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# A review on *Moringa oleifera*- A potent medicinal herb

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## Abstract

*Moringa oleifera* L. (Family: Moringaceae) is an incredibly useful medicinal herb, possess significantly high nutritional value. It is an exceptionally healthy herb which is edible and its tree could easily and cheaply be cultivated and grown in Pakistan. It is also known as super food as it contains indigenous basis of highly digestible protein, iron, calcium, potassium, Vitamins A, C, E and polyphenols. *Moringa* is rich source of phytochemicals such as myricetin, phenolic substances, phenolic acids, flavonoids, isothiocyanates, tannins and saponins, quercetin, zeatin and kaempferol flavonoids which are effective antioxidants that have several therapeutic benefits. It is used as a medical herb having various health benefits. Moreover, different portions of moringa such a seed, roots, buds, leaves, flowers and bark, possess various forms of biological actions, such as anti-inflammatory, antimicrobial, anti-carcinogenic, antihypertensive, anti-hyperlipidemic, antidiabetic hepatoprotective and neuroprotective activities, that helps in the treatment of different aliments. The current review highlights the medicinal, therapeutic properties of and mechanisms of compounds extracted from *Moringa oleifera* also gaining new perspectives for further researches and advancement.

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**Introduction**

*Moringa oleifera* (MO) grows owing to its nutrient-rich seeds, edible leaves and flowers that can be used as food, medication, cosmetic oil or livestock feed. The height varies between 5 to 10 meters. Different experiments have been demonstrated positive effects on health (James and Zikankuba, 2017). MO is also used in developing countries as a source of fruits, medicinal plants and edible oil. It is an essential nutrient- rich vegetative plant and is commonly considered as a versatile food that can be eaten in all sections (Kumssa *et al*., 2017). Most researchers consider using MO as an alternative for preventive treatment or to relieve and avoid symptoms of the disease. Nevertheless, Western (traditional) medicine has been very reluctant in pursuing its dietary and medicinal potential, considering such research, observation, recommendations and specific assertions. This tentative approach is surprising because many "super foods" including garlic and green tea have been well known (Xiong *et al*., 2018). *Moringa* contain thirteen species from tropical and subtropical ecosystems, varying from tiny to large trees in height. MO is a *Moringa* family vine, the key crop in Asia and Africa, which is commonly grown in northwestern India. It is an ancient inhabitant of Pakistan, India, Bangladesh and Afghanistan in the Himalayan region and is popular here for various name of the field such as benzolive, kroll, drumstick tree, horseradish tree, marango and malunggay. In tropical and subtropical areas such as Asia, Eastern and Southern Asia, it has recently drawn scientific and socioeconomic focus (Abdull Razis *et al*., 2014). *Moringa* claimed as a nutrient-rich due to its anti-ulcer, anti-diabetic, hepatoprotective, diuretic and cholesterol lowering capacity. It has also been used in skin and hair care products. The aim of this review is to advise for daily intake of *Moringa* as it can supply the body with adequate energy and antioxidants to both strengthen the immune system and to avoid viral diseases effects.

*Bioactive compounds*

*Moringa* plants have an extensive range of bioactive compounds that can be obtained from different vegetative structures. These bioactive molecules include carbohydrates, phenolic compounds, phenolic acids, flavonoids, isothiocyanates, tannins, and saponins, oils and fatty acids, proteins and functional peptides and have great potential to be used in several formulations of food products (Saucedo-Pompa *et al*., 2018). Raw MO leaves are healthy source of Vitamin A which has a great importance in the function of vision, fertility, growth and formation of the fetus, protection and division of the cells. MO leaves also contain carotenoids with capacity for provitamin A. The content of vitamin C in *Moringa* leaves is more as compare to oranges, act as antioxidant which defends the body from the adverse effects of free radicals, contaminants and toxins. It is also a great source of beta-carotene, vitamin C, polyphenols and vitamin E, which are close in amount to those present in nuts, act as an antioxidant; shows inhibit cell proliferation (Gopalakrishnan *et al*., 2016). Dried moringa leaves are a major source of polyphenolic compounds including flavonoids and phenolic acids. The synthesized flavonoids in planta are a reaction to microbial infections and have a specific structure benzopyranone chain. Flavonoid intake has been shown to reduce persistent oxidative stress- related diseases, including respiratory disease and cancer.

