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# MEDICINAL PROPERTIES OF *Moringa oleifera*: A REVIEW

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## ABSTRACT

*Moringa oleifera* is a tropical species that is known by various regional names as benzolive, drumstick tree, kelor, marango, mlonge, mulangay, nébéday, saijhan, and sajna. Over the past two decades, many reports have been published describing its nutritional and medicinal properties. Its utility as a non-food product has also been extensively described, (e.g. lumber, charcoal, fencing, water clarification, lubricating oil). As with many reports of the nutritional or medicinal value of a natural product, there are an alarming number of purveyors of "healthful" food who are now promoting *M. oleifera* as a medicine. Those who charge a premium for products containing *Moringa oleifera* must be held to a high standard. Those who promote the cultivation and use of *M. oleifera* in regions where hope is in short supply must be provided with the best available evidence, so as not to raise false hopes and to encourage the most fruitful use of scarce research capital.

## INTRODUCTION:

The plant *Moringa oleifera* is a native to the Indian sub-continent and naturalized in tropical and sub-tropical areas around the world, it belongs to the family *Moringa*cae and is a deciduous tree or shrub, fast-growing, drought resistance, average height of 12 meter at maturity. This plant has twelve other varieties of species and they are as follows: *Moringa arborea, Moringa borziana, Moringa concanensis, Moringa drouhardii, Moringa hildebrandtii, Moringa longituba, Moringa ovalifolia, Moringa peregrina, Moringa pygmaea, Moringa arivae, Moringa ruspolian* and *Moringa stenoprtala.*

Since the beginning of human civilization, medicinal plants have been used by mankind for its therapeutic value. Nature has been a source of medicinal agents for thousands of years and an impressive number of modern drugs have been isolated from natural sources. Many of these isolations were based on the uses of the agents in traditional medicine. The plant-based, traditional medicine systems continues to play an essential role in health care, with about 80% of the world's inhabitants relying mainly on traditional medicines for their primary health care (Owolabi *et al*., 2007). Medicinal plants are plants containing inherent active ingredients used to cure disease or relieve pain (Okigbo *et al*., 2008). The medicinal properties of plants could be based on the antioxidant, antimicrobial antipyretic effects of the phytochemicals in them (Cowman, 1999; Adesokan *et al*., 2008). The ancient texts like Rig Veda (4500-1600 BC) and Atharva Veda mention the use of several plants as medicine. The books on ayurvedic medicine such as *Charaka Samhita* and *Susruta Samhita* refer to the use of more than 700 herbs (Jain, 1968). According to the World Health Organization (WHO, 1977) "a medicinal plant" is any plant, which in one or more of its organ contains substances that can be used for the therapeutic purposes. The term "herbal drug" determines the part/parts of a plant (leaves, flowers, seeds, roots, barks, stems, etc.) used for preparing medicines. In India, the ayurvedic system has described a large number of such medicines based on plants or plant product and the determination of their morphological and pharmacological or pharmacognostical characters can provide a better understanding of their active principles and mode of action.

In the last few decades there has been an exponential growth in the field of herbal medicine. It is getting popularized in developing and developed countries owing to its natural origin and lesser side effects (Brahmachari, 2001). Herbal drugs constitute a major share of all the officially recognized systems of health

in India *viz*. Ayurveda, Yoga, Unani, Siddha, Homeopathy and Naturopathy, except Allopathy. More than 70% of India's 1.1 billion populations still use these non-allopathic systems of medicine (Vaidya and Devasagayam, 2007). In many developing countries, a large proportion of the population relies on traditional practitioners and their armamentarium of medicinal plants in order to meet health care needs. Although modern medicines may exist side-by-side with such traditional practice, herbal medicines have often maintained their popularity for historical and cultural reasons. Such products have become more widely available commercially, especially in developed countries. Use of herbal medicines in developed countries has expanded sharply in the latter half of the twentieth century. In India, herbal drugs are an integral part of The Indian System of Medicine (Ayurveda) which is an ancient and mainstream system (Rai, 2005).

