



"Exploring The Pharmacological Potential Of Moringa Oleifera: An Overview Of Bioactive Compounds And Health Benefits"

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Abstract

Moringa oleifera, a tropical plant commonly known as the drumstick tree, holds immense promise as a source of pharmacologically active compounds with potential health benefits. This review aims to provide a comprehensive overview of the bioactive compounds found in Moringa oleifera and their associated pharmacological effects on human health. Moringa oleifera is rich in a wide range of bioactive constituents including vitamins, minerals, antioxidants, flavonoids, phenolic acids, and glucosinolates. These compounds contribute to its diverse pharmacological activities, including antioxidant, anti-inflammatory, antimicrobial, anticancer, antidiabetic, cardioprotective, hepatoprotective, and immunomodulatory effects. The antioxidant properties of Moringa oleifera help in scavenging free radicals and reducing oxidative stress, thereby protecting cells from damage and preventing various chronic diseases. Its anti-inflammatory activity can

alleviate inflammatory conditions, while its antimicrobial properties may combat infections. Furthermore, *Moringa oleifera* shows promise in cancer prevention and treatment due to its ability to inhibit tumor growth and induce apoptosis in cancer cells. Its potential role in managing diabetes, cardiovascular diseases, liver disorders, and immune-related ailments has also been explored. Overall, this review highlights the pharmacological potential of *Moringa oleifera* and underscores the need for further research to elucidate its mechanisms of action, optimize therapeutic applications, and harness its full therapeutic potential for human health and well-being.

Key Word: Moringa, moringinine, Quirectin, Lemonene etc.

Introduction:

Moringa is known by several names, including "miracle tree" or "tree of life," *Moringa oleifera* is a multipurpose plant with many health, medical, and environmental advantages. Originating in the northwest Indian state of the Himalayas, *moringa* has expanded throughout tropical and subtropical regions of the world because of its capacity to adapt to a broad range of soil types and temperatures.

Malnutrition can be effectively treated using *Moringa oleifera*, a member of the Moringaceae family. Because its leaves, pods, and seeds contain a range of vital compounds, *moringa* is high in nutrients. *Moringa* is actually claimed to have seven times the vitamin C content of oranges, ten times the vitamin A content of carrots, seventeen times the calcium content of milk, nine times the protein content of yoghurt, and fifteen times the potassium content of bananas. *Moringa* is a sustainable treatment for malnutrition since it is simple to grow.

It's frequently grown for its tender seed pods and leaves, which are used as traditional herbal medicine and as vegetables. Water filtration is another application for it. *M. oleifera* is classified as an invasive species in a number of nations, however it "should be regarded at present as a widely cultivated species with low invasive potential" because it "has not been observed invading intact habitats or displacing native flora."

Botanical Features Moringa oleifera:

Moringa oleifera is a deciduous tree that grows quickly and can grow up to a height of 05 to 10 meters. It is a member of the Moringaceae family. Its bark is smooth and pale gray in color, and its trunk is often thin. The branches of the tree are drooping and have compound leaves, which are made up of tiny leaflets. The oval, brilliant green leaves are grouped in pairs along the stems.

All year long, loose axillary panicles up to 15 cm long bear flowers. Fruit is huge and unique, measuring up to 90 cm in length and 12 mm in width. It has two grooves on each face and is periodically constricted before tapering to a point that is 3- (4-) angled. Additionally, they have a light brown hue.

Kingdom: Plantae
Order: Brassicales
Family: Moringaceae
Genus: Moringa

➤ **Geographical Distribution:**

Mostly found in tropical and subtropical settings, the moringa plant, *Moringa oleifera*, is distributed geographically around the planet. The following describes the geographical areas where moringa is typically found:

1. Origin and Native Range:

It is thought that *Moringa oleifera* originated in northwest India in the foothills of the Himalayas. It is indigenous to Bangladesh, Nepal, Pakistan, India, and other countries on the Indian subcontinent. Moringa has been farmed and used for its nutritional, medicinal, and industrial qualities for generations in its native region.

2. Africa:

Because moringa is tolerant of a wide range of soil types and temperatures, it is widely grown in several African nations. It can be found in sections of Southern Africa as well as in West, East, and Central Africa. Major producers of moringa include Nigeria, Ghana, Senegal, Kenya, Ethiopia, and Tanzania.

3. Asia:

Moringa is widely planted throughout Asia in addition to its original range in the Indian subcontinent. Southeast Asian nations like the Philippines, Thailand, Indonesia, Malaysia, and Vietnam are among those where it is grown. Additionally, areas of South Asia such as Sri Lanka, Myanmar, Cambodia, and Laos are home to moringa.

