MORINGA OLEIFERA;

MEDICINAL AND SOCIO–ECONOMIC USES

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INTRODUCTION

Moringa oleifera Lam. is the most widely cultivated species of the monogeneric family Moringaceae (order Brassicales), that includes 13 species of trees and shrubs distributed in sub-Himalayan ranges of India, Sri Lanka, North Eastern and South Western Africa, Madagascar and Arabia. Today it has become naturalized in many locations in the tropics and is widely cultivated in Africa, Ceylon, Thailand, Burma, Singapore, West Indies, Sri Lanka, India, Mexico, Malabar, Malaysia and the Philippines (Fahey, 2005).

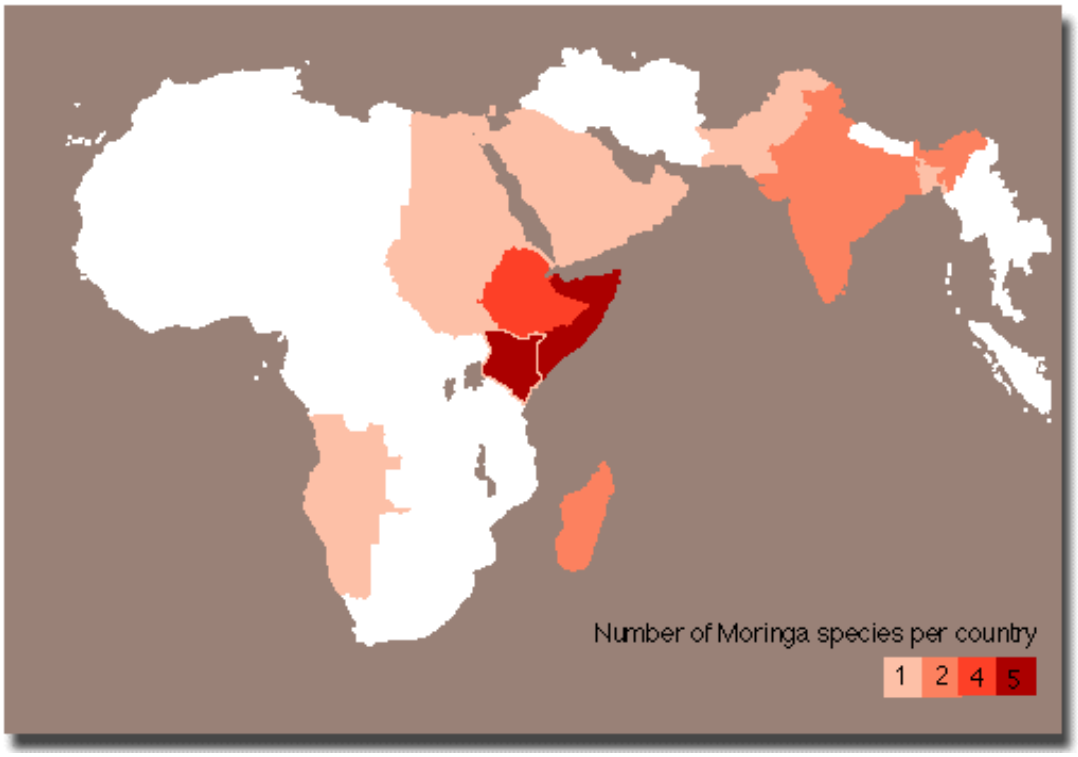

Fig. 1: Distribution of Moringa species

M. oleifera Lam. (syn. *Moringa pterygosperma* Gaerthn, *Moringa moringa* Millsp.) is called Morunga in the Dravidian language (India), which means “generic root”. Other regional names are *Kelor, Marango, Moonga, Mlonge, Mulangay, Nébéday, Saijhan,* and *Sajna* or *Benzolive*. English names are *Horseradish tree*, *Drumstick tree*, *Never Die tree*, *West Indian Ben tree* or *Radish tree* (Fahey, 2005).

M. oleifera 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. In the tropics it is used

as foliage for livestock. It is an exceptionally nutritious vegetable tree with a variety of potential uses.

HISTORY

Although the name “Shigon” for *M. oleifera* is mentioned in the “Shushruta Sanhita” which was written in the beginning of the first century A.D., there is evidence that the cultivation of this tree in India dates back many thousands of years. The Indians knew that the seeds contain edible oil and they used them for medicinal purposes. It is probable that the common people also knew of its value as a fodder or vegetable. 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 annual rainfall (Odee, 1998).

About two decades ago, in the southern states of India, and especially in Tamilnadu, *M. oleifera* was cultivated as single trees in homesteads, round cattle sheds, on farm boundaries, and as isolated plants in fences and as groups of trees on village waste lands. In the early 1990s in southern Tamilnadu people started growing perennial types - Moolanoor as an intercrop on field scale and their allies were cropped with vegetables and Sorghum. This system evolved as Moringa offered some protection to alley crops from drying winds during summer and Moringa provided some additional income.

