

Review Article

Moringa oleifera “The Mother’s Best Friend”

Egbuna Chukwuebuka

Department of Biochemistry, Faculty of Science, Chukwuemeka Odumegwu Ojukwu University, Uli, Nigeria

Email address:

egbunachukwuebuka@gmail.com

To cite this article:

Egbuna Chukwuebuka. *Moringa oleifera* “The Mother’s Best Friend”. *International Journal of Nutrition and Food Sciences*. Vol. 4, No. 6, 2015, pp. 624-630. doi: 10.11648/j.ijjnfs.20150406.14

Abstract: This paper is a review of *Moringa oleifera*. It called “The Mother’s Best Friend” for its ability to increase milk production in nursing mother, is a highly nutritious and medicinal plant. *Moringa* leaves contains 7 x the Vitamin C of Oranges, 4 x the Calcium of Milk, 4 x the Vitamin A of Carrots, 3 x the Potassium of Bananas, and 2 x the Protein of Yogurt. Due to its highly nutritional value, this review is aimed at creating awareness of its nutritional, medicinal and general usage by consulting current literatures. However, research had shown that virtually all part of the plant contains different types of chemical with great biological functions. Some act as anti-oxidants in free radical scavenging, relieving the body of oxidative stress and cancer. Others possess anti-bacterial, anti-viral, anti-fungal, anti-inflammatory, anti-spasmodic and diuretic properties. The list is inexhaustible. Many thanks to the numerous chemical composition of *Moringa*. The leaves contain quality protein that can compete with the likes of soybeans due to the fact that it contains all the essential amino acids in the right proportion. Carbohydrates, Vitamins, Minerals, Fatty acids (essential and non-essential), phytochemicals are in abundance. Many uses of *Moringa* had been reported. They serve as food for man and forage for animals, improving soil fertility, biogas production, cleaning agent, gum production, production of animal forage, pulp, and water purification among other uses. *Moringa* is a deciduous, perennial tree of height 10–12 m. It has the ability to survive different climatical conditions ranging from the rain forest zone to areas with little rainfall. They are propagated by seed and stem cuttings. It is a fast growing and evergreen plant.

Keywords: *Moringa oleifera*, Mother’s Best Friend, Anti-microbial, Phytochemical, Nutritional and Medicinal Uses

1. Introduction

Moringa oleifera is one of the World’s most useful trees, as almost every part of the tree can be used for food, medication and industrial purposes [1]. *Moringa* leaves had been reported to contain 7 x the Vitamin C of Oranges, 4 x the Calcium of Milk, 4 x the Vitamin A of Carrots, 3 x the Potassium of Bananas, and 2 x the Protein of Yogurt (Table 1) [2,3,4]. The leaves are highly nutritious and as such are highly recommended for infants and nursing mothers especially those from developing countries or area prone to cases of malnutrition. This is because both classes are at most risk of nutritional deficiencies. Infants are in the critical stage of their development while pregnant women and breast-feeding mothers are in need of constant supply of nutrient. *Moringa*, referred to as the “Mother’s Best Friend” because of its utilization to increase woman’s milk production [5,6,7], is in indeed a “Natural Gift of Nature”.

M. oleifera belongs to the Genus *Moringa*, which is the

only Genus in the Family Moringaceae. *M. oleifera* however, is one of the 14 species of the Moringaceae Family, native to Africa, Arabia, India, Southeast Asia, South America, the Pacific and Caribbean Islands [8].

Table 1. Nutritional comparison of *Moringa* fresh and dry leaves with common foods per 100 grams [2].

Nutrient	Common foods	Fresh Leaves	Dried Leaves
Vitamin A	1.8 mg Carrots	6.8 mg	18.9 mg
Calcium	120 mg Milk	440 mg	2003 mg
Potassium	88 mg Bananas	259 mg	1324 mg
Protein	3.1 g Yogurt	6.7 g	27.1 g
Vitamin C	30 mg Oranges	220 mg	17.3 mg

Because of its environmentally friendly nature of wide climatical adaptability in many tropic and sub-tropic regions of the world, the plant had gained lots of names such as Horseradish tree, Drumstick tree, Ben oil tree, Miracle tree, and “Mother’s Best Friend” [8]. In Nigeria, It is locally

called “*Okwe Oyibo*” in Igbo language, “*Zogale*” among the Hausa speaking people of Nigeria and “*Ewe Ile*” in Yoruba. Other names are “*Nuggekai*” in Canada, “*Sonjna*” in Marathi, “*Murungai*” in Tamil, “*Mashinga Sanga*” in Malayalan and “*Muringa*” in Konkani [9].