The main flavonoids found in moringa leaves are Myrecytin, Quercetin and Kaempferol, and their concentrations are 5.8, 0.207 and 7.57mg/g, respectively. Quercetine is an effective antioxidant that has several medicinal effects. For obese rats with metabolic syndrome Zucker it has hypolipidemic, hypotensive and anti-diabetic results. Phenolic acids are a sub-class of naturally occurring phenolic compounds in plants, originating from hydroxybenzoic acid hydroxycinnamic acid. These substances have propensities to be antioxidant, anti-inflammatory, anti-mutagenic and anti-cancer. The concentration of gallic acid 1.034mg/g, chlorogenic acid 0.489mg/g and caffeic acid 0.409mg/g on a dry basis (Hidayati *et al*., 2018). Chlorogenic acid (CGA) is a dihydrocinnamic acid ester and the primary phenolic acid in moringa. CGA is an element which helps in the synthesis of glucose, blocks the transportase of 6-phosphate glucose in the liver and helps to increase liver gluconeogenesis and degradation of glycogen.

CGA has anti-dyslipidemia properties as it can suppress overall cholesterol and triglycerides (TG) in the plasma of high-fat diet mice and reverse STZ-induced dyslipidemia in diabetic rats (Alegbeleye *et al.*, 2018). Tannin is a phenolic substance soluble in the water that precipitates alkaloids, gelatins and other protein. Their concentration is between 13.2 and 20.6g tannin/ kg in dry leaves and significantly higher in lyophilized leaves. It has also been confirmed that tannin has anti-cancer, anti-atherosclerotic, anti-inflammatory and anti- hepatotoxic properties (Vergara-Jimenez *et al.*, 2017). MO leaves are also a great source of saponins which are natural bio active compound formed from isoprenoids. The concentration of saponin in freezed leaves with MO ranged from 64g/kg dry weight to 81g/kg. Saponins have antioxidant effects against cancer (Sharma and Paliwal, 2013).

*Impact of moringa oleifera (mo) on communicable and non-communicable diseases*

*Moringa and its anti-microbial effects*

Many studies have been conducted to determine the antibacterial ability of extracts from roots, leaves and bark of *Moringa*. Lectins which were isolated from the MO seeds extracts have inhibitory effect on the growth, survival and permeability of bacteria (Stohs and Hartman, 2015). Additionally, MO root extract has been reported to contain as an active antibiotic pterygospermine with good antibacterial and fungicidal effects (Fakurazi *et al.*, 2012). Isolated deoxynicotin from chloroform fraction in MO root bark ethanol extract has antibacterial and antifungal function (Saini *et al.*, 2016) while stem-bark sap has antibacterial activity on *Staphylococcus aureus* and have strong inhibitory activity on Gram-positive bacteria (*Staphylococcus aureus* and Enterococcus) than gram-negative bacteria (E.coli and Salmoneela) (Tan *et al.*, 2015). Another study proved its anti-microbial and antifungal activity, the EtOAc extract of *Moringa* showed higher antimicrobial activity (Yee, 2019).

