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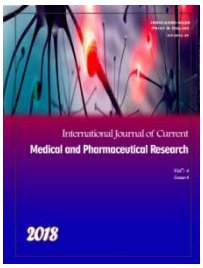

REVIEW OF HIGH-POTENTIAL PLANT *MORINGA OLIEFERA* (DRUMSTICK)

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ABSTRACT

Moringa oleifera Lam., commonly known as the 'drumstick tree, 'is native to the southern foothills of the Himalayas in north-western India, and widely cultivated in tropical and subtropical areas, of the world. It is recognized as a vibrant and have plethora of phytochemicals, which make plant high potential applications in medicines, functional food preparations, and Industrial application. It consists of large amount of minerals, proteins, carbohydrates, vitamins, fatty acids and oils. Every parts of plant has various medicinal properties including wound healing, anti-tumor, hepato protective, anti-fertility, antimicrobial, diuretic, anti-ulcer, cardio vascular, anticancer. The proteins extracted from the seed are used in water purification, and has potent antimicrobial and coagulant properties. This review focused on the use of Moringa for its medicinal use, its cultivation, industrial values, nutrition, and prominent pharmacological properties. The future perspectives of this wonder plant in these areas are discussed.

INTRODUCTION

The several herbs and plants products are a source of multifunctional compound, curing agents and bioactive compounds that are safe for consumption and has no side effects. About 70–80 % of the world's population relies on herbal medicine to prevent and cure diseases (Ekor 2014), and about 25 % of the synthetic drugs are manufactured from herbal plants (Pan *et al*.2013). The evaluation of various plant products for their traditional uses and medicinal value leads to the discovery of newer and sefer drugs for treating various ailments. Among various herbal plants, *Moringa oliefera* is one such plant having high nutritional and medicinal value, belonging to the family Moringaceae, commonly known as 'sahajan' in Hindi, Horse radish and drumstick in English. This plant various parts has various medicinal properties. Almost all the parts of this plant: leaf, root, bark, gum, fruit (pods), flowers, seed and seed oil have been used for various ailments such as anticancer, anti-inflammatory, antipyretic, antiulcer, antispasmodic antihypertensive, cholesterol lowering, antidiabetic and antimicrobial agent. It has the potential to eradicate malnutrition (Kunyanga *et al*. 2013). The Moringa is often considered as important famine food because of its high resistance to drought and arid conditions owing to their tuberous roots (Padayachee and Baijnath 2012). Each and every part of Moringa not only useful for medicinal purpose, but has other utilities such as functional food preparations, nutraceuticals, water purification, and biodiesel production (Saini 2015). *Moringa* leaves have a rich source of β-carotene, protein, vitamin C, calcium and potassium and act as a good source of natural antioxidants. Due to the presence of various types of antioxidant compounds such as ascorbic acid, flavonoids, phenolics and carotinoids make moringa leaves counteract the damage effect free radical (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 anaemia (Estrella *et al.*, 2000; Siddhuraju and Becker, 2003). *M. oleifera* roots are important agents for healing and nourishment. Moringa roots are used to prepare different medicines, perfumes, natural pesticides and fertilizers, for cleaning agents, animal fodder and many other important products. The roots are used to treat a variety of illnesses for its antibiotic properties (Fahey, 2005). Moringa leaf extract and its root extract has shown potential plant growth regulator and biopesticide on wheat crop (Majuhid manjoor *et.al*., 2015) The most important part used for water treatment is the waste product of the seed i.e. the defatted cake which can be obtained at a very low cost. The crude extract of *Moringa oleifera* seed is commonly used in water treatment and purification (Panday *et.al*., 2010). The immature pods, flowers, and foliage of this tree are used for culinary purposes in different parts of the world (Stevens *et al*. 2013). The foliage of M. oleifera (MO) has been established as a rich source of phenolics and glucosinolates (Amaglo *et al*. 2010), minerals, tocopherols, carotenoids, polyunsaturated fatty acids, ascorbic acid (Saini 2015), and folate (Saini *et al*. 2016). Moringa seed oil (yield 30–40 % w/w), also known as ''Ben oil'' is used for the production of biodiesel, because of the high content of monounsaturated fatty acids in the form of

