Journal of Medicinal Plants Research Vol. 6(48), pp. 5831-5839, 17 December, 2012
Available online at http://www.academicjournals.org/JMPR
DOI:10.5897/JMPR12.1187
ISSN 1996-0875 ©2011 Academic Journals

Review

An overview of the medicinal importance of Moringaceae

Berushka Padayachee and Himansu Baijnath*

School of Life Sciences, University of KwaZulu-Natal, Private Bag X 54001, Durban, South Africa.

Accepted 18 October, 2012

Moringa is a small genus comprising 13 species of trees and shrubs distributed in Africa and Asia. Moringa species have a broad variety of uses in medicine, food, cosmetics and oil production. Various parts possess many medicinal uses, pharmacological activities and provide sources of numerous medicinal compounds. Moringa oleifera is the best known and most widely distributed species in the genus and is the most popular and promising due to its multifarious beneficial uses. Over the past two decades, many reports have appeared in mainstream scientific journals documenting the nutritional and medicinal properties of this species. Organizations have also promoted and advocated M. oleifera as a "miracle tree" and as a result it has gained growing international interest. However, the Moringa genus includes 12 other species that have not yet been fully explored and recognized even though they have shown great potential and diversity as medicinal plants. Although, M. oleifera holds much promise in contributing to medicine and in alleviating malnutrition around the world; a genus of more potentially valuable and beneficial species remain almost unexamined and deserve further research into their uses. There is a large wealth of indigenous knowledge about the medicinal properties of the family, but further scientific investigation is warranted to confirm the indications of traditional practices. This review will present a compilation of available literature on the traditional medicinal uses, pharmacology and phytochemistry of all 13 species of the family and will highlight the importance of protecting these threatened species.

Key words: Moringaceae, *Moringa oleifera*, traditional medicine, pharmacology, phytochemistry.

INTRODUCTION

Moringaceae, a monogeneric family, with the single genus *Moringa* is characterized by 13 species of dicotyledonous tropical and sub-tropical flowering trees. Almost all *Moringa* species appear to have originated in India and Africa, but have since been introduced into several countries of the tropics (Amaglo, 2010). These countries include Madagascar, Namibia, South West Angola, Kenya, Ethiopia, Red Sea, Horn of Africa, India, Pakistan, Bangladesh and Afghanistan in the Northwestern region of the Himalayans (Fahey, 2005). *Moringa oleifera* commonly called the "horse-radish tree", is the most well known and widely naturalized of the 13 species and is a native of the sub-Himalayan tracts of northwestern India. It has now become widely known as a multi-purpose tree as it is grown for its nutritious pods, edible leaves and flowers and provides many beneficial properties including its use as a source of food, medicine, cosmetic oil, forage for livestock and water coagulant (Paliwal et al., 2011).

There is an explosion of published literature documented on the many applications of *M. oleifera* in food, medicine and water purification and it has gained much recognition because of its world-wide status as a "miracle tree" and a multi-purpose crop. It is also regarded as a life saving resource, worthy of intensive and widespread development. However, *M. oleifera* represents only 7% of a genus of which the rest of the gene pool remains unexplored and underutilized. Researchers have focused mainly on the nutritive values and vast medicinal properties of *M. oleifera*; hence, there is very little documentation or research done on the significance of the other species within the genus, which are equally as important and valuable. *Moringa* spp. are one of the

*Corresponding author. E-mail: baijnathh@ukzn.ac.za. Tel: +27 31 260 7464. Fax: +27 31 260 7809.

most useful tropical trees with a multiple array of uses. All plant parts of this genus are used in the indigenous systems of human medicine for the treatment of a variety of ailments. *Moringa* spp. are rich sources of various phytochemical compounds including glucosinolates; however, there are only detailed profiles for *M. oleifera*, *Moringa peregrina* and *Moringa stenopetala* (Amaglo et al., 2010). Furthermore, the pharmaceutical properties of the parts of the species have different pharmacological actions and as well as toxicity profiles, which have not yet been completely examined (Chinmoy, 2007). There is still a great need for further scientific examination of the less utilized species in the genus which could potentially represent a valuable commodity, both in food and medicine.

Thus far, no comprehensive review has been compiled from the literature documenting the medicinal importance of all species of the family Moringaceae. Information in this regard is still lacking. The versatile utility of *M. oleifera* as a medicine, functional food source, nutraceutical and water purifying agent extends to other important and unrecognized species in the family. Thus, the need for extensive documentation and focused research on the family as a whole and not only on *M. oleifera* has motivated us to bridge the information gap in this area, and to present a comprehensive review on the medicinal, pharmacological and phytochemical properties of the lesser known species in the family Moringaceae; *M. peregrina, Moringa concanensis, Moringa rivae, Moringa arborea, Moringa borziana, Moringa pygmaea, Moringa ruspoliana*, *Moringa hildebrandtii, M. stenopetala, Moringa ovalifolia, Moringa drouhardii* and *Moringa longituba* (Table 1).

MEDICINAL, PHARMACOLOGICAL AND PHYTOCHEMICAL PROPERTIES OF MORINGACEAE

M. peregrine

M. peregrina has a wide geographic range, growing from the Dead Sea area along the Red Sea to Northern Somalia and around the Arabian Peninsula to the mouth of the Arabian Gulf. It is an extremely fast growing tree or shrub that commonly reaches about 3 to 10 m in height just 10 months after the seed is planted (Abd El-Wahab, 1995). It has a grayish-green bark, long, alternate leaves, and yellowish white to pink, showy, fragrant flowers (Boulos, 2000). The fruits are elongate capsules, with a beak, glabrous and slightly narrowed between the seeds. The seeds are globose to ovoid or trigonous. *M. peregrina* usually inhabits crevices and the rocky slopes of mountains. *M. peregrina* is one of the most economically important and valuable medicinal plants in the Egyptian desert. However, its existence is threatened by over-grazing, uprooting and disturbance through unmanaged human activities (Zaghloul et al., 2010). It is used extensively for its medicinal value. It is used to treat headaches, fevers constipation, burns, abdominal pains, back and muscle pains and labor pains (Boulos, 2000). An infusion of the leaves and roots in water is used to treat malaria, stomach disorders, hypertension, asthma and diabetes (Mekonnen et al., 1999). The young leaves are also used traditionally in folk medicine as an anti-oxidant and wound healer (Nawash and Al-Horani, 2011). The seeds have different economic and medicinal importance due to its composition of oil which can also be used to treat abdominal pain (Van der Vossen, 2007). The seeds are also used as medicine in the Middle East and Sudan and the leaves can be described as "phytoactive" (Duke, 1983).

