient time. It is a plant with exceptional medicinal properties which can resolve 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 different potential of this exceptional plant.

Medicinal Properties

The assorted extracts of *Moringa*'s morphological parts such as seeds cotyledon, seeds' coat, stem bark, leaves, root bark are reported to possess antimicrobial potential (Arora *et al.*, 2001) In a recent study, aqueous extracts of *Moringa* 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). *Moringa* extracts was also found to be inhibitory against *Mycobacterium B. subtilis* (Eilert *et al.*, 1981). Beside antibacterial activity of *Moringa*, it also possesses 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 strain. 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).

Polyphenols, are the main plant compounds that are able to decrease oxidative damage in tissues by indirect enhancement of a cell or by free radical scavenging (Du *et al.*, 2010). The leaves of the *Moringa oleifera* tree have been reported to demonstrate antioxidant activity due to its high amount of polyphenols (Sreelatha and Padma, 2009; Verma *et al.*, 2009). A comparative study indicated that mature *Moringa oleifera* leaf extract exhibited that mature *Moringa oleifera* leaf extract exhibited better values of enzymatic and non enzymatic antioxidants.

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 *Moringa* 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).

Moringa roots and root bark possess several compounds with proven anti-spasmodic activity. *Moringa* root extracts is generally applied externally to cure inflammatory swellings. It contains an antibiotic,

pterogosperrin that is effective in the treatment of cholera. *Moringa* roots have shown hepatoprotective activity and the juice from the root bark relieves earaches and toothaches. They have also been reported as anti-inflammatory agent, stimulant in paralytic conditions, and as a cardiac/ circulatory tonic. It is also evidenced that roots are used in treating rheumatism, inflammations, auricular pains lower back or kidney pain, and constipation. An alkaloid 'spirachin' (a nerve paralytant) has also been found in the roots.

They are also a rich source of quercetin, a reputed flavonoid with hepatoprotective activity. The flowers are used as a tonic and diuretic and are a fine source of pollen for honeybees. The flowers have the ability to cure muscle diseases, tumors, and enlarged spleen and also decrease cholesterol, phospholipid and triglyceride. In a study by Anwar *et al.*, (2007) the consumption of *Moringa* flower extracts reduced the lipids in liver heart and aorta and also the augmented faecal cholesterol in hypercholesteromic rabbits.

M. oleifera leaves as ethno medicine to treat diabetes mellitus in addition the experimental findings by Soliman (2013) and Yassa (2014) have indicated the potential benefits of using the aqueous extract of *M. oleifera* leaves as a potent antidiabetic treatment. As per the recommendation by the World Health Organization (WHO) 14 gram/day of *Moringa* leaf-powder is sufficient to meet the nutritional demands of an adult. The findings of Ganatra *et al.*, (2012b) and Panda *et al.*, (2013) suggest that the cardio-protective potential of the isolated alkaloid from *M.oleifera* leaves is mediated through its free radical scavenging property. Therefore, *M. oleifera* can be prescribed as food supplement for coronary artery disease patients along with their regular medicines.*M. oleifera* also ameliorates alcohol-induced testicular toxicities with its antioxidant properties comparable to vitamin C. An interesting study by Rao *et al.*, 2001 demonstrates that pretreatment with the methanolic leaf extract of *M. oleifera* confers significant radiation protection to the bone marrow chromosomes in mice and leads to a 30 day prolonged survival after lethal whole-body irradiation. The study by Bakre *et al.*, 2013 [88] has justified the traditional use of the *M. oleifera* leaves extract for the treatment of epilepsy.

