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Moringa oleifera (Lam) – A nutritional powerhouse

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ABSTRACT

Moringa oleifera Lam., a medium sized tree species has gained importance due to its multipurpose usage and well adaptability to dry and hot climates of North-Western plains, central India and dry regions of peninsular India. It can be grown as a crop on marginal lands with high temperatures and low water availability, where it is difficult to cultivate other agricultural crops. It has an impressive range of medicinal uses with high nutritional value. Different parts of this plant contain a profile of important minerals and are a good source of protein, vitamins, carotene, amino acids and various phenolics. In addition to its compelling water purifying powers and it is also used as fodder. Numerous Research reports have appeared in different national and international scientific journals by studying its nutritional properties of Moringa over the past decades. This study provides a brief overview about multipurpose and nutrient content of Moringa oleifera tree.

Keywords: Multipurpose, nutrient content

The tree is native to the sub-Himalayan tracts of North-West India, Pakistan, Bangladesh and Afghanistan (Foidl *et al*.,2001) but has been widely grown tree around the world in Ethiopia, Pacific Islands, Florida, Sudan Caribbean, Philippines, South Africa, Asia, and Latin America and is naturalized in many locales. Moringa goes by many names. *Moringa oleifera* Lam., popularly called the "miracle tree". In Philippines, where the leaves of the moringa are cooked and fed to babies, it is called "mother's best friend" and "malunggay." Other names for it include the benzolive tree (Haiti), horseradish tree (Florida), Nébéday (Senegal) and drumstick tree or "drumstick tree" (Jahn, 1991) in India.

Arora *et al*., (2013) reported there were about 33 species of Moringaceae family. *Moringa oleifera* is one of the moringaceae families. Among those, best known of the thirteen species namely: *M.arborea, M. borziana, M. concanensis, M. drouhardi, M. hildebrandtii, M. longituba, M. oleifera, M. ovalifolia, M. peregrina, M. pygmaea, M. rivae, M. ruspoliana, M. stenopetala* are well known and found worldwide. Numerous studies have reported its multipurpose use like medicinal and nutritional benefits (Anwar *et al*., 2007).

Moringa oleifera has wide range of uses, among those, water purification, human consumption, medicine, fuel wood, dye, soil and water conservation, livestock forage and green manure (ECHO, 2009 and Melesse *et al*., 2011). All plant parts are having remarkable range of some functional and nutraceutical properties (Singh *et al*, 2012) make this plant a diverse biomaterials for food and allied uses. According to Dawit *et al*., 2016 *Moringa* has multipurpose use, well adapted and significant economic importance, as it has vital nutritional, industrial, and medicinal applications.

The leaves, flowers and fruits of this plant are used in the preparation of several delicacies in Indian sub continent. Associated with high nutritional value of its edible portions pave a way in making this plant more popular as an important food source in order to combat protein energy malnutrition problem prevailed in most of the under developed and developing countries of the world. Presence of various types of antioxidant compounds make this plant leaves a valuable source of natural antioxidants (Anwar *et al.*, 2007) and a good source of nutraceuticals and functional components as well (Makkar and Becker, 1996).

The Moringa plant has been consumed by humans throughout the century in diverse culinary ways (Iqbal *et al.*, 2006). Almost all parts of the plant are used culturally for its nutritional value, purported medicinal properties and for taste and flavor as a vegetable and seed. The leaves of *M. oleifera* can be eaten fresh, cooked, or stored as a dried powder for many months reportedly without any major loss of its nutritional value (Arabshahi-D *et al.*, 2007; Fahey, 2005). Epidemiological studies have indicated that *M.oleifera* leaves are a good source of nutrition and exhibit anti-tumor, anti-inflammatory, anti-ulcer, anti-atherosclerotic and anti-convulsant activities (Chumark *et al*, 2008; DanMalam *et al.*, 2001; Dahiru *et al.*, 2006). The investigation of the different parts of the plant is multidisciplinary, including but not limited to nutrition, ethnobotany, medicine, analytical chemistry, phytochemistry and anthropology (McBurney *et al.*, 2004).

