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Moringa- The Miracle Wellness Tree: A Review

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ABSTRACT

Moringa [*Moringa oleifera* (Lam.) Moringaceae] is a fast growing, deciduous, drought tolerant and tropical perennial tree. *Moringa oleifera* is called as a "Miracle Tree" due to not only its nutritional and pharmacological properties but also utilized as biofuel, water purifier and cosmetic industry. Every part of *Moringa oleifera* is a storehouse of essential nutrients. Edible parts of the plant includes the whole leaves, immature green fruits or seed pods, flowers and roots. Mature seeds yield 38-40 per cent edible oil called ben oil. Cosmetics such as anti-ageing creams, hair care products, face creams**,** aromatherapy oils and massage oils use moringa oil. Fresh Moringa leaves was collected from Department of vegetable science, Kerala Agricultural University, Thrissur. The KAU Moringa variety Anupama was selected for the study during the period of 2018-2020. Moringa is indeed a miracle tree with enormous potential which is yet to be explored for therapeutic and commercial applications.

Key words: Ben oil, Miracle tree, *Moringa oleifera,* Moringa.

Moringa oleifera is a fast-growing, drought-resistant tree of the family Moringaceae, native to the Indian subcontinent. Common names include moringa, drumstick tree (from the long, slender, triangular seed-pods), horseradish tree (from the taste of the roots, which resembles horseradish) and ben oil tree or benzolive tree. Moringa tree is also known as the 'miracle tree'. The leaves, fruit, sap, oil, root, bark, seed, pod and flowers are known for its health benefits, medicinal properties and cosmetic uses.

It is a fast growing, medium sized deciduous tree, propagated as a perennial plant from cuttings and seeds (Seshadri and Nambiar, 2003). It mainly grows in semi-arid, tropical and subtropical regions, although the drought resistance properties of the plant makes it more suitable for drier regions (Farooq *et al.*, 2012). The roots are susceptible to water-logging and tend to rot in such conditions. It is also able to tolerate a wide range of soil types, the optimum being a well-drained sandy or loamy soil (pH 5-9). *Moringa oleifera* is valued for its multiple economic, medicinal and neutraceutical properties worldwide. This plant has been honored as "Botanical of the Year-2007" by the National Institute of Health (NIH). The Africans used to call it "Never Die" or "Miracle Tree" for its ability to treat more than 300 diseases.

Nutritive constituents of *Moringa oleifera*

Every part of *M. oleifera* is a store house of important nutrients and anti-nutrients. Table 1 depicts the nutritive properties of various parts of moringa.

Leaves

Moringa leaf proteins range from 29.1 to 35.3 g/100g dry weight. The leaves of *M. oleifera* are rich in minerals like calcium, potassium, zinc, magnesium, iron and copper. Vitamins like beta-carotene of vitamin A, vitamin B such as folic acid, pyridoxine and nicotinic acid, vitamin C, D and E also present in *M. oleifera*. Phytochemicals such as tannins, sterols, terpenoids, flavonoids, saponins, anthraquinones, alkaloids and reducing sugar present along with anti-cancerous agents like glucosinolates, isothiocyanates, glycoside compounds and glycerol-1-9-octadecanoate. Moringa leaves also have a low calorific value and can be used in the diet of the obese.

El Sohaimy *et al.* (2015) confirmed that, Moringa leaves has high amount of essential amino acids; methionine, leucine, isoleucine, histidine, phenylalanine, valine, threonine, arginine and lysine. Moringa leaves have low level of anti-nutritional factors compared to other leaf vegetables and produce no toxic effect on consumption (Teixeira *et al.*, 2014).

Moringa is rich in phytosterols like stigmasterol, sitosterol and kampesterol which are precursors for hormones. These compounds increase the estrogen production, which in turn stimulates the proliferation of the mammary gland ducts to produce milk. It is used to treat malnutrition in children younger than 3 years. About 6 spoonfuls of leaf powder can meet a woman's daily iron and calcium requirements, during pregnancy.