Elbatran et al. (2005) investigated the phytochemical and pharmacological properties of *M. peregrina* and determined the presence of four flavonoidal compounds; quercetin, quercetin-3-*0*-rutinoside (rutin), chrysoeriol-7-0-rhamnoside and 6,8,3,5-tetramethoxy apigenin. The compounds displayed anti-inflammatory activities by significantly inhibiting carrageenan-induced rat paw oedema and they also exhibited marked analgesic properties. In addition, *M. peregrina* inhibited the development of gastric lesion in rats (Elbatran et al., 2005). Investigations into the ethanolic fractions of aerial parts of *M. peregrina* yielded several compounds which showed potent cytotoxic activity against colon cancer cells (HCT116) and breast cancer cells (MCF-7) comparable to that of doxocrubicin, a known anti-cancer drug. Both aqueous and ethanolic extracts of *M. peregrina* showed anti-hyperglycemic effects on streptozitocin-induced diabetes in rats by causing a significant decrease in blood glucose levels (El-Alfy et al., 2011).

Abdel-Rahman et al. (2010) reported on the isolation of six constituents from the aerial parts of *M. peregrina*: lupeol acetate, α-amyrin, β-amyrin, sitosterol, sitosterol-3-O-D-glucoside and apigenin which displayed anti-bacterial activity. The seed oil displayed significant anti-bacterial activity against *Candida albicans*, *Escherichia coli*, *Enterobacter cloacae*, *Klebsiella pneumoniae* and *Pseudomonas aeruginosa* (Lalas et al., 2012). The seed oil also showed dose-dependent anti-cancer activity by inhibiting the growth of 3 cancer cell lines; breast adenocarcinoma cells (MCF-7), hepatocellular carcinoma (HepG2) and colon carcinoma (HCT-116). The seed oil also showed higher anti-oxidant activity comparable to that of known anti-oxidants, -tocopherol, butylated hydroxyanisole (BHA) and butylated hydroxytoluene (BHT) (El Baky and El-Baroty, 2012). A full chemical characterization of the seed oil showed high levels of oleic and gadoleic acids, while the dominant saturated acids were palmitic acid and stearic acid. β-sitosterol was found as the most predominant component of the sterolic fraction of the oil and campesterol, stigmasterol and brassicasterol were also found. α-, γ- and δ- tocopherols, which are natural anti-oxidants were also detected (Tsaknis, 1998). Hence, the seed oil of *M. peregrina* provides a significant source of anti-oxidant and anti-proliferative compounds which are necessary for the promotion

Table 1. Overview of the distribution, growth forms, and various uses of 13 species of Moringaceae.

Moringa species	Growth form	Geographical distribution	Traditional practice	Use
M. peregrina	Shrub or small tree	Israel, Jordan, Saudi Arabia, Yemen, Pakistan, Egypt, Oman, Sudan, Ethiopia, Somali, Syria	Young seeds are eaten like peas and the mature seeds are fried or roasted like ground nuts. Prepared as infusions, tinctures, capsules and creams.	Oil (cooking and cosmetics), medicinal plant, water coagulant, ornamental, building material (Jahn, 1986).
M. oleifera	Tree	India, Bangladesh, Sri Lanka, Pakistan, Senegal, England, Egypt, Afghanistan, China, Nepal, Maldive Islands, Malaysia, Thailand, Vietnam, Indonesia, Phillipines, Papau New Guinea, Australia, Sierra Leone, Ghana, Nigeria, Uganda	Roots are prepared as decoctions; bark is used as decoctions for creams; leaves are commonly dried and crushed into a powder, used in soups and sauces; flowers are used for preparations to enhance taste and colour in dishes; pods are sliced and boiled in water with salt; seeds are prepared green, roasted or powdered, steamed and extracted as an oil.	Food source, water coagulant, oil (cooking and cosmetics), honey clarifier, medicinal plant, fodder, ornamental, firewood (Jahn, 1986).
M. concanensis	Tree	Pakistan, India, Arabia,	No data	Oil (cooking), medicinal plant (Anbazhakan et al., 2007)
M. rivae	Shrubs or trees	Kenya, Ethiopia	No data	Medicinal plant
M. arborea	Shrubs or trees	Kenya	No data	Medicinal plant (Olson, 1999)
M. borziana	Herbs or small shrubs	Somalia, Kenya	No data	Medicinal plant (Neuwinger, 2000)
M. pygmaea	Herbs or small shrub	Somalia	No data	Medicinal plant (Ithaka, 2012).
M. ruspoliana	Tree	Ethiopia, Somalia	No data	Medicinal plant (Odee, 2001)
M. hildebrandtii	Tree	Madagascar	No data	Medicinal plant, ornamental (Olson and Razafimandimbison, 2000).
M. stenopetala	Tree	Kenya, Ethiopia	Bark used for man, goats, sheep or cows as peppery and roborant (strengthening) soups; tender pods are eaten together with the leaves; twigs are picked for feeding goats, sheep or cows. Leaves are also eaten and sold in the markets during the rainy season.	Vegetable, spice, medicinal plant, water coagulant, ornamental, seed oil, lubricant, perfumery and soap production (Jahn, 1986).
M. ovalifolia	Tree	Angola, Namibia	No data	Vegetable, oil (cooking and cosmetics), fodder, ornamental (Jahn, 1986).
M. drouhardii	Tree	Madagascar	No data	Oil (cooking and cosmetics), water coagulant, medicinal plant, ornamental (Jahn, 1986).
M. longituba	Trees or shrubs	Somalia, Kenya, Ethiopia	No data	Water coagulant, medicinal plant (Jahn, 1986).