Numerous research reports have shown the multipurpose uses of most parts of *Moringa oleifera* in making food for human consumptions such as cake by Kolawole *et al*., 2013, yoghurt (Kuikman and connor, 2015), amla (Karim *et al*., 2015), weaning foods by Arise *et al*., 2014, bread by Chinma *et al*., 2014, soups (Babayeju *et al*., 2014) and biscuits by Alam *et al*., 2014.

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Table 1: Common Nutritional uses/benefits of different parts of *Moring oleifera* Lam. tree

Plant parts	Nutritional uses/benefits	Phytochemistry	References
Leaves	(i) *Moringa* leaves are very rich source of vitamin A, C, Calcium, Potassium, protein and essential elements in comparison to locally available in market *viz*. carrot, orange, cow milk, banana etc. The leaves may be supplemented as essential food and Alternative of tea leaves. The leaves can be serve to check malnutrition in the poor's. It is a nutraceutical and panacea for various diseases having 35 elements.(ii). Leaf powder used as hand washing product-hand hygiene to reduce gastrointestinal and respiratory illness.(iii). Leaves tender twigs and immature pods used as fodder for cattle's to increase milk.(iv). Pregnant woman consumed leaves and flowers to increase milk for infants.(v). Leaf powder used as biocontrol in crops, as fertilizers and pestisides.	Vitamin A 6.780mg – carrot : 1.890 mg; Vitamin C 220 mg – orange: 30 mg; Calcium 440 mg – cow's milk: 120 mg; Potassium 259 mg – banana: 88 mg; Protein6.6 mg – cow's milk: 3.2 mg; 14 macroelements and 21 microelements (total35 elements). During hand washing the mechanicalfriction by the dry leaf powder reduces thebacterial effect in comparison to non-medicatedliquid soap. Having higher percentage of vitamins,essential elements and proteins.Leaves having iron, minarals, vitamins andproteins.	Gyekye *et al*., 2014, Anwar *et al*., 2007, Fozia *et al*., 2012, Kamal, 2008, Mahmood *et al*., 2010, Ritu *et al*., 2011b, Ritu *et al*., 2011a, Parrotta and John, 2009 UNWFP, Dec, 2004 Mahmood *et al*., 2010, Parrotta and John 2009 -do- -do-
Stem	Stem pulp used in picking-sticks, and newspaper making and textile industries.Stem corky bark yield Fibbers used in making mats, paper, cordages etc.	Having cellophane	Parrotta and John, 2009
Pods	Immature pods cooked as vegetable or pickled, having high nutritional- and medicinal values.	Having higher percentage of vitamins essential elements, glycosides etc.	Parrotta and John, 2009
Seeds	(i) Seed powder paste used as water purifier to improve the quality of drinking water by absorbing the heavy metals *viz*. cadmium, copper, chromium, lead and zinc which are highly toxic to human being.(ii). The seeds can be used as nutritional supplements and for industrial and agriculture purpose. It is also being used in perfume industries, cosmetic, lubricate, soap as antioxidant activity oil being used as body cream. It can also used as vegetable in dailyconsumption.	*Moringa* is a cationic polyelectrolyte of short chain and low, molecular weight.Heavy metals having higher charges. Seeds oil locally know as "*ben oil*" *"Drumsticks*" similar to *olive oil* and is rich in Palmetic, stearic, Behenic and oleic acids. The oil is clear, odourless and resists rancidity, oil possesses 75% oleic acid.	Vikashni *et al*., 2012 Ojiako and Okeke, 2013

Source: (Bhargave et al., 2015)

Benefits of *Moringa*

There are many uses of *Moringa viz*., medicines, human food, water purification, animal fodder, alley cropping, fertilizer, living fence, domestic cleaning agent, fuel wood and other uses. *Moringa* has increased physical energy – it tune the body up with naturally occurring nutrients to make your energy last longer. Numerous research reports reveal that, parts of *Moringa* plant can be used in different ways. The uses of *Moringa oleifera* are well documented by Fahey (2005), as nutritional, industrial, medicinal, and agricultural advantage.