Pods and flowers

The pods are fibrous and are valuable to treat digestive problems and treat colon cancer. A research shows that immature pods contain around 46.78% fiber and around

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Table 1: Nutritive properties of *Moringa oleifera.*

Plant parts	Constituents	References
Leaves	Protein, β-carotene, vitamin C, calcium, potassium and antioxidants	Sena *et al.*, 1998
Pods	Fibre, protein, fats (oleic acid, Linoleic acid, linolenic acid) minerals, vitamins (β- carotene, B and C). Phytochemicals (tannins, saponins, phenolics, phytates, flavanoids, terpenoids and lectins).	Makkar and Becker, 1996
Root bark	Minerals (calcium, magnesium and sodium). Phytochemicals (morphine and moriginine)	Prosky *et al.,* 1988
Flowers	Sucrose, glucose, amino acids, traces of phytochemicals	Rocklin and Paul, 1983

20.66% protein content. Pods have 30% of amino acid content and flowers have 31%. The immature pods and flowers showed similar amounts of palmitic, linolenic, linoleic and oleic acids. Moringa pods treat diarrhea, liver and spleen problems and joint pain. The presence of PUFA in the pods can be used in the diet of obese.

In Asia, the flowers of *M. oleifera* are mixed together with other foods since they are rich in Ca^{2+}, K^{+}, waxes, alkaloids, quercetin and kaempferol. Quercetin and kaempferol are flavonoids, compounds with phenolic hydroxyl groups with antioxidant action that have potential therapeutic uses. Moringa flowers act as hypocholesterolemic, anti-arthritic agents and can cure urinary problems and cold.

Root bark

Root bark acts as a cardiac stimulant, anti-ulcer and anti-inflammatory agent. It contain minerals like calcium, magnesium and sodium, alkaloids like morphine, moriginine The alkaloid helps the bark to be antiulcer, a cardiac stimulant and helps to relax the muscles.

Seeds

Seeds contains fats, fibre, proteins, minerals, vitamins like A, B, C and amino acids. It also contains oleic acid (Ben oil), antibiotic called pterygospermin and fatty acids like linoleic acid, linolenic acid, behenic acid, Phytochemicals like tannins, saponin, phenolics, phytate, flavanoids, terpenoids and lectins. The presence of flavanoids gives its anti-inflammatory property. The antibiotic pterygospermin is responsible for antimicrobial properties. Nutrients present in the moringa mentioned in Table 2.

Bioactive compounds in Moringa

Moringa has enormous medicinal potential, which has long been recognized in the Ayurvedic and Unani system (Mughal *et al.,* 1999). Nearly every part of this plant, including root, bark, gum, leaf, fruit (pods), flowers, seed and seed oil have been used for various ailments in the indigenous medicine (Odebiyi and Sofowora, 1999). The multiple biological activities including anti-inflammatory, antimicrobial, hypoglycemic, hypocholestrolemic, antioxidant, antiproliferative and hepatoprotective activities are attributed to the presence of functional bioactive compounds, such as phenolic acids, ûavonoids, alkaloids, phytosterols, natural sugars, vitamins, minerals and organic acids (Mulugeta and Fekadu, 2014). Medicinal properties of different parts of moringa depicted in Table 3.

Table 2: Nutrients present in different parts of Moringa (100 g).

Nutrients	Leaves	Pods	Flowers
Calories (kcal)	92	26	51
Protein (g)	6.41	2.62	2.42
Fat (g)	1.64	0.12	0.15
Carbohydrate (g)	5.62	3.76	0.69
Fibre (g)	8.21	6.83	2.5
Vitamin B_1 (mg)	0.06	0.04	0.008
Vitamin B_2 (mg)	0.45	0.07	0.003
Vitamin B_3 (mg)	0.82	0.62	0.035
Vitamin C (mg)	108	71.86	33
Vitamin K (µg)	479	358	51
Calcium (mg)	314	33	54
Phosphorous (mg)	109	52.87	62
Potassium (mg)	397	419	123
Iron (mg)	4.56	0.73	0.50

Table 3: Medicinal properties of different parts of Moringa.

