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Pharmacological Review of *Moringa oleifera*



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ABSTRACT

Moringa oleifera is a plant that possesses high nutritional value and has been used in folklore medicine to treat various and socio-economic benefits. *Moringa oleifera* leaves were quantitatively analyzed and it was noticed that the aqueous extract had polyphenols, flavonoids, vitamin C which possess high antioxidant activity. *Moringa oleifera* have several medicinal uses like anti-oxidant, anti-inflammatory, hyperlipidemia, anti-depressant, anti-fungal, anti-ulcer, detoxification. Alcohol, hydroxyl, alkane, aldehydes, alkenes groups, nitro compounds, aromatic amines, aliphatic amines, and alkyl halides, among other functional groups, were found in the methanolic extract of *M. oleifera* leaves. The presence of flavonoids gives leaves antidiabetic and antioxidant properties. The presence of phytochemicals indicates the nutritional and medicinal properties of *M. oleifera* leaves.



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INTRODUCTION

Moringa oleifera (MO), commonly called as drumstick tree, horseradish, or benzolive tree, is autochthonous to South Asia, in the regions of Himalayas, India but now it is grown in various tropical and subtropical countries such as Afghanistan, Nepal, Bangladesh, Sri Lanka, South and Central America, West Indies, Philippines, and Cambodia.¹ *Moringa oleifera* belongs to the family Moringaceae, genus *Moringa*.² *Moringa oleifera* is a tropical fast-growing deciduous tree with a diameter of 20 to 40 cm at chest height and a height of 7 to 15 meters. The term "Miracle" comes from the fact that the tree pieces have several uses and functions.³ Despite the great economic importance, *M. oleifera* is still not well exploited and hence considered underutilized.⁴ The bioactive compounds embracing dietary fiber, flavonoids, phenolic acids, alkaloids, carotenoids, isothiocyanates, glucosinolates, tannins, saponins, oxalates, phytates and proteins, vitamins, minerals, and beta-carotene are abundant in *Moringa* leaves. There will be no dropping of nutritive value when stored for months as dried powders, they can be consumed fresh and can also be cooked. Few reported studies were done on the hypoglycemic potential of leaves of moringa leaves in humans, wherein a study was conducted to evaluate the antidiabetic potential of leaves of moringa in patients aging from 40 to 58 years who were suffering from type 2 diabetics.⁵ *Moringa oleifera* has embraced phytochemicals such as antidyslipidemic, antihelminthic, antihyperglycemic, anti-inflammatory, antimicrobial, antioxidant, antiproliferation, anti-ulcer, and hepatoprotective properties.⁶ The leaves of *Moringa oleifera* are bipinnate and tripinnate ranging up to 45 cm, the leaflets are hairy, green, and are nearly hairless on the upper surface. The twigs of moringa are green in color and hairy, the leaflets are 1 to 2 cm in length.⁷ *Moringa oleifera* is known as "mother's best friend" in the Philippines as it is used to improve the production of milk in the case of breastfeeding women.⁸

AIM

A review on *Moringa oleifera* for its Pharmacological and medicinal uses.

METHODOLOGY

A literature search was conducted using the keywords "*Moringa oleifera*,"

"Nutritive Properties," "Moringa leaf," "phytochemicals," and "biological activities" on electronic databases (Google Scholar) were thoroughly referred to compile published research works till January 2021.

USES OF MORINGA

Moringa provides a rich and rare combination of nutrients, amino acids, antioxidants, antiaging and anti-inflammatory properties used for nutrition and healing. Moringa is also known as the "Miracle Tree" and "Mother's Best Friend." Since 1998, the World Health Organization has promoted Moringa as an alternative to imported food supplies to treat malnutrition. Six phytochemicals with hypotensive, anticancer, and antibacterial properties have been identified which include benzyl isothiocyanate, niazimicin, pterygospermin, benzyl isothiocyanate, and 4-{ α -L-rhamnopyranosyloxy}benzyl glucosinolate.⁹