Species sequence following after Verdcourt (1985).

anti-proliferative compounds which are necessary for the promotion of health and prevention of diseases.

M. peregrina has the potential to become one of the world's most valuable plants due to its broad economical and medicinal importance; however, its existence is currently threatened in its environment due to human activities, hence the protection and conservation of its vulnerable habitat is very much needed.

M. oleifera

M. oleifera is the most well known of the 13 species of trees and shrubs in the genus *Moringa*. It is commonly known by regional names such as drumstick tree, kelor, murungai kaai, saijhan and benzolive; it is a rapidly growing tree that is widely cultivated and has now become naturalized in Afghanistan, Florida and East and West Africa (Paliwal et al., 2011). It ranges in height from 5 to 10 m; has tuberous roots, a whitish bark, soft, spongy wood, a short trunk and slender branches. The leaves are alternate, twice- or thrice-pinnate leaves and spirally arranged. The flowers pleasantly fragrant and 2.5 cm wide are white or cream-colored. The fruits (pod-like capsules) borne singly or in pairs, are light-green, slim, tender, firm and thinly woody. The seeds are spherical, 7 to 8 mm in diameter, with 4 papery wings and are yellow-grey. *M. oleifera* typically grows in semi-dry, desert or tropical soils (Arbonnier, 2004).

For centuries, people all over the world, including traditional healers have utilized different parts of the *Moringa* tree as traditional medicine. The medicinal uses are numerous and have been long recognized in the Ayurvedic and Unani systems of Medicine (Kumar et al., 2010). Scientific studies over the past few decades have substantiated many of the traditional folklore claims of the medicinal uses of *M. oleifera.* Almost all parts of this plant: root, bark, gum, leaf, fruit (pods), flowers, seed and seed oil have been used for treating various ailments such as skin infections, anemia, coughs, diarrhea swelling, headaches, gout, acute rheumatism, hysteria, cholera heart complaints, fevers, respiratory disorders, inflammation, digestive disorders, asthma, intestinal complaints, diabetes and rheumatism in the indigenous system of medicine (Chopra et al., 1994, Fahey, 2005). Specific parts of *M. oleifera* also exert many pharmacological activities such as: anti-cancer (Parvathy and Umamaheshwari, 2007; Masood, 2010); anti-oxidant (Moyo et al., 2012b); anti-inflammatory (Cheenpracha et al., 2010); immunomodulatory (Sudha et al., 2010); anti-diabetic (Jaiswal et al., 2009); anti-fungal (Chuang et al., 2007); anti-bacterial (Moyo et al., 2012a) and hepatoprotective (Buraimoh et al., 2011). The different parts of *M. oleifera* such as the roots, leaves, flowers, fruits and seeds are also known to be good sources of phytochemicals compounds. It is reported to contain alkaloids, flavonoids, carotenoids, tannins, anthraquinones, anthocyanins and proanthocyanidins (Goyal et al., 2007). These phytochemicals contribute to the healing properties of *M. oleifera*. Among the myriad of natural plants that are investigated for their therapeutic properties, and among the Moringaceae family alone, *M. oleifera* is regarded as one of the most important and beneficial because it is both a medicinal and functional food.

M. concanensis

M. concanensis is a small tree that is glabrous except for the young leaves and inflorescences and is widely distributed mainly in Pakistan, India and Arabia. The leaves are bipinnate, 45 cm long and oblong and the pods are linear, 30 to 45 cm long and sharply three-angled. The central trunk is covered with an extremely distinctive layer of very furrowed bark and the flowers have distinctive yellow petals, with red or pink veins (Manzoor et al., 2007). The capsules are straight, triquetrous and slightly constricted between the seeds, which are white or pale yellow and 3-angled (Anbazhakan et al., 2007). *M. concanensis* also emits a horseradish odour which is more intense than that of *M. oleifera* (Gaikwad et al., 2011). *M. concanensis* usually inhabits steep slopes in dense deciduous forests (Olson and Carlquist, 2001).

M. concanensis is widely used in the Ayurveda and Unani systems of medicine for the treatment of several ailments. It has been used for decades by tribal communities in the Nilgiris region in Tamil Nadu as an anti-fertility agent (Ravichandran et al., 2009). The root and root bark is used in traditional medicine to treat paralysis, epilepsy, rheumatism, fainting and abscess (Jayabharathi and Chitra, 2011). The stem bark is used to relieve bloating and the gum is used for headaches and dental problems (Anbazhakan et al., 2007). The leaves are used in the treatment of menstrual pain, constipation, jaundice, diabetes and skin tumours and to reduce cholesterol levels and blood pressure. The flowers are used in the treatment of thyroid problems and leucorrhea (Anbazhakan et al., 2007) and the fruits are used for curing liver and spleen diseases and joint pains (Jayabharathi and Chitra, 2011). The dried seeds are used in ophthalmic preparation and in the treatment of goitre, venereal affection, glycosuria and lipid disorders (Kale et al., 2010). Efforts were also made to formulate sun creams using extracted *M. concanensis* seed oil with an sun protection factor (SPF) value of 1.46 (Kale et al., 2010).

Investigations into the pharmacological activity of ethanolic extracts of the flowers of *M. concanensis* revealed anti-inflammatory activity in carrageenan induced hind paw edema models and also showed significant analgesic and anti-pyretic activity. Preliminary phytochemical screening indicated the presence of alkaloids, flavonoids, carbohydrates and phytosterols, which was suggested to be responsible for the aforementioned

activities (Jayabharathi and Chitra, 2011). Previous literature has also documented the presence of several phytochemical compounds; ascorbic, palmitic, oleic, stearic and linoleic acids in the seeds and fruits of *M. concanensis* (Verma et al., 1976).