Parts	Medicinal properties
Leaves	Asthma, hyperglycemia, skin diseases, bronchitis, cancer, blood pressure and cholesterol
Seeds	Hyperthyroidism, microbial infections, inflammatory diseases
Root	Cardiac stimulant, ulcer, inflammatory diseases
Flowers	Hypercholesterolemia, arthritis
Pods	Liver and spleen problems and joint pain
Gum	Healing wounds, asthma, rheumatism
Stem bark	Tuberculosis, cancer, ulcer

Therapeutic potential of *Moringa oleifera*

Anti-diabetic properties

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". *M. oleifera* is used to treat and manage the symptoms of diabetes for years.

Moringa has been shown to cure both Type 1 and Type 2 diabetes. In Type 1 diabetes the patients suffer from non-production of insulin, which is a hormone that maintains the

blood glucose level at the required normal value. Type 2 diabetes is one associated with insulin resistance. Type 2 diabetes might also be due to Beta cell dysfunction, which fails to sense glucose levels, hence reduces the signaling to insulin, resulting in high blood glucose levels. Several studies have shown that, moringa can act as an anti-diabetic agent. A study has shown that the aqueous extracts of *M. oleifera* can cure streptozotocin-induced Type 1 diabetes and also insulin resistant Type 2 diabetes in rats. The flavonoids like quercitin and phenolics have been attributed as antioxidants that bring about a scavenging effect on ROS. It can be hypothesized that the flavonoids in Moringa scavenge the ROS released from mitochondria, thereby protecting the beta cells and in turn keeping hyperglycemia under control. Diabetes leads to several complications such as retinopathy, nephropathy and atherosclerosis *etc.*

Cardiovascular activity

Ethanolic extract of *Moringa oleifera* leaves shows antihypertensive or hypotensive activity. It was found that thiocarbamate and isothiocyanate glycosides are responsible for this promising hypotensive activity.

The *in vitro* and *ex vivo* antioxidant properties, hypolipidaemic and anti-atherosclerotic activities of water extract of *Moringa oleifera* Lam. leaves. Hypocholestremic effect of crude leaf extract was supported by preventive effect of leaves of *Moringa oleifera* on hyperlipidemia induced by iron deficiency in male wistar rats.

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.

Anticancer properties

Moringa oleifera has other characteristic which make it a good compliment to cancer prevention or treatment plan. It contains an enormous amount of nutritional content; *Moringa 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.

Cancer is a common disease and one in seven deaths is attributed due to improper medication. Several factors like smoking, lack of exercise and radiation exposure can lead to the disease. *M. oleifera* can be used as an anti-cancer agent as it is natural, reliable and safe, at established concentrations. Studies have shown that moringa can be used as an anti-neoproliferative agent, thereby inhibiting the growth of cancer cells. Soluble and solvent extracts of leaves have been proven effective as anticancer agents. Glucosinolates in moringa shown in Table 4.

M. oleifera leaf extract was reported to cause membrane blebbing and apoptotic bodies to occur in human tumor cell line (KB) when the extract was introduced to the cell line, thus induced apoptosis. Morphological changes such as membrane blebbing and formation of apoptotic bodies are also one of the morphological alteration of apoptosis. The author also stated that *M. oleifera* showed an anti-proliferative effect by morphological changes, causing loss of cell viability and internucleosomal DNA fragmentation in KB cells due to chemical composition presented in the leaf extracts (Sreelatha *et al.,* 2011) shown in Fig 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

Table 4: Glucosinolates in moringa leaf extracts.