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oleic acid (C18:1) (Azam *et al*. 2005; Rashid *et al*. 2008). Its husk can be used for making activated carbon. The defatted cake (seed residue after oil extraction) can be used as fertilizer or processed for animal feed (Ganatra Tejas, *et.al*.,2012).This study provides an overview on the cultivation, nutritional values, Industrial and commercial use and pharmacological properties of Moringa.

Botanical descriptions and cultivation

M. oleifera can be grown in any tropical and subtropical regions of the world with a temperature around 25–35 ◦C. It requires sandy or loamy soil with a slightly acidic to slightly alkaline pH and a net rainfall of 250–3000 mm (M.B. Thurber). The direct seeding method is followed as it has high germination rates. Since Moringa seeds are expected to germinate within 5–12 days after seeding and can be implanted at a depth of 2 cm in the soil. Moringa can also be propagated using containers. The saplings are placed in plastic bags containing sandy or loamy soil. After it grows to about 30 cm, it can be transplanted. However, utmost care has to be taken while transplanting as the tap roots are tender and tend to get affected. The tree can also be cultivated from cuttings with 1 m length and 4–5 cm in diameter, but these plants may not have a good deep root system. Such plants tend to be sensitive to drought and winds.

Morphology

Moringa oleifera is a small, fast-growing evergreen or deciduous tree that usually grows as high as 9 m, with a soft and white wood and corky and gummy bark. Roots have the taste of horseradish. Root is tap, branched and grows deep within soil. Stem are erect, woody and fragile. Leaves are longitudinally cracked leaves, 30-75 cm long main axis and its branch jointed, glandular at joints, leaflets are glabrous and entire. The leaflets are finely hairy, green and almost hairless on the upper surface, paler and hairless beneath, with red-tinged mid-veins, with entire (not toothed) margins, and are rounded or blunt-pointed at the apex and short-pointed at the base. The twigs are finely hairy and green. Pods are pendulous, ribbed, seeds are 3-angled (R.K.Gupta 2010:A.Roloff *et.al*, 2009). Flowers are white, hermaphrodite, scented in large axillary down panicles. Seeds are winged or not winged, endospermic. Pollination is entomophilus. Floral formula is $Br+♀k_5c_5A_{5+5STD}G_{(3)}$

Nutrition

Parts of *M. oleifera* such as leaves, fruit, seed, flower, stem has affordable amount of nutrients. It contents essential minerals, micro-nutrient, and macro –nutrient. The leaves of *M. oleifera* are rich source of minerals like calcium, potassium, zinc, magnesium, iron and copper (J.N. Kasolo *et.al*., 2010). Vitamins like beta-carotene of vitamin A, vitamin B such as folic acid, pyridoxine and nicotinic acid, vitamin C, D and E also present in *M. Oleifera* (M. Mbikay,2012). Moringa leaves can be eaten fresh, cooked, or stored as dried powder for many months without refrigeration, and reportedly without loss of nutritional value and also have a low calorific value. The pods are fibrous and are valuable for digestion. A research shows that immature pods contain around 46.78% fibre and around 20.66% protein content. Pods have 30% of amino acid content, the leaves have 44% and flowers have 31%. The immature pods and flowers showed similar amounts of palmitic, linolenic, linoleic and oleic acids (D.I. Sánchez-Machado,*et.al*.,2010) .Moringa leaves can provide 1000 mg and Moringa powder can provide more than 4000 mg of calcium. Moringa leaves contain more Vitamin A than carrots, more calcium than milk, more iron than spinach, more Vitamin C than oranges, and more potassium than bananas," and that the protein quality of Moringa leaves better than that of milk and eggs. The dietary intake of zinc is essential for proper growth of sperm cells and necessary for the synthesis of DNA and RNA. *M. oleifera* leaves show around 25.5–31.03 mg of zinc/kg. Research show that Moringa seed oil contains around 76% essential fatty acid i.e linoleic acid, linolenic acid and oleic acid, leaf powder, fresh leaves making it ideal for use as a substitute for olive oil(S. Lalas, *et.al*.,2002). A complete list of nutrients available in leaves, pods and seeds are shown in Table 1.

