academicJournals

Vol. 9(9), pp. 456-461, September, 2015
DOI: 10.5897/AJFS2015.1346
Article Number: 85D538355442
ISSN 1996-0794

http://www.academicjournals.org/AJFS

African Journal of Food Science

Review

Moringa oleifera: An underutilized tree in Nigeria with amazing versatility: A review

S. G. Zaku[1*], S. Emmanuel[2], A. A. Tukur[1] and A. Kabir[1]

[1]Department of Energy Planning Analysis, Energy Commission of Nigeria.
[2]Chemistry Advance laboratory, Sheda Science and Technology Complex, Abuja, Nigeria.

Received 1 July, 2015; Accepted 2 September, 2015

This article aimed to review the potential of *Moringa oleifera* tree, emphasizing its nutritional applications for humans, industrial uses and its propagation methods, as not everyone knows the enormous benefits it has. It is an exceptionally nutritious vegetable tree with a variety of potential uses. The tree is considered one of the world's most useful trees, as almost every part of the tree can be used for food, or has some other beneficial property.

Key words: *Moringa oleifera*, benefits, water purification, nutritional composition growing.

INTRODUCTION

M. oleifera plant is used in difference ways as; domestic cleaning agent (crushed leaves), blue dye (wood), fencing (living trees), fertilizer (seed-cake) (Emmannuel et al., 2011a and b), foliar nutrient (juice expressed from the leaves), green manure (from leaves), gum (from tree trunks), honey- and sugar cane juice-clarifier (powdered seeds), honey (flower nectar), medicine (all plant parts), ornamental plantings, bio-pesticide (soil incorporation of leaves to prevent seedling damping off), pulp (wood), rope (bark), tannin for tanning hides (bark and gum), water purification (powdered seeds). M. oleifera seed oil (yield 30-40% by weight), also known as Ben oil, is a sweet non-sticking, non-drying oil that resists rancidity. It has been used in salads, for fine machine lubrication, and in the manufacture of perfume and hair care products (Tsaknis et al., 1999).

In the West, one of the best known uses for M. oleifera is the use of powdered seeds to flocculate contaminants and purify drinking water (Berger et al., 1984), but the seeds are also eaten green, roasted, powdered and steeped for tea or used in curries (Gassenschmidt et al., 1995). This tree has in recent times been advocated as an outstanding indigenous source of highly digestible protein, Ca, Fe, Vitamin C, and carotenoids suitable for utilization in many of the so called "developing" regions of the world where under nourishment is a major concern (Tsaknis et al., 1999). Moringa plant is an exceptionally nutritious tree with a variety of potential uses (Fahey, 2005).

BRIEF HISTORY OF *M. OLEIFERA* AS MEDICINAL PLANT

The history of Moringa dates back to 150 B.C. Historical proofs reveal that ancient kings and queens used Moringa leaves and fruit in their diet to maintain mental alertness and healthy skin. Ancient Maurian warriors of

*Corresponding author. E-mail: zakusamaila@yahoo.com.

India were fed with Moringa Leaf Extract in the warfront (Jahn, 1996). The Moringa drink was believed to add them extra energy and relieve them of the stress and pain incurred during war. These brave soldiers were the ones who defeated “Alexander” the Great. Inspired by the news of this Moringa drink, three young professionals started analyzing the nutritional benefits of Moringa tree. As their research deepened they were amazed by the huge amount of nutritional contents these small leaves and fruits bears (Makkar et al., 1997). Traditionally, besides being a daily used vegetable among people of these regions, the Moringa is also widely known and used for its health benefits. Among commoners, it has earned its name as ‘the miracle tree’ due to its amazing healing abilities for various ailments and even some chronic diseases. Several investigations were carried out to isolate bioactive compounds from various parts of the plant due to its various applications (Guevara et al., 1999). Therefore, herbal plants in medicine or known as phytomedicine are still trustworthy and widely applied as one of the alternative way in medicinal field due to its affordable cost (Abalaka et al., 2009).