Compound	Glucosinolates (mg/100g)		
	Seed pulp	Roots	Leaves
Glucomoringin	8619.44	3.99	77.7
Glucotropaeolin	3.17	0.27	15.66
Glucosinalbin	-	0.05	0.84
Glucoraphanin	3.57	0.58	2.2
Glucoiberin	0.09	0.02	0.05

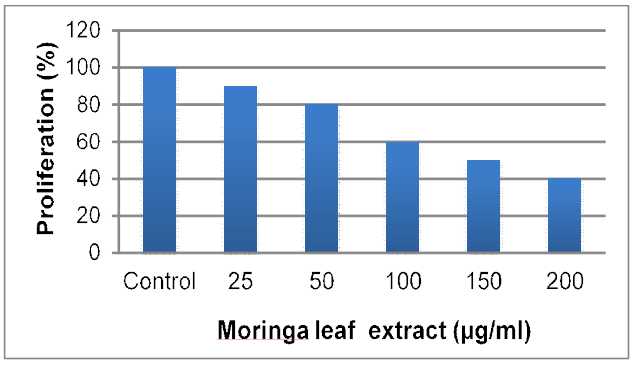

Fig 1: Antiproliferative effects of moringa leaves extract on KB cell.

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.

Prashith *et al.* (2010) studied the antibacterial and antifungal activity of steam distillate of *Moringa oleifera* Lam. A considerable reduction in the growth of bacteria was observed by distillate suggesting antibacterial effect. Among bacteria tested, more inhibition was observed in case of *E. coli* followed by *S. aureus, K. pneumoniae, P. aeruginosa and B. subtilis* shown in Fig 2.

Vinoth *et al.* (2012) studied the antibacterial activity of chloroform, ethanol and aqueous extracts of drumstick using agar well diffusion method, against the selected human pathogens such as *Escherichia Coli, Pseudomonas aeroginosa, Staphylococcus aureus* and *Salmonella typhii* shown in Fig 3. All the examined extract showed varying degrees of antibacterial activities against the pathogens. The phytochemical test was done to find the presence of active chemical constituents such as glycosides, alkaloids, tannins, flavonoids, terpenoids, saponins. The antibacterial activity of ethanol extract showed maximum zone of inhibition (14 mm) against *Salmonella typhii*. From the phytochemical analysis ethanol extract of drumstick showed the presence of flavanoids, tannins, glycosides and terpenoids.

Inhibition of fungi was observed as reduced colony diameter in plates poisoned with distillate as compared to control plates. More inhibition of *A. niger* was observed followed by *A. oryzae, A. terreus* and *A. nidulans* shown in Fig 4. The antimicrobial activity of steam distillate of

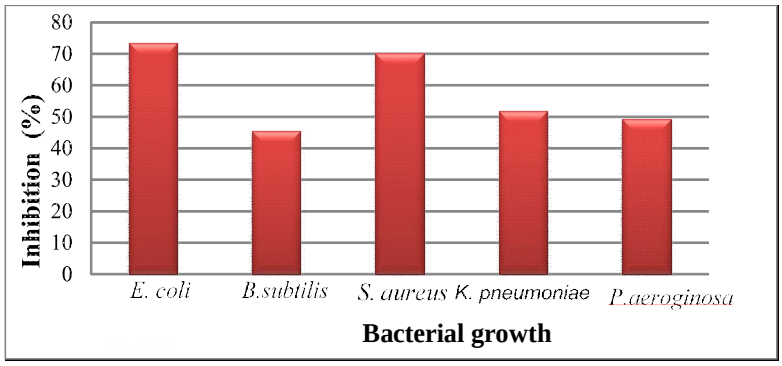

Fig 2: Anti-bacterial effect of Moringa leaf extract.

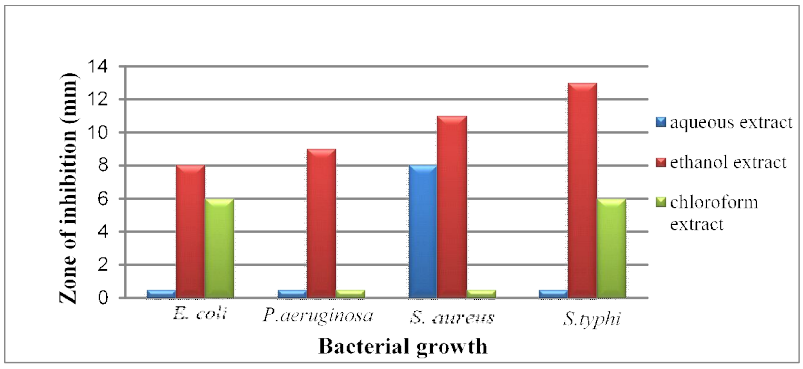

Fig 3: Anti-bacterial effect of different Moringa leaf extract.