Moringa oleifera has great potential for prevention of different diseases like nutrient deficiency, cancer, anemia as well as for dirty water purification. *Moringa* powder contains sufficient amount of vitamins, minerals, protein, phenols and other phytonutrients. This makes the tree a medicine for many different diseases (Gedefaw, 2015). *Moringa oleifera* has also promoted by World Health Organization as an alternative to imported food source to treat malnutrition (Sreelatha and Padma, 2009).

Human consumption of moringa

The young leaves are edible and are commonly cooked and eaten like spinach or used to make soups and salads. They are an exceptionally good source of provitamin A, vitamins B, and C, minerals (particular iron), and the sulphur-containing amino acids methionine and cystine. The young green pods are very tasty and can be boiled and eaten like green beans. The pods are best for human consumption at the stage when they can be broken easily without leaving any visible strings of fibre. These are rich in free leucine. Seeds should be eaten green before they change colour to yellow. A tasty hot sauce from the roots can also be prepared by cooking them in vinegar.

Major use as edible pods, leaves and flowers. This species has been principally utilized for fruit and leaves as vegetable and to some extent for edible flowers and seed oil particularly in India, Pakistan, Philippines, Hawaii and many parts of Africa (Watt, 1889 and Anwar *et al*., 2005). Very young pods (10–15 days old) taste like asparagus and are commonly consumed as vegetable and for culinary preparations. In Bihar and Orissa tender pods garnished with mustard seed paste are cooked like beans and consumed with rice (panibhaat). Mature pods are used in preparation of soups and stews. Scraped drumstick pulp is made into a tasty dish called 'moringa bhartha' (like the dish prepared from brinjal). Drumstick curry is prepared by adding boiled pieces or pulp into pigeonpea curry).

In South India pods of medium maturity (35–50 days old) are used in recepies like 'Sambhar' preparation (pigeonpea pulse cooked with seasonal vegetables). Towards the end of dry season when other leafy vegetables are few in market the younger leafy tips and tender leaves are used as vegetable, condiment and in salads as the coriander leaves. In Orissa the leafy vegetable and fully ripe green fruits are marketed and consumed with rice during summer months. Vegetable called ''sanjana saag'' or ''sanjana tarkari'' is prepared from fresh young leaves (cooked with green gram, pumpkin, potato or taro) is commonly recommended as a special food supplement for pregnant women, lactating mothers, in patients suffering from osteoporosis and bone fracture (Dr. DR Pani, NBPGR, Cuttack; pers. comm.).

Dried leaves are powdered and stored for off season use. In parts of West Bengal and adjoining regions of Bangladesh they (called sojne fool) are generally cooked as a delicacy prepared using green peas and potato and consumed especially during spring. Moringa leaf powder is used as a 100 per cent natural food supplement and can be consumed in different ways. The leaf powder can be mixed with juices or beverages using a teaspoon. One teaspoon of Moringa will provide a full range of nutrients required by the body. Moringa leaf powder can also be mixed with vegetables or soup that is prepared for consumption. In Africa, 25 g of Moringa powder is administered to pregnant women daily to improve prenatal nutrition (Diatta, 2001). Apart from plain leaf powder, Moringa powder is also sold in capsules. The daily intake is about two capsules a day (one capsule in the morning and one at lunch time).

In northern India mainly the Punjabi, Sindhi and Multani communities prepare flowers as a delicacy after boiling/frying with curd (Ms NK Chaudhari, ex NBPGR, New Delhi; pers. comm.). Young flowers (both pink and white form) packed in packets are commonly sold during February–March in city markets of northern India (Arora and Pandey, 1996). During exploration to Bilaspur district (foothills of Himachal Pradesh) the second author recorded sale of flowers/buds in wholesale market (pers. comm.). In Bihar and Orissa flower buds and tender leaves are mixed in batter (gram flour) and consumed after deep frying.

According to Marcu (2005), no negative effects from daily consumption of Moringa leaves and seeds have ever been reported. Marcu (2005) further indicated that Moringa has the following health benefits:

Reduces cholesterol levels and triglycerides ("bad" fats),

Controls blood sugar and helps normal sugar and energy balance,

Offers vitamins and minerals, vital for maintaining normal physiology and

Offers powerful anti-aging and anti-inflammatory natural substances, many with anti-cancer properties.