SOCIO-ECONOMIC IMPORTANCE

Moringa is one of the most useful tropical trees. The relative ease with which it propagates through both sexual and asexual means and its low demand for soil nutrients and water after being planted makes its production and management easy. Introduction of this plant into a farm which has a biodiverse environment can be beneficial for both the owner of the farm and the surrounding eco-system (Fuglie, 1999).

USES OF *M. OLEIFERA*

Human consumption of *M. oleifera*

M. oleifera leaves are highly nutritious. The young leaves are edible and are commonly cooked and eaten like spinach or used to make soups and salads. The leaves can be consumed either in raw, cooked or dried over a screen for several days and ground into a fine powder that can be added to almost any food as a nutrient supplement (Makkar and Becker, 1996), such as pap, cereals and drinks to improve their nutritive value (Gardener and Ellen, 2002). The leaves which were boiled resulted in three times more bio-available iron than the raw leaves. These results were also seen in the powdered Moringa leaves. The protein quality of *Moringa* leaves compares very well with that of milk and eggs (Gardener and Ellen, 2002). On other hand, In 100 g dry matter, they contain 29±6 g of protein 28±6 mg of iron, 1,924±288 mg of calcium, 15,620±6,475 IU of vitamin A and 773±91 mg of vitamin C. This is at least twice the protein in milk and half the protein in egg, and has more iron than in beef, more calcium than in milk, equal vitamin A to carrot and more vitamin C than in orange (Wangcharoen and Gomolmanee, 2013). *Moringa* is the sole genus of the flowering plant *Moringaceas* with 13 species out of which are; *Moringa oleifera, Moringa stenopetala, Moringa peregrine and Moringa doughardii. Moringa* leaves contain seven times the vitamin C of oranges, four times the vitamin A of carrots, four times the calcium of milk, three times the potassium of bananas and two times the protein in yoghurt (Gopalan et al., 1989). Johnson (2005) observed that the leaf, seed and fruits of *M. oleifera* are naturally rich sources of vitamins and minerals. In an analysis of 100 g of the edible portion of fresh *M. oleifera* leaves parts have shown to contain much of the following water soluble vitamins; 2.6 mg of vitamin B_1 (thiamine), 20.5 mg of vitamin B_2 (riboflavin), 8.2 mg of vitamin B_3 (nicotinic acid) and 220 mg of vitamin C. In addition, this same portion of edible product contains the following fat-soluble vitamins: 16.3 mg of vitamin A, 113 mg of vitamin E (alpha-tocopherol acetate) as much as 423 mg of the lipotropic element, chorine, 19.2 g of fibre and several key minerals: 2003 mg of calcium, 368 mg of magnesium 204 mg phosphorus, 1324 mg of potassium, 3.1 mg of copper, 28.2 mg of Iron and 870 mg of selenium (Johnson, 2005). In addition to these vitamins and minerals, one of the most significant benefits of *M. oleifera* is the ability of this plant to provide as much as 27.1 g of protein (nearly one-third of the edible portion); containing all of the essential amino acids. These leaves could be a great boom to people who do not get protein from animal source such as milk and egg. It also contains arginine and histidine, the two amino acids especially important for infants (Gopalan et al., 1989). Dried *M. oleifera* leaf powder in capsules has become a popular food supplement for many in Thailand (Wangcharoen and Gomolmanee, 2011).

They are an exceptionally good source of provitamin A, vitamins B, and C, minerals (in particular iron), and the sulphur-containing amino acids methionine and cystine (Chawla et al., 1988). 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 (Dogra et al., 1975). The seeds must first be boiled for a few minutes to remove the fine transparent hull and the water drained before they are eaten. Seeds should be eaten green before they change color to yellow. The hull is not desirable as food because it tastes bitter.

Moringa oleifera nutritional values

The Moringa’s incredible medicinal usage which is claimed by many cultures and communities is based on science (Table 1). Through research, the Moringa was

Table 1. Analysis of dried leaf powder contains the following per 100 g of edible portion.