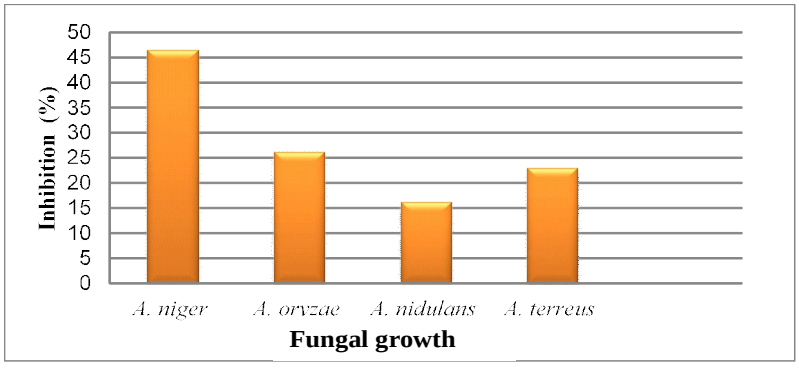

Fig 4: Anti-fungal effect of Moringa leaf extract.

drumstick could be attributed to the inhibitory components present in the distillate fraction.

Antioxidant effects

Usually, natural compounds rich in polyphenols have strong antioxidant properties and can decrease oxidative damage in tissues by scavenging free radical. The methanol extract of *M. oleifera* leaves contains chlorogenic acid, rutin, quercetin glucoside and kaempferol rhamnoglucoside, whereas in the root and stem barks, several procyanidin peaks are detected.

Fitria *et al.* (2015) determined antioxidant activity, total phenolic, total flavonoids and phytochemicals in moringa leaves and moringa stem. Analysis used in this study was 1, 1-diphenyl-2-picrylhydrazyl (DPPH) method for antioxidant activity. Moringa leaves and moringa stem had the ability to scavenge free radicals. The results showed that moringa leaves had higher ability to scavenge free radical, total phenolic and total flavonoid than moringa stem. Ferulic acid and rutin were found in both samples shown in Fig 5. The high activity of antioxidant in moringa leaves was due to the high value of phenolic content and flavonoid content in this sample.

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. Methanolic extract of root bark, aqueous extract of roots, methanolic extract of leaves and flowers as well as ethanolic extract of seeds of *Moringa oleifera* has shown anti-inflammatory activity in carrageenin induced paw edema model. Aurantiamide acetate and 1,3- dibenzyl urea, isolated from roots shown this anti-inflammatory activity so the responsible for anti- inflammatory activity of *Moringa oleifera* roots.

In diseased control animals, paw edema was induced by CFA inoculation and the process was seen to be biphasic. An acute phase was evidenced on Day 5 followed by a delayed sustained chronic phase that reached a plateau starting from Day 11 onwards to Day 21. Significant, very significant and highly significant decreases in the primary lesion were evident on Day 5 in rats in the Moringa extract (100 mg), Moringa extract (200 mg) and dexamethasone-treated groups, respectively, as compared to the diseased controls. Paw edema volume of each animal was measured on days 1, 3, 5, 9 and 21 of the exposures to the various treatments (Shailaja *et al.,* 2007) shown in Fig 6.

Wound healing activity

Aqueous extract of *Moringa oleifera* leaves shown wound healing property on male swiss albino mice. It significantly