Table 1 Nutrient content of dried leaves, Fresh leaves, Moringa pods, fresh (raw) and seed contained the following per 100 grams of edible portion

Nutrient	Leaf Powder	Fresh leaves	pods	Seeds
Moisture (%)	7.5	75	86.9	
Calories	205	92	26	-
Protein (g)	27.1	6.7	2.5	35.97± 0.19
Fat (g)	2.3	1.7	0.1	38.67± 0.03
Carbohydrate (g)	38.2	13.4	3.7	8.67± 0.12
Fiber (g)	19.2	0.9	4.8	2.87± 0.03
Ca (mg)	2003	440	30	45
Mg (mg)	368	24	24	635± 8.66
P (mg)	204	70	110	75
K (mg)	1324	259	259	-
Cu (mg)	0.57	1.11	3.1	5.20± 0.15
Fe (mg)	28.2	7	5.3	-
S (mg)	870	137	137	0.05
Oxalic acid	1.6%	101	10	
VitaminE-tocopherol acetate(mg)	113	-	-	751.67± 4.41
VitaminA-Bcarotene (mg)	16.3	6.8	0.11	-
√itamin B1 -thiamine (mg)	2.64	0.21	0.05	0.05
Vitamin B3 -nicotinic acid (mg)	8.2	0.8	0.2	0.2
Vitamin B2 -riboflavin (mg)	20.5	0.05	0.07	0.06
Vitamin C -ascorbic acid (mg)	17.3	220	120	4.5± 0.17
Isoleucine (g/16g N)	0.83%	6.3	4.4	4.35(g/100g protein)
Arginine (g/16g N)	1.33%	6.0	3.6	8.06(g/100g protein)
Histidine (g/16g N)	0.61%	2.1	1.1	2.01(g/100g protein)
Tryptophan (g/16g N)	0.43%	1.9	0.8%	-
Methionine (g/16g N)	0.35%	2.0	1.4	14.76(g/100g protein)
Threonine (g/16g N)	1.19%	4.9	3.9	3.32(g/100g protein)
Leucine (g/16g N)	1.95%	9.3	6.5	5.27(g/100g protein)
Lysine (g/16g N)	1.32%	4.3	1.5	3.24(g/100g protein)
Phenylanaline (g/16g N)	1.39%	6.4	4.3	4.53(g/100g protein)
valine	1.06%	7.1	5.4	3.09(g/100g protein)

Per 100 gm /plant material ref (L.J. Fuglie *et.al*.,,2005, P.T. Olagbemide,*et.al*.,2014)

Phyto –constituent

M. oleifera is used as food and medicine to treat and combat malnutrition and various diseases in all over the world due to its high range of phytochemical presence in each and every part (R.Dhakar *et.al*.2011). Moringa has been found to be a good source of polyphenols tannins, sterols, terpenoids, flavonoids, saponins, anthraquinones, alkaloids, reducing sugar and antioxidants (G. Mishra *et.al*;2011). Vanillin, omega fatty acids, carotenoids, ascorbates, tocopherols, beta-sitosterol, moringine, kaempferol, and quercetin have been reported in its flowers, roots, fruits, and seeds. Phytochemicals such as glucosinolates, isothiocyanates, glycoside compounds and glycerol-1-9-octadecanoate compounds shows anti cancerous activity. Moringine and moringinine are two alkaloids mainly found in the stem bark (Kerharo, 1969).

