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Moringa and its medicinal properties: A review

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Abstract
Moringa oleifera originated from India, and grows around the all tropics and subtropics. Moringa can tolerate both severe drought and frost conditions and also cultivated across the world. Whole parts of moringa are a full receptacle of essential nutrients and every part of the tree is suitable for either nutritional or commercial purposes. Moringa leaves are rich source of major and trace minerals, vitamins and other essential phytochemicals. Moringa leaves are also used to feed malnourished people and it also has lactogogues property so it prefer for lactating mothers to augment milk production. It is a potent antioxidant, anticancer, anti-inflammatory, antidiabetic and antimicrobial agent. *Moringa oleifera* seed, a natural coagulant is extensively used in water treatment. Moringa also has medicinal property like it cures diabetes, cancer and the fortification of moringa with other substances used in commercial products. This review explores the use of moringa across disciplines for its medicinal value and deals with cultivation, nutrition, commercial and prominent pharmacological properties of this "Miracle Tree".

Keywords: *Moringa oleifera,* Medicinal property, Lactogogues property, Phytochemicals, Minerals and vitamins

Introduction
Moringa oleifera, recognized as Vaivai in Fiji, Tamaligi (Samoa), Oloha-kerafo in their confined language, and Sahjan in our local language, it is an indigenous species that can be used as complementary feed in ruminant diets. Fruits, seeds, leaves and flowers are consumed as nourishing vegetables in lots of countries. *Moringa oleifera* belongs to monogeneric family Moringaceae (Makkar and Becker, 1997) [36]. Till date thirteen species of moringa tree have been reported in this family. *Moringa oleifera* is most widely cultivated species (Padayachee *et al*., 2012) [43] and, originates from the north-west province of India, principally Himalayan Mountains of the south. *Moringa oleifera* is a quick growing*;* a pantropical versatile tree, with excessive biomass production and can bear varying environmental conditions (Foidl *et al*., 2001) [25]. *Moringa oleifera* is also known as horseradish tree, drumstick tree, ben oil tree and benzoil tree.

Uses of *Moringa oleifera*
Humans are consuming the entire component of the moringa tree as their food. Some researchers have been reported that moringa can be used in many forms such as moringa seed powder, alley cropping for biomass production, leaves and treated seed-cakes for animal feed, crushed leaves as cleaning agent, flower nectar for honey, green leaves as green manure, wood as blue dye, seed cakes fertilizers and leaves for biogas production and the juice extracted from the leaves can be used as foliar nutrient (Ramachandran *et al*., 1980) [49]. All parts of moringa are either used as medicine or for feeding (Livestock and human both) **(**Popoola *et al*., 2013) [47]. The yield of moringa seed oil is 30-40% by weight and is known as Ben oil which is nonsticky, nondrying, sweet oil, and is resist to rancidity. It is an overwhelming alternative indigenous natural source of lipid, digestible protein, vitamins (ascorbic acid and carotenoids) and minerals (Calcium, Iron) that can be utilized by most of the developing country around the world (Fahey *et al*., 2001) [22]. To augment the milk production some developing country use moringa leaves as medicine. Women consume moringa leaves to enhance breast milk production in many Asian and African countries (Fuglie, 2005) [26]. Moringa leaves improve the immunity of host since; it has very strong antioxidant activity (Yang *et al*., 2006) [63].