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The plant is having high medicinal and therapeutic properties and investigated in the scientific departments throughout the world, due to their potent pharmacological activities, low toxicity and economic viability, when compared with synthetic drugs. *Moringa oleifera* is having many medicinal uses and has long been recognized in the Ayurvedic and Unani system of medicine. Pharmacological studies have shown that the extract of plant have antioxidant, anticarcinogenic, antiinflammatory, antispasmodic, antidiuretic, antiulcer, antibacterial-fungal, insecticide, alexeteric, antihelminthic, to alter blood-lipid properties, antidiabetic, in ocular – skin and throat diseases, strengthen immune powder, good wound healer, insects bites etc. Therefore, the plant is not only food supplement but also have wide range of medicinal properties for humankind

Nutritional Properties

The indigenous knowledge and use of *Moringa oleifera* is referred in more than 80 countries including India and locally known in over 200 languages. The popularity and its uses by various societies (Greek, Egyptian, Roman and Indian) for thousands of years with writings dating as far back as 150 AD. Historical proofs reveal that ancient kings and queens used "*Moringa oleifera*" leaves and fruits in their daily diet to maintain mental, alertness, healthy skin and vigour. Ancient "Maurian warriors" of India were fed with the leaf extract of this tree in the warfront. *Moringa oleifera* is sometimes called "Mother Best Friend" and "Miracle Tree". Since 1998, the World Health Organisation (WHO) has promoted this tree as an alternative to imported food supplies to treat malnutrition in poor countries.

A large number of reports on the nutritional qualities of *Moringa* now exist in both the scientific and the popular literature. *Moringa* has been in use since centuries for nutritional as well medicinal purposes. These include vitamin C, which fights a host of illnesses including colds and flu; vitamin A, which acts as a shield against eye disease, skin disease, heart ailments, diarrhea, and

many other diseases; Calcium, which builds strong bones and teeth and helps prevent osteoporosis; Potassium, which is essential for the functioning of the brain and nerves, and Proteins, the basic building blocks of all our body cells. Another important point is that *Moringa* leaves contain all of the essential amino acids, which are the building blocks of proteins. It is very rare for a vegetable to contain all of these amino acids. And *Moringa* contains these amino acids in a good proportion, so that they are very useful to our bodies. These leaves could be a great boon to people who do not get protein from meat. *Moringa* even contains arginine and histidine two amino acids especially important for infants. Arginine and histidine, are especially important for infants who are unable to make enough protein for their growth requirements *Moringa* could be an extremely valuable food source.

Lots of literature is available on the nutritional qualities and medicinal uses of this tree. It is a very rich source of Vitamins, macro and micro elements, amino acids, essential oils, proteins etc. If someone consumed per day 70 gms of dried leaves of tree have 35 essential elements (includes 14 macro and 21 micro elements) in the body. The nutritive value of this tree is much higher than oranges, carrots, milk, banana, protein of Yogurt. Thus, the tree can be used to combat malnutrition, especially among infants and nursing mothers.

Moringa is a super food tree with a remarkable source of proteins, calcium (Ca), Iron (Fe) and vitamin C. It contains all the essential nutritional elements that are vital for human beings and livestock. It has been demonstrated that the dry leaves of *M. oleifera* contain 7 times more vitamin C than orange, 10 times vitamin A than carrot, 17times calcium than milk, 15 times and potassium than bananas, 25 times iron than spinach and 9 times proteins than yogurt.

In addition, it contains vitamin B, chromium, copper, magnesium, manganese, phosphorus and zinc. Being a rich source of proteins *Moringa* leaves are recommended by doctors, nutritionists and community health workers to cope with the problems of malnutrition worldwide. *Moringa* contains 40.139 mg total carotenoids /100g fresh leaves, of which 47.8% (18.9 mg/100g) is β -carotene, which is adequate for the dietary requirements of children, adults and lactating. Moreover, 100g of the dried leaves contain 660mg ascorbic acid, 28.2 mg iron, 2,003mg calcium, 630mg phosphorus, 1,120mg oxalic acid and 0.9g fiber. Studies on *Moringa* has revealed its potential to combat vitamin A and other micronutrient