Ravichandran et al. (2009) determined the presence of alkaloids, saponins, glycosides, steroids and terpenoids in hydroalcoholic and ethyl acetate extracts in the leaves of *M. concanensis.* The physico-chemical characteristics of the seeds and seed oil of *M. concanensis* was determined by Manzoor *et al.,* (2007) who showed the presence of high levels of oleic acid followed by moderate levels of palmitic, stearic, behenic, and arachidic acids. The high oxidative stability of the seed oil was attributed to the presence of considerably high concentration of α-, γ- and δ-tocopherols. Gaikwad et al. (2011) determined the presence of major compounds; pentadeconic, 11- octadecenoic, eicosanoic, hexadecanoic and docosanoic acids in the seed oil.

M. concanensis has shown great potential and diversity as a medicinal plant and deserves further research into its pharmacology and phytochemistry to validate some of the traditional claims. It also has good potential as a valuable seed crop for its high quality oil.

M. rivae

M. rivae is a small, slender shrub or tree that is found in various parts of Kenya or Southern Ethiopia (Verdcourt, 1985). The leaves are alternate, pinnate and the leaflets are oblong to elliptic and glabrous. The flowers are yellowish or reddish and honey scented and the fruits are 9-ribbed pendulous pods, 30 to 45 cm long, and tomentose when young. The seeds are embedded in the pits of the valves, and are 3 angled, winged, blackish and rounded. *M. rivae* is found in rocky hillsides in tall scrubs (Olson and Carlquist, 2001).

In Sindh in Pakistan, the leaves of *M. rivae* are used to treat weakness of the thigh and calf muscles, and the gum is used for arthritis. The methanolic extract of the plant showed anti-bacterial, anti-fungal, insecticidal and phytotoxic activities (Folk Medicine, 2010). No information on the phytochemistry of *M. rivae* is available.

M. arborea

M. arborea is a shrub or tree that is distributed in Kenya. It is well characterized by its large flowers and seeds and glabrous stems and is closely related to *M. rivae* (Verdcourt, 1985). It grows up to 15 m and has a smooth, grey, slender bark. The flowers are cream, with a pink calyx, in subterminal inflorescences to 15 cm long. *M. arborea* inhabits rocky canyons in low limestone lands (Olson and Carlquist, 2001). The roots of *M. arborea* are used for medicinal purposes by the Kenyans (Olson, 1999). No further information is available on the pharmacological and the phytochemical properties of this plant.

M. borziana

M. borziana is a woody herb or small shrub that is distributed in Kenya and Somalia and grows up to 5 m high. The leaves are pinnate, glabrous and stipitate and the leaflets are pale to yellow green and elliptic to obovate.

The flowers are zygomorphic with yellowish-red and spatulate flowers. The fruits are purplish-brown with waxy bloom and the seeds are 3.8 cm long overall with 3 conspicuous wings (Eggli, 2004). *M. borziana* is usually found in disturbed grasslands or shrub lands (Olson and Carlquist, 2001).

An infusion of the root powder of *M. borziana* mixed with milk has been used in traditional medicine to treat abdominal pain and hemorrhoids (Neuwinger, 2000). There is no reported literature on the phytochemistry or pharmacological effects of this species.

M. pygmaea

M. pygmaea is a delicate, tuberous shrub or herb that is distributed mainly in Somalia. The leaves are pinnate, glabrous with 3 to 4 pairs of pinnae and the leaflets are obovate and yellowish-green. The flowers are yellow or dull purple and receptacle cup-shaped. The flowers are bisexual, borne in axillary panicles and white to yellow or red in colour. The fruits are capsules, ribbed and appear sometimes with an elongated beak and the seeds are 3-winged or wingless without endosperm (Eggli, 2004). *M. pygmaea* occurs mainly in grassy areas, shrubs and hillsides (Olson and Carlquist, 2001). The tubers of *M. pygmaea* are crushed and placed in water containers for livestock to eliminate stomach parasites. It is also used to treat intestine diseases (Ithaka, 2012). There is no literature available on the pharmacological actions or phytochemistry of *M. pygmaea.*

M. ruspoliana

M. ruspoliana is distributed in Ethiopia and Somalia and is easily distinguished by its simple pinnate leaves and large flowers (Verdcourt, 1985). The leaflets are the largest in the family, reaching nearly 15 cm in diameter, and are the thickest and toughest leaflets in the family. The flowers are pink with green bases. It usually inhabits disturbed grassy woodlands on low limestone plateaus (Olson and Carlquist, 2001). *M. ruspoliana* is used in the treatment of various conditions including abdominal pains, eye and throat infections, sexually transmitted diseases in humans, tsetsefly bites and livestock (mainly camels) diseases in the Wajir, Moyale

and Mandera districts of Kenya (Odee, 2001). There is no literature available on the pharmacological actions or isolated compounds of *M. ruspoliana.*

M. hildebrandtii

M. hildebrandtii is a deciduous tree that is endemic to Madagascar and has now become extinct in the wild, but has survived in large numbers through traditional horticultural practices (Olson and Razafimandimbison, 2000). *M. hildebrandtii* can grow up to 25 m high and strongly resembles the baobab trees due to its bloated water-storing trunk. It has tripinnate compound leaves that can be up to a meter long and it has small whitish flowers which are borne in large sprays (Verdcourt, 1985). The fruits are spindle-shaped capsules that are 450 to 650 mm long and constricted between the seeds which is pale brown, ovoid trigonous, edge-winged and35 to 40 mm long (Eggli, 2004). *M. hildebrandtii* occurs in mainly in windbreaks or gardens (Olson and Carlquist, 2001). The pulpy wood has been collected for medicinal use (Olson and Razafimandimbison, 2000). There are no Investigations into the pharmacological actions or phytochemistry of *M. hildebrandtii.*

M. stenopetala

M. stenopetala, indigenous to Northern Kenya and Southern Ethiopia, is of utmost importance to the Ethiopian agricultural community as it is a major drought resistant vegetable plant. It is a small tree, up to 10 m tall with a swollen, bottle shaped trunk, whitish bark and alternate, pinnate leaves with elliptical to ovate leaflets. The bisexual flowers are regular and have free sepals and cream flushed pink petals. The fruits are elongate 3-valved capsules which are 20 to 50 cm long and the seeds are elliptical to trigonous and 6 to 9 cm long with 3 thin wings. *M. stenopetala* usually occurs on rocky ground near permanent water and is also found in both wetlands and dry areas (Bosch, 2004).

