International Journal of Agricultural Sciences
Volume 12 | Issue 1 | January, 2016 | 115-122 ■ e ISSN-0976-5670
DOI:10.15740/HAS/IJAS/12.1/115-122
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A REVIEW

'Drumstick tree' (*Moringa oleifera* Lam.) is multipurpose potential crop in rural area of India

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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. *Moringa oleifera* Lam. (family: Moringaceae) is a highly valued plant, distributed in many countries of the tropics and subtropics. 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, β -carotene, amino acids and various phenolics. The moringa plant provides a rich and rare combination of zeatin, quercetin, β - sitosterol, caffeoylquinic acid and kaempferol. In addition to its compelling water purifying powers and high nutritional value, *M. oleifera* is very important for its medicinal value and it is also used in Dairy and meat production in dry regions is very complex due to low quality and shortage of fodder, especially in dry periods. In case of fodder shortage. *i.e.* unavailability of fodder in December through May as currently green fodder is least available after wheat, alfalfa, brassica and maize harvesting. This leads towards reduced livestock production and low-quality milk and meat products. and enlarging the gap between the availability of resources and the meeting of human and animals necessities. People are fulfilling their requirements for food and shelter by depleting natural resources. *Moringa oleifera* is one of those plants that has been neglected for several years but now is being investigated for its fast growth, higher nutritional attributes, and utilization as a livestock fodder crop. 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.

Key Words : *Moringa oleifera*, Antinutritional factors, Livestock fodder, Nutritional quality, Medicinal uses, Pharmacological properties, Natural coagulant

View Point Article : Choudhary, S.K., Gupta, S.K., Mahdi, S. Sheraz and Kumar, Nikhil (2016). 'Drumstick tree' (*Moringa oleifera* Lam.) is multipurpose potential crop in rural area of India. *Internat. J. agric. Sci.*, **12** (1) : 115-122.

Article History : Received : 12.12.2015**; Accepted :** 22.12.2015

INTRODUCTION

The moringa tree, *Moringa oleifera*, has probably been the most popular plant in India. *Moringa oleifera* Lam belongs to a onogeneric family of shrubs and tree, Moringaceae and is considered to have its origin in Agra and Oudh, in the northwest region of India and south of the Himalayan mountains. This tree can be found growing naturally at elevations of up to 1,000 m above sea level. It can grow well on hillsides but is more frequently found growing on pastureland or in river basins. It is a fast growing tree and has been found to grow to 6 – 7 m in one year in areas receiving less than 400 mm mean

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annual rainfall (Odee, 1998). It is now cultivated throughout the Middle East, and in almost the whole tropical belt. *Moringa oleifera* Lam is native to south Asia, but grows in tropical Africa and Latin America (Ramachandran *et al.*, 1980). The tree is native to India but has been planted around the world and is naturalized in many locales. Moringa goes by many names. In the 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 (India). There are about 13 species of moringa trees in the family Moringaceae. The plant possesses many valuable properties which make it of great scientific interest. These include the high protein content of the leaves twigs and stems, the high protein and oil contents of the seeds, the large number of unique polypeptides in seeds that can bind to many moieties, the presence of growth factors in the leaves, and the high sugar and starch content of the entire plant. Equally important is the fact that few parts of the tree contain any toxins that might decrease its potential as a source of food for animals or humans.

Moringa (*Moringa oleifera*) is a valuable tree with nutritional, medicinal, industrial and numerous agronomic uses (Crosby, 2007). In Guatemala, moringa is used as food, feed, ornament, live fence, soap, insect repellent, fuel, and medicine for many ailments including joint, skin, digestive and respiratory diseases (Cáceres *et al*., 1991). And good growth after germination. Germination of hulled seed was, however, very poor. Cáceres *et al.* (1991) observed a drop in viability of moringa seed from 94 to 78 per cent in 12 months of storage. the leaves of *Moringa oleifera* Lam is claimed to possess cholesterol-reducing effect and is used to treat patients with heart disease and obesity. For this reason it was decided to resolve this claim by investigating the effects of the crude extract of leaves of *Moringa oleifera* Lam (English: Horseradish plant or drumstick tree) on the serum, liver and kidney cholesterol of the wistar rat. Its effects on serum total protein, and albumin, were also examined in the same animal model. In Nigeria, *Moringa oleifera* leaves are eaten as vegetables without any side effects being reported. These leaves are also eaten commonly as a food by infants and children in south India, because the high content of b-carotenes helps to prevent the development of vitamin A deficiency blindness.

The present review article gives a detailed discussion on the nutritional quality of moringa parts and their palatability for livestock, fish and poultry, as well as suitable growing conditions and cultural practices.