With the migration of people from south to north India, the demand for Moringa products increased. However attempts to grow this crop in North India were not very successful due to wide variations in temperature. In all the places concerned, with their differing conditions, cultivation of *M. oleifera* was not given the required attention and systematic production practices were not followed as people failed to notice that it was a commercially viable alternate crop in Arid Zone Horticulture. The taboo that ghosts dwell in Moringa trees and the fact that it was inauspicious to have the first vision of the tree when day dawns were further reasons for this situation. In spite of this, the leaves and fruits were sought after and utilised by rich and poor alike.

These perennial ecotypes cultivated had some undesirable features such as large trunks (1-2 mts.); they grew very tall (5-6 mts), and were always seen oozing gum, often with swarms of hairy caterpillars. These hairy caterpillars undergo metamorphosis into pupa during which they shed their hairs which are dispersed by wind causing itching in human beings. People saw that hairy caterpillar and *M. oleifera* were inseparable and this was the reason for growing the tree as a backyard crop or in remote parts of farms (Anbarassan et al., 2001).

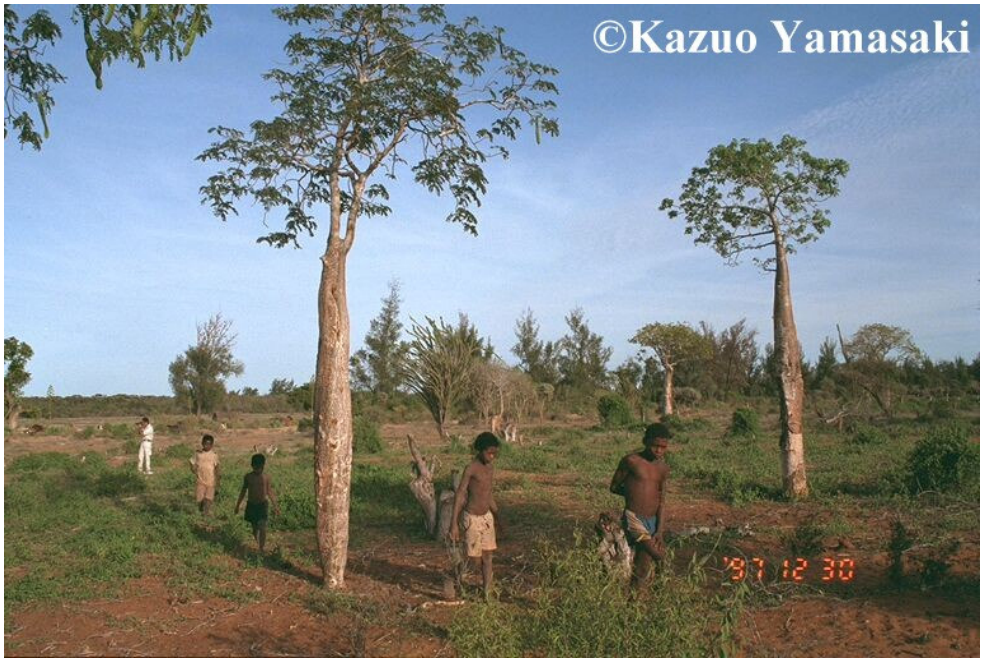

Figure 2: *M. oleifera* in Ifaty, Madagascar.

The cheapest vegetables available during summer are greens and aubergines (egg plant). Farmers found that growing Moringa crops during this season was remunerative. Thus, Moringa gained a foothold as a summer vegetable. Its unique flavour and aroma became popular. In South India any meal with out Moringa products and pulses is considered incomplete. The demand for the pod of *M. oleifera* also increased due to increased urban settlements and migration of people to urban colonies. With taste and flavour as deep seated customs, ethnic Indians settled elsewhere in the world, predominantly in the Far East and Gulf countries, and longed for Moringa products in their diet. All these simultaneous developments led to the focus on commercial cultivation of *M. oleifera* and organised market networking (Anbarassan et al., 2001).

With the demand for bulk quantities of Moringa products, farmers started increasing the number of trees by taking branch cuttings of perennial types in the late 1980s.The limb

cuttings failed to sprout when cut during improper seasons. The delicate buds which are located on the very surface of the bark were damaged during collection and transportation. The productivity of these trees was erratic and in most cases, these trees were not fertilised or properly maintained.

Even at this stage commercial cultivation was not thought of. The perennial ecotypes that were cultivated are Jaffna, Moolanur, and Savahacherry etc. Attempts to seed propagate these ecotypes also met with failure as the seedlings took several years to flower and fruit. These were not true-to-type as their pods had varied characters (long, medium and short). Due to cross pollination, the offspring exhibited a mosaic of plant characters (Anbarassan, Sreeja, Kalaiselvi, Parvatham, & Vedamuthu 2001).