It also provides many nutritional benefits and local medicinal value. *M. stenopetala,* although not as valued as *M. oleifera* for its medicinal properties, offers a wide range of traditional medicinal benefits. The bitter-tasting water left over after cooking the leaves is consumed for several medicinal purposes by the traditional communities of Ethiopia. The leaves and roots, mixed with the water are used to treat malaria, hypertension, stomach disorders, asthma and diabetes (Mekonnen et al., 1999). The Konso-speaking natives in Ethiopia consume the leaves to prevent colds and anaemia, and the Gidole and Burji use it for the treatment of digestion problems and dysentery. Further in northern part, both rural and urban communities use the broth of the leaves and the crushed bark to cure malaria. In Arba Minch, the leaves are also used to treat hypertension and diabetes (Jahn, 1991). The bark is used by the Njemp people in Kenya to treat coughs, while the roots are used by the Konso to treat epilepsy (Demeulenaere, 2001). The leaves and roots are also used in many areas of Ethiopia to treat malaria, hypertension, colds, asthma stomach problems and diabetes (Bosch, 2004).

Ethanol extracts of the leaves and roots of *M. stenopetala* have shown anti-fungal activity against *Trypanosoma brucei* and *Leishmania donovani*, while crude seed extracts have shown anti-bacterial activity by strongly inhibiting the growth of *Staphylococcus aureus*, *Salmonella typhi*, *Shigella* species and *Candida albicans* (Bosch, 2004). The aqueous extracts of the leaves showed hypoglycemic effects in non-diabetic rabbits. It was found to exert a dose-dependent decrease in blood glucose concentration, although it was less potent than the anti-diabetic drug glibenclamide (Makonnen et al., 1997). The seeds of *M. stenopetala* also have pharmacological value, as they displayed anti-microbial activity attributed mainly to benzyl isothiocyanate which is an active bactericide and fungicide (Bosch, 2004). Walter et al. (2011) further showed the anti-bacterial activity of hexane and methanol extracts of the seeds against *Salmonella typhi, Vibrio cholerae* and *Escherichia coli*. It was suggested that the extracts of *M. stenopetala* have the potential to be natural anti-microbial agents and can be applied in controlling bacteria that cause water borne diseases. In addition, the essential oils of the seeds displayed significant anti-trypanosomal activity and cytotoxic activity against human promyelocytic leukemia cells (Nibret and Wink, 2010). Eilert et al. (1981) determined the presence of glucosinolates, namely, 4(α-l-rhamnosyloxy) benzyl isothiocyanate in the seeds of *M. stenopetala*. These compounds exert many biological activities, especially anti-cancer activity due to their ability to kill cancer cells by inducing apoptosis, depleting the co-enzyme, adenosine triphosphate and leading the cells to oxidative stress (Nibret and Wink, 2010). Bennett et al. (2003) analyzed the major secondary metabolites in the tissues of *M. stenopetala* and determined the presence of low amounts of 4-monoacetyl-4-(R-L-rhamnopyranosyloxy)-benzylglucosinolate isomers, but significant amounts of 4-(R-L-rhamnopyranosyloxy)-benzylglucosinolate and benzylglucosinolate in the stem tissue. The root tissues contained both 4-(R-L-rhamnopyranosyloxy)-benzylglucosinolate and benzylglucosinolate. The leaves of *M. stenopetala* contained quercetin 3-*O*-rhamnosylglucoside (rutin) and traces of quercetin 3-*O*-glucoside (Bennett et al., 2003)

The raw leaves of *M. stenopetala* are also known to contain isothiocyanates (cyanogenic glucosides), which is a known goitrogenic factor that can be detrimental to humans. Previous studies conducted in Ethiopia have shown a significant correlation between the prevalence of goitre and the frequency of consumption of the leaves. Abuye et al. (2003) determined the presence of cyanogenic

glucosides in the raw leaves (88.8 mg/100 g) and cooked leaves (79 mg/100 g) of *M. stenopetala* and suggested that although these concentrations are less than what is expected to cause goiter; significant and frequent consumption of the leaves may exacerbate hypothyroidism since it is widely grown and consumed by populations living in areas of incidence of endemic goitre.

M. stenopetala is a promising tree for nutrition, water purification and herbal medicine and it has many beneficial qualities, similar to those found in *M. oleifera.* There is however, still a great need for further detailed chemical and pharmacological evaluation of *M. stenopetala.* In the future, this tree could have the potential to surpass *M. oleifera* as an important multi-purpose crop.

M. ovalifolia

M. ovalifolia is an erect, deciduous tree that grows up to 7 m high and is distributed from Central Southern Namibia to Southwestern Angola. It has a smooth, resinous bark and alternately arranged compound leaves with leaflets that grow up to 25 mm long. The white flowers are borne in branched axillary sprays with 4 to 5 petals and the three-angled pendulous pods are brown and 400 mm long. *M. ovalifolia* occurs mainly in desert or arid savannah vegetation and in rocky hillsides (Olson and Carlquist, 2001). *M. ovalifolia* is a poorly known species and little is documented about its medicinal, pharmacological and phytochemical properties.