deficiencies. *Moringa* leaves also possess amazingly higher methionine + cysteine (43.6 g kg⁻¹ protein) contents which are similar to that of human milk, cow's milk and chicken egg. Makkar and Becker (1997) studied the nutritional status of different parts of *Moringa* plant. They analyzed that the leaves contained 260 g kg⁻¹ crude protein while soft twigs and stems contain 70 g kg⁻¹ and 60 g kg⁻¹ crude protein, respectively. The degradation ability of crude protein in rumen per 24 h was about 64, 79 and 67% of the total dry matter present in the leaves, twigs and stems, respectively. No trypsin, lectins and amylase inhibitors, cyanogenic glucosides and glucosinolates were found in leaves but, a negligible amount of tannins i.e., 12 g kg⁻¹ was observed

Other Useful Properties

New uses of *Moringa oleifera* have been found by many researchers for the last two decades which introduced new material in pharmaceutical and water treatment industry. *Moringa oleifera* are unique because of their tremendous amounts of minerals but lower amounts of harmful compounds and it can be considered as safe supplement because besides that it is not toxic. In addition, it was found that it can work as a biosorbent for heavy metals in water treatment. Therefore, it can be considered as a natural product and environmentally friendly material. It was found that *Moringa oleifera* leaves extract is a good sorbent for Pb(II) from aqueous solutions. Chemically Modified *Moringa oleifera* leaves powder was used by for optimization of Cd(II), Cu(II) and Ni(II) biosorption. Removing of Cd(II) from waste water was achieved using fresh leaves as biosorbent. *Moringa* seeds could be used as a less expensive biosorbent for the removal of cadmium (Cd) from aqueous media (Sharma *et al.*, 2006). The aqueous solution of *Moringa* seed is a heterogeneous complex mixture having various functional groups, mainly low molecular weight organic acids (amino acids). These amino acids have been found to constitute a physiologically active group of binding agents, working even at a low concentration, which because of the ability to interact with metal ions is likely to increase the sorption of metal ions (Brostlap and Schuurmans, 1988). The proteineous amino acids have a variety of structurally related pH dependent properties, generating a negatively charged atmosphere and play an important role in the binding of metals (Sharma *et al.*, 2006).

Biopesticides, being a promising alternative to conventional pesticides are eco-friendly, cost-effective and are ineffective to non-target organisms as birds,

insects, and mammals. When used in Integrated Pest Management (IPM) programs, biopesticides can significantly reduce the use of conventional pesticides without affecting the crop yield. According to JW Fahey *Moringa* seed oil has the potential to be deployed as a biopesticide. The aqueous *Moringa* seed extract (AMSE) and leaf extracts have been reported to exhibit insect repellent and fungicidal properties (Abdalla).

Biodiesel is an alternative to petroleum-based conventional diesel fuel and is defined as the monoalkyl esters of vegetable oils and animal fats. Biodiesel has been prepared from numerous vegetable oils, such as cottonseed, canola (rapeseed), palm, soybean, peanut and sunflower oils. The greatest potential for *M. oleifera* is currently thought to be in its cultivation for the production of biodiesel. A yield of about 20 metric tones of pods / hectare / year is achievable for this species. This could provide 3000 and 4000 liters of biodiesel / hectare / annum. After acid pre-treatment to reduce the acid value of the *M. oleifera* oil, biodiesel is obtained by a transesterification procedure with methanol and an alkali catalyst at 60°C. The methyl esters (biodiesel) obtained from *Moringa* seed oil exhibit a high cetane number of approximately 67, one of the highest found for a biodiesel fuel. Overall, *M. oleifera* oil appears to be promising input for biodiesel (Schill, Santosh).

