MORINGA OLEIFERA MIRACLE TREE FOR GREEN TECHNOLOGY: A REVIEW

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Abstract

Moringa oleifera is a native tree of the sub-Himalayan parts of Northwest India. It is now widely cultivated across tropical belt areas. It is generally used in a number of developing countries as a vegetable, a medical plant, and a source of vegetable oil. The fresh leaves are rich in vitamins A and C. Leaves extract has therapeutic potential for the prevention of many diseases. *Moringa oleifera* seeds have been found to be a natural coagulant, flocculant, softener, disinfectant, and sludge conditioner, organics and heavy metal remover in water and waste treatment. Extracted seed oil is good edible oil, lubricant oil, and as feedstock for biodiesel. It can be used for soap making, perfume, and cosmetics. The seeds husk and pods left over can be steamed activated to produce high quality activated carbon. The residual solids left from oil extraction and filtration process can be considered as animal feed with high nutritive value, and as soil fertilizer. The trunk is used in the paper industry. The roots are used for medicinal purposes. Therefore, it is very important for green technology to pay attention to this tree which can produce environmentally friendly products with almost zero waste.

Keyword: *Moringa oleifera*, water treatment, medicine, bioproducts, biodiesel.

1. Introduction

Moringa oleifera (M.O) is a native tree of the sub-Himalayan parts of Northwest India, Pakistan and Afghanistan. It is now widely cultivated across Africa, South America, most part of South – East Asia for example: Malaysia, Indonesia, Thailand (Muyibi, 1998), The Philippines, Cambodia, Middle East, and Central America, and the Caribbean islands (Tsaknis et al., 1999), Brazil (Silva et al., 2010) mainly as a result of its introduction by Indian migrants who valued the young green pods as vegetables and by the British in former colonies as an attractive ornamental tree (McConnachie et al., 1999). The flowers and fruit (which are called "pods") are used as a vegetable, and the trunk is used in the paper industry (Tsaknis et al., 1999). It is also known as a tropical plant containing an active coagulating compound in the seeds, and dry M.O. seeds have been found to be a natural coagulant in the treatment of turbid water in various countries (Jahn, 1984; Muyibi & Evison, 1995; Ndabigengesere & Narasiah, 1995; McConnachie et al., 1999).

2. *Moringa oleifera* Tree

The *Moringaceae* family is a single genus family of shrubs (Jahn, 1984; Ndabigengesere & Narasiah, 1995). All *Moringa* species are native to India, from where they have been introduced into many warm countries, and the most common species are M.O. (Tsaknis et al., 1999). Fourteen species have so far been identified and all possess coagulant properties in varying degrees (Jahn, 1988). It is a fast growing tree and can tolerate draught, sandy soil, bacteria and fungi (Karmakar et al., 2010). It thrives in subtropical to tropical dry to moist climates, tolerating rainfall from 25 to 300 plus cm annually with temperatures ranging from 19 to 28 °C (Karmakar et al., 2010). It is generally used in a number of developing countries as a vegetable, a medical plant, and a source of vegetable oil. It can be propagated from seeds or cuttings even in poor soil requiring minimum attention and it can survive long periods of drought. The tree ranges in height from 5 to 10 meter, and sometimes even 15 meter (Tsaknis et al., 1999). The fruits are usually 25-45 cm long; contain ~ 20 seeds, which are globular, ~ 1 cm in diameter, and three winged, with wings produced at base of the apex, 2-2.5 cm long, 0.4-0.7 cm wide. The seeds are three-angled and on average weigh ~ 0.3 gm, with the Kernel responsible for 70-75% of the weight. The fast growing high yielding M.O. can yield an average of three tonnes seed per hectare as against an average of two tonnes of sunflower and half tonne for groundnut (Muyibi et al., 2002). M.O. trees are capable of producing seed pods within the first year after planting, full fruit bearing can be expected by the second full year, and the trees can continue producing pods for several years (Karmakar et al., 2010). M.O. seeds does not need upstream processing to release the seeds (Kibazohi & Sangwan 2011) and this is an additional economic advantage.

Figure 1: *Moringa oleifera*

3. *Moringa oleifera* Uses

3.1. Water and wastewater Treatment

Jahn, (1984, 1988) has presented M.O. as a coagulant after her studies in the Sudan when she noticed that Sudanese village women used it at home to clear the turbid Nile water. Later,

Muyibi (1994) in a laboratory based study observed that M.O. seeds had coagulating and softening properties in addition to being a pH correctant (alkalinity reduction), as well as having a natural buffering capacity, which could handle moderately high to high alkaline surface and ground waters. It has an additional advantage of high bacteria reduction during water treatment.