Moringa thrives well in a variety of soil conditions preferring well-drained sandy or loamy soil that is slightly alkaline. It can grow well in the humid tropics or hot dry lands and can survive in less fertile soils and drought condition [7]. It is found in all the geographical zones in Nigeria, from rain forest zone, savannah to the semi-desert zones. Although susceptible to wind damage, it is a good source of forage for livestock [10, 11]. This tree has the potential to improve nutrition, boost food security and foster rural development [12].

In many developing countries like Nigeria, it is evident that a large percentage of the population relies on herbal medicine which are prepared solely or in combination in the form of concoction and administered for the treatment, and prevention of various diseases. Although modern medicines may exist side-by-side with such traditional practices, herbal medicines have often maintained their popularity for historical and cultural reasons [13]. *Moringa* although underutilized in many rural dwellings due to lack of knowledge of its use, is one of such plants that has proved useful for such traditional practices. The present review intends to create awareness regarding the benefits of *Moringa*, the “Mothers Best Friend” or the “Miracle Tree”.

2. Description of *Moringa*

Moringa (Fig. 1) is a fast growing, evergreen, deciduous tree of height 10–12 m [14]. The leaves (Fig. 2) are bipinnate or more commonly tripinnate, up to 45 cm long, and are alternate and spirally arranged on the twigs [15]. The flowers are fragrant and bisexual, surrounded by five unequal thinly veined yellowish-white petals [14]. Flowering begins within the first six months after planting. In seasonally cool regions, flowering will only occur once a year between April and June. In more constant seasonal temperature and with constant rainfall, flowering can happen twice or even all year-round [14].

The fruits are pendulous (i.e. hanging) (Fig. 1), linear, three-sided pods with nine longitudinal ridges, usually 20 to 50 cm long, but occasionally up to 1 m or longer, and 2.0 to 2.5 cm broad [15]. The pods, each usually containing up to 26 seeds (Fig. 3), are dark green during their development, and take approximately 3 months to mature after flowering [16]. They turn brown on maturity, and split open longitudinally along the three angles, releasing the dark brown, trigonous seeds. An average-sized *Moringa* tree of fifteen to twenty feet in height can produce hundreds or even thousands of seed pods, yielding countless seeds each and every year [9]. The bark exudes a gum when wounded which is initially white in color but changes to reddish brown or brownish black on exposure [15]. Trees grown from seeds develop a deep, stout taproot with a wide-spreading system of thick, tuberous lateral

roots. Taproots do not develop on trees propagated from cuttings [17].



Figure 1. *Moringa* tree [18].



Figure 2. The leaf stalk of *Moringa* [19].



Figure 3. The seeds of *Moringa* [2].

Scientific Classification of *Moringa*

Moringa is one of the 14 species of the Moringaceae family.

It can be classified as follows:

Kingdom	Plantae
Division	Magnoliophyta
Class	Magnoliopsida
Order	Brassicales
Family	Moringaceae
Genus	<i>Moringa</i>
Species	<i>Oleifera</i>

3. Cultivation of *Moringa*

3.1. Requirements

The optimal annual rainfall for *Moringa* range from 700 to 2200 mm, but it's capable of growing in areas with an annual rainfall of between 250 and 3000 mm [20, 21, 22]. As a sun and heat-loving plant which does not tolerate freeze or frost, it grows best where the average maximum daily temperature is within the range of 25 and 35 °C, although it can survive summer temperatures of up to 48 °C for a limited period of time and can tolerate frosts in winter [20]. This tree grows in a wide variety of soils, but it prefers well-drained, sandy or loamy soils. *Moringa* will grow in clay soils but cannot tolerate water logging for any extended period of time [20]. It grows well in alkaline conditions of up to a pH of 9 [20]. However, it prefers neutral to slightly acidic soils [21, 23]. *Moringa* may also tolerate relatively saline soils [24].