*M. oleifera* is one of the best known medicinal plant. The *Moringa* plant has been consumed by humans (Iqbal *et al*., 2006). It is one of the richest plant sources of Vitamins A, B, C, D, E and K (Anwar and Bhanger, 2003; Babu 2000; Caceres *et al.*, 1992; Dayrit *et al*., 1990; Delisle *et al*., 1997). The vital minerals present in *Moringa* include Calcium, Copper, Iron, Potassium, Magnesium, Manganese and Zinc. It has more than 40 natural anti-oxidants. *Moringa* has been used since 150B.C. by ancient kings and queens in their diet for mental alertness and healthy skin. The leaves, pods, seeds, gums, bark and flowers of *Moringa* are used in more than 80 countries to relieve mineral and vitamin deficiencies, support a healthy cardiovascular system, promote normal blood-glucose levels, neutralize free radicals, provide excellent support of the body's anit-flammatory mechanisms, enrich anemic blood and support immune system. It also improves eyesight, mental alertness and bone strength. It has potential benefit in malnutrition, general weakness**,** lactating mothers, menopause**,** depression and osteoporosis. It is also used to make an efficient fuel, fertilizer and livestock feed. *Moringa* leaf has been purported to be a good source of nutrition and a naturally organic health supplement that can be used in many therapeutic ways (McBurney *et al*., 2004; Fahey, 2005; DanMalam *et al*., 2001).

*Moringa* was highly valued in the ancient world. The Romans, Greeks and Egyptians extracted edible oil from the seeds and used it for perfume and skin lotion. In the 19th century, plantations of *Moringa* in the West Indies exported the oil to Europe for perfumes and lubricants for machinery. People in the Indian sub-continent have long used *Moringa* pods for food. The edible leaves are eaten throughout West Africa and parts of Asia. For centuries, people in many countries have used *Moringa* leaves as traditional medicine for common ailments. Clinical studies have begun to suggest that at least some of these claims are valid. With such great medicinal value being suggested by traditional medicine, further clinical testing is very much needed. A study was done in Pakistan to examine the physico-chemical characteristics of *M. oleifera* seeds and seed oil from a wild provenance of Pakistan. The *Moringa* seeds exhibited an oil yield of 34.80%. Protein, fiber, moisture and ash contents were 31.65, 7.54, 8.90 and 6.53%, respectively (Fig.1).

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. 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 (Anbarassan *et al.,* 2001). 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 We need to explore therapeutic, nutritional and benefit of this gift of nature reported to be one of the world's most useful trees. *Moringa* has received

attention in many countries in the tropics and sub-tropics and its leaves, pods and seeds form part of the traditional cuisine in these countries. Although *Moringa* is used in West, Central and East Africa and although it grows in some parts of South Africa, the plant itself, as well as its uses, are mostly unknown to South Africans in general (National Research Council, 2006).

Literature study and a few informal discussions held in Tshwane and Mokopane in the Gauteng and Limpopo provinces of South Africa respectively indicated that although some people use *Moringa* in their diets (mostly Indians) its usage is not documented in South Africa. However, the listing of *Moringa* as an herb in South Africa in a recent publication (Roberts, 2007) may be an indication that awareness of the plant in South Africa is on the increase. There is therefore an opportunity to introduce *Moringa* as a food source, which could lead to an increase in diversity of the dietary intake, especially among rural populations of South Africa. It has been shown in a recent survey that 33% of South African children under the age of six suffer from vitamin A deficiency. Ramachandran *et al.*, (1980) reported the vitamin A content of *Moringa* as 11,300 IU per 100 g edible portion. The original source did quote the value as beta carotene, which should read 11,300 IU beta carotene per 100 g edible portion (McBurney *et al*., 2004). Babu (2000) reported vitamin A content as 3767 IU per 100 g edible portion. A publication of Kuhnlein (2003) quoted *Moringa* in Niger as containing 5880 µg beta-carotene per 100 g edible portion. This data of Kuhnlein (2000) is recommended by McBurney *et al.*, (2004). An initiative was launched by FAO to analyse the nutrient composition of traditional leafy vegetables so as to standardise the nutrient content per 100 g edible portion (FAO, 2008).

**Fig.1: *Moringa oleifera***

1. **Origin and Habitat:** *M. oleifera*, an important medicinal plant is one of the most widely cultivated species of the family Moringeneric the *Moringa*ceae, that is native to the sub-himalayan tracts of india, Pakistan, Bangladesh and Afghanistan. The rapidly grown tree (also known as Ben oil tree, horseradish tree, drumstick tree benzolive tree, kelor, marango, mlonge, moonga) was utilized by the ancient Romans, Greeks and Egyptain. It is highly valued from time immemorial because of its vast medicinal properties. It is now widely cultivated and has become naturalized in many location in the tropics (James, 1983).
2. **Description:** *M. oleifera* is a short, slender, deciduous, perennial tree, grows to about 10 m tall, rather slender with drooping branches; branches and stem are brittle, with corky bark; leaves are feathery, pale green, compound, tripinnate, (30-60 cm long), with many small leaflets, 1.3-2 cm long, 0.6-0.3 cm wide, lateral ones somewhat elliptic, terminal onesobovate and slightly larger than the lateral ones; flowers are fragrant, white or creamy-white, (2.5 cm in diameter), borne in sprays, with five(5) at the top of the flower; stamens are yellow; pods are pendulous, brown, triangular, splitting lengthwise into 3 parts when dry,( 30-120 cm long, 1.8 cm wide), containing about 20 seeds embedded in the pith. The pod is tapering at both ends, nine (9) ribbed; seeds are dark brown, with 3 papery wings (James, 1983).
3. **Ecology and Cultivation:** *M. oleifera* is strictly a tropical plant and grows well at lower elevations, both under wet and seasonal conditions, but can be found up to 1300m altitude. It can be grown in various