SOCIO-ECONOMIC IMPORTANCE

Studies from around the World illustrate how wild resources often form an integral part of livelihood (Scoones et al.,1992). Wild resources provide materials for utensils and construction, and contribute to improved diets and health, food security, income generation, and genetic experimentation. These resources are typically associated with hunting and gathering societies where they often have special cultural significance, but they also play important roles more intensive or specialized agricultural systems.

The socio-economic value of biological diversity resides not only in the direct use that one makes of biological resources, but also in the indirect uses, such as the ecological services (e.g.: improvement of the quality of water and air, the fixing of nitrogen, the formation of soils), socio-cultural uses (e.g.: religious and cultural functions), recreational and aesthetic uses (e.g.: tourism of vision), etc. These uses end up at the level of feeding and the different sectors of activity that are interested in biological diversity.

M. oleifera 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 (Foidl et al., 2001). Distinction of cultivars has not yet been formally carried out. *M. oleifera* was well

known to the ancient world, but only recently has it been "rediscovered" as a multi-purpose tree with a tremendous variety of potential uses. The pleasant-tasting edible oil which can be extracted from the seeds was highly valued by the ancient Roman, Greek and Egyptian civilizations for use in making perfume and in protecting skin, and during the 19th century *M. oleifera* plantations in the West Indies were exporting the oil (known as Ben oil) to Europe for use in making perfumes and as a lubricant for fine machinery.

In the Indian sub-continent *M. oleifera* has long been cultivated for its edible fruit: today these are exported, fresh and in tins, to consumers in Asia and Europe. The edible leaves of the tree are very nutritious and are consumed throughout West Africa as well as in some parts of Asia. Powder from seed kernels works as a natural coagulant which can clarify even very turbid water, removing up to 99% of the bacteria in the process.

M. oleifera is certainly under-exploited at present. Its numerous uses as a vegetable, seed oil, gum, hedge tree, ornamental and medicinal plant, and its easy propagation and cultivation justify more intensive research into its biological and economic potential. Germplasm exist in natural stands and maintenance of long, large fruited types is usually practiced.

MORPHOLOGY

M. oleifera is a fast growing deciduous shrub or small tree up to 12 m tall and 30 cm in diameter with an umbrella-shaped open crown (unless repeatedly coppiced). It is a softwood tree with timber of low quality. The bark is corky and gummy. Leaves are alternate, oddly bi- or tri-pinnate compound, triangular in outline and 20– 70 cm long. Each pinnae has 3–9 pairs of 1–2 cm long ovate leaflets, soft dark green above and whitish below. The white, fragrant flowers that are obliquely monosymmetric and papilionoid (the median petal is adaxial) with five stamens, are in axillary pendulous panicles 1.5–2 cm long from leaf corners. The fruit pods, called “drumsticks” are 15–45 cm long, 9-ribbed capsules opening by three valves to release the seeds. The seed hull is brownish semi-permeable and has three white wings that run from top to bottom. Each tree can produce 15’000 – 25’000 seeds per year. All parts of the Moringa tree are edible but the roots, which are used as a condiment in the same way as horseradish,

contain the alkaloid spirochin, a potentially fatal nerve paralyzing agent (Hensleigh & Holaway, 1992; Makkkar & Becker, 1997).

Figure 3: M. oleifera in Berenty, Madagascar.

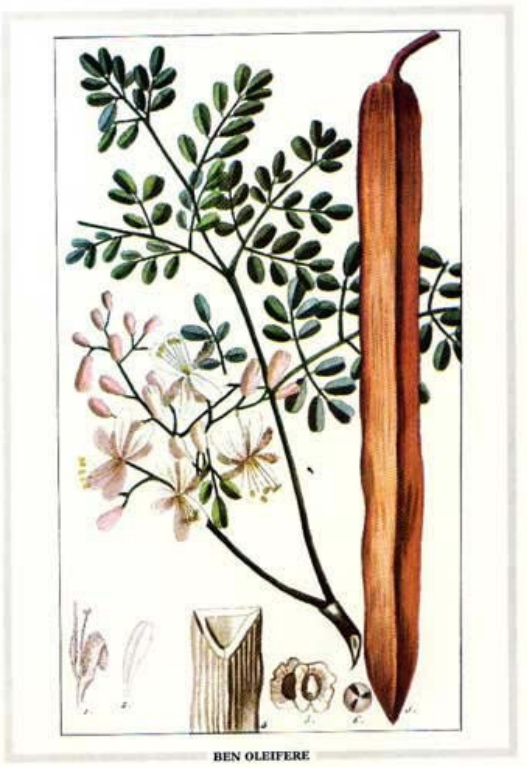

Figure 4: Plate of *M. oleifera.*

ECOLOGY

M. oleifera is a drought-resistant pioneer species mainly growing in semi-arid tropical and subtropical areas. It is found up to 1000 m altitude and in areas with annual rainfall of 750–2,250 mm. While it grows best in dry sandy soil, it is adaptable to various soil conditions from 4.5 to 8 pH, but does not tolerate water logging and freezes or frosts (Hensleigh & Holaway, 1992). *M. oleifera*, which can easily adapt to varied ecosystems and farming systems, is known for its resistance to drought and diseases. The tree is fast growing as it has been found to grow 6-7m in one year in areas receiving less than 400 mm mean annual rainfall (Odee, 1998).