Nutritional value per 100 g	Values
Moisture (%)	7.5
Calories (Kcal)	205
Protein (g)	27.1
Fat (g)	2.3
Carbohydrate (g)	38.2
Fiber (g)	19.2
Trace minerals	
Calcium (mg)	2,003
Magnesium (mg)	368
Phosphorus (mg)	204
Potassium (mg)	1,324
Iron (mg)	28.2
Sodium (mg)	870
Vitamins	
Vitamin A-Beta Carotene (mg)	16.3
Vitamin B_1 – thiamin (mg)	2.64
Vitamin B_2 – riboflavin (mg)	20.5
Vitamin B_3 - nicotinic acid (mg)	8.2
Vitamin C ascorbic acid (mg)	17.3
Vitamin E tocopherol acetate mg)	113
Amino acids	
Arginine (g/16 g N)	1.33%
Histidine (g/16 gN)	0.61%
Lysine (g/16 gN)	1.32%
Tryptophan (g/16 gN)	0.43%
Phenylanaline (g/16 gN)	1.39%
Methionine (g/16 gN)	0.35%
Threonine (g/16 gN)	1.19%
Leucine (g/16 gN)	1.95%
Isoleucine (g/16 gN)	0.83%
Valine (g/16 gN)	1.06%
Other constituents	
Oxalic acid (mg)	1.6%

Source: Jahn (1996).

found to contain many essential nutrients, for instance, vitamins, (Fahey, 2005; Hsu et al*.,* 2006; Kasolo et al*.,* 2010). Nutrition content of a plant plays an essential function in medicinal, nutritional, and therapeutic properties (Al Kharusi et al*.,* 2009). It is believed that Moringa leave to consist high sources of vitamin C, calcium and potassium as well as protein. It works as an effective source of natural antioxidants. Due to the presence of several sorts of antioxidant compounds such as flavonoids, ascorbic acid, carotenoids, and phenolics, Moringa is able to extend the period of food containing fats (Dillard and German, 2000; Siddhuraju and Becker, 2003). It was also found that each different part of the Moringa tree which was studied, be it the fruits, seeds, leaves, flowers, bark and roots, all resulted in the discovery of at least one, or in most studies, a number of beneficial nutrients. It was similarly mentioned in an article by the Trees. For Life organization that 'every part of the Moringa tree is said to have beneficial properties that can serve humanity'. In addition, the 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). These compounds were reported to demonstrate certain chemopreventive activity, by inducing apoptosis (Brunelli et al*.,* 2010).

Industrial uses of *M. oleifera* oil

The oil content of de-hulled seed (kernel) is approximately 42%. The oil is brilliant yellow. It is used as a lubricant for fine machinery such as timepieces because it has little tendency to deteriorate and become rancid and sticky (Ramachandran et al., 1980). It is also useful as vegetable cooking and frying oil. The oil is known for its capacity to absorb and retain volatile substances and is therefore valuable in the perfume industry for stabilizing scents. The free fatty acid content varies from 0.5 to 3%. The seed oil of Moringa contains approximately 13% saturated fatty acids and 82% unsaturated fatty acids (Ferrao and Mendez, 1970). It has a particularly high level of oleic acid (70%). Other vegetable oils normally contain only about 40% oleic acid.

Water purification

Moringa seeds contain between 30-42% oil and the press cake obtained as a by-product of the oil extraction process contains a very high level of protein (Olsen, 1987). Some of these proteins (approximately 1%) are active cationic polyelectrolytes having molecular weights between 7-17 K Dalton (Olsen, 1987). The cationic polyelectrolytes neutralize the colloids in muddy or dirty water since the majority of these colloids have a negative electrical charge. This protein can therefore be used as a non-toxic natural polypeptide for sedimenting mineral particles and organics in the purification of drinking water, for cleaning vegetable oil, or for sedimenting fibers in the juice and beer industries. It thus works as a primary coagulant as natural bridges are continuously formed between the colloid particles. In contrast, industrial coagulants such as alumina can be toxic. Their proper use requires qualified personnel and the majority of underdeveloped countries don't have the means of producing them. In addition, these industrial coagulants are expensive and represent a considerable drain on the hard currency reserves of developing countries. It has