M. drouhardii

M. drouhardii is a small, deciduous tree (10 to 18 m tall) that is endemic to the Toliara province in South-Western Madagascar where it occurs wild and planted. It has a swollen bole, short branches, a whitish bark containing resin and alternate, 3-pinnate leaves. The flowers are bisexual, regular and ovate with yellowish-white petals. The fruits are elongate capsules, 30 to 50 cm long, trigonous, with a beak and glabrous and the seeds are trigonous to ovoid and whitish in appearance and do not have wings. *M. drouhardii* naturally inhabits scrubs on exposed rocky limestones or densely vegetated slopes (Olson and Carlquist, 2001; Van der Vossen, 2007).

The oil of the seeds of *M. drouhardii* has excellent qualities in medicinal products and is used as medicinal massage oil. The wood and scented bark are used for the treatment of coughs and colds. The pulpy wood has been collected for medicinal use (Olson and Razafimandimbison, 2000). The highest amount of poly-unsaturates found in the *Moringa* spp. occurs in the seed oil of *M. drouhardii* with 3.6% (Kleiman et al., 2008). The methanolic and aqueous extracts of the seeds showed anti-oxidant activity which was attributed to known anti-oxidants phenols and ascorbate (Yang et al., 2006). The ability of *M. drouhardii* to adapt easily to very dry conditions and the use of its seed oil in cosmetic and medicinal applications warrant further research efforts into the possibility of domestication and utilization in small-scale industries (Munyanziza, 2007).

M. longituba

M. longituba is a shrub or subshrub that grows in Northeastern Kenya, Southeastern Ethiopia, and much of Somalia. It is 2 to 6 m tall and has a smooth, pale grey bark. The leaves are 2- to 3- pinnate, young densely pubescent and later glabrescent and the leaflets are oblong, elliptic or obovate. The flowers are bilateral and symmetrical with a long tubular hypanthium and have pale rose to bright pink petals. The fruits are purple-brown with bloom and the seeds are 2 to 3 cm long and have wings (Eggli, 2004). *M. longituba* inhabits low hillsides in dry scrub on rocky soil or wooded grasslands on deep soil (Olson and Carlquist, 2001). *M. longituba* is used in traditional medicine, particularly for treating intestinal disorders of camels and goats, for which the root is given internally.

It is also used in the treatment of various conditions including abdominal pains, eye and throat infections, sexually transmitted diseases in humans, tsetsefly bites and other livestock (mainly camels) diseases in the Wajir, Moyale and Mandera districts of Kenya (Odee, 2001). There is no reported literature documenting the pharmacological value and phytochemical constituents of *M. longituba.*

CONCLUSION

Moringaceae comprises a large genus of many species in its different growth forms that are widely distributed, but less utilized. Some of these species grow in rural parts of the tropics, but are not fully explored for their many properties including their medicinal and pharmacological value, and are also not fully acknowledged by the World Health Organization. *M. oleifera* is the most well known of the genus and is given wide recognition and acknowledgment for its multi-purpose use in medicine, nutrition, water purification, the environment and in socio-economic applications. However, more effort should be given to *M. oleifera* to be exploited as a food plant with medicinal value. *Moringa*-based food and medicinal products could be manufactured and exported to other parts of the world where it does not grow and can be commercialized.

There is also tremendous potential for widespread recognition of the other 12 species in the genus *Moringa* that are equally as important and valuable. Further breeding programs as well as scientific research initiatives should be undertaken for the lesser known plant species that have great potential from a nutritional and medicinal

point of view. *M. peregrina, M. concanensis, M. stenopetala, M. ovalifolia* and *M. drouhardii* as outlined in this review are some of the less common species that have shown enormous potential for utilization in various aspects such as in nutrition, medicine, cosmetics and water coagulation. *M. rivae*, *M. arborea*, *M. borziana*, *M. pygmaea*, *M. ruspoliana*, *M. hildebrandtii* and *M. longituba* also possess great diversity as medicinal plants. If the true potential of these species can be capitalized on, it would be of great benefit to the rural communities in many parts of the world who rely heavily on indigenous plants to sustain their livelihoods. The main challenges that face these communities such as water sanitation, food resources and nutrition and lack of medicine can then be addressed. The lesser known of the 13 species in the family Moringaceae are also the most genetically vulnerable in their respective habitats due to a number of factors, ranging from unsustainable exploitation and destruction by wildlife to persistent drought. Further research and development is critically needed for *Moringa* species and it should be focused mainly on the conservation of genetic resources, breeding programmes and intensive scientific studies. Efforts need to be expanded in this regard so that these valuable species do not go unnoticed and receive the attention they so rightfully deserve. If the genus that consists of more potentially beneficial species can be further explored and evaluated for its various properties, it can contribute to the conservation and appreciation of a natural resource.

REFERENCES

Abd El-Wahab RH (1995). Reproduction Ecology of Wild Trees and Shrubs in Southern Sinai, Egypt. Masters dissertation, Suez Canal University, Ismailia, Egypt.

Abdel-Rahman Tahany MA, Hegazy AK, Sayed AM, Kabiel HF, El-Alfy T, El-Komy SM (2010). Study on combined antimicrobial activity of some biologically active constituents from wild *Moringa peregrina* Forssk. J. Yeast Fungal Res. 1(1):015-024.

Abuye C, Urga K, Knapp H, Selmar K, Omwega AM, Imungi JK, Winterhalter P (2003). A compositional study of *Moringa stenopetala* leaves. East Afr. Med. J. 80(5):247–250.

Amaglo NK, Bennett RN, Lo Curto RB, Rosa EAS, Lo Turco V (2010). Profiling selected phytochemicals and nutrients in different tissues of the multipurpose tree *Moringa oleifera* L., grown in Ghana. Food Chem. 122:1047–1054.

