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Multipurpose Tree: Moringa (*Moringa oleifera* Lam)

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ABSTRACT

Moringaoleifera is a multi-purpose herbal plant used as human food and an alternative for medicinal purposes worldwide. Its different parts are source of proteins, vitamins and minerals and have different pharmacological and biotechnological potential. Various parts of this plant such as the leaves, roots, seed, bark, fruit, flowers and immature pods act asanti-asthmatic, antitumor, anti-inflammatory, diuretic, antiulcer, antihypertensive, cholesterol lowering, antidiabetic, antioxidant, antibacterial, hepatoprotective and antifungal activities. Moreover, *M. oleifera* seeds are widely used in water treatment due to their coagulation, flocculation and sedimentation properties by reducing organic matter and microbial load. Moringa leaves contain 21.8 per cent crude protein, 22.8 per cent acid detergent fiber and 30.8 per cent neutral detergent fiber as well as 412.0 g/kg of crude fat, 211.2 g/kg of carbohydrates and 44.3 g/kg of ash which are useful to increase livestock production. In addition, due to its high nutritional value and several medicinal properties, this tree may act as a nutritional and medical alternative for socially neglected population. In this context, a brief overview about multipurposes of *Moringa oleifera*, emphasizing its chemical constituents, nutritional, pharmacological and antimicrobial properties, applications in the treatment of water effluents, social and environmental aspects have been delineated.

Key Words: Moringa, Medicinal properties, Nutritional value, Antimicrobial properties, Livestock, Water treatment.

INTRODUCTION

Moringa oleifera is the most widely cultivated species of a monogeneric family (Moringaceae) that is native to the sub-Himalayan tracts of India, Pakistan, Bangladesh and Afghanistan .Moringaceae is a single genus family of shrubs and trees, which comprise of 13 species, distributed in the Indian subcontinent (*M. oleifera* and *M. concanensis*), Kenya (*M. longituba* and *M. rivae*), North eastern and Southwestern Africa (*M. stenopetala*), Arabia, and Madagascar (*M. drouhardii*and *M. hildebrandtii*) (Padayachee and Baijnath, 2012; Saini, 2015).

It is commonly referred to as the miracle tree because of the multipurpose uses of its plant parts. According to the Food and Agriculture Organization's (FAO) report, about 70–80 per cent of the world's population, especially in developing countries, relies on herbal medicine to prevent and cure diseases (Ekor, 2014) and about 25 per cent of the synthesized drugs are manufactured from medicinal plants (Pan *et al,* 2013). Moringa (*Moringa oleifera* Lam) is a type of local medicinal Indian herb. Moringa tree has been of many uses to human ranging from consumption to domestic usage, animal forage, plant manure, bio pesticides and as ornamental plants. According to Ayurveda traditional medicine system Moringa can prevent more than 300 diseases (Ganguly, 2013). For centuries and in many cultures around the world, the medicinal usage of the Moringa has been used to treat various health problems (Khawaja *et al*, 2010; Hamza, 2010; Singh and Sharma, 2012). It gave high oil yield, which has good antioxidant capacity

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Table1. The nutrient composition of leaves, leaf powder, seeds and pods.

Nutrient	Fresh leaves	Dry leaves	Leaf powder	Seed	Pods
Calories (cal)	92	329	205	–	26
Protein (g)	6.7	29.4	27.1	35.97 ± 0.19	2.5
Fat (g)	1.7	5.2	2.3	38.67 ± 0.03	0.1
Carbohydrate (g)	12.5	41.2	38.2	8.67 ± 0.12	3.7
Fibre (g)	0.9	12.5	19.2	2.87 ± 0.03	4.8
Vitamin B1 (mg)	0.06	2.02	2.64	0.05	0.05
Vitamin B2 (mg)	0.05	21.3	20.5	0.06	0.07
Vitamin B3 (mg)	0.8	7.6	8.2	0.2	0.2
Vitamin C (mg)	220	15.8	17.3	4.5 ± 0.17	120
Vitamin E (mg)	448	10.8	113	751.67 ± 4.41	–
Calcium (mg)	440	2185	2003	45	30
Magnesium (mg)	42	448	368	635 ± 8.66	24
Phosphorus (mg)	70	252	204	75	110
Potassium (mg)	259	1236	1324	–	259
Copper (mg)	0.07	0.49	0.57	5.20 ± 0.15	3.1
Iron (mg)	0.85	25.6	28.2	–	5.3
Sulphur (mg)	–	–	870	0.05	137