soils but thrives best in fertile, well-drained sandy loams. In India the plant is propagated by planting limb cutting 1-2 m long, from june to August, preferably. The plant starts bearing pods 6-8 months after planting but regular bearing commence after the second year. The tree bears for several years. The plant thrives best on forest zone ranging from subtropical dry to moist through tropical very dry to moist forest life zones. *M. oleifera* reported to tolerate annual precipitation of 4.8 to 40.3 dm, annual temperature of 18.7 to 28.5°C and pH of 4.5 to 8. The plant thrives in subtropical and tropical climates, flowering and fruiting freely and continuously grows best on a dry sandy soil and is Drought resistant. *M. oleifera* is easily cultivated by cutting or by seeds. Seeds can be sown either directly or in containers. No seed pretreatment is required and seeds sprout readily in 1-2 weeks. Plants raised from seed produce fruit of unpredictable quality. Shield budding is successful, and budded trees begin to bear in 6 months and continue to give a good crop for 13 years. As it is essentially a vegetative propagation crop, breeding methods like single-plant selection, mass selection and exploitation and maintenance of vigour are transgressive. Stem cuttings are usually preferred because they root easily. When grown for its roots, seeds are sometimes planted in row like vegetable. (James, 1983).

4. **Tradition uses:** Traditionally, the plant is used as antispasmodic, stimulant, expectorant and diuretic. Fresh root is acrid and vesicant (has the taste of horse-radish). Internally it is used as stimulant, diuretic and antilithic. Its gum is bland and mucilaginous. The seed are acrid and serves as stimulant. The bark is emmenogogue, abortifacient, antifungal and antibacterial. Its flowers are claimed to becholagogue, stimulant, tonic and diuretic and useful to increase the flow of bile. The plant is also used as cardiac circulatory tonic and antiseptic. The pods are believed to be antipyretic, anthelmintic; fired or pods are used in diabetes. The root juice is employed as cardiac tonic, antiepileptic, used for nervous debility, asthma, enlarged liver, spleen. Almost every part of plant is of value for food. Seed is said to be eaten like a peanut in Malaya. The foliage is eaten as greens, in salads, in vegetable curries, as pickles and for seasoning. The leaves are pounded up and used for scrubbing utensils and for cleaning walls. Seeds yield 38-40% of non-drying oil, known as Ben oil, used in arts and for lubricating watches and other delicate machinery. The oil is clear, sweet and odorless, never becoming rancid; consequently it is edible and useful in the manufacture of perfumes and hairdressings. *M. oleifera* wood yield blue dye. Leaves and young branches are relished by livestock. The *Moringa* is commonly planted in Africa as a living fence (Hausa) tree. Trees planted on graves and are believed to keep away hyenas and its branches are used as charms against witchcraft. Bark can serve for tanniang; it also yields a coarse fibre (Hartwell, 1967).
5. **Nutrition**: *Moringa* trees have been used to combat malnutrition, especially among infants and nursing mothers. Three non-governmental organizations in particular- Trees for Life, Church World Service and Educational Concerns for Hunger Organization have advocated *Moringa* as "natural nutrition for the tropics." Leaves can be eaten fresh, cooked, or stored as dried powder for many months without refrigeration, and reportedly without loss of nutritional value. *Moringa* is especially promising as a food source in the tropics because the tree is in full leaf at the end of the dry season when other foods are typically scarce.