NUTRITIVE PROPERTIES

The leaves of Moringa are rich in Potassium, Calcium, Iron, and Vitamin A, C and the quality of the protein present is better than that present in milk and eggs. The leaves of Moringa are used to prevent malnutrition in the case of infants and feeding mothers.¹⁰ The calcium, iron, and potassium content of the leaves also showed significant differences. *M. oleifera* contained the greatest amounts of beta-carotene, ascorbic acid (Vitamin C), α -tocopherol (Vitamin E), and iron among four Moringa cultivars studied. Fresh leaves of *M. oleifera* are good sources of carotenoids such as trans-lutein, trans-b-carotene, and trans-zeaxanthin. *M. oleifera* leaves have also been found to contain a significant amount of essential amino acid and are rich in alpha-linolenic acid. The leaves are known to be an excellent source of a wide range of dietary antioxidants.¹¹ *Moringa oleifera* is rich in minerals that are important for development and growth. *Moringa oleifera* leaves contain 1000mg and the leaf powder contains more than 4000 mg of calcium content them. Apart from calcium, moringa leaf powder contains contain 20 mg of iron which is more than that obtained from spinach and beef, moringa leaf powder acts as a good source of iron as iron is important for the synthesis of DNA and RNA, in the medication of anemia and for the development of sperm cells. Leaves of *Moringa oleifera* contain flavonoids such as quercetin which are known for their anticancer, anti-proliferative, antidiabetic, antioxidant properties. Apart from flavonoids, *Moringa oleifera* is also rich in vitamins and minerals which are essential and important for boosting our immune system and in the treatment of several diseases.¹² *Moringa oleifera* is a

rich source of vitamins such as vitamin A which is essential for the healthy growth of hair and the eyes, vitamin B, and vitamin C. Along with vitamins, *Moringa oleifera* also contains phosphorous which is important for the development of bones, teeth and in the synthesis of several proteins which are essential for the working of the body, in the synthesis of ATP, for the normal functioning of the cell, and in the recovery of the damaged cells and the tissues.¹³

PHARMACOLOGICAL PROPERTIES OF *MORINGA OLEIFERA*

M. oleifera is often referred to as a panacea and can be used to cure more than 300 diseases. Moringa has long been used in herbal medicine by Indians and Africans. The presence of phytochemicals makes it a good medicinal agent.

1) ANTIBACTERIAL ACTIVITY

The extract of *Moringa oleifera* leaves using different solvents such as methanol, ethanol, chloroform is effective in contradiction to Gram-negative bacteria such as *Shigella shinga*, *Pseudomonas aeruginosa*, *Shigella sonnei*, and *Pseudomonas* spp and six Gram-positive bacteria: *Staphylococcus aureus*, *Enterobacter aerogenes*, *Escherichia coli*, *Salmonella typhi*, *Streptococcus-Beta-haemolytica*, *Bacillus subtilis*, *Sarcina lutea* and *Bacillus megaterium*.¹³ The antibacterial activity of *Moringa oleifera* is due to the presence of benzyl-isothiocyanate, a bio-compound that interrupts the mechanism of synthesis of essential enzymes which are important for the proliferation of bacterial cells, thus inhibiting the growth of the bacteria effectively. Tannins and gallic acid, which hinder *Vibrio* spp., and saponins, tannins, isothiocyanates, and phenolic compounds, such as alkaloids and flavonoids, which have inhibitory action, are also ascribed to the antibacterial activity of *M. oleifera* extracts.¹⁴

The anti-bacterial effect of MO-Zinc oxide nanomaterials was investigated against by measuring the zone inhibition diameter, wherein it was observed that the zone of inhibition was increasing with increase in the addition of the nanomaterial against both Gram-positive and Gram-negative pathogenic, thus confirming the antibacterial effect of MO-Zinc oxide nanomaterials.¹⁵

Antibacterial activity of *Moringa oleifera* methanol and n-hexane seed extracts on three bacterial species which are the cause of the water borne disease. Methanol extracts of *M. oleifera* resulted in remarkable inhibition of *E. coli*. The results from this study suggest

that the extracts of *Moringa* seeds contain bio-compounds whose antibacterial potentials are high when compared to that of the extracts obtained from that of the leaves.¹⁶

2) ANTI-DIABETIC PROPERTIES

Moringa oleifera is effective in the treatment of Type 1 and Type 2 diabetes.¹² Anti-diabetic action is due to the presence of glucomoringin, phenols, flavonoids, quercetin-3-glucoside, fiber, and phenol.¹

The effect of MO on lipid profile was evaluated and it was observed that there was remarkably decrease in the liver weight, blood glucose level and relative liver weight in MO-treated group when compared to other groups. There was remarkable decrease in the low-density lipoprotein (LDL), cholesterol (CHOL) and elevation in the High-density lipoprotein (HDL) in MO treated groups.¹⁷

The combined effect of MO and *Vernonia aygdalina* (VO) was evaluated for their anti-diabetic effect, wherein it was observed that the three important liver enzymes, alkaline phosphate (ALP), alanine amino transaminase (ALT) and asparate amino transaminase (AST) were remarkably lowered in the combined treatment than the individual extract treatments, it was also noticed that MO extract was more effective on AST, ALP, ALT when compared with standard drugs. The total protein albumin concentration was remarkably elevated in case of combined treatment when compared with the single extract administered group. The body weight of experimental groups were initially reduced followed by a sudden rise in weights when combined extract was administered. These results suggest that single and combined extracts of MO and VA can prevent diabetes induced damage to the liver.¹⁸