Nutritional specifications of *Moringa oleifera* plant
Intact part of *Moringa oleifera* is a depository of essential nutritional and antinutritional

factors. Different age group of plant serves as valuable source nutrient. The powder of moringa leaves is a rich source of some essential major and trace minerals like Calcium, Potassium, Zinc, Magnesium, Iron and Copper, it is also a depot of some vitamins like vitamin A (beta-carotene), vitamin B (folic acid), vitamin B5 (nicotinic acid), vitamin B6 (pyridoxine), vitamin C, D and E and also rich in amino acid like lysine (Fahey, 2005) [23]. In case of obese people, it can also be used as low calorific food. Moringa leaves, pods and flowers have higher amount of unsaturated and saturated fatty acid palmitic, linolenic, linoleic and oleic acids. 4000 mg of Calcium found by providing 1000 mg of Moringa leaves and it is far greater than amount of Calcium provide by milk that is 300–400 mg by 8 ounce (1 ounce= 28349.5) of milk, it can provide Iron more than beef and spinach and it can also be provided vitamin C greater than orange that is 200 mg/100 g of vitamin C (*Ramachandran et al*., 1980) [49]. Moringa leaves also provide 25-31 mg of Zinc/kg, which is essential for the proper development of the sperm cells and formation of DNA and RNA. The fresh leaves of moringa is an excellent source of vitamin A (Ferreira *et al*., 2008) [24] which is essential for proper vision, reproduction, embryonic growth and development, immune competence and cell differentiation (Alvarez *et al*., 2014) [7].

Phytochemicals present in *Moringa oleifera* and their uses

Every parts of moringa contain various types of antinutrients which have modest adverse effect over the beneficial actions. It is rich in plant secondary metabolites such as polyphenols, tannins, terpenoids, anthraquinones, alkaloids, terpenoids, sterols and some types of soluble carbohydrate including anti cancerous substances like glycerol-1-9-octadecanoate, isothiocyanates, glucosinolates and few amount of glycoside compounds (Makkar and Becker, 1997) [36].

Polyphenols

Dried leaves of moringa are laden with principal chemical compounds such as flavonoids and phenolic acids (Pandey and Rizvi, 2009) [45]. Flavonoids are synthesize by the plant against the microbial infections, as a protective substance (Kumar and Pandey, 2013; Bovicelli *et al*., 2002) [33, 13]. In animal trials flavonoids are found to involve as curative agent in response to some chronic diseases, which is associated with oxidative stress, including cardio vascular disease and cancer. Myrecytin, quercetin and kaempferol are the main flavonoids which are found in moringa leaves (Sultana and Anwar, 2008) [57].

Phenolic acids are naturally present in plants, they have strong antioxidant, anti-inflammatory, antimutagenic and anticancer properties (El-Seedi *et al*., 2012, Verma *et al*., 2013) [20, 61]. Most abundantly gallic acid is present in the dried leaves of moringa (Prakash *et al.,* 2007) [48] and ester of chlorogenic acid (CGA) which has a role in glucose metabolism (Amaglo *et al.,* 2010) [8]. It reduces hepatic gluconeogenesis and glycogenolysis by inhibition of glucose-6-phosphate translocase in rat liver (Karthikesan *et al*., 2010) [31]. CGA has also been used to reduce the glycemic response in rodents (De Sotillo and Hadley, 2002) [17]. CGA has anti-dyslipidemic properties; it reduces plasma total cholesterol and triglycerides (TG) in obese Zucker rats (Cho *et al*., 2010) [14].

Alkaloids, glucosinolates and isothiocyonates

Different variety of alkaloids have been isolated from *Moringa oleifera* leaves which includes N, -L-rhamnopyranosyl vincosamide, phenylacetonitrile, pyrrolemarumine, 40-hydroxyphenylethanamide-, -L-rhamnopyranoside and its glucopyranosyl derivative (Panda *et al*., 2013, Sahakitpichan *et al*., 2011) [44, 53].

Glucosinolates

All most every part of Moringa (stem, leaves, flowers, pods and seeds) contain Glucosinolates, 4-O-(a-L-rhamnopyranosyloxy)-benzylglucosinolate or glucomoringin, where as roots of Moringa are rich in benzyl glucosinolate (glucotropaeolin) (Amaglo *et al*., 2010) [8]. Isothiocyanates, nitriles, and thiocarbamates have strong hypotensive (blood pressure lowering) and spasmolytic (muscle relaxant) effects which mainly occurs due to enzymatic catabolism of glucosinolates by action of endogenous plant enzyme myrosinase (Anwar *et al*., 2007) [9]. Both glucosinolates and isothiocyanates have imperative health-promoting properties (Dinkova-Kostova and Kostov, 2012) [18].