   A large number of reports on the nutritional qualities of *Moringa* now exist in both the scientific and the popular literature. Any readers who are familiar with *Moringa* will recognize the oft-reproduced characterization made many years ago by the Trees for Life organization, that "ounce-for-ounce, *Moringa* leaves contain more Vitamin A than carrots, more calcium than milk, more iron than spinach, more Vitamin C than oranges, and more potassium than bananas," and that the protein quality of *Moringa* leaves rivals that of milk and eggs. These readers will also recognize the oral histories recorded by Lowell Fuglie in Senegal and throughout West Africa, who reports (and has extensively documented on video) countless instances of lifesaving nutritional rescue that are attributed to *Moringa* (Fuglie, 1999, 2000). In fact, the nutritional properties of *Moringa* are now so well known that there seems to be little doubt of the substantial health benefit to be realized by consumption of *Moringa* leaf powder in

situations where starvation is imminent. Nonetheless, the outcomes of well controlled and well documented clinical studies are still clearly of great value.

In many cultures throughout the tropics, different-tiation between food and medicinal uses of plants (e.g. bark, fruit, leaves, nuts, seeds, tubers, roots, flowers), is very difficult since plant uses span both categories and this is deeply ingrained in the traditions and the fabric of the community (Lockett *et al.*, 2000).

6. **Phytochemistry:** Phytochemicals are, in the strictest sense of the word, chemicals produced by plants. Commonly, though, the word refers to only those chemicals which may have an impact on health, or on flavor, texture, smell, or color of the plants, but are not required by humans as essential nutrients. An examination of the phytochemicals of *Moringa* species affords the opportunity to examine a range of fairly unique compounds. In particular, this plant family is rich in compounds containing the simple sugar, rhamnose, and it is rich in a fairly unique group of compounds called glucosinolates and isothiocyanates (Fahey *et al.*, 2001; Bennet *et al.*, 2003). For example, specific components of *Moringa* preparations that have been reported to have hypo-tensive, anticancer, and antibacterial activity include 4-(4'-O-acetyl-α-L-rhamnopyranosyloxy)benzyl isothiocy-anate **[1],** 4-(α-L-rhamnopyranosyloxy)benzyl isothiocy-anate **[2],** niazimicin **[3]**, pterygospermin **[4],** benzyl isothiocyanate **[5],** and 4-(α-L-rhamnopyranosyloxy) benzyl glucosinolate **[6].** While these compounds are relatively unique to the *Moringa* family, it is also rich in a number of vitamins and minerals as well as other more commonly recognized phytochemicals such as the carotenoids (including β-carotene or pro-vitamin A). These attributes are all discussed extensively by Lowell Fuglie (1999) and others, and will be the subject of a future review in this series (Fig.2).