*Moringa and its hypo-lipidemic effects*

Many bioactive compounds found in leaves may affects homeostasis of the liposomes. Phenolic compounds and flavonoids play a key role in regulating lipids. They reduce plasma cholesterol concentration by forming insoluble complexes and increasing their fecal excretion, thereby inhibiting the activity of pancreatic cholesterol esterase, reducing and delaying cholesterol absorption and combine with bile acids. By reducing the cholesterol, *Moringa* has a significant impact on blood lipid levels, it also alleviated the harmful elevation of cholesterol, triglycerides, low-density lipoprotein cholesterol, malondialdehyde, and the activities of alanine aminotransferase and aspartate aminotransferase in serum due to high fat diet. Cholesterol biosynthesis, in which 3-hydroxymethylglutaryl coenzyme A (HMG-Co-A) reductase catalyzes the bile cholesterol derived from the liver absorbs cholesterol and shows hypolipidemic effect. *Moringa* leaves also contain β-sitosterol, having cholesterol lowering effect. Saponin stops cholesterol from being ingested by binding to the molecule and bile acids, leading to the reduction in the enterohepatic production of bile acids and an increase fecal excretion. Decreased excretion of bile acid is compensated by decreased synthesis of bile acid in liver cholesterol, leading to reduce cholesterol in plasma (Helmy *et al.*, 2017).

*Moringa and its anti-oxidant Effects*

There is high concentration of antioxidants like beta-carotene present in MO leaves, used for patients with inflammation, including asthma and cardiovascular disease and cancer. Antioxidants work against free radicals produced in the body. A recent study in children showed that MO leaves may be an important source of vitamin C, which fights a host of illnesses including colds and flu; vitamin A, which acts as a shield against eye disease, skin disease, heart ailments, diarrhea, and many other diseases (Mahmood *et al.*, 2010). The MO leaves extracts also contain tannins, saponins, flavonoids, terpenes and glycosides having medicinal properties. Such compounds have been shown to be effective antioxidants, antimicrobials agents against cancer. Phenolic compounds are classified as key antioxidants owing to their role of inactivating lipid-free radicals or their ability to keep free radicals from decomposing hydroperoxides because of their redox properties, help to neutralize free radicals and decompose peroxides (Niedzwiecki *et al.*, 2016).

Methanol extracts of MO leaves contained chlorogenic acid, rutin, quercetin glucoside and many proanrthocyanidin found in the root and stem (Atawodi *et al.*, 2010). *Moringa* is considering as a medicinal plants and it extracts show strong anti-free radical activity and prevent oxidative damage due to the presences of polyphenol (Elgamily *et al.*, 2016).

*Moringa and its anti-Inflammatory Effects*

Inflammation is a system for protection inside the body. The immune system detects damage to cell, irritants and pathogens and start healing (Dai and Medzhitov, 2017). Chronic inflammation may help develop chronic inflammatory disease and disorders like cardiovascular diseases, diabetes, obesity, asthma and colitis (Anwar *et al.*, 2016). Inflammatory cytokines like tumor necrosis factor alpha can up-regulate the production of nitric oxide (NO) and prostaglandin E2 (PGE-2), thereby stimulating inducible nitric oxide synthase (iNOS), epoxy synthase-expression or enhancement of its activity, cyclooxygenase-2 (COX-2) and microsomal PGE synthase 1 (mPGES-1) in target cells. It has also been reported that MO not only reduces the response of human monocyte-derived macrophages stimulated by lipopolysaccharide (LPS) but also reduces TNF-α, IL-6 and IL-8. Furthermore acetic acid-induced acute colitis rat models, oral intake of hydroalcoholic extracts (MSHE) from MO seeds in three increasing doses (50, 100 and 200mg/kg) may reduce the mass of the distal colon, edema tissue, ulcer and mucosal inflammation severity, ulcerative colitis. Thus in acetic acid- induced acute colitis rat model, it may be considered as an effective treatment for inflammatory bowel disease (Kooltheat *et al.*, 2014).

Different studies also support that *Moringa* may stop the production of inflammatory markers like COX-2 and NO, TNF-α, IL-6 and IL-1β secretion. The extract of moringa seeds contains isothiocyanate help to reduce edema and inflammatory markers production in body. Furthermore another study was done on urinary tract infection (UTI) patients and it was observed that with the treatment of MO bar extract, 66% symptoms were cured in patients while 13% reported mild relief (Alvarez *et al.*, 2013).