Vanillin, sitosterol, β-sitostenone, 4-hydroxymellin and octacosanoic acid have been isolated from the stem of *M. oleifera* (Faizi *et al.*, 1994a). The leaves, have been found to contain phenolics and flavonoids which have various biological activities, such as antioxidant, anti carcinogenic, (M. Mbikay, *et.al* 2012; A,R.Verma *et.al*, 2009) immunomodulatory, antidiabetic, antiatherogenic, and hepatoprotective functions and the regulation of thyroid status (L. A. Cajuday ,*et.al*,2010). Leaves contain trace elements that are essential to human health. For example, magnesium, iron, selenium, and zinc play an important role in metabolism, Among glucosinolates, 4-O-(a-L-rhamnopyranosyloxy)-benzylglucosinolate (glucomoringin) is the most predominant in the stem, leaves, flowers, pods and seeds of M. oleifera (Amaglo *et al*. 2010). Although in the roots, benzyl glucosinolate (glucotropaeolin) is the most prominent. The highest content of glucosinolate is found in the leaves and seeds. The enzymatic catabolism of glucosinolates by the endogenous plant enzyme myrosinase produces isothiocyanates, nitriles, and thiocarbamates that are known for strong hypotensive (blood pressure lowering) and spasmolytic (muscle relaxant) effects (Anwar *et al*. 2007). The potent antioxidant activity MO is attributed to the high concentration of these polyphenols. Purified, whole-gum exudate from *M. oleifera* has been found to contain L-arabinose, -galactose, -glucuronic acid, and L-rhamnose, -mannose and -xylose, while a homogeneous, degraded-gum polysaccharide consisting of L-galactose, -glucuronic acid and L-mannose has been obtained on mild hydrolysis of the whole gum with acid (Bhattacharya *et al.*, 1982). Flowers contain nine amino acids, sucrose, D-glucose, traces of alkaloids, wax, quercetin and kaempferol; the ash is rich in potassium and calcium (Ruckmani *et al.*, 1998). They have also been reported to contain some flavonoid pigments such as alkaloids, kaempherol, rhamnetin, isoquercitrin and kaempferitrin (Faizi *et al.*, 1994a; Siddhuraju and Becker, 2003). Antihypertensive compounds thiocarbamate and isothiocyanate glycosides have been isolated from the acetate phase of the ethanol extract of *Moringa* pods (Faizi *et al.*, 1998). The cytokinins have been shown to be present in the fruit (Nagar *et al.*, 1982).

Theraputic Use

The different parts of the *Moringa oliefera* tree, including roots, bark, leaves, flowers, fruits, and seeds are traditionally used in various therapeutic applications, including, abdominal tumors, hysteria (a psychological disorder), scurvy, paralysis, helminthic bladder, prostate problems, sores and other skin infections. Various utility of different parts of Moringa are shown in Table 2

Other industrial uses

Various scientific literatures have revealed the enormous usefulness of *Moringa oleifera* plants which make it industrially significant. The seed of *M.oleifera* used as a coagulant, disinfectant for purifying water and adsorbent for heavy metal. Its oil can be used as biodiesel.

Seed oil as Biodiesel

Biodiesel is a renewable and eco-friendly alternative to conventional non-renewable fossil petrodiesel fuel. Biodiesel refers to long-chain alkyl (methyl, ethyl, or propyl) esters made by chemically reacting lipids of vegetable oil and animal fat. The vegetable oils obtained from cottonseed, Moringa, palm, peanut, rapeseed, soybean, and sunflower have been successfully used in biodiesel preparation. M. oleifera seeds contain 33-41 % (w/w) oil, known as ‘‘ben oil’’, because of the contents of behenic acid (C22, docosanoic acid, &7 % w/w), which possesses significant resistance to oxidative degradation (Rashid *et al*. 2008). The presence of significant amount of monounsaturated fatty acids in the form of oleic acid (C18:1, 72.2 %), Moringa seeds oil is a potential substance for biodiesel production. Da Silva *et al*. (2010) characterized Moringa oliefera oil of the Brazilian genotype for biodiesel production. In recent times, Azad *et al*. (2015), reviewed the prospect of M. oleifera seed oil as a sustainable biodiesel fuel and concluded that MO is one of the prospective industrial crops for biodiesel production in Austria.