Moringa as a source of biogas

Moringa plants (approximately 30 days old) were milled together with water. The fibre was separated by filtration through a mesh with 5 mm pores and the liquid fraction produced was then added to a biogas reactor.With an average feed of 5.7 g of volatile solids the gas production was 580 litres of gas kg^{-1} of volatile solids. The average methane content of the gas was 81 per cent.

Moringa as fodder

Various research reports and reviews have highlighted the importance of the moringa leaves, fresh pods, seeds, roots are being widely used by human and animal because of their higher essential nutrients contents (CSIR 1962 and Hartwell, 1971). Scientists devoted to livestock research, however, are not only interested in finding good-quality fodders that can increase milk and meat production, but they are also looking for species that can be grown and exploited in environmentally friendly ways and cultivated inexpensively, such demands are also met by moringa. Researchers (Richter *et al*., 2003; Sanchez *et al.*, 2006 and Mendieta-Araica *et al*., 2011) have explored moringa cultivation practices and its utilization as livestock fodder. Moringa trees are used for diverse purposes because they are easy to maintain once their roots have developed and established (moringa trees have a deep tap root system when they are grown from seeds and an adventitious root system when they are grown from stem cuttings). Its root penetrate deep into soil to search for water and nutrients, which enables moringa trees to tolerate severe conditions.

Moringa crop produces high dry matter (DM), between 4.2 and 8.3 t ha^{-1}, depending on the fertilizer, accession, season and ecological zone (Palada *et al*., 2007). Foidl *et al.* (2001) carried out a moringa biomass production project and tested different planting densities to get maximum biomass values. They found that at higher planting densities, more biomass can be achieved. Moringa leaves are rich in nutrients like iron, potassium, calcium and multivitamins, which are essential for livestock weight gaining and milk production (Newton *et al*., 2010 and Mendieta-Araica *et al.*, 2011). Moringa leaves also contain 21.8 per cent crude protein (CP), 22.8 per cent acid detergent fibre (ADF) and 30.8 per cent neutral detergent fibre (NDF), as well as 412.0 g kg–1 of crude fat, 211.2 g kg^{-1} of carbohydrates and 44.3 g kg^{-1} of ash (Oliveira *et al*.,1999 and Sanchez *et al*. 2006). All these compounds are useful to increase livestock production. Moreover, low-quality livestock fodders or rations can be improved by adding moringa leaves as a supplement, which increases the dry matter intake (DMI) and the digestibility of the fodder by livestock, as well as increasing the protein intake in fish diet (Richter *et al.*, 2003).

Alum

The kernels of moringa can be crushed and its water extract used for purification of water and the water extract is a viable replacement coagulant for chemicals such as aluminium sulphate (alum) in developing countries.

The properties of the natural polypeptides produced from Moringa seeds have been employed with particular effectiveness in both Egypt and Sudan for cleaning water from the Nile, specifically for human consumption (Foidl *et al.*, 2001). The dried seeds of Moringa used to purify unsafe water. By leaving the dried seeds in a bottle of unclean water overnight, between 90-95 per cent of the bacteria can be purified (Goodwater, 2011).

Moringa oil

Moringa oil can be used for human consumption, as it is edible oil, an excellent salad oil, illuminant, lubricant, biofuel and in cosmetic industry (Rashid *et al.*, 2008). The seeds yield 38–40 per cent of non-drying, sweet, odourless and clear oil that resembles the olive oil (Anwar *et al.*, 2005 and 2007).

De-hulled seeds (kernel) of Moringa which contain approximately 40 per cent oil known as Ben oil. The oil is highly nutritious and has a fat composition similar to olive oil. The oil is used as a lubricant for watches and fine machinery such as timepieces, because it has a minimal tendency to deteriorate and become rancid and sticky (Ramachandran *et al.*, 1980). Moringa oil is also used in the perfume industry for stabilising scents due to its capacity to absorb and retain volatile substances.

Other uses

Other uses of the species are met from plant (as hedge and agro/social forestry), leaves (fodder), seeds (seed cake as fertilizer), roots (especially from seedlings; pickle with vinegar), fuel wood (soft, porous and yellowish), bark gum (used for food seasoning and in calico printing), flowers (good source of nectar) and coarse fibre (Wealth of India, 1962 and Guha *et al.*, 1968).