CULTIVATION

In India, the *M. oleifera* is propagated by planting limb cuttings 1–2 m long, so that pods and leaves remain within arms reach. A plant in cultivation starts bearing pods 6–8 months after planting while regular bearing commenced after the second year. The tree can bear for several years (Duke, 1983). Pruning aims at enhancing the production and controlling tree height. After pruning, it takes only three weeks for the tree to be ready for a harvest. To fight against caterpillars which are the main pests attacking Moringa in Niger, farmers apply DDT.

The crop is extremely heterozygous because it is highly cross pollinated in nature and there is a wide variability in yield and components. As a result, the maintenance of genetic purity represents the limitation for large scale cultivation.

Figure 5: Open fruit with seeds of *M. oleifera.*

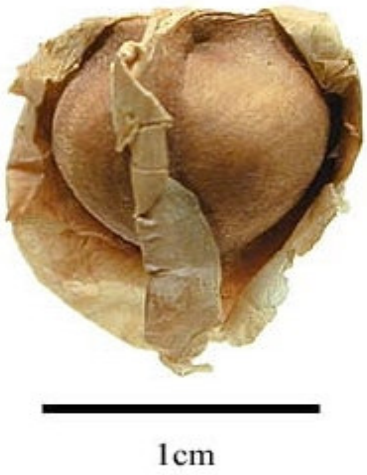

Figure 6: Seed of *M. oleifera*

THE USES

The Moringa tree is a multi-function plant. It has been cultivated in tropical regions all over the world for the following characteristics: 1) high protein, vitamins, mineral and carbohydrate content of entire plants; high value of nutrition for both humans and livestock; 2) high oil content (42%) of the seed which is edible, and with medicinal uses; 3) The coagulant of seeds could be used for wastewater treatment (Foidl et al., 2001). This plant has been well documented for its medicinal importance for a long time. The

stem bark, root bark, fruit, flowers, leaves, seeds and gum are widely used in India folk medicine. The ground powders of seeds and roots are also a spice, and it is where the origin of the name horseradish tree comes from. The pods and seeds are tastier while they are young and before they turn brown. In Malaysia, the young tender pods are cut into small pieces and added to curries (Abdulkarim et al., 2005).

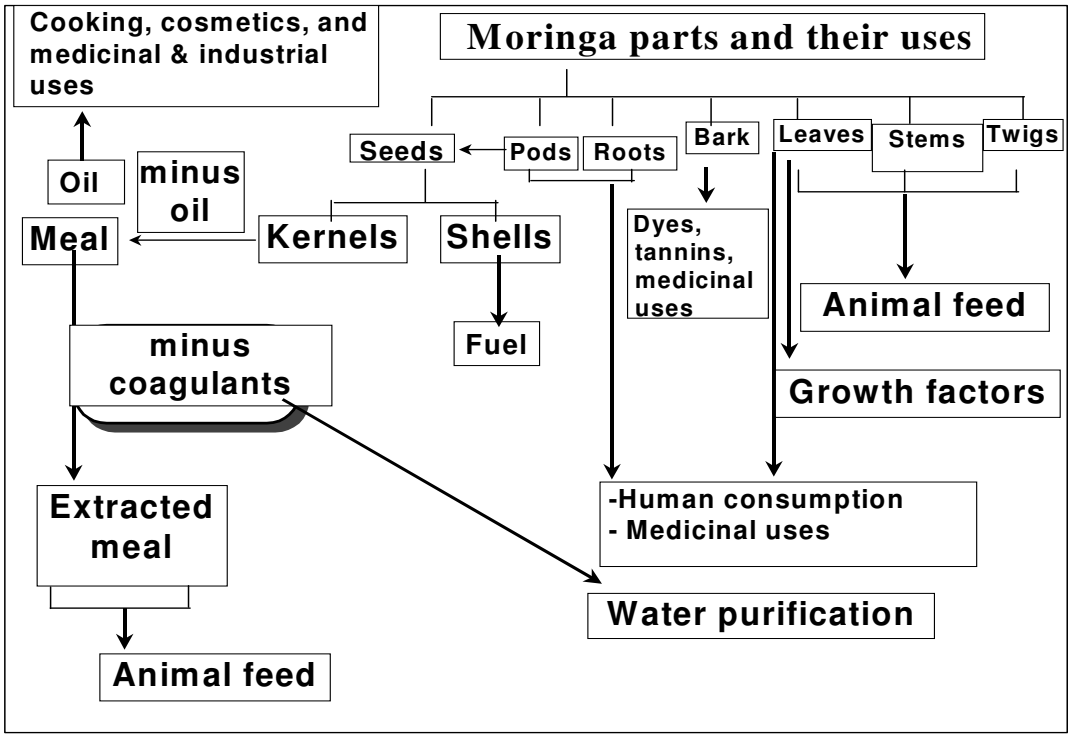

Figure 7: Uses of different parts of *M. oleifera* (Foidl et al., 2001).