Seed as adsorbent for heavy metals

Heavy metals are one of the most important pollutants affecting the quality of water and soil. They have significant toxic effect on the health of human and the aquatic species hence their removal is very necessary. Different heavy metal find their way in the water bodies due to industrial activities such as electroplating, mining, tanneries, fossil fuel combustion etc. Scientific studies conducted have revealed that shelled and non-shelled *Moringa oleifera* seed contains about 37% and 27% of protein (Ndibewu, *et.al*., 2011). The adsorptive capacity of the seed is due to the presence of proteins, some fatty acids, carbohydrate with contains cellulosic interlinked lignin in their structure

Table 2 medicinal uses of different parts of Moringa

Parts of moringa	Cure diseases	References
leaves	Act as antiseptic, anticancer, antimicrobial, Antioxidant, antidiabetic and anti-atherosclerotic agents, neuroprotectant, Anti-anemic Anti-hypertensive. Treat asthma, hyperglycemia, Dyslipidemia, flu, heart burn, syphilis, malaria, pneumonia, diarrhea, headaches, scurvy, skin diseases, bronchitis, eye and ear infections. Also reduces,blood pressure and cholesterol. Enhances lactation.	J.L.Rockwood et.al.(2013);M.Mbikay,et.al. (2012); L.J. Fuglie(2005); O.S. Ijarotimi,et.al.,(2013), I.L.Jung,(2014),M.K. Choudhary,et.al.,(2013)
Seeds	Seeds of moringa help in treating hyperthyroidism, Chrohn’s disease, antiherpes-simplex virus arthritis, rheumatism, gout, cramp, epilepsy and sexually transmitted diseases, can act as antimicrobial and anti-inflammatory agents	J.L.Rockwood,et.al.,(2013),J.N.Kasolo, et.al.,(2010); M.D. Thurber, et.al.,(2010) ;C. Sutalangka,et.al.,(2013),;S.Nair, et.al.,(2011)
Root	acts as a cardiac stimulant, anti-ulcer and anti-inflammatory agent, Scurvy, Low.Back/Kidney Pain,	O.S. Adeyem, et.al.,(2014); T.G. Monera,(2012)
Bark	Aphrodisiac, acts as a cardiac stimulant, anti-ulcer and anti-inflammatory agent, Epilepsy,headach	Faizi S, et al. (1998), Fuglie LJ (1999), Gilani AH, et.al. (1994)
Fruit	treat diarrhea, liver, skin and spleen problems, and joint pain. Act as anti diabetic and anti hypertensive	L.J. Fuglie 2005
Flower	act as hypocholesterolemic, anti-arthritic agents can cure urinary problems and cold	[L.J. Fuglie 2005, C. Sutalangka,et.al.,(2013)
Gum	Rheumatism,dysentery, Headache, Abortifacient	Fuglie LJ (1999), Nath D, et.al. (1992)
Oil	Bladder, Gout, Scurvy, tonic	Fuglie LJ (1999)

It has aromatic-three dimensional polymer structure with an infinite apparent molecular weight thus favouring biosorption as a promising technique for removal of heavy metal (Ndibewu, *et.al*., 2011). Metals removed from water by using *Moringa oleifera* seed include arsenic, cadmium, zinc, nickel (Sharma,*et.al*.2007;Acheampong,2012). *Moringa oleifera* seed has been shown to remove arsenic from water according to study carried out, sorption studies in the batch experiment showed that the optimum condition for the removal of arsenic (III) and arsenic (V) was 60.21% and 85.06% respectively (Kumari *et.al*,2006). For cadmium removal, 85.10% removal was achieved, for the removal of nickel, 90% removal was achieved.