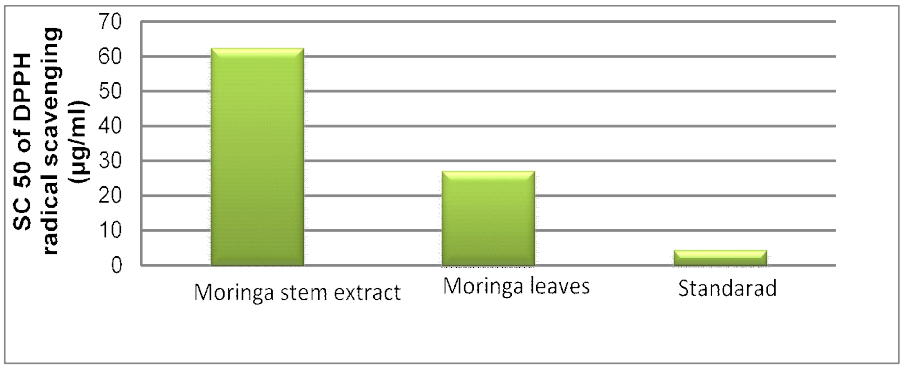

Fig 5: Antioxidant activity of Moringa stem and leaf extract

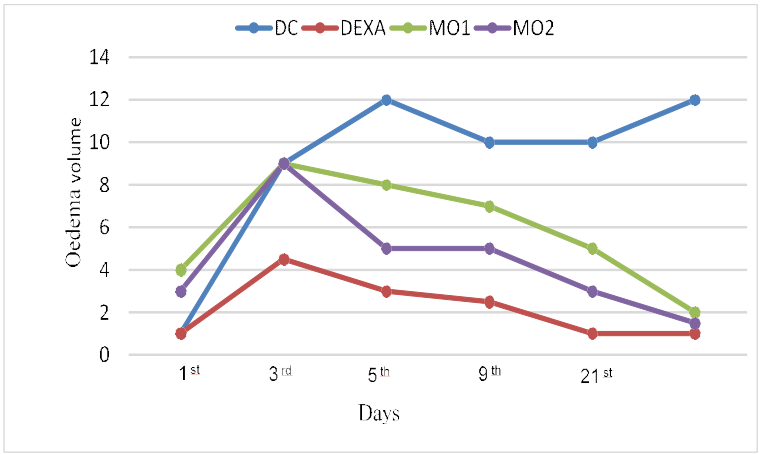

Fig 6: Effect of Moringa leaf extract on oedema volume.

increase wound closure rate, skin breaking strength, granuloma breaking strength as well as decrease in scar area. *Murivenna* is an ayurvedic medicine and this is added to the quicken the healing process and gives almost instant relief from swelling, stiffness, pain and inflammation.

Hepatoprotective activity

Ethanolic extract of leaves and alcoholic extract of seeds of *Moringa oleifera* shown hepatoprotective effect in isoniazid, rifampicin, pyrizinamide induced liver damage and diclofenac induced hepatic toxicity in rat, respectively.

The effect of different concentrations of Moringa leaves extract (150, 200 and 250 mg/kg body weight) against antitubercular drugs. Rats treated with antitubercular drugs (isoniazid, rifampicin, pyrizinamide) developed significant hepatic damage, as observed from elevated serum levels of hepatospecific enzymes such as AST, ALT and ALP. The serum bilirubin concentration was also increased in rats treated with antitubercular drugs (Pari and Ashok, 2002). It is shown in Table 5.

Anti-anaemic activity

Anaemia is a widespread public health problem associated with an increased risk of morbidity and mortality, especially in pregnant women and young children. It is a condition caused by both nutritional (vitamin and mineral deficiencies) and non-nutritional (infection) factors. One of the most contributing factors is iron deficiency which is considered the number one contributor to the global burden of diseases. Anaemia can result in impaired cognitive development, reduced physical work capacity and in severe cases, increased risk of mortality, particularly during the perinatal period. Anaemia may also result in reduced growth and increased morbidity.

Rats whose diets were supplemented with dry *M. oleifera* leaf powder had higher mean weight gain than the control. This confirms the report of (Nambiar and Seshadri, 2001) that supplementation of food with *M. oleifera* leaf powder results both in increased food intake and weight gain. Supplementation of feed with *M. oleifera* leaf powder at 5% protein level produced better results than control.

Central nervous system activity

Treatment with *Moringa oleifera* leaves extract restores mono amine levels of brain which may be useful in Alzheimer's disease. Methanolic extract of *Moringa oleifera* root bark was tested on frog and guinea pig and it shown local anaesthetic activity in both animal models.