been employed with particular effectiveness in both Egypt and Sudan for cleaning water from the Nile specifically for human consumption (Berger et al., 1984). The wings are removed from the dry seeds and then the seeds are ground to powder. The powder is mixed with water, agitated for approximately five minutes and after about an hour, then filtered through a piece of woven fabric to obtain pure water. Alternatively, a cloth containing the seed powder is suspended in water, generally overnight, to coagulate impurities (Berger et al., 1984). The cloth containing the seeds is then removed, and the purified water is decanted leaving behind the coagulated particles on the bottom. Up to 99% of colloids can be removed. Only one seed is required per litre for slightly contaminated water and two seeds for very dirty water.

Moringa oleifera as plant growth enhancers

The extract obtained from the leaves of Moringa in 80% ethanol contains growth enhancing principles (hormones of the cytokinine type). The extract can be used in the form of a foliar spray to accelerate the growth of young plants. Use of the growth hormone spray will also cause the plants to be firmer and more resistant to pests and disease. Plants that are treated with this growth hormone spray will also produce more and larger fruit and will consequently have a higher yield at harvest time. The extract can be obtained either through press extraction or by using an ultra-turrax (Al-Kharusi et al., 2009) and filtering 20g of tender leaves in a total volume of 675 ml of 80% aqueous ethanol (Makkar and Becker, 1996). Spraying the leaves of plants with the Moringa extract prepared in 80% ethanol and then diluted with water produced some notable effects such as a longer, more vigorous life-span, heavier roots stems and leaves, bigger fruits and higher sugar levels etc. The extract produces an overall increase in yield of between 20-35% based on data such as the stem diameter, number of nodules, number of axels, number of flower buds, and number of fruits per flower bud (Makkar and Becker, 1996).

CULTIVATION OF *M. OLEIFERA*

M. oleifera is one of the vegetables of the Brassica order and belongs to the family Moringaceae. The Moringaceae is a single genus family with 13 known species (Khawaja et al., 2010). *M. oleifera* is a small native tree of the sub-Himalayan regions of North West India, which is now indigenous to many regions in Islands and South America but is now found worldwide in the tropics and sub-tropics. It grows best in direct sunlight under 500 m altitude. It tolerates a wide range of soil conditions, but prefers a neutral to slightly acidic (pH. 6.3-7.0), well-drained sandy or loamy soil. Minimum annual rainfall requirements are estimated at 250 mm with maximum at over 3,000 mm, but in waterlogged soil the roots have a tendency to rot. Trees can be easily grown from seed or from cuttings. Moringa seeds have no dormancy period, so they can be planted as soon as they are mature and they will retain the ability to germinate for up to one year (Fuglie, 1999). Moringa trees will flower and fruit annually and in some regions twice annually. During its first year, a Moringa tree will grow up to five m in height and produce flowers and fruit. Left alone, the tree can eventually reach 12 m in height with a trunk 30cm wide; however, the tree can be annually cut back to one meter from the ground. The tree will quickly recover and produce leaves and pods within easy reach.

In the nursery

Poly bags with dimensions of about 18 cm in height and 12 cm in diameter is used. The soil mixture for the sacks should be light, that is 3 parts soil to 1 part sand. Plant should be 2 or 3 seeds in each sack, 1 to 2 centim deep. Keep moist but not too wet. Germination will occur within 5 to 12 days, depending on the age of the seed and pre-treatment method used. Remove extra seedlings, leaving one in each sack. Seedlings can be out-planted when they are 60 – 90 cm high. When out-planting, cut a hole in the bottom of the sack big enough to allow the roots to emerge. Be sure to retain the soil around the roots of the seedling.
To encourage rapid germination, one of three pre-seeding treatments can be employed;

1) Soak the seeds in water overnight before planting.
2) Crack the shells before planting.
3) Remove shells and plant kernels only.