3) ANTIOXIDANT ACTIVITY

The antioxidant assay of flowers and dried leaves of *Moringa oleifera* reveal that they are rich in phytochemicals. And when the total phenolic content (TPC) and total flavonoid content (TFC) of selected vegetables such as spinach, cabbage, broccoli, peas and to that of the dried leaves and flowers of *Moringa oleifera* and it was noticed that the total phenolic content was twice to the of the selected vegetables and the dried leaves of *Moringa oleifera* has greater phenolic content when compared it with the fruit and seeds of *Moringa oleifera*, these findings suggest that the dried leaves, fruit, and seeds of moringa have greater antioxidant activity.¹³ The *Moringa* genus is rich in bioactive polyphenols, which makes it a

potent antioxidant, and the extracts obtained from mature and tender leaves display higher antioxidant activity and avoid the damage caused by oxidative stress due to the enhancement in the levels of polyphenols in the cells.¹⁹ The oxidative damage which is due to a high-fat diet appears to be inhibited by the intake of extracts obtained from leaves of *Moringa oleifera*.⁷

Enzymatic and Non-enzymatic antioxidant levels present in the tender and mature leaves were analyzed and it was observed that there was higher activities of enzymatic and non-enzymatic antioxidants were present in mature leaf extract. The results from *In vitro* λ DNA exposed to H₂O₂ was evaluated in presence and absence of leaf extracts and it was observed that the DNA damage caused was remarkably reversed by the tender and mature leaf extracts of *Moringa oleifera*. These results suggest that tender and mature leaf extracts have potent antioxidant activity against free radicals and prevent DNA damage.²⁰

The ethanolic extracts of leaf rachis, leaf tissues, inflorescence rachis reduced DPPH faster than other extracts. The chromatogram results showed that the ethanolic extract from the flowers, fundamental tissue of stem and leaf tissue, inflorescence rachis showed that it contained three flavonoids and the saline extract from the leaf tissue and flowers showed two flavonoids.²¹

4) ANTI-INFLAMMATORY ACTIVITY

Moringa oleifera is rich in phytochemicals such as flavonoids and phenolic acids which are correlated with the anti-inflammatory property it own's.¹³ This is a fact that leaf, fruit, seed, and root extracts have been used since long back in the enhancement of inflammation-related disorders, for example, asthma, allergic rhinitis, atopic dermatitis, and rheumatoid arthritis.²² *Moringa oleifera* methanolic and aqueous root and bark extracts, as well as methanolic extracts of leaves and flowers and ethanolic extracts of seeds, have anti-inflammatory properties. *In-vitro* anti-inflammatory activity from the hot water infusions of flowers, leaves, roots, seeds, and stalks or bark of *Moringa oleifera* using carrageenan-induced and the extract was pharmacologically evaluated.⁷

Inflammatory biomarkers such as cytokines IL-6, TNF- α , chemokine MCP-1 which were elevated in diabetic groups were remarkably decrease upon treatment with MO in the liver of diabetic rats.¹⁷

5) ANTICANCER EFFECTS

The anticancer property of *Moringa oleifera* is studied to know its effects on oxidative stress, DNA damage and several research studies report that it is effective to hinder the development of cancer cells and the viability of acute lymphoblastic leukemia, hepatocellular carcinoma cells, and acute myeloid leukemia.²³ The extracts obtained from the bark and leaf of *Moringa oleifera* are prominent in hindering the development of pancreatic, breast, and colorectal cancer cells.¹⁹ The extracts of *Moringa oleifera* with solvents such as Dichloromethane and methanol possess anticancer activity without showing toxic effects on human fibroblasts against human hepatocellular carcinoma, colorectal adeno carcinoma, and breast adeno carcinoma.¹⁴ Several research studies elucidate that the reason behind the inhibition of cellular growth is due to the induction of reactive oxygen species in the cancer cells, which lays a path for the apoptosis of the cells, the compounds such as glucosinolates, niazimicin, and benzyl isothiocyanate which are present in the leaves of *Moringa oleifera* are the reason for its chemopreventive activity.¹²

The results from carrageenan test reveal that the ethanolic extract of MO showed a remarkable and non-dose dependent diminution in the percentage of inflammation at different intervals of time after administration.²⁴