Tannins and Saponins

Moringa leaves are excellent source of saponin and tannins, tannins are the water soluble phenolic compounds which give alkaloids, gelatin and other proteins on precipitation. The concentration of tannins in dry leaves ranges from 13.2 to 20.6 g tannin/kg (Richter *et al*., 2003) [51]. Tannins have anti-cancer, antiatherosclerotic, anti-inflammatory and anti-hepatoxic properties (Adedapo *et al*., 2015) [4].Whereas saponins have anti-cancerous properties (Tian *et al*., 2013) [59]. Saponin is a natural compound made by an isoprenoidal-derived aglycone, moiety that's covalently linked with one or more sugar moieties (Augustin *et al*., 2011) [10]. Their concentration in freeze-dried leaves ranges from 64 and 81 g/kg of dry weight (Makkar and Becker, 1996) [35].

In India, at present the dairy cows are a model of remarkable productive efficiency. In high yielder's, the average milk production is nearly 15,000 kg/cow, and 75% or more of the energy consumed is diverted towards milk production and other physiological functions beyond maintenance. Livestock's are spirit of the agricultural sector in all tropical countries (Steinfield *et al*., 2006) [55] and the dairy industry improves economic magnitude of the country. The livestock farms have massive number of productive stocks and generally follow stall feeding and providing mainly grasses as maintenance fodder, locally existing by-products of grains, and commercial feeds accessible in the market as concentrates. The indigenous and cross bred cows are the most popular and produce around 1-10 kg milk per day (range, 5–15 kg) by feeding concentrate with roughage 1–8 kg per day, which has a squat in crucial nutrients. In duration of the dry period solitary farmers cannot manage to pay the cost of conventional concentrates feed for feeding to their animals, because these conventional feeds are expensive. Hence, there is a need for an alternative feed source, which is economical and easily accessible that may contain valuable components for animal diet and can easily be produced and be readily made available. *Moringa oleifera*, recognized as Vaivai in Fiji, Tamaligi (Samoa), Oloha-kerafo in their confined language, and sahjan in our local language, it is an indigenous species that can be used as complementary feed in ruminant diets. Fruits, seeds, leaves and flowers are consumed as nourishing vegetables in lots of countries.

Preventive role of *Moringa oleifera* on chronic disease

Hypolipidemic effect

Bioactive compounds present in the leaves of *Moringa oleifera* have potent impact on Lipid homeostasis (Siasos *et al*., 2013) [54]. Flavonoids predominantly involve in the lipid regulation in spite of this all phenolic compounds have the capacity to regulate lipid metabolism by the inhibition of pancreatic cholesterol esterase activity and by this mechanism they reduce and delay cholesterol absorption, and its binding with bile acids, by forming insoluble complexes and increasing their fecal excretion, thereby it decrease plasma cholesterol concentration (Adisakwattana and Chanathong, 2011) [5]. The extracts of *Moringa oleifera* are showing their hypolipidemic activity by the inhibition of both lipase and cholesterol esterase (Toma *et al*., 2012) [60]. *Moringa oleifera* show strong impact on lipid profile by reducing cholesterol. *Moringa oleifera* leaves maintain cholesterol homeostasis mainly by two processes: In first process of cholesterol biosynthesis, the rate limiting process and cholesterol absorption of both dietary cholesterol and cholesterol cleared from the liver through biliary secretion catalize by 3-hydroxymethyl glutaryl CoA (HMG-Co-A) reductase, and the ethanolic extract of *Moringa oleifera*, depress activity of HMG-CoA reductase for support the further hypolipidemic action (Hassarajani *et al*., 2007). In addition to other secondary bioactive compound *Moringa oleifera* leaves contain β- sitosterol one other type of bioactive compound have cholesterol lowering effects. β-sitosterol, is the main compound which have cholesterol lowering effect in high fat fed rat plasma (Halaby *et al*., 2013) [28]. Saponins prevent the absorption of cholesterol by the binding with bile acids, by the binding of saponin, enterohepatic circulation of bile acids reduces and feacal excretion of bile acid increases (Oyedepo *et al*., 2013) [42]. The increased bile acid excretion is offset by enhanced bile acid synthesis from cholesterol in the liver, leading to the lowering of plasma cholesterol (Oyedepo *et al*., 2013) [42].