Direct seeding

If water is available for irrigation (in a backyard garden), trees can be seeded directly and grown anytime during the year. Prepare planting pit first, water, and then fill in the pit with topsoil mixed with compost or manure before planting seeds. In a large field, trees can be seeded directly at the beginning of the wet season (Odee, 1998).

Growing from cuttings

Use hard wood, not green wood, for cuttings. Cuttings should be 0.45 to 1.5 m long and 10 cm thick. Cuttings can be planted directly or planted in sacks in the nursery. When planting directly, plant the cuttings in light, sandy soil. Plant one-third of the length in the ground (that is, if the cutting is 1.5 m long, plant it 50 cm deep). Do not over water; if the soil is too heavy or wet, the roots may rot. When the cuttings are planted in the nursery, the root system is slow to develop. Add phosphorus to the soil if possible to encourage root development. Cuttings planted in a nursery can be out-planted after two or three months (Odee, 1998).

Spacing

For intensive Moringa production, plant the tree every 3 m in rows 3 m apart. To ensure sufficient sunlight and airflow, it is also recommended to plant the trees in an east-west direction. When the trees are part of an alley-cropping system, there should be 10 m between the rows. The area between trees should be kept free of weeds. Moringa trees can be planted in gardens; the tree's root system does not compete with other crops for surface nutrients and the light shade provided by the tree will be beneficial to those vegetables which are less tolerant to direct sunlight. From the second year onwards, Moringa can be inter-cropped with maize, sunflower and other field crops. Sunflower is particularly recommended for helping to control weed growth (Fuglie, 1999). However, Moringa trees are reported to be highly competitive with eggplant (*Solanum melongena*) and sweet corn (*Zea mays*) and can reduce their yields by up to 50% (Olsen, 1987)

Pinching the terminal tips

When the seedlings reach a height of 60 cm in the main field, pinch (trim) the terminal growing tip 10cm from the top (Odee ,1998). This can be done using fingers since the terminal growth is tender, devoid of bark fiber and brittle, and therefore easily broken. A shears or knife blade can also be used. Secondary branches will begin appearing on the main stem below the cut about a week later. When they reach a length of 20 cm, cut these back to 10 cm. Use a sharp blade and make a slanting cut. Tertiary branches will appear, and these are also to be pinched in the same manner. This pinching, done four times before the flowers appear (when the tree is about three months old), will encourage the tree to become bushy and produce many pods within easy reach. Pinching helps the tree develop a strong production frame for maximizing the yield (Olsen, 1987). If the pinching is not done, the tree has a tendency to shoot up vertically and grow tall, like a mast, with sparse flowers and few fruits found only at the very top**.**

Watering

Moringa trees do not need much watering. In very dry conditions, water regularly for the first two months and afterwards only when the tree is obviously suffering. Moringa trees will flower and produce pods whenever there is sufficient water available. If rainfall is continuous throughout the year, Moringa trees will have a nearly continuous yield. In arid conditions, flowering can be induced through irrigation (Odee, 1998).

Fertilizing

Moringa trees will generally grow well without adding very much fertilizer. Manure or compost can be mixed with the soil used to fill the planting pits. Phosphorus can be added to encourage root development and nitrogen will encourage leaf canopy growth. In some parts of India, 15cm-deep ring trenches are dug about 10 cm from the trees during the rainy season and filled with green leaves, manure and ash (Olsen, 1987). These trenches are then covered with soil. This approach is said to promote higher pod yields. Research done in India has also showed that applications of 7.5 kg farmyard manure and 0.37 kg ammonium sulfate per tree can increase pod yields threefold (Morton,1991)

Pest and diseases

Moringa is resistant to most pests. In India, various caterpillars are reported to cause defoliation unless controlled by spraying. The budworm *Noordia moringae* and the scale insects *Diaspidotus* sp. and *Ceroplastodes cajani* are reportedly able to cause serious damage. (Fuglie,1999). Also mentioned as pests in India are *Aphis craccibora*, the borer *Diaxenopsis apomecynoides* and the fruit fly *Gitonia* sp (Olsen, 1987). Elsewhere in the world, where Moringa is an introduced tree, local pests are less numerous.