6) NEUROPHARMACOLOGY

Moringa oleifera helps in neuronal development and survival. It is reported that ethanolic extract from the leaves of *Moringa oleifera* at a concentration of 30 µg/mL in a concentration-dependent manner helps in the outgrowth and development neurites and neuronal differentiation from primary embryonic neurons. It was observed that *M. oleifera* leaf extract can elevate the number and length of dendrites and axonal branches, as well as the length of axons, which in turn enhance synaptogenesis.²⁵

7) ANALGESIC ACTIVITY

The analgesic activity of *Moringa oleifera* was evaluated by taking the leaf extracts by using ethanol as a solvent on albino mice with the help of writhing test and Edd's hot plate test by using acetic acid as an inducing agent and it was noticed that the leaf extracts had an analgesic activity which displays the central and peripheral analgesic activity of *Moringa oleifera*.²⁶ Besides the *Moringa oleifera* alcoholic extract, ethyl acetate, Diethyl ether,

Petroleum ether and n-Butanol display analgesic action. The effect was similar to aspirin the standard drug.²⁷

The ethanolic leaf extract of MO was evaluated for its analgesic activity by writhing test and Eddy's hot plate test, wherein it was observed that there was dose-dependent increase in the percentage inhibition of writhes at different concentrations of MO administered when compared with standard. The results from hot plate method reveal that ethanolic extract of MO at 400 mg/kg showed a remarkable analgesic activity thus conforming its effect on central and peripheral analgesic actions.²⁸

8) WOUND HEALING

Moringa oleifera leaves promote healing of wounds by amplification of the cells and by the migration of Diabetic Human Dermal Fibroblast cells. Recent research has found that diabetic animals had greater tissue regeneration and enhanced the tube-shaped structure epithelial protein in wound tissue as a result of leaf extraction, which promotes wound healing.²⁹ In the case of rat models, the aqueous leaf extracts of *Moringa oleifera* hold wound curing property.²⁷

Ethyl acetate fraction of MO leaf extract was evaluated at different concentrations. The cytotoxic effect of MO on HDF-N cells was not observed even at higher concentrations. The cell proliferation of HDF-N cells was seen at different concentrations and upon further increase of the concentration of MO, there was decline in the HDF-N cell proliferation. Scratch assay was performed to determine to understand the effects on spreading and migration of cells, it was noticed that there was lower concentration of MO fraction caused proliferation and migration of cells rapidly than that of higher concentration. At higher concentration, there was alteration in the morphology of size and shape of the cells, indicating toxicity. These results suggest that the ethyl acetate fraction of MO leaves promote wound healing by proliferation and migration.³⁰

Titanium dioxide nanoparticles synthesized using aqueous leaf extract of MO was evaluated for its wound healing activity and it was observed that there was enhanced wound contractions which also confirms its antimicrobial property.³¹

9) CARDIOPROTECTIVE ACTIVITY

The anti-atherosclerotic activity of the leaves of *Moringa oleifera* was evaluated in male New Zealand white rabbits and compared with the standard drug simvastatin. The rabbits were fed with high cholesterol diet. Different parameters such as conjugated diene, levels of cholesterol, plaque formation, and thiobarbituric acid reactive substances (TBARS) were tested and evaluated after the treatment. It was noticed that the TBARS formation was inhibited and it was observed that the lag time of conjugated diene was increased in case of in vitro and ex vivo in a dose-dependent manner. The study also reported that there was a reduction in the atherosclerotic plaque formation and the levels of cholesterol when administered with the aqueous extract of *Moringa oleifera* for about a period of 12 weeks. It was observed that the aqueous extract of *Moringa oleifera* has hypolipidemic properties and can be used in the prevention of cardiovascular diseases.³² It was observed that the hydroalcoholic extract of the leaves of *Moringa oleifera* can be used to treat cardiac diseases such as myocardial infarction via the isoproterenol-induced method.²⁷ The ethanolic extracts of *Moringa oleifera* extracts showed remarkable effects on the heart and when evaluated with different parameters such as heart weight, body weight, serum triglyceride, serum cholesterol levels of the rats which were induced with adrenaline.³³

CONCLUSION

The present study concludes that *M. oleifera* leaves possess phytochemicals, such as Alkaloids, Triterpenoids, Flavonoids, Tannins, Saponins, Glycosides, and Carbohydrates, etc., which are of high therapeutic value. The results of our study suggest that *M. oleifera* leaves are rich in phenolic compounds, flavonoids, and Vitamin C which have strong antioxidant activity. The present study suggests that the presence of phytochemicals in *Moringa oleifera* leaves acts as a good source of nutrients that can be used as a food and it also has the potent medicinal property to improve the health status of humans by consuming it. Further, the synthesis of the active principle can lead to the development of promising drugs in treating various diseases.

CONFLICTS OF INTEREST: No competing financial/personal interest exist.

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