Vegetative parts

All of the parts of the *M. oleifera* can be used in a variety of ways as food. It is full of nutrients and vitamins and is good as food for humans as well as fodder for animals. Moringa seeds help to clean dirty water and is a useful source of medicine. The tree provides lots of leafy material that is useful when using alley cropping systems. The leaves, especially young shoots, are eaten as greens, in salads, in vegetable curries, and as pickles. In India, Moringa extracts are commonly used as a phytotherapeutic agent. The leaves can be eaten fresh, cooked, or stored as dried powder for many months without refrigeration, and reportedly without loss of nutritional value. The leaves

are widely used, particularly in India, the Philippines, Hawaii and parts of Africa, as a highly nutritious vegetable supplement. The leaves are rich in starch, minerals, iron, vitamins A, B and C, calcium and protein. The leaves are considered to offer great potential for those who are nutritionally at risk and may be regarded as a protein and calcium supplement. It is particularly useful as a human food in tropical countries because the leaves appear towards the end of the dry season when few other sources of green leafy vegetables are available. The powder of dried leaves can be produced by drying the leaves and crushing or pounding them. This powder can then be added to sauces at the same time as other condiments or vegetables are added.

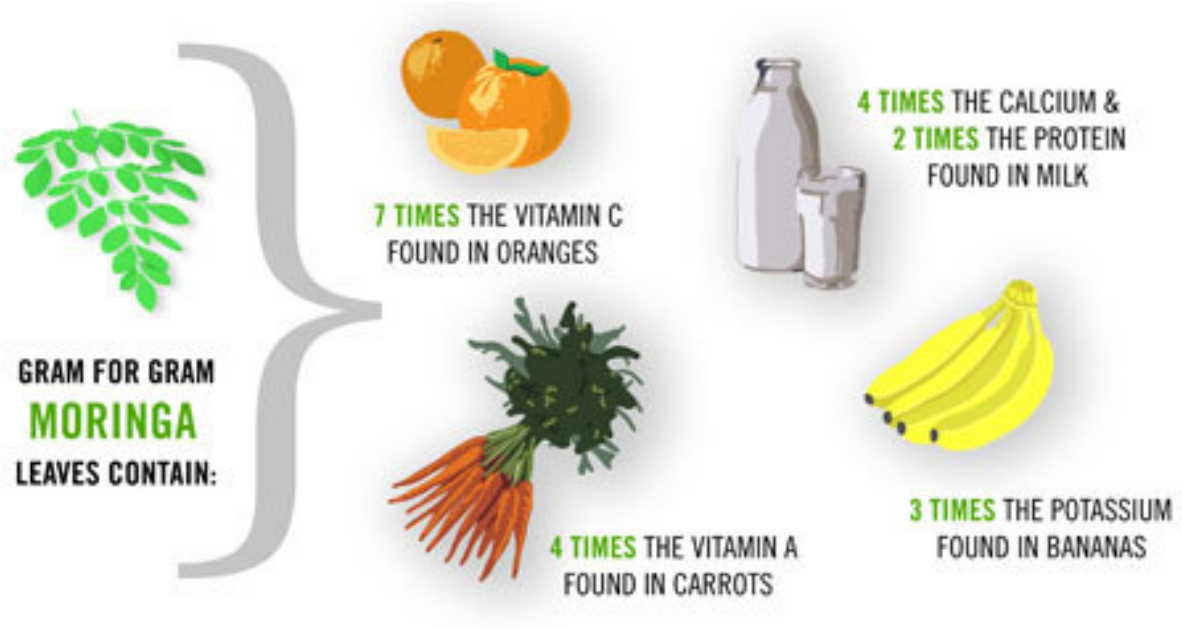

Figure 8: Nutritional value of Moringa leaves.

Table 1: Mineral contents of *M. oleifera* leaves from different agro climatic origins (Becker and Makkar in Foidl et al. 2001, unpublished).