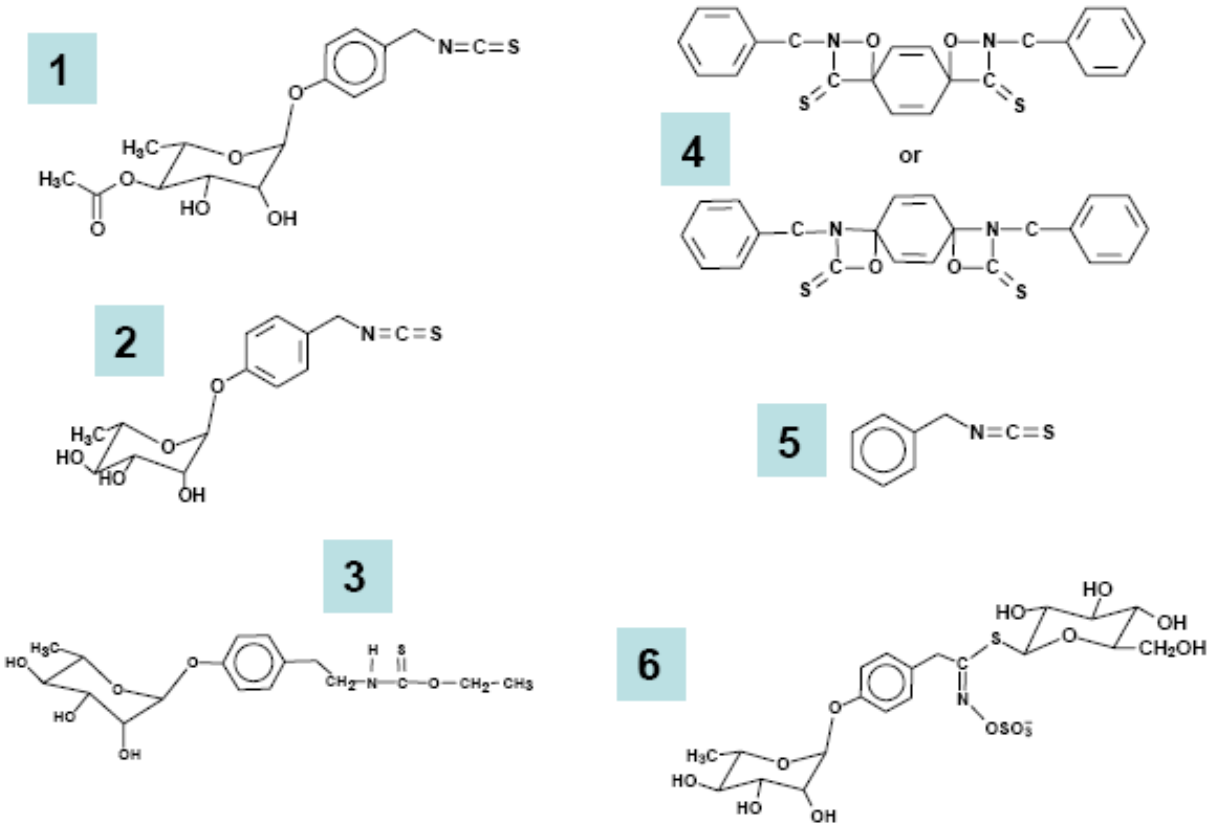


**Fig.2:** Structures of selected phytochemicals from *Moringa* spp.: 4-(4'-*O*-acetyl-α-L-rhamnopyranosyloxy)benzyl isothiocyanate **[1]**, 4-(-L-rhamnopyranosyloxy)benzyl isothiocyanate **[2]**,

niazimicin **[3]**, pterygospermin **[4]**, benzyl isothiocyanate **[5]**, and 4-(α-L-rhamnopyranosyloxy)benzyl glucosinolate **[6]**

7. **Pharmacological activity:** Many reports described *M. oleifera* as highly potent anti-in Xammatory (Ezeamuzle *et al*., 1996), hepatoprotective (Pari and Kumar, 2002), antihypertensive (Faizi *et al*., 1995) and anti-tumor (Murakami *et al*., 1998). Also, its seed has strong coagulative and antimicrobial properties (Eilert *et al*., 1981). The seed oil has physical and chemical properties equivalent to that of olive oil and contains a large quantity of tocopherols (Tsaknis *et al*., 1999). The leaf extracts in rats were found to regulate thyroid status and cholesterol levels (Tahiliani and Kar, 2000; Ghasi *et al*., 2000). In recent years, many people in Taiwan or China have been using the seed of *Moringa* as an herbal medicine to treat athlete's foot and tinea and found that it is Vective. For the Wrst time, in this communication we provide the evidence that extracts of *M. oleifera* have anti-fungal properties.

   *M. oleifera* is a highly valued plant, distributed in many countries of the tropics and subtropics. It has an impressive range of medicinal uses with high nutrition value. Different parts of this plant contain a profile of important minerals, and are a good source of protein, vitamin, B carotene, amino acids, and various phenolics. In addition to its compelling water purifying powers and high nutritional value, *M. oleifera* is very important for its medicinal value. Various part of this plant such as the leaves, roots, seed, bark, fruit, flowers and immature pods acts as cardiac and circulatory stimulants, possess antitumor, antipyretic, antiepileptic, anti-inflammatory, antiulcer, antispasmodic, diuretic, antihypertensive, cholesterol lowering, antioxidant, antidiabetic, hepatoprotective, antibacterial and antifungal activities. They are being employed for the treatment of different ailments in the traditional system of medicine. This research work will focus on the detailed phytochemical composition, medicinal uses, along with pharmacological properties of different parts of this multipurpose tree.

7.1 **Antimicrobial Activity:** The antimicrobial activities of *Moringa oleifera* leaves, roots, barks and seeds were investigated in vitro against bacteria, yeast, dermatophytes and helminthes pathogenic to man. By a disk-diffusion method, it was demonstrated that the fresh leaf juice and aqueous extract from the seeds inhibit the growth of *Pseudomonas aeruginosa* and *staphylococcus aureus* and that extraction temperatures above 56°C inhibit this activity. No activity was demonstrated against four other pathogenic gram positive and gram negative bacteria and *Candida albicans*. By a dilution method, no activity was demonstrated against six pathogenic dermatophytes (Caceres *et al*., 1991).

   Antibacterial effect of aqueous and ethanolic extracts of seeds of *Moringa oleiferain* the concentration of 1.5 unit and 1.10 unit in volumes 50, 100, 150 and 200 µl were examined against *Staphylococcus aureus*, *vibrio cholerea*, *Escherichia coli* (isolated from the organism and the aquatic environment) and *Salmonella enteritidis*. Antibacterial activity (inhibition halo> 13mm) against *S. aureus*, *V. cholera* and *E. coli* isolated from the white leg shrimp, *Litopenaeous vannmaei*, was detected in aqueous and ethanolic extract of moringa. *E. coli* isolated from tilapia fish and *Oreochrom isniloticus*, were sensitive to the ethanolic extract of *M. oleifera*.

