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Industrial and Agricultural Potentials of Moringa

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Abstract
Moringa is called the "miracle tree"" because the plant can provide as a food supplement for fortification, energy drinks, specialty creams (cosmetics, shampoos, etc.) and oil and especially in the current oil crisis, can be blended with diesel to form as "biofuel". The leaves can be used as food and oil can be extracted from the seeds as vegetable oil or as biofuel feedstock. According to published Report "Moringa Oil" (Jesus Benavides, et. al., 01.17.2008) the demand in the United States and European Union could only be filled by 3.8% and 7.3%, respectively, and there was a growing demand for biofuel production from 12B liters to 37B liters by 2010. As biofuel feedstock, Moringa seeds can produce up to 40 percent oil. This means that a kilo of seeds from the pods would yield 400 milliliters of oil, which can be seed either for cooking or as substitute for diesel. Jatropha was the toast in biofuel oil industry until Moringa was discovered as better source. More recently the ben oil has also been shown to be particularly effective in the manufacture of soap producing a stable lather with high washing efficiency suitable for some African countries. The seed oil is used in arts and for lubricating watches and other delicate machinery, and useful in the manufacture of perfumes and hairdressings. The pressed cake obtained after oil extraction may be used as a fertilizer. The industrial uses of the Moringa tree include the use of its wood in paper and textile industries, bark in the tanning industry, and the seeds in water purification. The dried leaves appear to be much more effective animal feed. One agriculturist fed his cows with just 2 kg of dry matter of Moringa per day in addition to the normal food he had been feeding them with and the milk production increased by 58 percent. Then he increased it to 3 kg per day, and the milk production increased by 65 percent. The extract obtained from the leaves of Moringa in 80 % ethanol contains growth enhancing principles (i.e. hormones of the cytokinine type). The extract can be used in the form of a foliar spray to accelerate the growth of young plants. Study on moringa and global warming revealed that 1 person emits 320kg of CO2/yr; it takes 23 Japanese Cedar trees takes 50 years to absorb this amount of CO2; it takes 2 Moringa trees 2 years to absorb this amount and 1 family car emits 2300kg of CO2/yr; it takes 160 Japanese Cedar trees 50 years to absorb this amount of CO2; it takes 10 Moringa trees 2 years etc (Muriel, 2010). Therefore, this review article tries to depict the industrial and agricultural potentials of Moringa.
Keywords: industry, biofuel, carbon emission and absorption, Moringa

Introduction

Moringa is the most widely cultivated species of a monogeneric family, the Moringaceae that is native to the sub-Himalayan tracts of India, Pakistan, Bangladesh and Afghanistan. This rapidly-growing tree (also known as the horseradish tree, drumstick tree, benzolive tree, ben oil tree and cabbage tree), was utilized by the ancient Romans, Greeks and Egyptians; it is now widely cultivated and has become naturalized in many locations in the tropics. It is a perennial softwood tree with timber of low quality, but which for centuries has been advocated for traditional medicinal, agricultural, and industrial uses. It is already an important crop in India, Ethiopia, the Philippines and the Sudan, and is being grown in West, East and South Africa, tropical Asia, Latin America, the Caribbean, Florida and the Pacific Islands.

All parts of the Moringa tree are edible and have long been consumed by humans. The many uses of Moringa (Fuglie LJ, 1999) include: alley cropping (biomass production), animal forage (leaves and treated seed-cake), biogas (from leaves and seed cake powder), domestic cleaning agent (crushed leaves), blue dye (wood), fencing (living trees), fertilizer (seed-cake), foliar nutrient (juice expressed from the leaves), green manure (from leaves), gum (from tree trunks), honey and sugar cane juice clarifier (powdered seeds), honey (flower nectar), medicine (all plant parts), ornamental plantings, bio-pesticide (soil incorporation of leaves to prevent seedling damping off), pulp (wood), rope (bark), tannin for tanning hides (bark and gum), water purification (powdered seeds). Moringa seed oil (yield 30-40% by weight), also known as Ben oil, is a sweet non-sticking, non-drying oil that resists rancidity. It has been used in salads, for fine machine lubrication, and in the manu-facture of perfume and hair care products. 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, 1984), but the seeds are also eaten green, roasted, powdered and steeped for tea or used in curries (Gassenschmidt, 1995). This tree has in recent times been advocated as an outstanding indigenous source of highly digestible protein, Ca, K, Fe, Vitamin A, Vitamin C, and carotenoids suitable for utilization in many of the so-called developing regions of the world. The objective of this paper is to provide a review of results from relevant studies and recommend the areas that need immediate and future attention by researchers, development and conservation workers, industrials,