4. Central and South America:

A number of Central and South American nations have adopted and grown moringa. Tropical nations such Brazil, Colombia, Mexico, Peru, and Ecuador are the places where it is grown. Moringa is prized in these areas for its nutritional qualities and promise in sustainable farming.

5. Caribbean and Oceania:

Countries in the Caribbean and Oceania areas are also known to cultivate moringa. Moringa planting has been adopted in islands including Fiji, Haiti, Jamaica, and the Dominican Republic. Because of its capacity to flourish in tropical temperatures, moringa can be grown in these areas.

6. Global Expansion:

Moringa cultivation has spread to different regions of the world as a result of its nutritive value, therapeutic qualities, and environmental advantages. Growing numbers of people are cultivating it in parts of North America, Europe, and the Middle East. It can be done so in greenhouses or other controlled environments.

Nutritional Value:

M. oleifera contains important nutrients and antinutrients in abundance in every part. Minerals like calcium, potassium, zinc, magnesium, iron, and copper are abundant in the leaves of M. oleifera. M. oleifera also contains vitamin C, D, and E, vitamin B, such as folic acid, pyridoxine, and nicotinic acid, and vitamin A's beta-carotene. Phytochemicals like tannins, sterols, terpenoids, flavonoids, saponins, anthraquinones, alkaloids and lessening sugar present alongside hostile to carcinogenic specialists like glucosinolates, isothiocyanates, glycoside mixtures and glycerol-1-9-octadecanoate. Moringa leaves likewise have a low calorific worth and can be utilized in the eating routine of the corpulent. The pods, which are useful for treating digestive issues and preventing colon cancer, are fibrous. According to a study, immature pods contain approximately 20.66% protein and 46.78 percent fiber. Units have 30% of amino corrosive substance, the leaves have 44% and blossoms have 31%. The youthful cases and blossoms showed comparative measures of palmitic, linolenic, linoleic and oleic acids.

Moringa has parcel of minerals that are fundamental for development and advancement among which, calcium is viewed as one of the significant minerals for human development. Moringa leaves can provide 1000 mg, while moringa powder can provide more than 4000 mg, while 8 ounces of milk can provide 300–400 mg. As an alternative to iron tablets, moringa powder can be used to treat anemia. While moringa leaf powder contains 28 mg of iron, beef only contains 2 mg of iron. According to reports [12], moringa has more iron than spinach. Zinc is required not only for the synthesis of DNA and RNA but also for the proper growth of sperm cells. M. oleifera leaves contain between 25.5 and 31.03 mg of zinc per kilogram, which is the recommended daily intake for zinc in the diet. Linoleic, linolenic, and oleic acids are all UFAs. Cholesterol levels can be controlled with these PUFAs. According to research, the approximately 76% PUFA content of moringa seed oil makes it an excellent alternative to olive oil. It is important to note that the location affects the composition of the nutrients.

Bioactive Compound in Moringa Leaves:

Moringa leaves contains various, bioactive compounds, which are biologically active and can exert beneficial effect on health. Following bioactive compound found in moringa leaves:

1. Vitamin and Minerals:

Moringa leaves are good source of vitamin A, C, D and vitamin B- complex, Moringa leaves also contain various essential minerals like calcium, potassium, iron, magnesium etc.

2. Phenolic Compound:

Phenolic compound include flavonoid such as quercetin, kaempferol and myricetin. These phenolic compound act as anti-oxidant in moringa leaves.

3. Alkaloids:

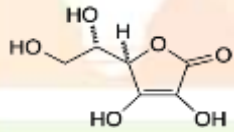
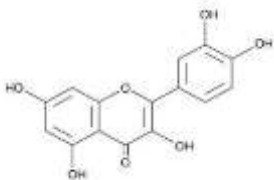
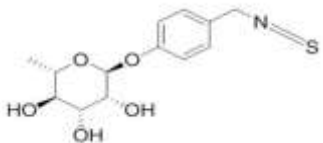
Moringa leaves contain alkaloids such as moringinine, which act as anti-hypertensive agent to control high blood pressure in body.

4. Essential amino acid:

Nine types of amino acid found in moringa leaves which are important for protein synthesis and overall health.

5. Other Bioactive Compound:

Some other bioactive compound like Glucosinolate, Isthocynate, Saponine Glycoside, Tannin, Terpenoids and Caetenoids etc found to be in moringa leaves which give potential anti-oxidant properties for reducing free radical's ad decrease chance of cancer.

S. No.	Bioactive Compound	Example	Properties
1.	Vitamin	 Ascorbic Acid	Antioxidant, Anti-Inflammatory, Neuroprotective etc.
2.	Phenolic Compound	 Quirectin	Anti-inflammation, Anti-cancer, Anti-Diabetic, Anti-allergic etc.
3.	Alkaloids	 Moringinine	Anti-hypertensive, Antioxidant, Analgesic, Anti-malarial etc.