The extract of MO leaves may stop the production of macrophages cytokines (TNF-α, IL-6) and IL-8) which may be induced by cigarette smoke. Quercetin which is an antioxidant present in the *Moringa* is 5 times more than grapefruit and okra. It fights against cancer cells by the controlling inflammatory process. Researchers documented reduced levels of inflammatory cytokines and stress in endoplasmic reticulum stress in animals fed with fermented product (Jaja-Chimedza *et al.*, 2017).

*Moringa and its hepato-protective effects*

*Moringa* leaves methanol extract providing a hepatoprotective effect, which may be attributed to the existence of quercetin presence. *Moringa oleifera* leaves has significant effects on levels of alkaline phosphatase (ALP), aspartate amino transferase (AST), alanine amino transferase (ALT), plus lipid reduction and lipid peroxidation concentration in rat liver. Its leaves have been discovered to minimize plasma ALT, AST, ALP, creatinine and to alleviate drug-induced hepatic and kidney damage. Related findings were found in a rabbits were taken as sample and treated with MO leaves and NiS04 for nephrotoxicity induction (Miltonprabu *et al.*, 2017).

Another experimental study was done on guinea pigs in which it was proved that Non-alcoholic fatty liver disease (NAFLD) can be prevented by treating MO leaves as a mod of liver steatosis, as demonstrated by reducing liver cholesterol and triglyceride concentrations. This reduction in liver lipids is associated with decrease inflammation and expression of genes included in lipid assimilation and inflammation (Ali *et al.*, 2018).

Lipid peroxidation (LPO) takes an essential role of body metabolism. It may inflict harm to cells and to the nerves if it disrupts the internal and external equilibrium, vivo study was done and observed that with the use of *Moringa* leaves for fifteen days, leaves effectively restore the rate of glutathione (GSH) and prevent liver peroxidation (Sinha *et al.*, 2016). Due to the presences of phytochemicals like ascorbic acid and phenols (catechin, epicatechin, ferulic acid, ellagic acid and myricetin), leaves play important role

in the elimination of free- radicals. In fact, the pre-administrstion of MO hydro-ethanol extract has an effective result on hepatotoxicity trial. The levels of lipid peroxidation, glutathione-S transferase (GST), glutathione peroxidase (GPx), and glutathione peptide reductase (GR) were similar to standard values, comparable to positive values. It was also observed through histopathological changes that liver toxicity caused by high fat diet and anti-tubercular drugs such as pyrazinamide, rifampicin, or isoniazid due to the low level of ALP, AST, ALT, LPO, and bilirubin, *Morinaga* plays an important role to protect liver from toxicity and damage (Giacoppo *et al*., 2015).

*Moringa and its anti- diabetic effects*

*Moringa* leaves several compounds may be associated with homeostasis of glucose. Like in reducing insulin resistance and processes of liver gluconeogenesis isothiocyanates present in the leaves have been proved. Phenolic acids and flavonoids influence homeostasis of glucose in such a manner as to influence the efficiency and function of beta cells and improve the sensitivity of insulin in adjacent tissues. Similarly, phenolic compounds, flavonoids and tannins have also been found to block pancreatic and intestinal enzymes. Its beneficial activity on carbohydrates metabolism has been shown in different ways including prevention and regeneration of the structure and function of beta cells, increasing insulin production and enhance the synthesis and utilization of glucose in cells. MO leaves may have anti-hyperglymic and hypoglycemic function due to the existence of terpenoids, linked to beta cell activation, and resulting insulin secretion. Likewise, flavonoids have been effective in reducing blood sugar levels. In another study, the levels of malondialdehyde were significantly lower in people who consumed MO extract, even the inflammatory cytokines TNF-α and IL-6 was improved (Omodanisi *et al*., 2017).

*Moringa and its anti-cancer Effects*

The anticancer result of *Moringa* has been tested for its chemo-protective properties and has been shown to prevent the development of various human cancer cells.