Table 2:Nutritional value of *Moringa oleifera*. (100^{-1} g of edible portion)

Component analyzed	Pods	Leaves	Leaf powder
Moisture (%)	86.9	75.0	7.5
Calories	26	92	205
Protein (g)	2.5	6.7	27.1
Fat (g)	0.1	1.7	2.3
Carbohydrate (g)	3.7	13.4	38.2
Fibre (g)	4.8	0.9	19.2
Minerals (g)	2.0	2.3	-
Ca (mg)	30	440	2003
Mg (mg)	24	24	368
P (mg)	110	70	204
K (mg)	259	259	1324
Cu (mg)	3.1	1.1	0.57
Fe (mg)	5.3	7	28.2
S (mg)	137	137	870
Oxalic acid (mg)	10	101	1600
Vitamin A - B carotene (mg)**	0.11	6.8	16.3
Vitamin B – choline (mg)	423	423	-
Vitamin B_1 – thiamin (mg)	0.05	0.21	2.64
Vitamin B_2 – riboflavin (mg)	0.07	0.05	20.5
Vitamin B_3 – nicotinic acid (mg)	0.2	0.8	8.2
Vitamin C – ascorbic acid (mg)	120	220	17.3
Vitamin E – tocopherol acetate (mg)	-	-	113
Arginine (mg)	90	402	1325
Histidine (mg)	27.5	141	613
Lysine (mg)	37.5	288	1325
Tryptophan (mg)	20	127	425
Phenylanaline (mg)	108	429	1388
Methionine (mg)	35	134	350
Threonine (mg)	98	328	1188
Leucine (mg)	163	623	1950
Isoleucine (mg)	110	422	825
Valine (mg)	135	476	1063

Source : Choudhary et al., 2016

The coagulating ability of the seed powder has been used to purify water to make it suitable for drinking in arid regions. It is a cheaper bioabsorbent for removal of heavy metals and organic compounds (Sharma *et al*., 2006). It is used in treatment of rheumatism, venomous bites, fever, cardiac and circulatory diseases, abdominal tumours, counter-irritant, external stimulant of skin, purgative, expectorant, mild diuretic, epilepsy and hysteria (Singh and Kumar, 1999 and Anwar *et al*., 2005 and 2007). TNAU is exploring the potential use of seed oil as biofuel on an industrial scale with the Western Australian Agriculture Authority (WAAA; Business Line 10 July 2008).

Use of moringa in addressing malnutrition is a challenge for India and other developing nation (Rahim *et al.,* 2007). The tree is a good source for calcium, phosphorus and iron. The leaves are rich in protein content (27%), vitamins A and C, beta carotene, potassium, calcium, iron and phosphorus and are good source of natural antioxidants and thus, enhance the shelf-life of fat containing foods (Gupta *et al.,* 1989). Leaves, flowers and young fruits are rich in gluconsinolates (Wealth of India 1962; D'souza and Kulkarni, 1993).

Nutritional value of moringa

A prolonged and good-quality food supply is essential for the development of any stable community. People should be able to fulfill their nutritional requirements consuming vegetables, fruits, cereals, meat and milk, but many of these products are not affordable for a great number of persons, especially those who live below the poverty line. Therefore, in the communities constituted by poor or extremely poor people, plants that are

particularly nutritious are valuable members of the available spectrum of plants. Moringa seems to have the potential for solving, these problems in the communities and could play an important role in sustainable communities due to its high nutritious quality and adaptability to diverse and challenging environments.

It has long been cultivated and all its parts been consumed and used for a variety of purposes across the tropics (Jahn, 1984). This is because if its impressive range of nutritional and medicinal values (Bukar *et. al.*, 2010). Oluduro (2012) reported the presence the following minerals in the leaves: – sodium (11.86), potassium (25.83), calcium (98.67), magnesium (107.56), zinc (148.54), iron (103.75), manganese (13.55) among others in parts per million and nutrients such as carbohydrate (45.43%), protein (16.15%), fat (9.68%), crude fibre (9.68%), moisture (11.76%) and ash (10.64%) (Nweze, 2014).