investors and policy makers.

The Industrial Potentials of Moringa

Biogas production

The seed cake powder obtained from hexane extract of *Moringa stenopetala* was analyzed for biogas production (Eyasu M. 2008). The percentage composition of the total solids of the seed cake powder was about 93%. This leaves the moisture content of the feedstock to be only 7% (Table 1).

Table 1: Physico-chemical characteristics of *Moringa stenopetala* Seed cake Powder

Constituents Percentage composition

Seed Powder Constituents	Percentage composition
Total Solids	92.94%±0.38
Volatile Solids	82.01%±1.08
Moisture Content	7.06±0.38
Carbon	45.10%±1.08
Nitrogen	3.52%±0.01
C/N ratio	12.78

(Source: Eyasu M. 2008)

Studies on the most favorable percentage of total solids for biogas production suggestedan average of 7-9% (Yadvika, 2004). The mobility of the methanogens within the substrate is gradually impaired by increasing solids content, and the biogas yield may suffer as a result. Therefore much water is required to bring the total solids percentage of the seed cake powder from 93% to 8%. This can be considered as disadvantage in areas that suffer from water drought. Availability of water should be taken into account for the large scale implementation of biogas production from materials with higher solid content such as *Moringa stenopetala* seed cake powder.

The percentage composition of volatile solids of the seed cake powder is about 82% of the total solids portion (Table 1). This indicates that a large fraction of the seed cake powder is biodegradable. Therefore, *Moringa stenopetala* seed cake powder can be considered as an important feedstock for biogas production.

Table 1: Total volume of Biogas in all the digesters

Type of Digester	Amount of Biogas (ml)
A1	6970
A2	6673
A3	6445
B1	7980
B2	7765
B3	7510
C1	7217
C2	7995
C3	7220

Source: Eyasu M. 2008

Mean Value for Amount of Biogas in Digesters of “A”=6696ml±263.25

Mean Value for Amount of Biogas in Digesters of “B” =7751.67ml±235.28

Mean Value for Amount of Biogas in Digesters of “C” =7177.25ml±71.32

However, the composition of the biogas in each of the digesters was estimated with an indirect measurement. First the volume of the biogas displaced was measured by the downward displacement of water. The volume of the water displaced corresponds to the amount of biogas produced from the digester in the given time. Subsequently, the composition of methane in the biogas was estimated by allowing the gas to pass through a 5% NaOH solution. Principally biogas is composed of Methane and Carbon dioxide, the CO2 dissolves in the basic solution to form bicarbonates. Therefore, the amount of NaOH displaced is approximately equal to the amount of methane in the biogas. However, it should be noted that the traces (N2, H2S) that may constitute the biogas may have been accounted with the amount of methane.

Table 3: Average percentage of methane share from the biogas

Type of Digester	Average percentage of methane
“A” Type	64.4% ±1.97
“B” Type	70.9% ±1.56
“C” Type	67.87% ±2.15

Source: Eyasu M. 2008

Table 3 shows the composition of methane in the biogas in each of the digesters in which gas samples were taken from each of the digesters at three different retention times. The portion of methane in digesters of type A, B and C ranged from 62.2%-66%, 70%-72.7% and 65.7%-70%, respectively. In general, the composition of methane in all of the digesters is within the range of 62%-72%. This finding is almost similar to the result

obtained from Gas Chromatography analysis. However, the fraction of methane through the indirect measurement was higher than the Gas Chromatography value. This may be due to the presence of trace substances that constitute the biogas could have been accounted in the indirect measurement.