A variety of scientific studies have been demonstrated the ability of MO leaves to defend tissues and cells from oxidative DNA damage associated with cancer and degenerative diseases. The extract modulated oxidative stress and caused DNA fraction. Similarly, the extract upregulated apoptotic markers leading to death of cancer cells. Mo fruit extract induced apoptosis through mitochondria in human melanoma a 2058 cells via improved ROS manufacturing, caspase-nine,-three/7 activities and mapk phosphorylation (Guon and Chung, 2017).

Numerous bioactive molecules, namely four-(α-l-rhamnosyloxy) benzyl isothiocyanate, niazimicin and β-sitosterol-3-o-β-d-glucopyranoside found in MO are responsible for their anti-cancers attributes. Stem and seed infusions are mentioned to demonstrate the role of cytotoxic, anticancer and antitumor activities. In addition, MO leaves extract have been shown to be beneficial in pancreatic and breast cancers. In pancreatic cells, MO has been shown to regulate the growth of pancreatic cancer cells, suppress nfkb signaling and improve the effectiveness of chemotherapy by improving the potency of the drug in these cells (Christianto and Smarandache, 2019).

For certain breast cancer cells, the anti-proliferative properties of MO have already been confirmed. A study of Abd-rabou *et al*. evaluated the consequences of numerous extracts from MO, which include leaves and roots, and preparations of nanocomposites of those compounds in opposition to hepg, breast mcf 7 and colorectal hct116/caco2 cells. All these preparations had been powerful on their cytotoxic effect, as measured by using apoptosis. Numerous animal research have also showed the efficacy of MO leaves in stopping cancer in rats with hepatic carcinomas brought about by means of diethyl nitrosamine and in suppressing azoxymethane-caused colon carcinogenesis in mice, moreover, MO leaves additionally have anti-inflammatory, anti-tumor and anti-cancer results (Al-asmari *et al*., 2015).

We speculated that the chemo preventive impact of MO arose from fatty acids found in which would possibly modulate cells proliferation and/or apoptosis and anti-inflammation which plays a crucial position in colon carcinogenesis.

It has been stated that human colon tumor growth is promoted via oleic acid through mechanisms that comprise a growth in fatty acid oxidation and disturbance of membrane enzymes. In comparison, olive oil, a critical supply of omega-nine oleic fatty acid, may save you against the development of colorectal cancers as it have an impact on secondary bile acid styles inside the colon. Any other speculation for chemo preventive effect of MO pods may be because of the modulation of detoxing enzyme. It's been proven that MO pods extract has the capability for modulating section i and ii enzymes which include cytochrome b5, cytochrome p450, catalase, glutathioneperoxidase, reductase and s-transferase in mice (Vergara-Jimenez *et al.*, 2017).

Another study determined the anti-proliferative and apoptopic consequences of MO leaf extracts the use of human tumor kb cell line as a model system. Qualitative evaluation of the leaf extracts confirmed the presence of phenolic compounds such as quercetin and kaempferol, flavonoids, and have trace quantities of alkaloids. The observe studies established the anti-proliferative impact of MO by displaying its capability to set off loss of cell viability, morphology exchange, internucleosomal DNA fragmentation, and reactive oxygen species generation in kb cells (Sadek *et al.*, 2017). The aqueous extracts of MO leaves exhibited evident antineoplastic activity towards a lung cancer cell line as well as numerous different types of most cancers cells. The infusion brought on apoptosis, inhibited tumor cells, and decreased the internal ranges of reactive oxygen species in human most cancers cells. Moringa roots have exhibited precise estrogenic, anti-estrogenic, progestational, and anti-progestational activities. Its effectiveness in treating ovarian cancers have become obvious after the publication of recent studies demonstrating that benzyl isothiocyanate and phenethyl isothiocyanate induce apoptosis in ovarian cancer cells in vitro (Alegbeleye, 2018).