Moringa seeds are one of the best natural coagulants discovered so far (Ndabigengesere and Narasiah, 1998). Crushed seeds are a viable replacement of synthetic coagulants (Kalogo *et al.*, 2000). In Sudan, seed crude extract is used instead of alum by rural women to treat the highly turbid Nile water because of a traditional fear of alum causing gastrointestinal disturbances and Alzheimer's disease (Crapper *et al.*, 1973; Miller *et al.*, 1984; Martyn *et al.*, 1989; Muyibi, 1994). *Moringa* seeds are very effective for high turbidity water and show similar coagulation effects to alum (Muyibi and Evison, 1995b). The coagulation effectiveness of *M. oleifera* varies depending on the initial turbidity and it has been reported that *M. oleifera* could reduce turbidity by between 92% and 99% (Muyibi and Evison, 1995b). *Moringa* seeds also have softening properties in addition to being a pH correctant (alkalinity reduction), as well as exhibiting a natural buffering capacity, which could handle moderately high to high alkaline surface and ground waters. The *Moringa* seeds can also be used as an antiseptic in the treatment of drinking water (Obioma and Adikwu, 1997). Ongoing research is attempting to characterize and purify the coagulant components of *Moringa* seeds

(Ndabigengesere *et al.*, 1995; Gassenschmidt *et al.*, 1995).

It is believed that the seed is an organic natural polymer (Jahn, 1984). The protein powder is stable and totally soluble in water. *Moringa* coagulant protein can be extracted by water or salt solution (commonly NaCl). The amount and effectiveness of the coagulant protein from salt and water extraction methods vary significantly. In crude form, the salt extract shows a better coagulation performance than the corresponding water extract (Okuda *et al.*, 1999). This may be explained by the presence of a higher amount of soluble protein due to the salting in phenomenon. However, purification of the *M. oleifera* coagulant protein from the crude salt extract may not be technically and economically feasible.

Moringa seeds also possess antimicrobial properties (Olsen, 1987; Madsen *et al.*, 1987). Broin *et al.* (2002) reported that a recombinant protein in the seed is able to flocculate Gram-positive and Gram-negative bacterial cells. In this case, microorganisms can be removed by settling in the same manner as the removal of colloids in properly coagulated and flocculated water (Casey, 1997)

Several lab-experimentation has shown that *Moringa* spray has marked beneficial effects on crops plants. The effects of sprays accelerated the growth of young plants that became firmer, more resistant to pests and disease, longer life-span, heavier roots, stems and leaves and large fruits with increased yield (20-35%). *Moringa* fermented leaf juice was also tested for its growth promoting attributes in Brassica oleracea and the results were promising (R.Rajmani). There are prospects of widespread introduction and utilization of drumstick fermented leaf juice by the Agriculture sector. It also implies that it may be worthwhile for small margin farmers to take up the production of drumstick fermented leaf juice for healthy cultivation and merge into the Organic Integrated Nutritional Management programme in India and other countries. This practice would not only alleviate plant macro and micro-nutrient deficiencies but also enrichment of soil for several crops

Conclusion

Moringa truly appears to be a "Miracle" plant having countless benefits for humanity and thus should be taken as a high quality gift of nature at very low price. The *Moringa oleifera* Lam. is providing very good nutrition as protein essential elements supplements, but also a very

good in curing and prevention of many diseases in human being.

The seed-powder can be used as water purifier, particularly for heavy metals and other impurities in water. More researches should be undertaken for its optimum production as a crop and its phytochemical should also be isolated for the synthesis of drugs for the utilization of humankind. This plant truly appears to be a miracle tree having unlimited benefits for people and thus should be taken as a high quality gift of nature at very low price.

Thus, due to multifarious uses of this tree India and state Government in particular take initiative to plant more and more trees in unutilized areas. India could easily fight against the problems of malnutrition, hunger, poverty, diseases, unemployment and edible oil export and earn lot of foreign exchange. As a conclusion, more attention need to be paid to the uses of *Moringa oleifera* leaves in a large scale in where the *Moringa oleifera* tree can be grown to produce more natural products and environmentally friendly materials.

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