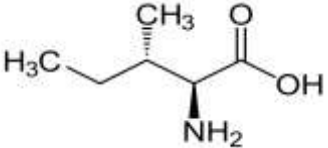
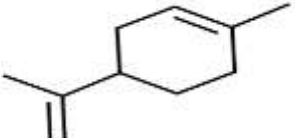
4.	Essential amino acid	 Isoleucine	Immune Booster, Anti Diabetic etc.
5.	Others	 Lemonene	Anti- Inflammatory, Anti-Microbial, Skin health etc.

Table 1: Bioactive Compound in Moringa Leaves

➤ **Moringa leaves in Inflammation:**

• **Reduction of Pro- inflammatory kinetics:**

Moringa leaves have been shown to inhibit the pro inflammatory cytokines such as $\text{TNF-}\alpha$, IL-6, and IL-1 β . These cytokines play vital role in promoting inflammation in various diseases.

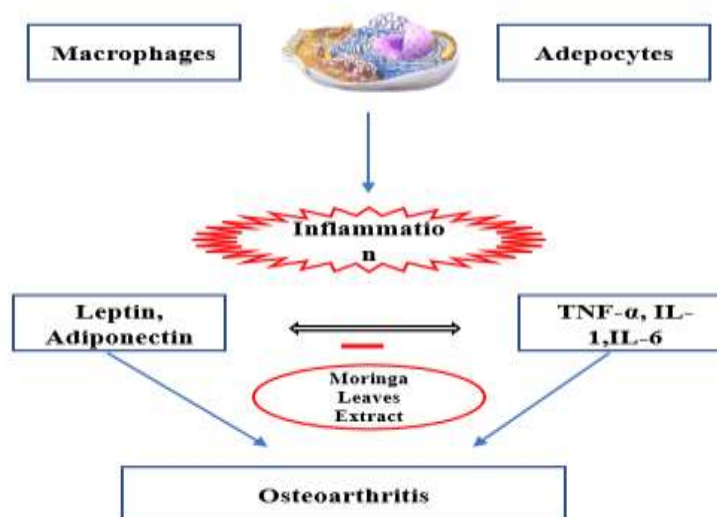


Figure : Reduction of Pro- inflammatory kinetics

• **Inhibition of Inflammatory Enzyme:**

Moringa leaves inhibit the activity of inflammatory enzyme involve in inflammation, such as cyclooxygenase (COX) and lipoxygenase (LOX). This inhibition helps reduce the production of inflammatory mediators like prostaglandin and leukotrienes.

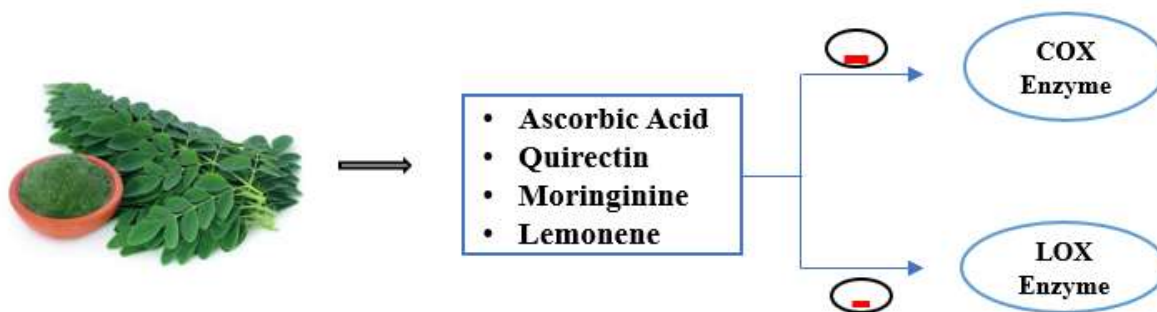


Figure: Inhibition of Inflammatory Enzyme

➤ **Moringa leaves in Blood Sugar level:**

The possible impact of moringa leaves on blood sugar levels, especially in diabetics, has been investigated. Some studies have showed encouraging effects, but additional research is required to completely understand the mechanisms and effectiveness. Moringa leaves contain a number of chemicals, including flavonoids, polyphenols, and isothiocyanates, which may help to explain some of its possible health advantages for blood sugar regulation. These substances may lessen insulin resistance, increase insulin sensitivity, and control the metabolism of glucose.

Moringa leaf extract or powder has been linked to improvements in glucose tolerance and a decrease in fasting blood sugar levels in a few small-scale experiments conducted on humans and animals. To validate these results and ascertain the ideal dosage and duration of moringa supplementation for efficiently controlling blood sugar levels, larger and more thorough clinical investigations are required.