Moringa and reproductive health

Moringa plants has the potential to be developed into a culinary of breastfeeding mothers, compounds contain phytosterols (included in the steroid classification), which works to improve and expedite the production of milk (laktogogum effect). Its effect on breast milk production has been proven.

The levels of prolactin in the intervention group was higher than them in the control group. It is because the capsules of Moringa leaves contain chemical compounds of phytosterol (poliferol and sterols), which the compound plays a role to increase prolactin levels. High prolactin levels have a function to improve, accelerate and facilitate milk production. Breast milk production was measured based on the indicator of baby's weight and sleep duration. The findings of this study indicated that there were mean differences of baby's weights between the intervention and control groups in the 1st day, 7th day and 15th day of treatments (Yuni *et al.,* 2017).

Commercial applications

Cosmetic industry

The oil extracted from the seed, with yields of up to 39 %, is used to make cosmetics (as a skin moisturizer, conditioner and emollient) and as an ingredient in soaps, salves, creams and sunscreen (Ayerza, 2012). The major fatty acid is oleic acid, which is widely recommended in the preparation of pharmaceutical ointments. It has high cosmetic value, helps to remove dirt from the skin and is considered as superb cleansing agent. It has non-drying characteristics, can be easily blended with other essential oils; these properties make moringa oil as excellent massage oil (Plate 1, 2). Currently it is widely used in the formulations of body creams, lotions, balms, scrubs and anti-hair fall formulations. In cosmetics, it is preferred over other oil as it does not leave greasy after feel.

Moringa biofuel

Biodiesel is a renewable and eco-friendly alternative to conventional non-renewable fossil petrodiesel fuel. Biodiesel refers to long-chain alkyl (methyl, ethyl, or propyl) esters made by chemically reacting lipids of vegetable oil and animal fat. As biofuel feedstock, moringa seeds can produce up to 40 per cent 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.

Biodiesel was prepared from *M. oleifera* oil by alkali-catalyzed transesteriûcation with methanol after acid pre-

Table 5: Effect of Moringa leaves on Anti-tubercular drug induced liver damage.

Group	AST (IU L^{-1})	ALT (IU L^{-1})	ALP (IU L^{-1})	Bilirubin (mg dl^{1})
Normal	62.79±3.79	23.68±2.08	9.05±0.527	0.26±0.02
Anti-tubercular drugs	105.22±4.10	45.83±2.12	23.11±1.20	0.99±0.07
Anti-tubercular drugs + Moringa leaf extract (150 mg/kg)	92.91±3.50	40.53±2.34	19.81±1.41	0.82±0.01
Anti-tubercular drugs + Moringa leaf extract (200 mg/kg)	85.06±3.03	36.39±1.33	16.33±1.28	0.67±0.03
Anti-tubercular drugs + Moringa leaf extract (250 mg/kg)	78.37±3.37	31.56±2.06	12.43±0.83	0.48±0.03

treatment. The most conspicuous property of biodiesel derived from M. oleifera oil is the high cetane number of approximately 67, which is among the highest reported for a biodiesel fuel. The oxidative stability of *M. oleifera* based biodiesel fuel is also enhanced compared to other biodiesel fuels. Thus, biodiesel derived from *M. oleifera* oil is an acceptable substitute for petrodiesel, also when compared to biodiesel fuels derived from other vegetable oils (Rashid *et al.*, 2008).

Water purification

Seed powder, with and without the husk, has coagulant, flocculant, water softening and disinfectant effects. However, the use of moringa seed is less efficient than some commercial coagulants such as aluminum sulfate and ferric sulfate, but its low cost and biodegradability makes it a potential candidate in developing countries (Suhartini *et al.,* 2013).

Turbidity is caused by suspended negatively charged particles and natural organic matter present in the water. On account of the surface electrical charge, these particles mutually repel each other, making it difûcult for them to aggregate and settle. Thus, to overcome the repulsive charge and “destabilize” the suspension, a coagulant with the opposite charge is added to the water. A large number of active proteins with ûocculating properties have been isolated and extracted and characterized from moringa seeds. This cationic protein is commonly known as *Moringa oleifera* cationic protein (MOCP, also referred to as Floc), which actively inhibits bacterial cell growth and settles negatively charged particles in a solution.