   Bacteria are listed at first position among the microorganisms causing opportunistic diseases (Kone *et al.*, 2004). Innumerable antibacterial agents are currently employed in treating bacterial infections. However, the widespread and indiscriminate use of antibacterial agents resulted in development of drug resistance among many virulently pathogenic bacterial species (Berkowitz, 1995). Many of the currently used antibacterials are associated with adverse effects such as toxicity, hypersensitivity, immunosuppression, and tissue residues posing public health hazard. Further, the newer broad spectrum antibiotics are cost prohibitive and are not within the reach of poor Indian farmer. These disadvantages undermine the therapeutic utility of the currently available antibacterials and thus necessitating the need for finding alternative remedies for treatment of bacterial diseases. As the global scenario is now changing towards the use of non- toxic and eco-friendly products, development of modern drugs from traditional medicinal plants should be emphasized for the control of various human and animal diseases. *M. oleifera* is one such plant which is reported to possess several medicinal properties. The different parts of this plant viz.

leaves, stem bark, root bark, flowers, fruits and seeds are used in the indigenous systems of medicine for the treatment of variety of human ailments (Chopra *et al.,* 1956; Nadkarni, 1976). During recent years considerable work has been done to investigate the pharmacological actions of the leaves and seeds of *M. oleifera* on scientific lines but only limited work has been reported so far on antibacterial activity of *M. oleifera* root bark though it is reported to possess varied medicinal properties. Therefore, it was considered worthy to investigate the antibacterial activity of *M. oleifera* root bark. Bark used to cure Dental Caries/Toothache, Common cold, External Sores/Ulcer, Anti-Tumor, Snakebite, Scorpion bite, Digestive, Headache, Antinutrietional factors and Scurvy (Fahey, 2005).

The *Moringa* plant has been the object of much research due to its multiple uses and well-known bactericidal potential (Suarez *et al.,* 2003; Ghebremichael *et al.,* 2005). Medicinal plants are an important element of indigenous medical systems that has persisted in developing countries. The plant kingdom was estimated to produce over 500,000 natural products and about 40 to 80 thousand per plant species (Bhatt, 1995). Recently, the use of traditional medicine based on plants has received considerable interest (Han *et al.,* 2002). There are national and indigenous rights over plant derived resources. Basic scientific investigations based on medicinal plants and indigenous medical systems have increased. It has been estimated that 1 to 10% of the large diversity of 250,000 to 500,000 plant species on the Earth have been studied chemically and pharmacologically for their medicinal properties (Farnsworth, 1991; Verpoorte, 2000). Recently a new benefit of *Moringa* was suggested: the leaves seem to contain a substance that stimulates plant growth and increases crop production.

7.2 **Anti-inflammatory Activity:** In most cases, inflammation is the body's response to another process rather than a disease or illness in its own right. Inflammation is a result of the body's own natural immune response and is usually caused by the increased presence of plasma white blood cells in the affected area. This response involves the vascular systems as well as the autoimmune response and is a necessary part of the healing process, but can cause serious problems when the inflammation becomes chronic or is extreme in its duration or extent. Inflammation is usually categorized as either acute or chronic and treatment for the condition is dependent in the part on the cause of the inflammation and its and its acute or chronic status.

7.3 **Anticancer Activity:** *M. oleifera* has other characteristic which make it a good compliment to a cancer prevention or treatment plan. It contains an enormous amount of nutritional content; *M. oleifera* contains vitamins, minerals, and amino acids which are critical for good health. It is loaded with calcium, iron, potassium, protein, vitamin A and C, and as many more properties which promote a healthy body that has the tools to fight cancer. It is known to have anti-inflammatory, anti-viral, antioxidant, anti-allergenic and pain relief uses. It has also been put to use to fight a variety of infections.

7.4 **Antidiabetes activity:** Diabetes is a disease that is characterized by problems involving the hormone insulin. In healthy people, the pancreas releases insulin; insulin then works to help the body use and store the fat and sugar that is derived from the food that people eat. With diabetes, insulin can be compromised in a couple of different ways. In some cases, the pancreas doesn't produce any insulin at all. Other times, the body does not react in the right way to insulin- this is known as "insulin resistance". Finally, diabetes is sometimes characterized by a pancreas that product an insufficient volume of insulin. As with any disease or condition, doctor and researcher are constantly seeking new ways to treat and manage diabetes. *M. oleifera* is used to treat and manage the symptoms of diabetes for years.