Mineral	**Nicaragua**	**India**	**Niger**
Macro elements (g kg^{-1} DM)			
Calcium	17.5	26.4	13.9
Phosphorus	1.16	1.36	1.22
Magnesium	0.11	0.11	0.11
Sodium	1.16	2.73	2.61
Potassium	19.1	21.7	18.4
Micro-elements (mg kg^{-1} DM)			
Iron	582	175	347
Magnese	47.1	51.8	113.9
Zinc	13.5	13.7	24.2
Copper	11.2	7.1	10.6

The root is applied externally as a poultice in cases of inflammation, as a valuable rubefacient. It is also used as a substitute for horseradish. The effect of oral application of aqueous and alcoholic extracts of *M. oleifera* root-wood has been studied in male Wistar albino rats. Ethylene glycol feeding resulted in hyperoxaluria as well as increased renal excretion of calcium and phosphate. Supplementation with aqueous and alcoholic extracts of *M. oleifera* root-wood significantly reduced the elevated urinary oxalate, showing a regulatory action on endogenous oxalate synthesis. The increased deposition of stone forming constituents in the kidneys of calculogenic rats was also significantly lowered by curative and preventive treatment using aqueous and alcoholic extracts. The results indicate that the root-wood of *M. oleifera* is endowed with antiurolithiatic activity.

Economic uses

According to Verma et al. (1976) *M. oleifera* is a fast growing tree being planted in India on large scale as a potential source of wood for the paper industry. The wood provides a pulp that is considered suitable for paper, wrapping, textiles and cellophane. In Jamaica, exudate is used for blue dye.

Uses in folk medicine

All parts of the tree have been used in folk medicine practices. According to Fahey, J.W. (2005), the medicinal use of Moringa is summarized in table 3-2.

Table 2: Medicinal use of *M oleifera* in folk medicine (Fahey, 2005 and Rajangam et al., 2001).

Plant parts	**Traditional use condition/Effect**	**Pharmacognosy/ compounds**[a]
Leaves	Anti-bacterial, Infection, Urinary Tract Infection, Epstein-Bar Virus (EBV), Herpes Simplex Virus (HSV-1), HIV-AIDS, Helminthes, Trypanosomes, Bronchitis, External Sores/Ulcers, Fever, Hepatic, Anti-Tumor, Prostate, Radio protective, Anti-Anemic, Anti-hypertensive, Diabetes/hypoglycemia, Diuretic, Hypocholestemia, Thyroid, Hepatorenal, Colitis, Diarrhea, Dysentery, Ulcer/Gastritis, Rheumatism, Headache, Antioxidant, Carotenoids, Energy, Iron deficiency, Protein, Vitamin/mineral deficiency, Lactation Enhancer, Antiseptic, Catarrh, Lactation, Scurvy and Tonic.	Antibiotic/ **6,2** Cancer prevention/ **1,3**
Bark	Dental Caries/Toothache, Common cold, External Sores/Ulcer, Anti-Tumor, Snakebite, Scorpion bite, Colitis, Digestive, Epilepsy, Hysteria, Headache, Antinutrietional factors, Abortifacient, Aphrodisiac, Birth Control and Scurvy	Antibiotic/ **6,2** Cancer prevention/ **1,3**
Roots	Dental Caries/Toothache, Common cold, Trypanosomes, External Sores/Ulcers, Fever, Asthma, Cardiotonic, Diuretic, Hepatorenal, Diarrhea, Flatulence, Anti-spasmodic, Epilepsy, Hysteria, Headache, Abortifacient, Aphrodisiac, Rubefacient, Vesicant, Gout, Hepatamegaly, Low back/Kidney Pain, Scurvy and Splenomegaly.	Antibiotic/ **6,2** Cancer prevention/ **1,3**
Exudate	Dental Caries/Toothache, Syphilis, Typhoid, Earache, Fever, Asthma, Diuretic, Dysentery, Rheumatism, Headache, Abortifacient and Rubefacient.	Antibiotic/ **6,2** Cancer prevention/ **1,3**
Flowers	Throat infection, common cold, anthelmintic, anti-tumor, rheumatism, diuretic, tonic, hysteria, abortion	Antibiotic/ **6, 2** Cancer prevention/ **1, 3**
Pods	Anthelmintic, skin cancer, anti-hypertensive, diabetes, joint pain	Antibiotic/ **6, 2**
Seeds	Anthelmintic, Warts, anti-tumor, Ulcer, rheumatism, arthritis, antispasmodic, goitrogen, mineral/vitamin deficiency	Antibiotic/ **6, 2** Cancer prevention/ **1, 3**

[a] See Figure 9.