3.2. Propagation

Moringa can be propagated from seed or cuttings. Direct seeding is possible because the germination rate is high. Air layering propagation method is possible but difficult [25]. Propagation by cuttings is often preferred to plants raised from seeds, which are reportedly slower to flower and fruit and produce fruit of inferior quality [26]. Some studies suggest that trees grown from seeds produce longer roots than those from cuttings and may be preferable for planting in semiarid and arid regions where water table depth is a potential growth-limiting factor [27]. The tree regenerate vigorously after cutting, producing four to eight shoots per

stump [28]. Cuttings of 1 meter length and a diameter of at least 4 cm can be also used for propagation [29]. At least one third of the cutting must be buried in the soil.

3.3. Harvesting and Preparation of *Moringa* Leaves

Moringa leaves are harvested from tree and washed thoroughly to remove dust and soil. Leaves are dried in shade to avoid destruction of its phytonutrients. The dried leaves are pulverize, sieved and stored in air tight container for future use. *Moringa* powder (Fig. 4) can be added to food to supplement its vitamin, mineral and protein content. A few spoonful of the leaf powder can be added to any meal to make it more nutritious. The powder can be taken by mixing with the Orange juice or any other beverages [30].



Figure 4. The powdered *Moringa* leaves [30].

4. Chemical Composition of *Moringa*

Since the chemical content of plants are affected by the type of soil or climatical condition they grow [31], it would be expected that there will be variation in the chemical composition reported by different researchers. Also the method adopted for analysis and the state of the leaves i.e. whether fresh or dried could contribute to variation in values obtained.

4.1. Proximate Composition

Moringa leaves is highly nutritious. It is rare to find a plant leaf that will compete with *Moringa*. Its dry leaves had been reported to contain Carbohydrates (23.6 %) which serves as a source of energy, Crude fibre (35.0 %) which help in bowel movement, Moisture (10.0 %) which constitute about 80% of the blood, a vital medium for oxygen transport, Ash (10.0 %) which is taken to be a measure of mineral content in food which is required by the body for proper physiological functioning [32]. The Crude protein (30.29 %) of dry leaves [33], gives the measure of the total protein content and protein helps in growth and repair of body tissues among numerous other functions. The Crude fat of

the dry leaves is 6.50 %. Fat serves as an alternate source of energy when there is shortage of glucose for the production of ATP.

4.2. Amino Acids Composition

Amino acids are essential component of all living organisms. They are the monomeric units of proteins. And a particular protein has a unique sequence of its own amino acid. This implies that the deficiency of a particular amino acid could result to medical health complication because the synthesis of that particular protein would not be complete. Thus, the good news is that the "Mother's Best Friend" offers incredible opportunities for animals that won't be able to synthesize essential amino acids on its own to tap from. Also, they contribute to the formation of glucose, acting as a buffer when other precursors are of short supply [34].

A recent study carried out on the amino acid composition of *M. oleifera* leaves by Sobhy *et al.* [35] revealed different concentration of amino acids including the essential and non-essential amino acids (Table 2). Moyo *et al.*, [33] in their studies reported that it also contained Cysteine (0.01 %). Tryptophan is also present. Glutamine and asparagine could however be synthesized from glutamate and aspartate.

Makkar and Becker, [36] stated that the amount of all the essential amino acids contained in the leaves of *Moringa* were higher than the amino acid pattern of the FAO reference protein, soyabeans. Also, the sulphur-containing amino acids in kernel proteins were present at higher concentrations than those specified in the amino acid pattern of the FAO reference protein but other essential amino acids were deficient [36]. It is important to note that apart from serving as a precursor for the synthesis of protein which could be enzymes, each amino acid has a specific function in the animal's body [33]. In general, amino acids are required for the production of enzymes, immunoglobins, hormones, growth, and repair of body tissues and form the structure of red blood cell [37].

Table 2. The Amino acid composition of the dried leaves of *Moringa* [35].