➤ **Moringa leaves in blood pressure control:**

• **Nitric Oxide Production:**

Moringa leaves can help in the production of nitric oxide, which is essential for vasodilation. Vasodilation helps relax blood vessels, reducing blood pressure.

• **Calcium Channel Blocker Activity:**

Certain compounds in moringa leaves can act as natural calcium channel blockers, which help relax blood vessels and reduce blood pressure.

➤ **Moringa Leaves as Immune Booster:**

Moringa leaves, known as "nature's miracle tree," are rich in nutrients and antioxidants contributing to overall health and immune function. Packed with essential vitamins (A, C, E, and K), minerals, proteins, and antioxidants, moringa leaves play a crucial role in supporting the body's defence system.

➤ **Pharmacological Action of Moringa Leaves:**

Anti-inflammatory Effects:

Compounds contained in moringa leaves, including isothiocyanates and flavonoids, indicate anti-inflammatory activities. They suppress inflammatory pathways in the body, potentially lowering inflammation associated with many disorders.

Bioactive substances found in moringa leaves, such as quercetin, kaempferol, and chlorogenic acid, prevent the synthesis of pro-inflammatory mediators such prostaglandins, cytokines (such as interleukins and tumor necrosis factor-alpha), and nitric oxide synthase. Moringa leaves contribute to the reduction of inflammation by lowering the concentrations of these inflammatory chemicals.

Moringa leaves contain some chemicals that disrupt the body's important inflammatory signaling pathways, including the NF-kappaB pathway. One transcription factor that controls the expression of genes linked to inflammation is called NF-kappaB. Moringa leaves decrease NF-kappaB activation, which in turn reduces inflammation.

Anti-Microbial Effect:

The pharmacological characteristics of moringa leaves, which are sourced from the Moringa oleifera tree, have been investigated, including their antibacterial activities. The primary source of moringa leaves' antimicrobial activity is their abundance of bioactive substances, including glucosinolates, alkaloids, phenolic acids, and flavonoids. These substances work against bacteria, fungus, viruses, and parasites through a variety of methods.

In Brain:

Antioxidants found in moringa leaves, including flavonoids, phenolic compounds, and vitamins C and E, aid in the fight against oxidative stress in the brain. Neurodegenerative illnesses like Parkinson's and Alzheimer's are linked to oxidative stress, and antioxidants can help shield neurons from harm. Moringa leaves may improve cognitive function, according to studies. The compounds present in moringa leaves, such as flavonoids and polyphenols, have been connected to enhanced memory, learning, and

cognitive function. Moreover, they might improve neurotransmitter activity, fostering the best possible brain signaling.

Hypoglycaemic Effect:

It has been demonstrated that the bioactive substances found in moringa leaves, such as isothiocyanates, chlorogenic acid, and quercetin, reduce blood sugar levels. These substances may improve glycemic management by increasing insulin sensitivity, promoting cell uptake of glucose, and inhibiting the enzymes responsible for carbohydrate metabolism. Studies indicate that specific chemicals included in moringa leaves may enhance insulin sensitivity, hence facilitating cells' enhanced response to insulin and increased uptake of glucose from the bloodstream. This can lessen the chance of insulin resistance, a defining feature of type 2 diabetes, and help avoid hyperglycemia.

Cardioprotective Effect:

Moringa leaves have a number of cardioprotective qualities, such as the capacity to enhance heart function and guard against myocardial injury. Moringa leaf compounds may improve heart health and function by lowering myocardial oxidative stress, enhancing cardiac contractility, and preventing ischemia-reperfusion injury.

The anti-arrhythmic properties of moringa leaves may aid to normalize cardiac rhythm and fend against arrhythmias. The inhibition of aberrant electrical activity in the heart and the modification of ion channels and neurotransmitter release in cardiac cells may be the causes of these effects.

There may be hypotensive (blood pressure-lowering) effects from moringa leaves. Moringa leaves include compounds including quercetin and kaempferol that have been linked to vasodilation, which relaxes blood vessels and increases blood flow.

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Conclusion:

The drumstick tree, or *Moringa oleifera*, is a plant that is valued for its dietary and therapeutic qualities. Its abundance of different bioactive substances, including vitamins, minerals, antioxidants, and phytochemicals, adds to its range of health advantages. Potential anti-cancer effects, anti-inflammatory and antioxidant qualities, as well as assistance for a number of human health issues like immune system function, diabetic control, and cardiovascular health, are some of these advantages. Investigating *Moringa oleifera*'s pharmacological potential may help clarify its medicinal uses and open the door to more studies on the benefits of this plant for human health and wellbeing.

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