3.1.1. Coagulant

Numerous laboratory studies have shown that M.O. seeds possess effective coagulation properties (Jahn, 1984, 1988; Muyibi & Okuofu, 1995; Muyibi & Evison, 1995; Ndabigengesere & Narasiah, 1995; McConnachie et al., 1999; Muyibi et al., 2002). They found that *Moringa oleifera* is quite efficient in reducing turbidity and micro organisms from raw water.

In addition, M.O. seed extract was confirmed as a feasible coagulant in removing surfactants from aqueous effluents such as: long-chain anionic detergents (Polyoxyethylene (3.5) Sodium lauryl ether sulfate (SLES)) as reported by Beltran-Heredia et al. (2012). Color removal from the distillery spent wash using M.O. seed was carried out by Prasad (2009) successfully. Bhatia et al (2007) reported that M.O. can be used as coagulant for pretreatment of palm mill effluent (POME).

3.1.2. Hard Water Softener

Many researchers have worked on the softening property to determine range and limits of using M.O. as a softener in water treatment (Muyibi & Evison 1995; Muyibi & Okuofu 1996).

3.1.3. Disinfectant

Suarez et al. (2002) found that *Moringa oleifera* has another advantage as disinfectant in water treatment. It might represent environment-friendly substitutes to commonly used coagulation and disinfecting agents.

3.1.4. Organics and Heavy Metal Remover (Biosorbent)

Drinking water is essential for life, and water contamination is of great importance to be controlled for healthy life. Cadmium is one of the most toxic metals affecting man, animals, and plants. It was considered one of the "priority pollutants", its excretion from the body is very low, and it has synergistic toxicity with other metals (Salim et al., 2008). Cadmium from surface water and wastewater where the cadmium level is high must be treated. There are some studies for removing cadmium from water using M.O. seeds (Sharma et al., 2006; Vanessa et al., 2010). The conventional sorbents includes fly-ash, zeolite, ferrites, limestone, and activated carbon which is the most commonly used sorbent but it requires regeneration and is costly (Salim et al., 2008). It was found that M.O. leaves extract is a good sorbent for Pb (II) from aqueous solutions (Harikishore et al., 2010).

M.O. bark *can* be successfully used for separation of Pb^{2+}, Ni (II) from aqueous solutions by Harikishore et al., 2010, and Harikishore et al., 2011, respectively. Removing of copper, nickel, and zinc was performed by Kalavathy & Miranda (2010) using M.O. wood.

3.1.5. Sludge Conditioner

Muyibi et al., (2001) concluded that, within the economic dosage range of *Moringa oleifera* of 3750 to 5000 mg/l, sludge volume reduction increases with increasing dosage.

3.2 Oil Production

The oil content and its properties show a wide variation depending mainly on the species and the environmental conditions. They can be distinguished largely by the colour and the size of the fruit (Tsaknis et al., 1999).

3.2.1. Edible Oil

M.O. seeds contains on average 40% oil by weight (Kibazohi & Sangwan 2011). Oil qualities from M.O. seeds are similar to that of olive oil with high oleic percentage of 72.2% compared to 65.0- 80.0 % in olive oil with high quality (Karmakar et al., 2010), 78% (Silva et al., 2010), 70.6% (Martin et al, 2010), and 71.6% (Lalas & Tsaknis, 2002).

3.2.2. Biodiesel

It is of great importance to find a suitable fuel alternative to fast depleting fossil fuel and oil reserves. Researchers have been re-directing their interests in biomass based fuels, which currently seem to be the only logical alternative for sustainable development in the context of economical and environmental considerations.

There has been strong international interest in M.O. with claims that it can annually produce 1000-2000 L of biodiesel from one hectare. Biodiesel produced from M.O. oil exhibit a high cetane number of approximately 67, one of highest found for a biodiesel fuel, enhanced oxidative stability (Rashid et al., 2008; Karmakar et al., 2010). M.O. are superior for vegetable oil production as a renewable fuel compared to other seeds (Kibazohi & Sangwan 2011). The produced M.O. methyl ester (MOME)/ biodiesel had fuel properties, which satisfied both ASTM D6751 and EN14214 standards and *Moringa* oil could be used as a suitable feed-stock for biodiesel production according to (Kafuku & Mbarawa, 2010; Kafuku et al, 2010; Silva et al., 2010; Rashid et al, 2011)

3.2.3. Lubricant

Moringa seeds oil can be used as lubricant in watch making and precision equipment (Ferrao & Ferrao, 1987).

3.2.4. Cosmetics and Soap

As natural products, seed oils have been commonly used for tropical skin application from ancient times to the present. M.O. oil is an excellent emollients and with high oxidative stability and can be used for personal care products. Ancient Egyptians recorded the use of *Moringa* oil in a wrinkle removal (Kleiman et al, 2008).