Anbazhakan S, Dhandapani R, Anandhakumar P, Balu S (2007).Traditional medicinal knowledge on *Moringa concanensis* Nimmo of Perambalur District, Tamilnadu. Anc. Sci. Life 26(4):42-45.

Arbonnier M (2004). Trees, Shrubs and Lianas of West Africa Dry Zones. CIRAD, Margraf Publishers, Paris, France. pp 417.

Bennett RN, Mellon F, Foidl N, Pratt JH, Dupont MS, Perkins L, Kroon PA (2003). Profiling glucosinolates and phenolics in vegetative and reproductive tissues of the multi-purpose trees: *Moringa oleifera* L. (Horseradish Tree) and *Moringa stenopetala* L. J. Agric. Food Chem. 51:3546-3553.

Bosch CH (2004). *Moringa stenopetala* (Baker f.) Cufod. In: Grubben GJH, Denton OA (Eds.), PROTA 2: Vegetables/Légumes, Wageningen, Netherlands, pp 395-397.

Boulos L (2000). Flora of Egypt.Vol I. Al Hadara Publishing, Cairo, Egypt. pp. 238.

Buraimoh AA, Bako IG, Ibrahim FB (2011). Hepatoprotective effect of ethanolic leaf extract of *Moringa oleifera* on the histology of paracetamol induced liver damage in Wistar rats. Int. J. Vet. Adv. 3(1):10-13.

Cheenpracha S, Park EJ, Yoshida WY, Barit C, Wall M, Pezzuto JM, Chang LC (2010). Potential anti-inflammatory phenolic glycosides from the medicinal plant *Moringa oleifera* fruits. Bioorg. Med. Chem. 18:6598–6602.

Chinmoy KB (2007). Possible role of *Moringa oleifera* Lam. root in epithelial ovarian cancer. Med. Gen. Med. 9(1):26.

Chopra RN, Chopra IC, Handa KL, Kapur LD (1994). Chopra's indigenous drugs of India. Academic Publishers, Calcutta, India. pp 366-367.

Chuang P-H, Lee C-W, Chou J-Y, Murugan M, Shieh B-J, Chen H-M (2007). Anti-fungal activity of crude extracts and essential oil of *Moringa oleifera* Lam. Bioresour. Technol. 98:232–236.

Demeulenaere E (2001). *Moringa stenopetala,* a subsistence resourcein the Konso district. Development potential of *Moringa* products. Proceedings of a workshop, 29 October – 2 November, Dar es Salaam, Tanzania.

Duke JA (1983). Handbook of Energy Crops. [http://www.hort.purdue.edu/newcrop/duke_energy/Camellia_sinensis.html] [Accessed 05/08/12].

Eggli U (2004). Illustrated Handbook of Succulent Plants: Dicotyledons. Springer, Berlin, Germany. pp. 324-326.

Eilert U, Wolters B, Nahrstedt A (1981). The antibiotic principle of seeds of *Moringa oleifera* and *Moringa stenopetala*. Planta Med. 42:55–61.

El-Alfy TS, Ezzat SM, Hegazy AK, Amer AMM, Kamel GM (2011). Isolation of biologically active constituents from *Moringa peregrina* (Forssk.) Fiori. (family: Moringaceae) growing in Egypt. Pharmacogn. Mag. (26):109–115.

El Baky HHA, El-Baroty GS (2012). Biological activity of the Egyptian *Moringa peregrina* seed oil. Paper presented at International Conference of Agricultural Engineering, CIGR-Ageng, 8 -12 July, Valencia, Spain.

Elbatran SA, Abdel-Salam OM, Abdelshfeek KA, Nazif NM, Ismail SI, Hamoouda FM (2005). Phytochemical and pharmacological investigations on *Moringa peregrina* (Forssk) Fiori. Nat. Prod. Sci. 11(4):199-206.

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

Folk Medicine (2010). The folk medicines used in the province of Sindh, Pakistan. *Moringa rivae* (Chiovenda)**.** International Center for Chemical and Biological Sciences http://www.iccs.edu/folkmed/P41.php [Accessed 03/08/12].

Gaikwad M, Kale S, Bhandare S, Urunkar V, Rajmane A (2011). Extraction, characterization and comparison of fixed oil of *Moringa oleifera* L. and *Moringa concanensis* Nimmo Fam. Moringaceae. Int. J. Pharm. Tech. Res. 3(3):1567-1575.

Goyal BR, Agrawal BB, Goyal RK, Mehta AA (2007). Phyto-pharmacology of *Moringa oleifera* Lam. An overview. Nat. Prod. Rad. 6(4):347-353.

Ithaka (2012). Jstor Plant Science. *Moringa pygmaea* Verdc. [family Moringaceae]. http://plants.jstor.org/flora/flos000847 [Accessed 05/08/12].

Jahn SAA, Musnad HA, Burgstaller H (1986). The tree that purifies water: cultivating multipurpose Moringaceae in the Sudan. Unasylva 152:23–28.

Jahn SAA (1991). The traditional domestication of a multipurpose tree *Moringa stenopetala* (Bak.f.) Cuf. in the Ethiopian rift valley. Ambio 20(6):244–247.

Jaiswal D, Rai PK, Kumar A, Mehta S, Watal G (2009). Effect of *Moringa oleifera* Lam. leaves aqueous extract therapy on hyperglycemic rats. J. Ethnopharmacol. 123:392–396.

Jayabharathi M, Chitra M (2011). Evaluation of anti-inflammatory, analgesic and antipyretic activity of *Moringa concanensis Nimmo.* J. Chem. Pharm. Res. 3(2):802-806.

Kale S, Gajbhiye G, Chaudhari N (2010). Formulation and *in vitro* evaluation of *Moringa concanensis,* Nimmo. Seed oils sunscreen cream. Int. J. Pharm. Tech. Res. 2(3):2060-2062.

Kleiman R, Ashley DA, Brown JH (2008). Comparison of two seed oils in cosmetics, *Moringa* and *Marula*. Ind. Crop Prod. 28(3):361-364.