Socio-economic importance:

Moringa is one of the most useful tropical trees. It propagates through both sexual and asexual means and it has low demand for soil nutrients and water after being planted and hence, its production and management easy and less cost of production. Introduction of this plant into a farm which enhances the biodiversity of the environment and also it can be beneficial for both the owner of the farm and the surrounding ecosystem.

Morphology and physical characteristics :

Moringa is a fast growing, perennial tree which can reach a maximum height of 7-12 m and a diameter of 20-40 cm at chest height. It has following morphology and physical characteristics.

Stem :

The stem is normally straight but occasionally is poorly formed. The tree grows with a short, straight stem that reaches a height of 1.5-2 m before it begins branching but can reach up to 3.0 m.

Branch :

The extended branches grow in a disorganized manner and the canopy is umbrella shaped.

Leaves :

The alternate, twice or thrice pinnate leaves grow mostly at the branch tips. They are 20-70 cm long, when young it is grayish-downy, long petiole with 8-10 pairs of pinnae each bearing two pairs of opposite, elliptic or obovate leaflets and one at the apex, all 1-2 cm long; with glands at the bases of the petioles and pinnae (Morton, 1991).

Flowers :

The flowers, which are pleasantly fragrant, and 2.5 cm wide are produced profusely in axillary, drooping panicles 10 to 25 cm long. They are white or cream colored and yellow-dotted at the base. The five reflexed sepals are linear-lanceolate. The five petals are slender-spatulate. They surround the five stamens and five staminodes and are reflexed except for the lowest (Morton, 1991).

Fruits :

The fruits are three lobed pods which hang down from the branches and are 20-60 cm in length. When they are dry they open into 3 parts. Each pod contains between 12 and 35 seeds.

Seeds :

The seeds are round with a brownish semi-permeable seed hull. The hull itself has three white wings that run from top to bottom at 120-degree intervals. Each tree can produce between 15,000 and 25,000 seeds/year. The average weight per seed is 0.3 g and the kernel to hull ratio is 75:25 (Makkar and Becker, 1998). Physical characterization of pods and seeds are given in Table 1.

Utilization of moringa:

Fig. 1 outlines important uses of various parts of the plant. The details are presented in subsequent

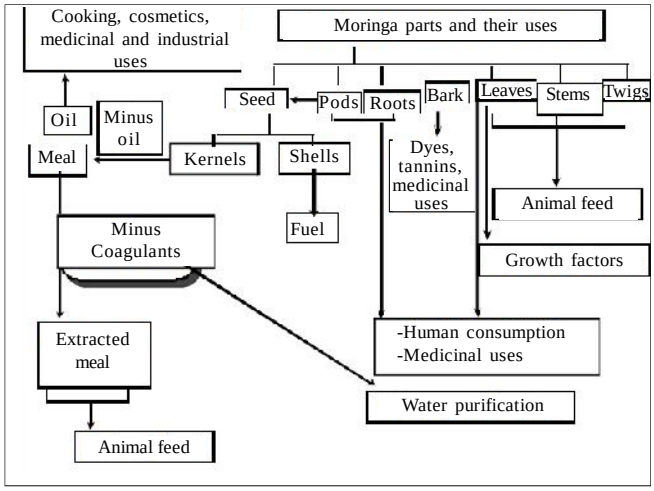


Fig. 1 : Uses of different parts of moringa

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.

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 per 1 kg of volatile solids. The average methane content of the gas was 81 per cent.

Moringa as fodder for livestock :

Various research reports and reviews have highlighted the importance of the moringa leaves, fresh pods, seeds and roots are being widely and increasingly used by humans and animals because of their higher contents of essential nutrients (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

Table 1 : Physical properties of pods and seeds of moringa by different scientist

Determination	1	2	3
Average weight of pod (g)	7.60	-	7.95
Average weight of seeds (g) / pod	3.59	5.03	4.83
Average number of seeds / pod	12	17	16
Average weight (g) / 100 seeds	29.9	29.6	30.2
Average weight of kernels (g) / 100 seeds	21.2	-	22.5
Per cent weight of kernel in relation to entire seed	72.5	-	74.5
Per cent weight of hull in relation to entire seed	27.5	-	25.5
Moisture in kernel (%)	4.5	-	6.5
Moisture in hull (%)	9.2	-	12.9
Moisture in whole seed (%)	5.8	-	7.5

Source : 1. Ferrao and Mendez (1970), 2. Carlos Foletti (1996; Personal communication), 3. Proyecto Biomasa (1996)

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 roots 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).