It can be used for soap making and in the perfume industry as well (Muyibi et al., 2002). *Moringa* seeds oil can be used for cosmetics (Ferrao & Ferrao, 1987).

3.3. Protein Supplement

The chemical composition of M.O. leaves contains: 27.2% protein, 5.9% moisture, 17.1% fat, and 38.6% carbohydrate on dry basis. The mineral composition expressed in mg for 100 gm of dry extracted leaves is 2098 calcium, 406 magnesium, 1922 potassium, 28.3 iron, 5.4 zinc, and 351.1 phosphor, the study recommended that M.O. leaves extract showed a balanced nutrition for population (Charles et al., 2011). In Thailand, M.O. leaves are considered a very good daily basis supplement (Poolsak et al., 2011). M.O. leaves can be used as a very high protein supplement for high producing cows, it contains much higher than those for various conventional protein supplements like seed meal of coconut, cotton seeds, ground nut, sesame, sunflower (Makkar & Becker 1996; Mendieta et al., 2011). Solvia et al., (2005) reported that M.O. leave extract have a high potential as alternative to soybean meal and rapeseed meal as protein source for its high total fatty acid content. It is reported by Shanker et al., (2007) that M.O. leaves, pods and bark are having bioenhancer for drugs and nutrients (Niaziridin & Niazirin). Sanchez et al., (2006) reported that the inclusion of *Moringa* as a protein supplement to low quality diets improved dry matter intake and digestibility of the diet and increased milk production and did not affect the milk composition.

3.4. Toxicity

The popularity of using M.O. as a nutritional supplement raises the question of possible toxicity at supra-supplementation levels. The results of Asare et al. (2012), concluded that hepatonephro-toxicity was nil with no abnormal haematology results. Awodele et al. (2012) supported other findings that aqueous leaf extracts is relatively safe when administrated orally.

3.5. Medicine

In addition to its nutritional value, M.O. has got many useful medicinal uses (Karmakar et al., 2010). The seeds have many bioactive compounds, which are used in anti-microbial, anti-genotoxic, anti-inflammatory and anti-tumor promoting activities, and can be used for rheumatism (Mani et al., 2007). It is proved by research work that M.O. leaves extract is good to regulate the hyperthyroidism (Pankaj & Anand 1999), antineoplastic agent to treat Sickle cell disease (Saalu et al., 2011), antiproliferation and induction of apoptosis on human cancer cell (Sreelatha et al., 2011). It works as antioxidant (Asma et al., 2005), anti fungal beside the use of its essential oil for anti-skin disease agent (Ping-Hsien et al., 2007). *Moringa* seeds oil can be used for purification of blood and enhancing cardiac function (Ferrao & Ferrao, 1987). Karadi et al. (2006) indicated that the M.O. root wood is endowed with anti-urolithiatic activity.

3.6. Other Uses

During production of coagulant, oil, and biodiesel, several residues such as press cake, husks, and glycerol are generated. These residues can be used for different purposes.

3.6.1. Activated Carbon

A low cost activated carbon can be produced from M.O. seed husks (Warhurst et al, 1997). Nadeem et al. (2006) prepared steam activated and chemically modified carbon from husk and pods of M.O. for lead removal. Sorption of Cd (II) was done by steam activated, untreated, surfactant-modified carbon powder, from husk and pods of M.O. (Nadeem et al. 2009).

3.6.2. Ethanol Production

The high cellulose content of M.O. (29.1%) suggests that this material could be considered as source of glucose for fermentative production such as ethanol and lactic acid, and xylitol (Martin et al, 2010).

3.6.3. Nutrition Supplement

The press cake can be utilized as raw materials in different bioprocesses for the production of chemicals and value added products such as amino acids, enzymes, vitamins, antibiotics and biopesticides, which are recognized to have a high nutritional value (Martin et al, 2010). The husks of *Moringa* with the high protein content (15.2%) might be positive for decreasing the cost of nutrient supplementation in downstream fermentation processes (Martin et al, 2010).

4. Conclusion

M.O. is a perfect example of a so-called "miracle tree"; it grows quickly in dry conditions, its green pods are edible ("Drumstick" in India), its seeds contain a good quality vegetable oil, and can be used as a coagulant to replace conventional coagulants in drinking water treatment. In addition, many parts of the plant have traditional medicinal uses. The seed husks and pods left over from the production of the vegetable oil and biodiesel have many uses.

Obviously, each country will have to grow this kind of tree to produce more environmentally friendly products, biodegradable, and zero waste industry. It could generate employment and hence constitute a new source of income to country like Malaysia and other tropical countries.

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Dear Dr,

APPROVAL ATTENDING CONFERENCE

With reference to the above matter, we would like to inform you that the Department of Research & Innovation has approved your application for attending conference as an oral presenter. Details of approval as per below:

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