Amino Acids	Composition (mg/100g)
Leucine	94.36
Lysine	69.13
Valine	62.34
Threonine	48.35
Isoleucine	46.98
Histidine	29.56
Glutamic Acid	18.03
Aspartic Acid	13.76
Arginine	7.65
Alanine	4.93
Phenyl Alanine	3.42
Serine	3.13
Glycine	2.31
Cysteine	2.15
Tyrosine	2.03
Proline	1.86
Methionine	0.43

4.3. Mineral Composition

Minerals are very vital for the growth and development of living organisms. Some are needed in quantum (macro) and some in minute quantity (trace). The deficiency of any of these mineral elements could be detrimental. Their mechanism of actions differs from each other. Some serve as cofactors of enzymes, while others function in different ways. A notable example is haemoglobin with a cofactor called heme with iron in its center. The deficiency of iron in the blood automatically results to anaemia. This is just one example. A study by Moyo *et al.*, [33] on the macro-element composition, revealed that it leaves are composed of 3.65 % Calcium, 1.50 % Potassium, 0.63 % Sulphur, 0.50 % Magnesium, 0.30 % Phosphorus and 0.164 % Sodium. Mayo and co-workers also investigated the micro-element composition and found it composed of Zinc (31.03 mg/kg), Copper (8.25 mg/kg), Manganese (86.8 mg/kg), Iron 490 (mg/kg), Selenium (363.00 mg/kg) and Boron (49.93 mg/kg).

4.4. Vitamin Composition

Vitamins are very essential for the growth and maintenance of life and are highly needed in the diet of man and other animals because the body cannot synthesize most of them. Some acts as anti-oxidants others perform specific functions. For instance, Vitamin A is necessary for many functions in the ruminants including vision, bone growth, immunity and maintenance of epithelial tissue [33]. Other vitamins including the water soluble (Vitamin B and C) and the fat soluble (Vitamin A, D, E and K) are very essential for the smooth functioning of the body system. Fuglie [2] reported that the dried powdered leaves contained 16.3 mg/100g of Vitamin A (β -Carotene), 2.64 mg/100g of Vitamin B1 (Thiamine), 20.5 mg/100g of Vitamin B2 (Riboflavin), 8.2 mg/100g of Vitamin B3 (Nicotinic acid), 17.3 mg/100g of Vitamin C (Ascorbic acid) and 113 mg/100g of Vitamin E (Tocopherol acetate).

4.5. Fatty Acid Composition

Fatty acids are the basic units of lipids or triglycerides. Fatty acids are alternate sources of energy because, when metabolized, yields large amount of ATP compared to glucose although with negative end product ketone. Fatty acids can either be saturated or unsaturated. They can also be classified as essential or non-essential. The essential ones are the ones that must be included in the diet because the body cannot synthesize them. Examples are Linoleic acid (an Omega-6 fatty acid) and α -Linolenic acid (an Omega-3 fatty acid). They are so named Omega-6 and Omega-3 respectively because the first double bonds are located in carbon 6 and 3 away from the Methyl end (Fig. 5 and 6).

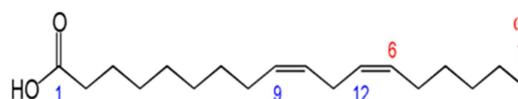


Figure 5. Linoleic acid (an Omega-6 fatty acid) [38].

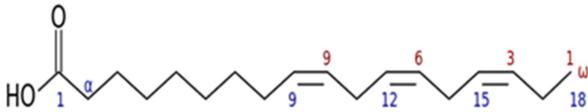


Figure 6. α -linolenic acid (an Omega-3 fatty acid) [39].

Omega-3 fatty acids are known to reduce blood clotting, lower the risk of heart disease while the omega-6 fatty acids increase blood clotting [40]. The deficiency of essential fatty acids usually results to physiological consequences such as skin disorders, delayed wound healing, sores in the scalps of infants and diarrhoea [40].

However, *Moringa* contained both the essential and non-essential fatty acids. Analysis carried out on the dry leaves of *Moringa* by Moyo *et al.* [33], revealed different compositions of saturated and unsaturated fatty acids (Table 3).

Table 3. Saturated Fatty Acids compositions [33].

Saturated Fatty Acids	Composition (%)
Capric (C10)	0.07
Lauric (C12)	0.58
Myristic (C14)	3.66
Palmitic (C16)	11.76
Margaric (C17)	3.19
Stearic (C18)	2.13
Arachidic (C20)	1.61
Heneicosylic (C21)	14.41
Behenic (C22)	1.24
Tricosylic (C23)	0.66
Lignoceric (C24)	2.91
Monounsaturated Fatty Acids	
Palmitoleic (16:1)	0.17
Oleic (18:1)	3.96
Polyunsaturated Fatty Acids	
Linoleic (18:2)	7.44
α -Linolenic (18:3)	44.57
γ -Linolenic (18:3)	0.20

4.6. Phytochemicals

Phytochemicals are non-nutritive plant chemicals that offer protection and prevention against diseases. More than 40 natural anti-oxidants have been reported to be present in *Moringa* [41]. The Presence of various types of antioxidant compounds make this plant leaves a valuable source of natural antioxidants [7] and a good source of nutraceuticals and functional components as well [36]. These include phenolic compounds, flavonoids, tannins, alkaloids, saponins, glucosides and numerous others [42]. These phytochemical contribute to the medicinal potential of *Moringa*.