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. Their high protein content is one of the most cited advantages of moringa leaves. For example, they contain 9 times more protein than yoghurt does (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 per cent, 4.7 per cent, 4.1 per cent, 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 per cent–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 (WHO). 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. 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 so 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). Another important advantageous characteristic of moringa is its high productivity of fresh material per unit area compared

with other forage crops. Moringa is especially useful as a forage for cattle both economically and productively given the problems facing typical cattle breeders. Major among these problems are:

–Low availability of feed during the dry season, which extends from December through May.

–Lack of capacity for pasturing animals as farmers generally own small areas and these are typically not well worked or managed.

–Nutritional imbalances caused by a lack of access to proteins, carbohydrates and minerals.

–Farmers have little control over the reproductive activities of their animals either as regards timing of mating or quality of sire.

Chemical constituents :

The protein content of fresh leaves does not vary substantially from place to place (Table 2).

Use:

Moringa kernel and meal as animal feed. The kernels of moringa can be crushed and its water extract used

Table 2 : Nutritional value of *Moringa oleifera*.* Moringa pods, fresh (raw) leaves and dried leaf powder have shown them to contain the following per 100 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	2,003
Mg (mg)	24	24	368
P (mg)	110	70	204
K (mg)	259	259	1,324
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

* From *The Miracle Tree:* Edited by Lowell Fuglie

** The B-carotene found in moringa is a precursor to retinol (Vitamin A). There are around 25 kinds of B-carotene. Efficiency of retinol production varies among types. Research is still required to know more about the B-carotene types in moringa leaves, particularly with what efficiency they are converted to retinol, and how much is lost or inactivated due to various moringa-processing methods.

for purification of water and the water extract is a viable replacement coagulant for chemicals such as aluminium sulphate (alum) in developing countries. As moringa oil can be used for human consumption, *M. oleifera* is frequently cultivated in homesteads, around cattle sheds, and on farm boundaries, fences and village waste lands and as an intercrop. Due to wide variations in temperature in northern part of the country this crop is not very successful. This potential crop of the tropical and subtropical regions still largely remains under cultivation on marginal and small farm holdings as source of vegetable for domestic use and local markets and less preferred for edible use. 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 (pani bhaat). 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. 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.

Other uses :

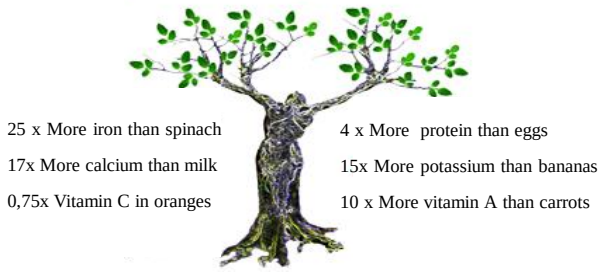
The oil from the seeds of *M. oleifera* is used as edible oil, an excellent salad oil, illuminant, lubricant, as biofuel and in cosmetic industry (Rashid *et al.*, 2008).

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).

***Moringa oleifera* tree**

Benefits of *Moringa oleifera* tree

***Moringa oleifera* seed pods**



***Moringa oleifera* - A supermarket on a tree**

Other multipurpose 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).

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 *M. oleifera* 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).

Conclusion :

In *M. oleifera* unique accessions from the diverse regions are to be identified, collected and screened for variability in fruit and leafy types as done in the india cultivars (reported to flower rarely and principally cultivated for foliage and abundantly fruiting types. Moringa is a good alternative for substituting commercial rations for livestock. The relative ease with which moringa can be propagated through both sexual and asexual means and its low demand of soil nutrients and water after being planted, make its production and management. Its high nutritional quality and better biomass production, especially in dry periods, support its significance as livestock fodder. One of its main virtues is its surprising versatility, because it can be grown as crop or tree fences in alley cropping systems, in agroforestry systems, and even on marginal lands with high temperatures and low water availabilities where it is difficult to cultivate other agricultural crops. For this, cultivation practices and systematic production are needed to gain momentum on commercial scale as an alternate crop in northern region especially in parts of dry/arid regions of India.

Future thrust :

– Assessment, augmentation and conservation of the moringa genepool having desirable traits.
– Identification of plant traits: relatively short stature plant, plants with low gestation period, annual bearing, year round fruit bearing, fruits bearing in clusters, good yield and quality of fruits (pulp taste) and seed yield.
– Studies on breeding biology, genetic improvement and hybridisation especially with the close relatives; identifying ecotypes for industrial value with higher percentage of seed oil, proteins, medicine and wide adaptability to agro-climate.
– Development of value added products for export.
– Molecular studies for identification of provenance source before conservation and exploitation of genetic resources (as done by Muluvi *et al.,* 1999).

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