Another research explored the impact of hot water extract of MO leaves, showed anti-proliferative effects in a549 lung cancers and esophageal cells. The extract enhanced the ROS which brought about the induction of p53, caspases, and cleavage of parp-1 which may cause apoptosis inside the cancer cells. Glucosinolates found in MO is effective against different types of cancers. It has the potential to cause apoptosis. Cancer cells swiftly proliferate and consequently anticancer agents are required to target their mode of action. Apparently, MO has been shown to own a extensive range of activity and can target numerous proteins and molecules to inhibit most cancers cellular development (Tiloke *et al.*, 2016).

*Moringa and its neuro-protective effects*

Dementia is a significant lack of global cognitive ability, including brain disorder, impairment of memory, concentration, language, and problem solving. It is a chronic neurodegenerative disorder that tend to evolve worldwide people age. Alzheimer's disease (AD) is the primary cause of dementia. It is a lifelong progressive neurodegenerative condition. ROS is associated with oxidative stress and can induce apoptosis via mitochondrial degradation and damage to lipids, proteins and DNA. Previous work has demonstrated that oxidative stress is known to be a significant cause in neurodegenerative diseases, including AD, Parkinson's disease (PD) and Huntington's disease (HD), and amyotrophic lateral sclerosis (ALS).Antioxidants have also gained broad interest as potential treatment for neurodegenerative diseases. While several attempts to find potential for AD therapies have not been found, no current therapies have been proven to delay or inhibit the progression of the disease. Owing to the high cost and associated side effects of prescription anti-dementia medications, natural products containing flavonoids have attracted great value as candidate drugs for the prevention and/or treatment of neurodegenerative diseases (Muzumbukilwa *et al.*, 2019).

It is believed that MO leaves has antioxidant property and give protection to the nerve system. An experimental study was done in which isothiocyanate isolated from the extract of MO seeds given to 1-methyl- 4 -phenyl- 1-2-3-6- tetrahydropyridine (MPTP)-induced sub-acute PD mouse model for a week, it was observed that isothiocyanate regulate the signaling pathways related to oxidative stress and

apoptosis and it is useful in the prevention of PD in clinical practice. Under extreme medical conditions, MO may promote the development and survival of neurons like extracting 30µg/mL ethanol extract from MO leaves can promote neuritis growth and neuronal differentiation of primary embryonic neurons in a concentration-dependent manner. Similarly *Moringa* leave oil may increase the number, length of dendrites, axon branches, and the length of axons and ultimately promote synapse formate (Omodanisi *et al.*, 2017). Many studies have also shown that MO leaf extracts can effectively enhance the visual memory and neurodegeneration of corneal ammonium 1 (CA1), CA2 and CA3 regions and the dentate gyrus of hippocampal tissue. It can also reduce malondialdehyde (MDA) content and acetylcholinesterase (AChE) activity and it may increase SOD and catalase activity. Accumulation of aluminium choride is very high in modern world, as it is used in bakery products, pickled processing, processed cheese manufacturing and cake decoration, which can induce neurotoxicity and depression, a serious health issue all over the world. Treatment or intervention is quite critical because side effects of long term use of antidepressants. Due to this reason safer antidepressant should be introduced like the administration of 300mg/kg of *Moringa* leaf extract for a month may reduce the expression of neuro-specific enolase (NSE) (Kou *et al.*, 2018).

## Conclusion

*Moringa* is a well-known herb due to its pharmacological and therapeutic properties. It has many bio-active components which provide additional health benefits beyond the essential needs. Due to its high nutritional bio availability and medicinal properties it aids against different aliment such as diabetes, elevated blood pressure, cancer, antioxidant activity of disease prevention, such as: cardiac attack, obesity, Parkinson's disease and Alzheimer's disease. *Moringa* extracts controls hypercholesterolemia which led to an increase in the body weight, total cholesterol, triglycerides, and reduction in the levels of HDL. It indicates a significant decrease in hepatic biomarkers levels and glucose levels. *Moringa* also has a major thermogenic impact because of this it serves as a hypolipidemic and thermogenic agent in problems related to obesity. *Moringa* still seems to be a "miracle" plant with endless advantages for mankind besides can thus be taken at a very reasonable price as a high-quality nature gift.

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There is no conflict of interest

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