All values are in 100 g per plant material (Fuglie, 2005, Olagbemide and Alikwe, 2014).

with potential for industrial, nutritional and health applications (Ogbunugafor *et al,* 2011).

Its cultivation brings a high amount of nutrients to the soil, in addition to protect it from external factors such as erosion, dehydaration and high temperatures.The leaves and twigs are used as fodder for cattle, sheep, goats and camels in many parts of its range (Mahatab *et al,* 1987; Negi, 1977). 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; Mendieta-Araica *et al,* 2011).

All parts of Moringa tree are edible and consumed by humans. Different parts of Moringatree are coming into limelight as a result of scientific proof that moringa is an important source of naturally occurring phytochemicals that provides basis for future feasible developments (Anwar and Bhanger, 2003). Despite the advantages, Moringa plant contain harmful chemicals, alkaloids and other phytotoxin which have potentially nerve-paralysing properties and other adverse effects when consumed in high doses (Annongu *et al*, 2014, Fahey *et al,* 2001). These compounds include moringine, moringinine, estrogene, pectinesterase, phenols including tannine (Annongu *et al,* 2014).

NUTRITIONAL COMPOSITION AND USES

Moringa was found to contain many essential nutrients, for instance, vitamins, minerals, amino acids, beta carotene, antioxidants, anti-inflammatory nutrients, omega 3 and 6 fatty acids (Fahey, 2005; Hsu *et al*, 2006; Kasolo *et al*, 2010).In addition, moringa was found to have a group of unique compounds containing sugar and rhamnose, which are uncommon sugar-modified glucosinolates (Fahey *et al*, 2001; Fahey, 2005; Amaglo *et al*, 2010).

A good dietary intake of zinc is essential for proper growth of sperm cells and is also necessary for the synthesis of DNA and RNA. *M. oleifera* leaves contain 25.5–31.03 mg of zinc/kg, which is the daily requirement of zinc in the diet (Barminas *et al,* 1998).

THERAPEUTIC USES

The different parts of the *M. oleifera* 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 (Farooq *et al,* 2012, Mbikay, 2012). *Moringa oleifera* contains phytochemicals which chemicals have significant medicinal uses like as antibiotics, anti-inflammatory, anti-asthmatic, anti-fibrotic/ulcer, anti-oxidant, diuretic and antiurolithiatic, for skin treatment, blood pressure regulation, anemia treatment and diabetes. Leaves of Moringa are known to have various biological activities, including antitumor, anticancer, prevention of cardiovascular diseases and antioxidant (Ananias, 2015). It has been used traditionally to treat constipation (Anwar *et al,* 2007). It also has hepato and nephro-protective activity, hypocholesterolemic, hypolipidemic and antiatherosclerotic activity. Moringa trees have been used to combat malnutrition, especially among infants and nursing mothers (National Research Council, 2006; Horseradish, 2013). Moringa leaves have been proposed as an iron-rich food source (31% Daily Value per 100 g consumed) to combat iron deficiency (Olson and Carlquist, 2001).

MORINGA OIL USES

Moringa seed contains appreciable quantity of oil, popularly known as Ben-Oil in dehulled (~42%) and shelled seeds (25-37.5%), depending on the extraction methods (ethanol, methanol or acetone), soil-type and environment conditions. This oil is used in lubricants, perfume industry and cooking purposes. It has an appreciable shelf life hence avoids rusting and oil sticking in machines (Ramachandran *et al,* 1980).