Seed as water purifier

Moringa oleifera seed in different extracted and purified forms has proven to be effective at removing suspended material, soften hard waters, removal of turbidity, chemical oxygen demand (COD), colour and other organic pollutant (Bina B *et.al*.,2010; Muyibi SA, *et.al* (1996); Ndabigengesere(1998)). The proposed mechanism of the active coagulation components in *Moringa oleifera* seed protein is assumed that positively charged proteins attach to parts of surfaces of negatively charged particles through electrostatic interactions. This leads to formationof negatively and positively charged areas of the particle surface. Due to particle collision and neutralization, enmeshment of suspended particles forms flocs with a net-like structure (Ndabigengesere *et.al*.,(1998)) .Several studies have reported on the performance of *Moringa oleifera* seeds as an alternative coagulant or coagulant aid for various treatment of water such as turbidity, alkalinity, dissolved organic carbon (DOC), humic acid and hardness removal in raw water (Fahmi,2011; Lea M (2010)). Earlier studies have also recommended the use of MO seed extracts as coagulant for water treatment for the removal of various pollutants such as orange 7 dye, alizarin violet dye in water (Marandi2012; Beltrán-Heredia 2009). Recent study (Prasad RK (2009)) carried out colour reduction studies on distillery spent wash using *Moringa oleifera* seeds and optimum colour reduction was found to 56% and 67% using NaCl and KCl salt respectively.

Moringa oleifera seed as disinfectant

Moringa oleifera seed as disinfectant for drinking water purposes. However, the research on *Moringa oleifera* seed are used as disinfectant in water till date was conducted by Bichi *et al*.,(2012)which revealed that the seed extracts has a great potential usage as disinfectant.

Moringa leaf as plant growth regulator

Moringa leaf extract is enriched with cytokinin, auxin and abscisic acid like growth substances. Its leaves have antioxidant like ascorbate, phenolics (Sidduraju, *et.al*.,2003). Hence aqueous extract of leaf contain growth enhancing substances and can be used as biostimulant. The scientific studies has revealed that foliar application of M.oleifera leaf extract beneficial for vigour growth (chang, *et.al*. ,2007), deeper root development and better seed germination(Kannaiyan, *et.al*., 2000), delayin fruit senescence and improve yield quality(Phiri, *et.al*., 2010).It also impart on the ability of crops to withstand adverse environmental conditions(chang,*et.al*.,2007)

CONCLUSION

Moringa oleifera a popular medicinal plant in India is known to be effective against a number of aliments and popularly used in traditional medicinal system. All part of his plant is reported to be highly potential from medicinal point of view. Many studies have also been conducted on the performance of Moringa seeds, bark stem, flower for available useful phytochemical especially those which contents antibacterial, antifungal, and anti cancer properties. Therefore, it is important to identify the active constituents of Moringa plants and its parts for a better understanding of its medicinal properties. Reports on the antimicrobial effects of the protein purified from *M. oleifera* are very rare. Since this plant naturally occurs in varying habitats, it is native to expect a great magnitude of variation in the concentration and composition of chemical ingredients in different parts of the tree. However, the extent to which the chemical composition varies in populations adapted to varying habitats is not known. Thus, detailed studies are required to examine this aspect. In view of its multiple uses, the *M. oleifera* plant needs to be widely cultivated in most of the areas where climatic conditions favour its optimum growth. In this way, a maximum yield of its different useable parts could be achieved to derive the maximal amount of commodities of a multifarious nature for the welfare of mankind. Indo gangetic plains of India provide opportunity for its large planting and subsequent used of the purified extract of different parts in pharmaceutical uses leading to development of newer, safer, effective and affordable herbal drug

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