Ravikumar and Sheeja, (2013) conducted an analysis on the heavy metals cadmium, copper, chromium and lead before and after treatment of water with *Moringa oleifera* seed coagulant. The results showed that Moringa seeds were capable of adsorbing the heavy metals tested in some water samples. The percentage removal by Moringa seeds were 95% for copper, 93% for lead, 76% for cadmium and 70% for chromium.

Growth hormone

Fresh 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.

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 (CSIR, 1962).

Moringa capsules

Moringa capsules are composed of 100% leaf powder. It is recommended to consume 3 capsules/ day that are equivalent to 1,500 mg daily. This can substitute the superfood, a combination of nutrients and antioxidants to some extent (Plate 3).

Food industry

Moringa has enormous application in food industry. Moringa leaf powder is used in preparations of ice cream, bread, muffins, chocolate bars, smoothies, soups, energy drinks *etc* (Plates 4-9). Moringa tea is also an emerging product from Moringa. Apart from these Kerala Agricultural University standardised the technologies for Moringa for Moringa instant soup mix, Moringa *chutney,* Moringa fruit pulp and dehydrated powder.

Anti-nutritional factors

The dried leaves of Moringa are a great source of polyphenol compounds, such as flavonoids and phenolic acids. Flavonoids, which are synthesized in the plant as a response to microbial infections, have a benzo-pyrone ring as a common structure. Intake of flavonoids has been shown to protect against chronic diseases associated with oxidative

Plate 1: Moringa seed oil.

Plate 2: Moringa seed.

Plate 3: Moringa capsules.

Plate 4: Tea.

Plate 5: Ice cream.

Plate 6: Chocolate bar.

Plate 7: Cake.

Plate 8: Honey.

Plate 9: Energy drinks.

stress, including cardiovascular disease and cancer. Moringa leaves are a good source of flavonoids. The main flavonoids found in Moringa leaves are myrecytin, quercetin and kaempferol, in concentrations of 5.8, 0.207 and 7.57 mg/g, respectively.

Alkaloids are a group of chemical compounds, which contain mostly basic nitrogen atoms. Several of these compounds, including N, L-rhamnopyranosyl vincosamide, phenylacetonitrile pyrrolemarumine, hydroxyphenylethanamide-L-rhamnopyranoside and its glucopyranosyl derivative, have been isolated from *Moringa oleifera* leaves.

Glucosinolates are a group of secondary metabolites in plants. Both glucosinolates and isothiocyanates have been found to have important health-promoting properties. Tannins are water-soluble phenolic compounds that precipitate alkaloids, gelatin and other proteins. Their concentrations in dried leaves range between 13.2 and 20.6 g tannin/kg being a little higher in freeze-dried leaves. Tannins have been reported to have anti-cancer, antiatherosclerotic, anti-inflammatory and anti-hepatoxic properties.

Moringa leaves are also a good source of saponins, natural compounds made of an isoprenoidal-derived aglycone, covalently linked to one or more sugar moieties. The concentrations of saponins in MO freeze-dried leaves range between 64 and 81 g/kg of weight. Saponins have anti-cancer properties.

CONCLUSION

Moringa is a miracle tree that is locally available to the common man both in India and other countries, because of the nutritional and medicinal importance of moringa, the demand for moringa and its value added products are increasing which in turn demands for year round supply further research needs to be focused to develop the moringa industry tailoring it to improve livelihood, nutrition and poverty. *Moringa oleifera* is a tree brought from the mind of God to the hands of man**.** It was recognized by the National Institute of Health as the Botanical of the Year for 2007 and praised again in 2011 and 2012. It is valued worldwide for its ability to treat over 300 diseases. Africans have honoured it with names that translate to: “Never Die,” and “The Only Thing that Grows in the Dry Season,” and “Mother’s Milk.” It’s safe to say that this plant has saved more lives in 3rd world countries than any other.

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