AGRICULTURAL USES

Besides its nutritional and medicinal value and multiple uses, Moringa improves livelihood security and crop diversification (Gadzirayi *et al,* 2013) and is of considerable interest for future adaptation of agriculture to climate change (Padulosi *et al,* 2011). It has several agricultural uses as fertilizer, growth hormones, fodder, insecticide, larvicide, ovicide and antifungal. *Moringa oleifera* has anticoccidial effect on poultry parasitic diseases, antiviral effect on poultry viral disease and antibacterial effect son poultry bacterial diseases.

LIVESTOCK FEED

Besides being used for human consumption the leaves of this tree have been reported to be used as major component in animal feed/fodder. 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; Mendieta-Araica *et al,* 2011). Moringa leaves also contain 21.8% crude protein (CP), 22.8% acid detergent fiber (ADF), and 30.8% neutral detergent fiber (NDF) as well as 412.0 g/kg of crude fat, 211.2 g/kg of carbohydrates and 44.3 g/kg of ash (Oliveira *et al,* 1999; Sanchez *et al,* 2006). All these compounds are useful to increase livestock production.

Macronutrients like P, K, Ca, and Mg play key roles in building tissues and balancing the physiological, metabolic, and biochemical processes of livestock. Mg deficiency in cows makes them suffer from low blood Mg during lactation, which causes low milk yield. During lactation, 0.17%–0.20% Mg in dry matter is required for cows (NRC, 1996). Similarly, K is required for lactating animals. Beef cows require 0.70 per cent K in dry matter during lactation. Moringa leaves contain 20,718 and 106.3 mg/kg of macronutrients Mg and K, respectively. Hence, moringa leaves fulfill the dietary and nutritional requirements of livestock

Table 2. Comparative analysis (%) of fodder quality of stem and leaves of moringa as tree and fodder crop.

Moringa parts (%)	DM	CP	EE	CF	Ash	NDF	ADF
Moringa fodder leaves	7.8	21.87	6.5	4.5	12	8	6
Moringa fodder stem	8.0	8.75	2.0	20.0	12.5	28	21
Moringa fodder leaves and stem	7.6	15.31	3.0	14.5	12	16	12
Moringa tree leaves	8.6	23.51	3.0	7.50	13.5	11	6
Moringa tree stem	8.6	10.93	1.0	26.5	10.5	36	26
Moringa tree leaves and stem	9.2	16.41	2.5	17.5	11	21	15

DM = dry matter; CP = crude protein; EE = ether extract; CF = crude fiber; NDF = neutral detergent fiber; ADF = acid detergent fiber

animals. Moreover, the mixing of moringa leaves with other fodders or grasses can also contribute towards better livestock performance and high yield of good quality products.

Aregheore (2002) found that goats fed with fresh *M. oleifera* leaves at 20 and 50 per cent as replacement for batiki grass (*Curvularia ischaemi*) had higher live-weight gain and higher digestibility of dry matter, crude protein, neutral detergent fiber, and organic matter than the control group. Moreover, *M. oleifera* can replace sesame meal as a protein source in diets for lactating goats. The inclusion of moringa leaf meal increases feed intake, enhances nutrient digestibility and ruminal fermentation and increases milk yield. Milk fatty acid profile is positively modified in goats fed moringa leaf, as the relative percentage of unsaturated fatty acids and CLA are increased whereas saturated fatty acids are decreased. An inclusion rate of 15% MLM (replacing 75% of sesame meal) in the diet was the most suitable level for lactating goats under the experiment conditions (Kholif *et al,* 2015).

As a nutrient source supplement to forage, *M. oleifera* leaf meal improves not only growth performance but also milk output and the quality of cows and goats (90–92). According to Sarwatt *et al* (2004) Moringa improved the milk yield due to a positive effect on the rumen environment, leading to increased rumen microbial output, and that the protein in Moringa also has good rumen bypass characteristics. Kholif *et al* (2019) showed that dietary *M. oleifera* leaf extract (up to 20 ml dose in basal diet) can enhance milk yield by ~6% and energy-corrected milk yield by 12%. They also found that total saturated fatty acids in milk decreased by ~4.6–5.6%, whereas total unsaturated fatty acids increased by a ~11.5–13.9%.