7.5 **Anticholesterol Activity:** Cholesterol is a necessary element in building and repairing cells within the body. There are two basic types of cholesterol. Low-density and high-density lipoproteins, known as LDLs and HDLs respectively, play very different roles in maintaining physical health. HDLs help to eliminate fatty deposit from the bloodstream, enhancing cardiovascular health and promoting healthy veins and arteries. The forms of cholesterol are typically denser and more compact than their low-density counterparts. LDLs are better known as bad cholesterol and have nearly the opposite effect on the body causing lipid deposits to form in blood vessels and contributing to heart disease, stroke and other

cardiovascular disease. White blood cells in the bloodstream attack LDL buildups, causing inflammation and worsening blockages caused by this form of cholesterol. *Moringa* leaf extract contains powerful diuretic medicine that can reduce the level of bad cholesterol in the blood and to help the body flush these harmful substances more quickly and easily.

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.

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. 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. Dried or fresh leaves are also used in foods such as soups and porridges (Lockett *et al.,* 2000), curry gravy and in noodles, rice or wheat (Abilgos *et al.,* 1999). Farmers have added the leaves to animal feed to maintain a healthy livestock (Sarwatt *et al*., 2002; Fahey, 2005; Sancheza *et al.,* 2006) while utilizing the manure and vegetable compost for crop growth (Fahey, 2005). Newer applications include the use of *Moringa* powder as a fish food in aquacultural systems (Dongmeza *et al.,* 2006). In the West, one of the best known uses for *Moringa* is the use of powdered seeds to flocculate contaminants and purify drinking water (Berger *et al.,* 1984; Gassenschmidt *et al.,* 1995; Olsen, 1987) but the seeds are also eaten green, roasted, powdered and steeped for tea or used in curries (Gassenschmidt *et al.,* 1995).

*Moringa* leaves are used as feed for cattle, pigs and poultry. When *Moringa* leaves constituted 40 to 50% of feed, it was found in research studies that milk yields for dairy cows and daily weight gains for beef cattle increased by 30%. The birth weight of calves increased by 3 to 5 kg Some animals, such as chickens will not voluntarily consume *Moringa* leaves or *Moringa* leaf powder (Price, 2000).

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 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.

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 litre 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 nontoxic 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. 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.

*Moringa* could be used as green compost. The juice from the fresh leaves can be used to produce an effective plant growth hormone (Price, 2000; Foidl *et al.,* 2001). This hormone increases the yield by 25 – 30 % for nearly any crop including onion, bell pepper, soya, maize, coffee, tea and other plants. The active substance is zeatin; a plant hormone from the cytokinines group, which is available as a spray.

8. **Antimicrobial Peptide:** Antimicrobial peptides have been reported to act directly, and non-specifically, on membranes, which seems to be the reason for the difficulties microbes face in becoming resistant to them. Target microorganisms include: gram positive bacteria, gram negative bacteria, fungi and

enveloped viruses. The membranes of multicellular species are rarely affected by antimicrobial peptides. Antimicrobial peptides probably interact with the membranes in two stages. First, cationic amino acids are attracted by negative charges (e.g. phospholipid headgroups) on the surface. Second, hydrophobic and positively charged patches of the peptide interact with the aliphatic fatty acids and the anionic components respectively. This induces membrane destabilisation, and bacteria are thought to be killed by the leakage of cytoplasmic contents, the loss of membrane potential, the change of membrane permeability, the change of lipid distribution, the entry of the peptide and blocking of anionic cell components or the triggering of autolytic enzymes (Zaseoff, 2002; Koczulla and Bals, 2003). The membrane is the location of many important biochemical processes, which may be disturbed in this way.

In the literature there is a consensus about the requirement of a specific structural property for an antimicrobial peptide to be fully active, but it is rarely specified. There are three models proposed for the membrane destabilisation mechanism (Koczulla and Bals, 2003): 1) In the barrel-stave model the peptides aggregate and form ordered channels which render the membrane leaky (Tossi *et al.*, 2000). 2) The aggregate channel model predicts that unstructured peptide aggregates penetrate the membrane where they form transient pores and enter into the cell plasma (Matsuzaki, 1999). 3) The carpet model hypothesises, that the membrane is covered by the peptide which induces a bending of the membrane and thus induces a breaking and disaggregation (Shai, 1999; Shai, 2002).