Antioxidant effect

Antioxidant present in moringa strongly works against the damage caused by the free redicals. High antioxidant concentration found in the moringa leaves which have anti inflammatory effect in cancer, hypertension, and cardiovascular diseases (Mensah *et al*., 2012; Bamishaiye *et al*., 2011) [38, 12]. β-Carotene is also a strong antioxidant found in moringa leaves. Moringa leaves contain combination of antioxidants including vitamin A (Ferreira *et al*., 2008 [24]; Lopez-Teros *et al*., 2017 [34]). *Moringa oleifera* have antimicrobial and anti-carcinogenic activity (Ayoola *et al*., 2008; Davinelli *et al*., 2015) [11, 16]. Phenolic compounds found in *Moringa oleifera* have capacity to inactivate lipid free radicals due to their redox properties. These properties of phenolic compounds play a key role in neutralizing free radicals, quenching singlet or triplet oxygen, or decomposing peroxides (Pokorny *et al*., 2001; Zheng and Wang, 2001) [46, 64]. Earlier studies have found that diverse types of leaf extracts of *Moringa oleifera* inhibit 89.7–92.0% of peroxidation of linoleic acid and scavenge the superoxide radicals in different doses in the carotene-linoleic acid system. Iqbal and Bhanger (2006) [29] reported that the environmental temperature and properties of soil have significant effects on antioxidant activity of *Moringa oleifera* leaves.

Anti-inflammatory and Immunomodulatory effect

Waterman *et al*. (2015) [62] found that isothiocyanates present in *Moringa oleifera* decreases the gene expression and production of inflammatory markers in RAW macrophages. Different extracts of *Moringa oleifera* leaves stimulated both cellular and humoral immune responses in immune deficient mice, by increases numbers of white blood cells, percent of neutrophils and serum immunoglobulins (Sudha *et al*., 2010; Gupta *et al*., 2010) [56, 27]. In addition, quercetin also reduces the inflammatory process by inhibiting the activity of neutral factor kappa-beta (NF-k) (Das *et al*., 2012) [15].

Hepato-protective effect

The hepatoprotective effect is found in the methanolic extract of *Moringa oleifera* leaves; moringa leaves protect the liver by the action of quercetin (Anwar *et al*., 2007 [9]; Tejas *et al*., 2012) [58]. *Moringa oleifera* leaves had consequently effects on the levels of liver enzymes aspartate amino transferase (AST), alanine amino transferase (ALT) and alkaline phosphatase (ALP). Some authors found that moringa leaves reduce lipids and lipid peroxidation levels in the liver of rats (Halaby *et al*., 2013) [28]. In some studies moringa also reduce plasma ALT, AST, ALP and creatinine and to ameliorate hepatic and kidney damage induced by drugs (Almatrafi *et al*., 2017) [6]. Also, Das *et al*. (2012) [15] found the same pattern in reduction in liver enzymes in high fat diet blend with moringa leaves, fed to rats (Iqbal and Bhanger, 2006) [29]. Some researchers also reported that guinea pigs, fed moringa extract with their routine diet show low level of serum ALT, AST, ALP, and creatinine.