Kumar P, Singh K, Kumar A (2010). Hepatoprotective studies on aerial parts of *Moringa oleifera* Lam. on carbon tetrachloride induced liver cell damage in albino rats. Ann. Biol. Res. 1 (1):27-35.

Lalas S, Gortzi O, Athanasiadis V, Tsaknis J, Chinou I (2012). Determination of antimicrobial activity and resistance to oxidation of *Moringa peregrina* seed oil. Mol. 17:2330-2334.

Makonnen E, Hunde A, Damecha G (1997). Hypoglycaemic effect of *Moringa stenopetala* aqueous extract in rabbits. Phytother. Res. 11(2):147–148.

Manzoor M, Anwar F, Iqbal T, Bhanger MI (2007). Physico-chemical characterization of *Moringa concanensis* seeds and seed oil. J. Amer. Oil. Chem. Soc. 84:413–419.

Masood MK (2010). Evaluation of anti-cancer activity of *Moringa oleifera* Lam on EAC bearing mice. Masters dissertation, Hanagal Shri Kumareshwa College of Pharmacy, Bagalkot, Karnataka, India.

Mekonnen Y, Yardlely V, Rock P, Croft S (1999). *In vitro* antitrypanosomal activity of *Moringa stenopetala* leaves and roots. Phytother. Res. 13:538–539.

Moyo B, Masika PJ, Muchenje V (2012a). Antimicrobial activities of *Moringa oleifera* Lam. leaf extracts. Afr. J. Biotechnol. 11(11):2797-2802.

Moyo B, Oyedemi S, Masika PJ, Muchenje V (2012b). Polyphenolic content and antioxidant properties of *Moringa oleifera* leaf extracts and enzymatic activity of liver from goats supplemented with *Moringa oleifera* leaves/sunflower seed cake. Meat Sci. 91:441–447.

Munyanziza E (2007). *Moringa drouhardii* Jum. In: Van der Vossen, HAM, Mkamilo, G.S. (Editors). PROTA 14: Vegetable oils. PROTA Publishers, Wageningen, Netherlands. pp 118.

Nawash OS, Al-Horani AS (2011). The most important medicinal plants in Wadi Araba desert in South West Jordan: A review article. Adv. Environ. Biol. 5(2):418-425.

Neuwinger HD (2000). African traditional medicine: a dictionary of plant use and applications with supplement: search system for diseases. Part 1 of African Traditional Medicine: A Dictionary of Plant Use and Applications with Supplement: Search System for Diseases. Medpharm Scientific Publishers, California, U.S.A. pp 344.

Nibret E, Wink M (2010). Trypanocidal and antileukaemic effects of the essential oils of *Hagenia abyssinica, Leonotis ocymifolia, Moringa stenopetala*, and their main individual constituents. Phytomedicine 17:911–920.

Odee DW, Muluvi GM, Machua J, Olson ME, Changwony M (2001). Domestication of *Moringa* species in Kenya. Development potential for *Moringa* products. Proceedings of a workshop, 29th October- 2nd November, Dar es Salaam, Tanzania.

Olson ME (1999). *Moringa arborea.* Missouri Botanical Garden. http://www.mobot.org/gradstudents/olson/marborea.html [Accessed 01/09/12].

Olson ME, Razafimandimbison SG (2000). *Moringa hildebrandtii* (Moringaceae): a tree extinct in the wild but preserved by indigenous horticultural practices in Madagascar. Adansonia 22(2):217-221.

Olson ME, Carlquist S (2001). Stem and root anatomical correlations with life form diversity, ecology, and systematics in *Moringa* (Moringaceae). Bot. J. Linn. Soc. 135:315-348.

Paliwal R, Sharma V, Pracheta (2011). A review on horse radish tree (*Moringa oleifera*): A multipurpose tree with high economic and commercial importance. Asian J. Biotechnol. 3:317-328.

Parvathy MVS, Umamaheshwari A (2007). Cytotoxic effect of *Moringa oleifera* leaf extracts on human multiple myeloma cell lines. Trends Med. Res. 2(1):44-50.

Ravichandran V, Arunachalam G, Subramanian N, Suresh B (2009). Pharmacognostical and phytochemical investigations of *Moringa concanensis* (Moringaceae) an ethnomedicine of Nilgiris. J. Pharmacog. Phytother. 1(6):076-081.

Sudha P, Syed S, Asdaq SMB, Dhamingi S, Chandrakala GK (2010). Immunomodulatory activity of methanolic leaf extract of *Moringa oleifera* in animals. Indian J. Physiol. Pharmacol. 54 (2):133–140.

Tsaknis J (1998). Characterisation of *Moringa peregrina* Arabia seed oil. Grasas y Aceites 49(2):170-176.

Van der Vossen HAM, Mkamilo GS (2007). PROTA 14: Vegetable oils. PROTA publishers, Wageningen, Netherlands. pp. 119-120.

Verdcourt B (1985). A synopsis of the Moringaceae. Kew Bull. 40(1):1-23.

Verma SC, Banerji R, Misra G, Nigam SK (1976). Nutritional value of *Moringa.* Curr. Sci. 45:769-770.

Walter A, Samuel W, Peter A, Joseph O (2011). Antibacterial activity of *Moringa oleifera* and *Moringa stenopetala* methanol and n-hexane seed extracts on bacteria implicated in water borne diseases. Afr. J. Microbiol. Res. 5(2):153-157.

Yang R-Y, Tsou SCS, Lee T-C, Chang L-C, Kuo G, Lai P-Y (2006). *Moringa,* a novel plant rich in antioxidants, bioavailable iron and nutrients. J. Am. Chem. Soc. 17:224-239.

Zaghloul MS, Abd El-Wahab RH, Moustafa AA (2010). Ecological assessment and phenotypic variation of Sinai's remnant populations of *Moringa peregrina.* Appl. Ecol. Environ. Res. 8(4):351-366.