The Advantages of Moringa Biogas

First of all, a bio gas plant can contribute to solve a waste problem for industries with organic wastes.Secondly, a biogas plant can provide cheap energy to that industry, or even provide energy for sale - energy to the grid or Methane and even Hydrogen (for fuel cells) to e.g. vehicles.

Thirdly, a biogas plant produces a digestate that can be an excellent fertilizer (with less smell than manure), and which can be sold e.g. to farmers. Replacing chemical fertilizers with this bio fertilizer will add important minerals to the soil, and thereby contribute to increase the fertility of farmed land.

Fourthly, a biogas plant can contribute not only to reduce and replace the use of fossil fuels, but in fact also reduce natural Methane releases to the atmosphere, and thereby actually contribute to fight the climate change.

Fifthly, a biogas plant can serve the food producing industry well as a marketing measure.

Moringa in Cosmetic Industry

Moringa oil is highly valued in the cosmetic industry for its unique property. Moringa oil is light and spreads easily on the skin. It is best for massage and aromatherapy applications. Moringa oil application is used in the following range of products.

- Ant ageing creams
- Hair care products
- Soaps and Liquid body wash
- Aromatherapy oils
- Massage oil
- Face creams
- Perfumes and Deodorants

(Source: Floratech Report)

Moringa oil has exceptional anti ageing properties. The antioxidants and the nutrients present in the Moringa oil help to curb the activity of the free radicals on the skin. The free radicals are the agents that cause damage to the skin tissues and pave way for skin wrinkles. Antioxidants rich Moringa oil curbs the activities of free radicals and hence finds a place in the anti ageing creams.

Moringa oil can be used in creams, lotions, balms, scrubs, body oils, and hair care formulations at the ratio of 3-100%. It also has nourishing and emollient properties giving it benefits for use in skin and hair care products. Moringa oil, as olive oil is useful in lifting dirt out of the hair and is an efficient natural cleanser. Good antioxidant properties, considered to be the factor behind its remarkable stability. By simply wetting the hair, massaging the oil into the scalp and rinsing can effectively clean and moisturize the scalp. It has nourishing and emollient properties, making it an excellent Massage Oil, which leaves the skin with a silky feeling. Rich in Palmitoleic, Oleic and Linoleic acids, Vitamins A and C and unsaturated fatty acid, Moringa oil has excellent moisturising and nourishing qualities. Moringa oil blends easily with essential oils and this combined with its non-drying quality and its ease of dispensability on the skin makes it as perfect massage oil. Web Design & Development India

Skin moisturizing benefits are derived from the fact that moringa seed oil is high in vitamins A and C and unsaturated fatty acids. Moringa seed oil contains antiseptic and anti-inflammatory properties, which help heal minor skin complaints such as cuts, bruises, burns, insect bites, rashes and scrapes quickly. Moringa oil is also helpful for purposes of tanning or maintaining a tan as this oil is rich in copper and calcium, important nutrients for the skin.

Moringa Butter

Various butters (moringa, shea, olive, and cocoa) were incorporated into anhydrous stick formulations at 10% and tested for skin hydration using a Corneometer CM 825 (Courage+Khazaka, Cologne, Germany) in a double-blind, randomised, vehicle controlled, in vivo clinical study. The results show that after one application of the test articles, the formulation containing 10% moringa butter increased skin hydration at every time point up to four hours, far better than any of the other butter-containing test articles, $p<0.05$. The anhydrous stick containing the moringa butter produced a peak skin hydration increase of 55%, which was more than double the skin hydration produced by any of the other test articles. (Source: Floratech Report)