Anti-hyperglycemic (Antidiabetic) effect

Moringa leaves contain principal active compounds Isothiocyanates regulate glucose homeostasis, reduce insulin resistance as well as hepatic gluconeogenesis (Waterman *et al*., 2015 [62]; Fabio *et al*., 2014 [21]). Phenolic acids and flavonoids affect glucose homeostasis by influencing cell mass and function and increasing insulin sensitivity in peripheral tissues (Oh and Jun, 2014 [40]; Oboh *et al*., 2015 [39]). Previous reports showed that Phenolic compounds, flavonoids and tannins inhibit intestinal sucrase and up to a certain extent pancreatic amylase activities (Augustin *et al*., 2011) [10]. Moringa show its beneficial impact on carbohydrate metabolism, including preventing and restoring the integrity and function of cells, increasing insulin activity, improving uptake of glucose and utilization (Makkar and Becker, 1996) [35]. Leaves of moringa contain terpenoids show hypoglycemic and antihyperglycemic activity, terpenoids also involved in the cell stimulation and subsequent insulin secretion, including terpenoids, flavonoids also have strong hypoglycemic action (Manohar *et al*., 2012) [37]. In a study where diabetes was induced peritoneally by injection with streptozotocin, rats were fed the equivalent of 250 mg/kg of moringa for 6 weeks, using control and diabetic animals. The groups consuming *Moringa oleifera* extract had significant decreases in malonaldehyde and improvements in the inflammatory cytokine-TNF and IL-6 when compared to control animals (Omodanisi *et al*., 2017) [41].

Hypotensive effect

Moringa oleifera leaves contain many bioactive compounds, which have been used by various drug industries for

stabilizing blood pressure, including nitrile, mustard oil glycosides and thiocarbamate glycosides. The four compounds, isolated from ethanol extract of moringa leaves that is niazinin A, niazinin B, niazimicin and niazinin A + B these factors show blood pressure lowering effect in rats that may be due to Calcium antagonist effect (Anwar *et al*., 2007 [9]; Dubey *et al*., 2013 [19]). A recent study reported that moringa reduced vascular oxidation in spontaneously hypertensive rats (Randriamboavonjy *et al*., 2017) [50].

Effects on ocular diseases

Vitamin A deficiency is a major cause of blindness, which responsible for impaired dark adaptation to night blindness. Moringa leaves, pods and leaf powder contain high concentrations of vitamin A, which help to prevent night blindness and eye problems. Leaves and oil consumption improves vitamin A and delay the development of cataract.

Anticancer Effect

Various bioactive compounds present in moringa, including 4 (L rhamnosyloxy) benzyl isothiocyanate, niazimicin and sitosterol-3-O-D-glucopyranoside, have anti-cancerous property (Abdull *et al*., 2014) [3]. Chemo preventive properties of moringa are known by its capacity to inhibit the growth of several cancer cells (Karim *et al*., 2016) [30]. Various bioactive compound present in moringa leaves protect organisms and cells from oxidative DNA damage, associated with cancer and degenerative diseases (Randriamboavonjy *et al*., 2017) [50]. Khalafalla and his coworkers (2010) [32] reported that the moringa leaves extract inhibited the viability of acute myeloid leukemia, acute lymphoblastic leukemia and hepato cellular carcinoma cells. In breast cancer cells, the antiproliferative effects of moringa were also demonstrated (Adebayo et al. 2017). Abd-Rabou *et al*. (2017) [1, 2] evaluated the effects *Moringa oleifera* extracts, including leaves and roots, and preparations of nanocomposites of these compounds against HepG, breast MCF_7 and colorectal $HCT116/Caco_2$ cells. All these preparations were effective on their cytotoxic impact, as measured by apoptosis (Abd-Rabou *et al*., 2017) [2]. Several animal studies have also confirmed the efficacy of *Moringa oleifera* leaves in preventing cancer in rats (Sadek *et al*., 2017) [52].

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