APPLICATION OF SEED IN WATER TREATMENT

As adsorbent

Several studies have shown that *Moringaoleifera* seeds have excellent adsorbent property which have been utilized for the removal of concomitants such as metals, organic matter and even pesticides. The seed can be modified into various forms either grinded as a dry powder, defatted seed cake (after oil extraction) or the seed husk converted to activated carbon. These various forms have been evaluated for their adsorption property in removing metals and other organic chemicals. Metals removed from water by using *Moringaoleifera* seed include arsenic, cadmium, zinc, nickel (Sharma *et al,* 2007; Sharma, 2008; Kumari *et al,* 2006; Bhatti *et al,* 2007 and Acheampong *et al*, 2012).

As coagulant agent

Moringa seeds are one of the best natural coagulants discovered so far. Crushed seeds are a viable replacement of synthetic coagulants

(Crapper *et al,* 1973). *Moringaoleifera* 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 *et al,* 2010; Beltrán-Heredia *et al,* 2009; Katayon *et al,* 2006; Noor *et al,* 2013; Muyibi and Evison, 1996; Ali *et al,* 2010; Tat *et al,* 2010).

IMPLICATIONS OF MORINGA TREE TO CLIMATE CHANGE MITIGATION

The ability of the tree to mitigate the effects of climate change is also impressive. *Moringa oleifera* is called a Never Die plant because of its adaptability to weather, soil and other environmental vagaries according to Fuglie, 2000. The heavy flushes produced by the trees even during the dry season act as good sink for carbon dioxide absorption and utilization, thus reducing the level of atmospheric carbon dioxide which is one of the major courses of ozone layer depletion and global warming. Moringa tree is a climate change-adaptable crop for life sustenance against food insecurity threats (Ndubuaku *et al,* 2014).

ECONOMICAL USES

The potentials of Moringa tree in the production of biogas is being explored. Foidl *et al* (2001) estimated that more than 4,400 cubic meters of methane could be produced per hectare of moringa per year. This is up to twice as much as can be produced per hectare per year from sugar beet leaves, a common plant material for biogas. The sole crop of maize and sweet potato were compared with the maize plus Moringa and sweet potato plus Moringa, the results indicated a decrease in soil acidity from 1.86 to 1.60. Moringa plus maize and Moringa plus sweet potato combination produced the highest crop growth than the sole crop (Abusuwar and Abohassan, 2017). *Moringaoleifera* leaves can be utilized as plant growth promoter. There are five different groups of growth regulators including auxins, gibberellins, abscisic acid, ethylene and cytokinins which enhance food production (Agbogidi *et al,* 2013).

CONCLUSION

The *Moringaoleifera* plant is the most inexpensive and credible alternative to not only providing good nutrition, but also the cure and prevention of a lot of diseases. Based on the scientific reports, *M. oleifera* is an inexpensive, eco-friendly and socially beneficial alternative, especially for the socially neglected population, suffering from poverty and malnutrition and for those who have limited access to technological resources.Moringa has a direct effect on agriculture, nutrition, health, water, environment, biodiversity and sanitation.Due to its multiple uses and wide range of adaptability, Moringa is an ideal crop for sustainable food production. Generally, *Moringa oleifera* offers very interesting opportunities for small holder farmers as food supplement, medicine, nutrition, water treatment, livestockfeed, vegetable, oil, foliar spray, green manure, natural fertilizer, cosmetic, fodder, soil and water conservation and reduce greenhouse gas emission. Other pharmacologically reported effects include antimicrobial, anti-inflammatory, antioxidant, antiulcer, antiurolithiatic activity etc. So, for future prospective, Moringa can be included in routine diet to get its maximum benefits and to avoid several diseases as well as malnutrition. 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.

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