Perfume industry

Perfume manufacturers esteem the oil for its great power of absorbing and retaining even the most fugitive odours. This Moringa Oil is in demand because it is so stable and resistant to rancidity and it has long been valued for its enfleurage property by the perfume industry. Moringa oil is useful in the manufacture of perfume and hairdressings. The oil is known for its capacity to absorb and retain volatile substances and is therefore valuable in the perfume industry for stabilising scents. Moringa seed oil contains antiseptic and anti-

inflammatory properties, which help heal minor skin complaints such as cuts, bruises, burns, insect bites, rashes and scrapes quickly. The addition of Moringa seed oil produces a rich and creamy lather and, unlike any other plant-based oil, actually increases the cleansing ability:

- It clears pimples and prevents recurrence, if used regularly
- It removes wrinkles & will prevent sagging of facial muscles
- Helps clears black heads & spots.
- Makes face glow.
- Helps to tighten the skin pores.
- It is able to purify the skin, balance the secretion of oil & remove skin fatigue. Regular use diminishes the formation of blackheads for all skin type. Counteracts the effect of pollution
- Keeps skin healthy and glowing.

There are reports of moringa being used in cosmetic preparations as far back as 1400 BC, wherein an allegedly successful remedies to treat wrinkles consisted of: gum of frankincense wax; fresh moringa oil; Cyprus grass. The mixture was ground finely, mixed with fermented plant juice, and applied daily. Web Design & Development India

Pharmaceutical Industry

Time immemorial all parts of Moringa tree are used in traditional medicine and modern medicine today.Gums are widely employed in the pharmacy as thickeners, suspending agents, emulsifying agents, binders and film formers. With the increase in demand for natural gums, it has been necessary to explore the newer sources of gums to meet the industrial demands. Gum of the tree *Moringa oleifera* has been reported to have gel forming potential for topical application (Panda et. al., 2006). In view of the easy availability of the plant, the exudates from the stem of the tree *Moringa oleifera* was investigated for its application as suspending agent in pharmaceutical formulations. *Moringa oleifera* is a small genus of quick growing tree distributed in India. The stem of the tree exudes a gum which is initially white in colour but changes to reddish brown or brownish black on exposure. It is sparingly soluble in water but swells in contact with water giving a highly viscous solution. It is a polyuronide consisting of arabinose, galactose and glucoronic acid in the proportion of 10: 7: 2 moles; rhamnose is present in traces (Wealth of India, 1998).

Moringa biofuel

As biofuel feedstock, moringa seeds can produce up to 40 percent oil. This means that a kilo of seeds from the moringa pods would yield 400 milliliters of oil, which can be sold either for cooking or as substitute for diesel. From a hectare of land planted to moringa, about 20,000 kilos of seeds could be collected. This translates to some 8,000 liters of oil worth some US$5,000.00 if processed accordingly. With the prices of fuel skyrocketing to a record high of about US$140, 00 per barrel, massive cultivation/propagation of moringa and processing the seeds for oil, may not be the answer to the problem, but certainly, it will give a respite to the existing crisis.
(Source: biotechforlife.com.ph/malunggay_biocommerce).

Pulp and paper industry

The wood provides a pulp that is considered suitable for newsprint, wrapping, printing and writing papers. The bark and gum can be used in tanning hides. The wood yields a blue dye. (Council of Scientific and Industrial Research 1962)

Food industry

Moringa seed contains about 35% oil. Sweet and non- sticking, this oil is often extracted for cooking and in rare cases, even lubrication purposes. It does not turn rancid, is excellent in salads, can be used for soap making, and burns without smoke (von Maydell, 1986). Moringa oil is known as the most stable natural oil, which is a good source of behenic acid and is used as a preservative in food industries. It is an excellent salad oil. The Moringa oil has odorless to mild nutty flavour. It is also used as vegetable cooking oil. Due to its high quantities of Oleic Acids is good for sautéing and deep frying. The bright yellow oil with a pleasant taste has been compared in quality with olive oil. It can also be used in dressings. The Moringa oil is clear, sweet and odorless, never becoming rancid, consequently it is edible. www.moringaoil.com. : Articlebase.com: January 1, 201

Agricultural Potential of Moringa

Green manure

Using moringa as a green manure can significantly enrich agricultural land. In this process, the land is first tilled. Moringa seed is then planted 1-2 cm deep at a spacing of 10x10 cm or less. After 25 days, the seedlings are plowed into the soil to a depth of 15cm. The land is then prepared again for the crop desired.