Harvesting

When harvesting pods for human consumption, harvest when the pods are still young and snap easily. Older pods develop a tough exterior, but the white seeds and flesh remain edible until the ripening process begins. When producing seed for planting or for oil extraction, allow the pods to dry and turn brown on the tree. In some cases, it may be necessary to prop up a branch that holds many pods to prevent it breaking off. Harvest the pods before they split open and seeds fall to the ground. Seeds can be stored in well-ventilated sacks in dry and shady places (Tsaknis et al., 1999).

CONCLUSIONS/RECOMMENDATION

We call on the Nigeria Government to explore more of the full potential of this wonderful plant, a very promising crop when use as a raw material for biofuel production and alternative for water purification. They farmers should be encouraged to switch into commercial scale of planting *M. oleifera* in anticipation of the bigger market. For seeds alone, farmers can earn annual gross revenue of about sixty thousand dollars per hectare. Moringa dry leaf powder is a valuable nutrient for the poor communities, its boost the immune system to fight infections and thereby enhancing the well-being of malnourish and HIV persons.

Conflict of interests

The authors did not declare any conflict of interest.

REFERENCES

Abalaka ME, Olonitola OS, Onaolapo JA (2009). *Momordica charantia* using Wistar rats to determine safety level and usefulness of the plant ethnochemotheraphy. Int. J. Appl. Sci. 3:1-6.

Al-Kharusi LM, Elmardi MO, Ali A (2009). Effect of mineral and organic fertilizers on the chemical characteristics and quality of date fruits. Int. J. Agric. Biol. 11: 290-296.

Amaglo NK, Bennet RN, Curto RBL (2010). Profiling selected phytochemicals and nutrients in different tissues of the multipurpose tree *Moringa oleifera* L., grown in Ghana. J. Food Chem. 122:1047-1054.

Berger MR, Habs M, Jahn SA, Schmahl S (1984). Toxicological assessment of seeds from *Moringa oleifera* and *Moringa stenopetala*, two highly efficient primary coagulants for domestic water treatment of tropical raw waters. East Afr. Med. J. 61:712-716.

Brunelli D, Tavecchio M, Falcioni C (2010). The isothiocyanate produced from glucomoringin inhibits NF-kB and reduces myeloma growth in nude mice *in vivo.* Biochem. Pharmacol. 79:1141-1148.

Chawla S, Saxena A, Seshadri S (1988). *In-vitro* availability of iron in various green leafy vegetables. J. Sci. Food Agric. 46:125-127.

Dillard CJ, German JB (2000). Review Phytochemicals: nutraceuticals and human health. J. Sci. Food Agric. 80:1744-1746.

Dogra PD, Singh BP, Tandon S (1975). Vitamin content in Moringa pod vegetable. Curr. Sci. 44:31.

Emmanuel SA, Zaku SG, Adedirin SO, Muazu T, Thomas SA (2011). Moringa oleifera seed-cake, alternative biodegradable and biocompatibility organic fertilizer for modern farming. Agric. Biol. J. N. Am. 2(9):1289-1292.

Emmanuel SA, Zaku SG, Emmanuel BS, Thomas SA (2011). Biodiversity and agricultural productivity enhancement in Nigeria: application of processed Moringa oleifera seeds for improved organic farming. Agric. Biol. J. N. Am. 2(5):867- 871.

Fahey JW (2005). *Moringa oleifera*: a review of the medical evidence for its nutritional, therapeutic and prophylactic properties part 1. Trees Life J. 1:5-20.

Fahey JW, Zalcmann AT, Talalay P (2001). The chemical diversity and distribution of glucosinolates and isothiocyanates among plants. Phytochemistry 56:5-51.

Ferrao AMBC, Mendez FJE (1970). Acidos gordos em oleo de Moringueiro (*Moringa oleifera* Lam.). Agronomia Angolana 8:3-16.