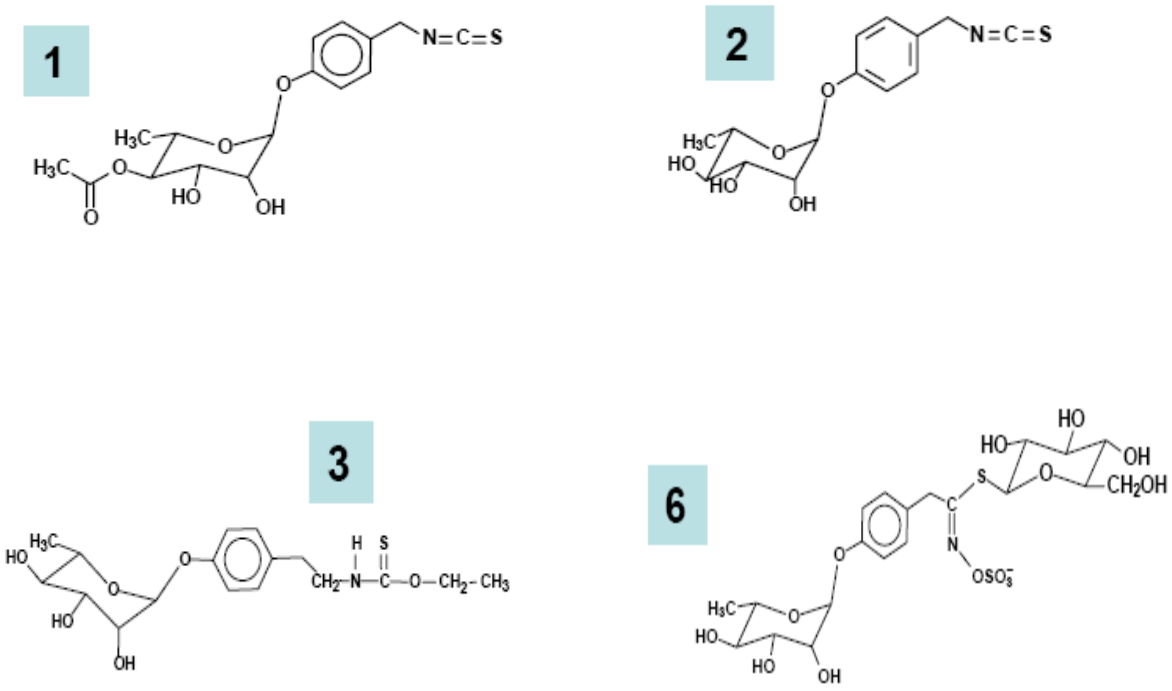

Figure 9: structures of selected phytochemicals from *Moringa oleifera*. 4-(4'-O-acetyl-α-L-rhamnopyranosyloxy) benzyl isothiocyanate [1], 4-(-L-rhamnopyranosyloxy) benzyl isothiocyanate [2], niazimicin [3] , and 4-(α-L-rhamnopyranosyloxy) benzyl glucosinolate [6].

Seed Oil

The seed of *M. oleifera* contains high quality edible oil (up to 40% by weight). In Haiti, the oil has been used as general culinary and salad oil. It resembles olive oil in its fatty acid composition (Abdulkarim et al., 2005). The characteristics of *M. oleifera* seed oil are especially desirable, because of the current trends of replacing polyunsaturated vegetable oils with monounsaturated fatty acids. The oil is also used as a lubricant for fine machinery, such as timepieces, for its little tendency of deteriorating and becoming sticky (Foidl et al., 2001). Moreover, the oil has the capacity to absorb and retain volatile substance and is therefore valuable in the perfume industry.

Table 3: Analysis of *M. oleifera* seed oil (modified from Abdulkarim et al., 2005).

Characteristic	Content (%)
Moisture content	7.9± 1.00
Crude protein[a]	38.3± 1.03
Fats/ oils	30.8± 2.19
Crude fibre	4.5± 0.38
Ash content	6.5± 0.15
Total carbohydrate	16.5

[a] Crude protein = N(%)×6.25

Water purification

After oil extraction of *M. oleifera* seeds, the left press cake contains water soluble proteins that act as effective coagulants for water purification. One to two seeds per liter are required for water purification. Seed powders are mixed with water, after hours, the water is filtered to get purified water. The charged protein molecules can serve as non-toxic natural polypeptide to settle mineral particles and organics in the purification of drinking water, vegetable oil, depositing juice (sugarcane) and beer (Foidl et al., 2001).

Recently, there is an increasing trend to evaluate some indigenous cheaper material for wastewater treatment. Since the conventional procedure of wastewater treatment has some disadvantages, such as incomplete metal removal, high cost and high energy requirements, biological materials have been recognized as cheap substitutes for wastewater treatment. Current studies report that Moringa seeds and pots are effective sorbets for removal of heavy mental and volatile organic compounds in the aqueous system (Akhtar et al., 2006, Sharma et al., 2006). It can be added in oxidation lagoons of wastewater treatment units to coagulate algae as well. The algae are removed by sedimentation, dried and pulverized, and then are used as protein supplement for livestock (Foidl et al., 2001). The unique characteristic of Moringa seeds could be a possible solution for the developing countries which are suffering from lack of clean drinking water.