Growth Hormone

The juice from fresh moringa leaves can be used to produce an effective plant growth hormone, increasing yields by 25%-30% for nearly any crop: onions, bell pepper, Soya, maize, sorghum, coffee, tea, chili, melon and others. One of the active substances is zeatin: a plant hormone from the Cytokinines group. This foliar spray should be used in addition to other fertilizers, watering and sound agricultural practices.

Wood

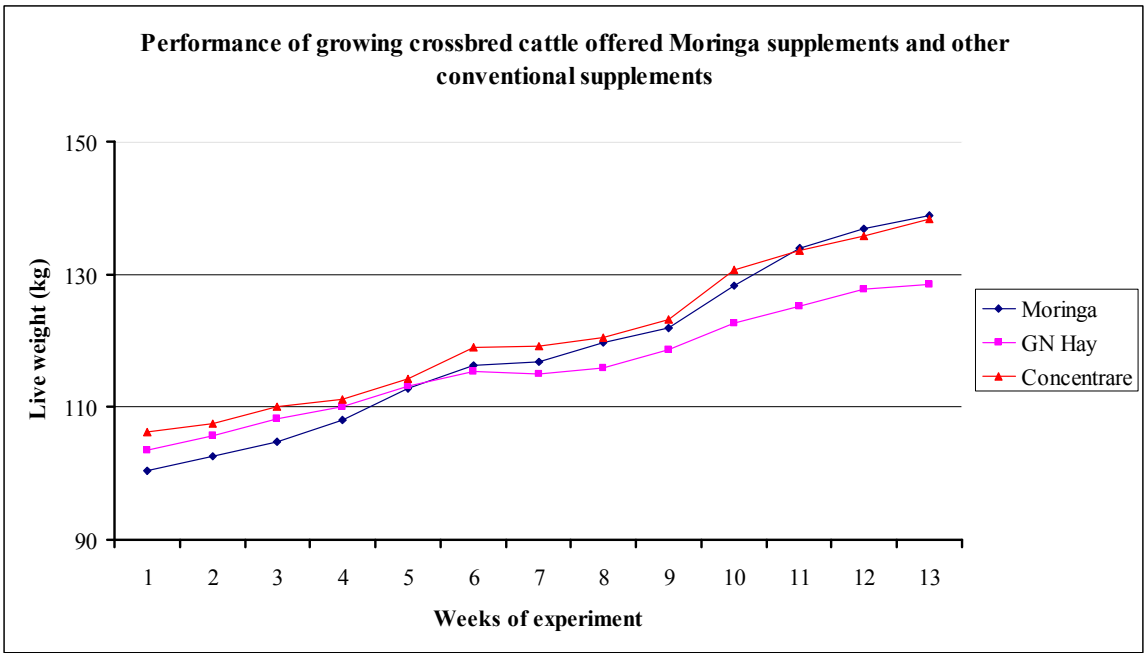
The wood is light, but provides a fairly good fuel for cooking. It has a density of 0.5 to 0.7 and yields approximately 4,600 kcal/kg (F/FR.F-D, 1992). The bark contains a gum that is used as a seasoning and a treatment for some stomach ailments.

In India, economic analysis has illustrated that cultivation of *Moringa oleifera* can be very profitable for farmers with access to urban markets. The leaves, pods, flowers, and wood are all in high demand, and even a few scattered trees can yield enough marketable produce to make frequent trips to town worthwhile (Sherkar, 1993).

Feed supplement

Animal response on a trial diet using *Moringa* to supplement a groundnut hay based diet has shown that there is no significant difference in performance when compared with animals supplemented with groundnut cake based concentrate.