Fuglie LJ (1999). The Miracle Tree: *Moringa oleifera*: Natural Nutrition for the Tropics. Church World Service, Dakar. 68 pp.; revised in 2001 and published as The Miracle Tree: The Multiple Attributes of Moringa, 172 pp.

Gardener H, Ellen E (2002). *Moringa* tree has many uses, from food to firewood. Yuma sun. Portal market, *Moringa* Tree Powder.

Gassenschmidt U, Jany KD, Tauscher B, Niebergall H (1995). Isolation and characterization of a flocculating protein from *Moringa oleifera* Lam. Biochim. Biophys. Acta 1243:477-481.

Gopalan C, Rama S, Balasubramanian SC (1989). Nutritive value of Indian foods. Natural Institute of Nutrition, Indian Council of medical Research. New Delhi.

Guevara AP, Vargas C, Sakurai H (1999). An antitumour promoter from *Moringa oleifera* Lam. Mutat. Res. 440:181-188.

Hsu R, Midcap S, Arbainsyah DWL (2006). *Moringa oleifera*: Medicinal and Socio-Economical Uses. International Course on Economic Botany, National Herbarium Leiden, the Netherlands.

Jahn SAA (1996). On the introduction of a tropical multipurpose tree to China traditional and potential utilisation of *Moringa oleifera* Lamark. Senckenb. Biol. 75(1-2):243-254.

Johnson B (2005). Clinical perspectives on the health effects of *Moringa oleifera*: A promising adjunct for balanced nutrition and better health. *KOS* health publications, August, 2005.

Kasolo JN, Bimenya GS, Ojok L (2010). Phytochemicals and uses of *Moringa oleifera* leaves in Ugandan rural communities. J. Med. Plants Res. 4:753-757.

Khawaja TM, Tahira M, Ikram UK (2010). *Moringa oleifera*: a natural gift - A review. J. Pharm. Sci. Res. 2:775-781.

Makkar HPS, Becker K (1996). Nutritional value and anti-nutritional components of whole and ethanol extracted *Moringa oleifera* leaves. Anim. Feed Sci. Technol. 63(1-4):211-228.

Makkar HPS, Becker K. (1997). Nutrients and anti-quality factors in different morphological parts of the *Moringa oleifera* tree. J. Agric. Sci. Cambridge 128: 311-322.

Morton JF (1991). The Horseradish Tree, *Moringa Pterygosperma* (Moringaceae) - A Boon to Arid Lands? Econ. Bot. 45(3):318-333.

Odee D (1998). Forest biotechnology research in drylands of Kenya: the development of Moringa species. Dryland Biodivers. 2:7-8.

Olsen A (1987) Low technology water purification by bentonite clay and *Moringa oleifera* seed flocculation as performed in Sudanese villages. Effects on *Schistosoma mansoni* cercariae. Water Res. 21(5):517-522.

Ramachandran C, Peter KV, Gopalakrishnan PK (1980). Drumstick (*Moringa oleifera*): A Multipurpose Indian Vegetable. Econ. Bot. 34(3):276-283.

Siddhuraju P, Becker K (2003). Antioxidant properties of various solvent extracts of total phenolic constituents from three different agroclimatic origins of drumstick tree (*Moringa oleifera* Lam.) leaves. J. Agric. Food Chem. 51:2144-2150.

Tsaknis J, Lalas S, Gergis V, Douroglou V, Spiliotis V (1999). Characterization of *Moringa oleifera* variety Mbololo seed oil of Kenya. J. Agric. Food Chem. 47:4495-4499.

Wangcharoen W, Gomolmanee S (2011). Antioxidant capacity and total phenolic content of *Moringa oleifera* grown in Chiang Mai, Thailand. Thai J. Agric. Sci. 44:118-124.

Wangcharoen W, Gomolmanee S (2013). Antioxidant activity changes during hot-air drying of *Moringa oleifera* leaves. Maejo Int. J. Sci. Technol. *7*(3):353-363.