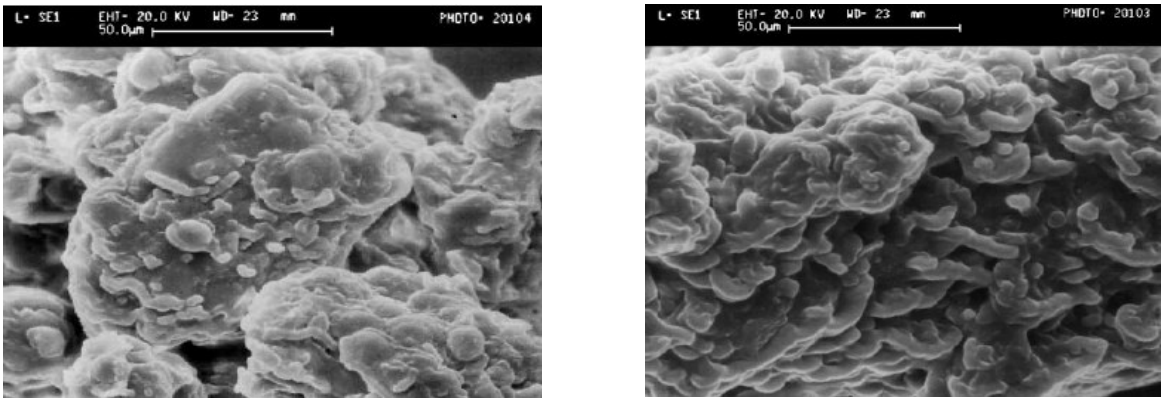

Figure 6. Left: Scanning electron micrograph (SEM) of untreated Moringa seeds showing large spherical clusters type morphology. SEM of As treated Moringa seeds showing dense agglomerated, etched dendrite type morphology (Kumari et al., 2006).

Pharmacological importance

Although the reproductive parts of *M. oleifera* are treated as panacea in the fork medicine (Table 2), it is critical to separate rigorous scientific evidence from anecdote. In particular, this plant family is rich in a fairly unique group of compounds called glucosinolates and isothiocyanates. The compounds benzyl glucosinolate (6) and cognate isothiocyanates (2) are verified the activity against a wide range of bacteria and fungi (Figure 3-3, Fahey, 2005). As for Moringa in cancer therapy, the recent examination of compound (1) and the related compound (3) were shown to be potent inhibitors of phorbol easter in lymphoblastoid cells. Compound (3) also inhibited tumor promotion in a mouse in recent studies. In an even more recent study, a dramatic reduction in skin papillomas was demonstrated. In the case of using *M. oleifera* as a cancer prevention plant, obviously, more rigorous studies are required in order to obtain biomedical endowments of this plant.

CONCLUSION

M. oleifera is a tropical tree whose numerous economic applications and facility of propagation are arousing growing international interest. The Moringa tree is cultivated to use as a vegetable (leaves, green pods, flowers, roasted seeds), for spice (mainly roots), for cooking and cosmetic oil (seeds) and as a medicinal plant (all plant organs).

Furthermore, the raw seeds are valuable because extracts have a flocculating protein that works as a coagulant of surface muddy and turbid water to tap-water in many African and Asian countries and Central America. Now that research and pilot scale tests have been carried out, consideration is being given to the production and use of the Moringa's coagulants at national and international levels. In Tanzania, a Franco-Swiss company has started large-scale production of Moringa seeds to that end.

The oil extracted from the seeds is not only comparable in terms of quality to olive oil as an oil for human consumption, but is also a raw material used by the cosmetics industry. *M. oleifera* is also a food-producing plant: In India, it is cultivated for the production of its fruit, while in the Sahelian zones of Africa its leaves are eaten as a vegetable. The planting of Moringa trees by smallholder farmers should be encouraged because it will improve both their health and income. The exceptional content in proteins, starch, minerals and vitamins of Moringa leaves have led to it being used as a food supplement in programmes to combat malnutrition and related diseases. There are plans to use these products in Europe and in the USA, in the form of tablets capable of competing with spiruline as a nutritional supplement. Research is also being carried out into the powers of the powder extracted from its leaves to boost the immune system, in particular with regard to HIV patients. *M. oleifera* is also of interest for cancer research because of its production of compounds with antibiotic activity such as the glucosinolate 4 alpha-L-rhamnosyloxy benzyl isothiocyanate.

M. oleifera is a true miracle of nature, obviously because it has so many benefits. In fact, people in India and Africa have known about the medicinal properties of the tree for generations and have thus used it to cure various diseases. However the knowledge was mainly considered as alternative science and a herbal remedy. Modern medical science has only just begun to accept their long held knowledge. Some are even of the opinion that *M. oleifera* is probably the most nutritious plant ever discovered. In southern Nigeria, the Moringa tree is known as *Idagba manoye* – which translates as 'growing up without sense'. One can hope that in the future, good sense prevails and the true potential of this tree and its many products is realised.

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Figure 10: A nutritional drink made of Moringa leaves.