However, some substance that reduces bioavailability of nutrients referred to as anti-nutrients had been identified especially in the seed. These includes Phytate (Fig. 7), Oxalates, Glucosinolates and Haemagglutinin [9, 36]. It contained a potentially fatal nerve paralyzing alkaloid called spirochin [43]. The presence of these compounds is not

worrying, because large amounts are required to elicit deleterious effects, and spirochin even displays antibacterial properties when consumed in smaller amount [44].

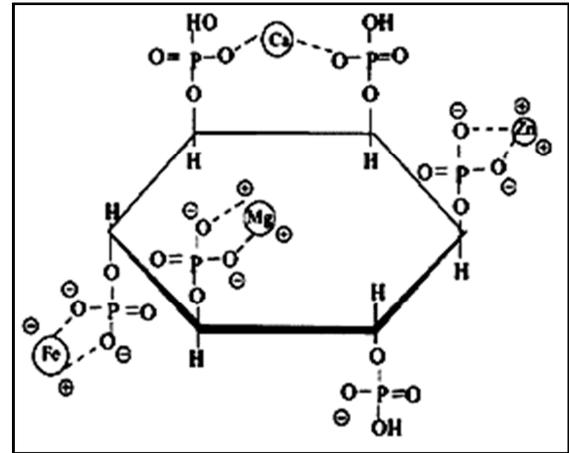


Figure 7. Structure of Phytate Chelating Metals at Neutral pH [45].

5. Uses of *Moringa*

5.1. General Uses

According to Fuglie [2] the many uses for *Moringa* could be summarized thus: alley cropping (biomass production), animal forage (leaves and treated seed-cake), biogas (from leaves), domestic cleaning agent (crushed leaves), blue dye (wood), fencing (living trees), fertilizer (seed-cake), 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, biopesticide (soil incorporation of leaves to prevent seedling damping off), pulp (wood), rope (bark), tannin for tanning hides (bark and gum). *Moringa* seed oil also known as Ben oil has been used in making salads, fine machine lubrication, and in the manufacture of perfume and hair care products [46]. Powdered seeds of *Moringa* had been used to flocculate contaminants and purify drinking water [47, 48, 49]. The seeds are also eaten green, roasted, powdered and steeped for tea or used in curries [49].

5.2. Medicinal Uses

The medicinal uses/benefits of *Moringa* cannot be exhausted. This is because almost all parts of the tree have been utilized within traditional medical settings. The flowers, leaves and roots are used for the treatment of ascites, rheumatism and venomous bites and as cardiac and circulatory stimulants in folk remedies [9]. The oil is applied externally for skin diseases [50]. The roots of the young tree and also root bark are rubefacient and vesicant [51, 52]. Leaf juice is used in hiccup (emetic in high doses); cooked leaves are given in influenza. The root-bark is used as antiviral, anti-inflammatory, analgesic [13]. Stem-bark and flowers are hypoglycaemic [13]. Infusion of seed is anti-inflammatory, antispasmodic and diuretic, also

given in venereal diseases [13]. *Moringa* support a healthy cardiovascular system, promote normal blood-glucose levels, neutralize free radicals that causes cancer, provide excellent support of the body's anti-inflammatory mechanisms, enrich anaemic blood and support immune system [41]. It also improves eyesight, mental alertness and bone strength. It has potential benefit in malnutrition, general weakness, lactating mothers, menopause, depression and osteoporosis [41].

6. Conclusion

Moringa is one plant that virtually contains all the whole nutrients needed by man. They contain both the most essential and non-essential nutrients. Increase awareness on the nutritional and medicinal potential of *Moringa* should form the priority of all health institutions especially those in the rural area where cases of malnutrition is prevalent. One way to achieve this is to encourage the cultivation of *Moringa* in family compounds as such making it the "Family Companion".

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