In a short term animal response study set up to validate the in vitro results using growing crossbred animals, in quantitative terms, animals offered *Moringa* leaves as supplements did attain a higher growth rate of 440 g/d compared to their counterparts offered conventional locally available concentrates (1:1 mixture of GNC and rice bran) that grew at the rate of 385 g/d although this difference did not attain statistical significance (Fig 2). As expected, the supplemented animals offered either *Moringa* or concentrate out-performed their counterparts offered only groundnut hay and gained only 274 g/d. The growth rate of the control animals was significantly lower than those of their supplemented counterparts (Aknbamijo et al. 2001).



(Source: Aknbamijo et al. 2001).

The implication is that high quality plant protein feed resource can be readily produced in a space pf two months. The possibility of replacing expensive groundnut cake with Moringa should be vigorously pursued.

Animal forage

Leaves are readily eaten by cattle, sheep, goats, pigs and rabbits. Branches are occasionally lopped for feeding cattle. Leaves can also be used for fish, chickens and several bird species. Chickens and birds feed on moringa seeds.

Fodder production

Mean fodder yield in the wet season was about six times higher than in the dry season (Table 4). In the rainy season, frequent harvests (4 to 6 week intervals) at a height of 150 cm gave the highest yields; however, for the 12 week intervals yields were lowest when the cutting height was 150cm. In the dry season, treatment responses were quite different, with the 12 week harvest interval giving highest yields with a cutting height of 100cm.

Table 4. Effect of cutting height, cutting interval and their interaction on seasonal fodder yield (t/ha) of *Moringa oleifera*

	Fresh matter by season			Dry matter by season		
	Rainy	**Drought**	**Total**	**Rainy**	**Drought**	**Total**
Cutting interval, weeks						
4	14.0[a]	1.25[b]	15.3	2.94[a]	0.27[b]	3.25
5	13.7[ab]	0.97[b]	14.7	2.88[ab]	0.21[b]	3.13
6	17.5[a]	1.22[b]	18.8	3.68[a]	0.26[b]	3.99
12	6.96[b]	5.05[a]	12.0	1.46[b]	1.09[a]	2.56
SEM	3.81	1.69	2.42	0.80	0.37	0.51
Cutting height, cm						
50	9.76[b]	1.94[ab]	11.7	2.05[b]	0.42[ab]	2.49
100	13.0[ab]	2.86[a]	15.9	2.73[ab]	0.62[a]	3.38
150	16.6[a]	1.62[b]	18.3	3.50[a]	0.35[b]	3.89
SEM	2.79	0.53	2.73	0.59	0.11	0.58
Probability	0.032	0.006	0.057	0.032	0.006	0.057
Interval	**	***	NS	*	***	NS
Height	*	**	NS	*	**	NS
Interval × Height	NS	***	NS	NS	***	NS

[abcd.] *Means in columns within main treatments with different superscripts are different at P<0.05*

Source:

The increase in forage yield with cutting height in the wet season was probably a reflection of the fact that availability of precipitation benefits taller plants more than their shorter counterparts as a result of better access of the former to sun light and hence higher rate of photosynthetic activity than the latter. In contrast, the reduction in yield in the dry season with cutting height was probably because lower cutting heights helped to conserve moisture as a result of lesser rate of evapo-transpiration at a time when soil moisture availability was limited. These contrasting findings are similar to those reported by Attah-krah and Sumberg (1988) for *Gliricidia sepium*.

It was observed in this study that when *Moringa* was left for a long time without being cut (i.e.: at 12 week harvest intervals in the wet season), it had the tendency to grow up straight and tall like a mast, growing leaves only at its crown. To prevent this, Fuglie and Sreeja (2001) recommended regular pinching of the terminal tips of the plant in the first few months of growth before it flowers for the first time. According to the authors, this will enable the tree to form branches and develop a strong production frame for maximizing its yield. This implies that flowering probably has a negative effect on fodder yield of *Moringa,* consistent with the findings of Odeyinka and Ademosun (1993) for Leucaena and Gliricidia.

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