The leaves are edible and are commonly cooked and eaten like spinach or used to make soups and salads. The composition of the amino acids in the leaf protein is well balanced (Foild *et al*., 2001; Ogbe and Afikku, 2011). The leaves and pods are helpful in increasing breast milk in nursing mothers during breastfeeding (Oluduro, 2012).

High protein content is one of the most cited advantages of moringa leaves. For example, they contain 9 times more protein than yoghurt (Mathur, 2006). In various reports (Chandan, 2006), it has been reported that cow, buffalo, goat and sheep milks provide average CP contents of 3.4 , 4.7 , 4.1 , and 6.3 per cent, respectively, while fresh and dry moringa leaves exhibit CP contents of 67.0 and 271.0 g kg^{-1}, respectively. These comparisons confirm that moringa leaves contain higher amounts of CP in comparison with milk. Moringa leaves are a rich protein source (Thurber and Fahey, 2009), they can be used by physicians, nutritionists and members of the health community to solve the malnutrition problem. One tablespoon of moringa leaf powder contains 9.9 – 13.6 per cent of the daily CP requirement of children and breast-feeding mothers. It has also been reported that the amino acid profile of moringa leaves meets the standards of the World Health Organization. Moringa leaves have higher amounts of all amino acids than are required for children, it is also reported that plant foods, especially cereal crops, have low lysine contents, while legumes show higher amounts. Moreover, they also reported that better lysine contents are being provided by livestock products, like milk. Moringa is also a very good source of all amino acids, including lysine. Moringa seed meal also has good amounts of all the amino acids, except for valine, lysine and threonine (Oliveira *et al.*, 1999) and also have 43.6 g kg^{-1} of protein of methionine + cysteine, which is very close to that of human milk, chicken eggs and cow milk. The seeds have been found to contain a non-toxic natural polypeptide that sediments mineral particles and organics in the purification of drinking water, for cleaning vegetable oil, and for sedimenting fibers in the juice and beer industries (Muyibi and Evison, 1995; Ndabigengesere *et al*., 1995).

Moreover, moringa dry leaves and fresh pods are also a good source of amino acids (Table 2). Arginine, valine and leucine contents were found higher in moringa dry leaves and fresh pods, while serine, glutamate, aspartate, proline, glycine, and alanine could not be detected in these moringa parts (CSIR, 1962).

The nutritional characteristics of the moringa tree are excellent hence it can easily be used as a fresh forage material for cattle. The leaves are rich in protein, carotene, iron and ascorbic acid and the pod is rich in the amino acid lysine (CSIR, 1962). Nutritional analysis indicates that Moringa leaves contain a wealth of essential disease preventing nutrients which make it suitable to be included in diets as food supplement **(**Krishnaiah *et al*., 2009). Moringa leaves have been used to combat malnutrition, especially among infants and nursing mothers and hasten uterine contraction during child birth in pregnant women (Oluduro, 2012). It has also been found that extract obtained from the leaves of Moringa in 80 per cent ethanol contains growth enhancing principles for higher plants (Makkar and Becker, 1996).

Moringa tree is indeed a miracle tree with enormous potentials yet to be fully explored in medicinal and food application. All parts of Moringa tree are said to have useful assets that can help humankind.

This study has tried to reviews a multipurpose uses and nutrient content of Moringa and suggestion for the human consumption to mitigate the nutritional disorders. Different studies reveal that, Moringa has a direct effect on agriculture, nutrition, health, water, environment, biodiversity and sanitation. The latest research has documented that, Moringa is one of the medicine to reduce the occurrence of water borne disease which is on record as one of the main causes leading to high incidence of deaths in the developing countries. Thus, Moringa seeds are capable of appealing and sticking fast to bacteria and viruses that are found in contaminated and turbid water.

Generally, Moringa offers very interesting opportunities for small farmers as food supplement, medicine, nutrition, water treatment, livestock feed, vegetable, oil, foliar spray, green manure, natural fertilizer, cosmetic, fooder, beauty care products, soil and water conservation and reduce greenhouse gas emission. Moringa should be promoted for further consumption to improve nutrition health of humanbeing. In order to discover and utilize full uses of this miracle tree, market development strategies, Strong policies, and research were required.

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