The polypeptide "Flo" was isolated by cation exchange chromatography from the seed extract of the tropical tree *M. oleifera* Lam. The extract is traditionally used for water clarification in African countries such as Sudan and Malawi (Eilert *et al.*, 1981). The peptide was found to act as a coagulant and its primary sequence was determined (Tauscher, 1994; Gassenschmidt *et al.*, 1995). Both recombinantly produced and synthetic versions of the peptide have been found to retain the coagulant activity (Broin, *et al.*, 2002, Suarez *et al.*, 2003). In addition it has been found to exert an antibacterial effect on many pathogenic bacterial strains, including antibiotic-resistant isolates of *Staphylococcus*, *Streptococcus* and *Legionella* species (Suarez *et al.*, 2003).

Antibacterial peptides are structurally highly divergent with a typical size of 12-45 amino acids. They can be classified as amphipathic α-helices, disulfide bond stabilised β-sheet structures, peptides with predominant amino acids or peptides with loop structures (Koczulla and Bals, 2003). In plants, antimicrobial peptides have been known for a long time and are classified into different families (Broekaert *et al.*, 1997; Schorder, 1999). Flo cannot be clearly associated with any one of the proposed classes.

Flo has sequence similarities to the larger B chain of 2S albumin seed proteins such as napins and mabilins. We used the 3-dimensional structure of a napin, as determined by NMR (Rico *et al.*, 1996), to design a homology based, bioinformatical model of Flo. The putative structure represents three α-helices linked by two loop regions (Fig. 3). The existence of three α-helical regions has been confirmed by secondary structure prediction. These predictions could not be supported by circular dichroism analysis of Flo in aqueous solution, where the peptide seemed to adopt a random coil structure. However the presence of artificial membranes induced a shift of the spectrum to a more α-helical conformation. Induced structuring is also reported for other α-helical antimicrobial peptides (Giangaspero, 2001).

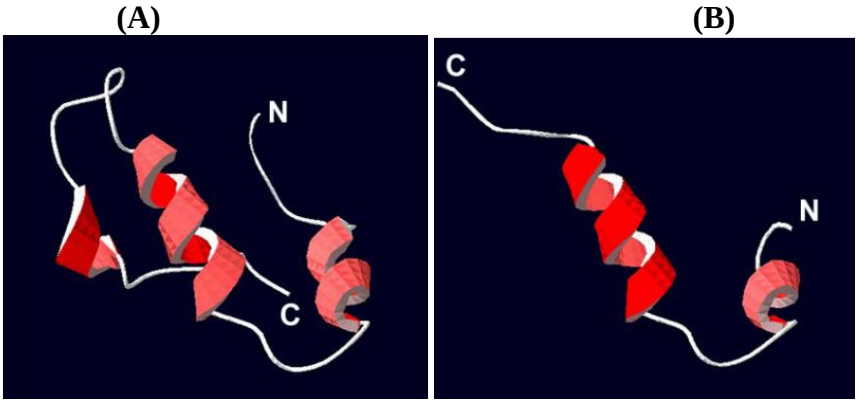


**Fig.3: 3-dimensional bioinformatical model based on the NMR structure of napin, a homologous 2S-albumin. (in red: α-helices)** A) Polypetide Flo, B) Sub fragment p4

## CONCLUSION

In the last few years various studies has been done for its antimicrobial activity from the extract made using chloroform, ethanol. The ethanolic extract of *M. oleifera* leaves has been demonstrated to exhibit anthelmintic activity against Indian earthworm (Rastogi *et al.*, 2011), antifungal activity against dermatophytes (Chuang *et al.*, 2007), antifertility (Prakash, 1998; Shukla *et al.*, 1981) and hypoglycemic potential (Jaiswal *et al.*, 2009). A study on evaluation of *M. oleifera* leaves extract on ovariectomy induced bone loss in rats records that the ethanolic extract of *M. olifera* leaves possess osteoprotective effect comparable with estradiol (Burali *et al.*, 2010) and has been reported to reduce cyclophosphamide induced immunodepression by stimulating cellular and humoral immunity in mice (Gupta *et al.*, 2010; Siddarth and Gupta, 2007). The aqueous extract of *M oleifera* leaves have been demonstrated to exhibit protective effect on ulcerated gastric tissue induced by aspirin, cerebral nodular lesion and cold stress in rats (Patel *et al.*, 2008), wound healing property in rats (Makkar and Becker, 1996) significant hypoglycemic and antidiabetic potential (Jaiswal *et al.*, 2009), antifertility activity (Prakash, 1998; Shukla *et al.*, 1981) and the regulatory control on thyroid hormone status in adult Swiss rats (Rathi *et al.*, 2006).

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