



Review Article

Ethnopharmacological use of *Moringa oleifera*: an updated review

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ABSTRACT

Moringa oleifera, commonly known as Moringa, is one of the most cultivated medicinal trees in South Asia. It is a member of the genus *Moringa* belonging to the family *Moringaceae*. The anticancerous efficacy of *Moringa* is one of the most important research topics in the world. *Moringa oleifera* contains good nutritional values and serves as an antioxidant, antispasmodic, antipyretic, antibacterial, anti-hypertensive, wound healing, and antiretroviral lead molecule which have been used to improve the activity of immune system. Dried powder of *Moringa* seeds has a special ability to bind the pollutants present in water. This plant proved its significant activity against different pathogenic microbes. *M. oleifera* is often known to be a "Miracle Tree" because of its strong immune-boosting and antimicrobial properties. *M. oleifera* extract contains Flavonoids, which have been used against many respiratory disease-causing viruses, such as respiratory syncytial virus and coronavirus. Topical application of ointment, as well as extract, is also helpful in enhancing the wound healing process. It is considered a good diet because it can prevent different chronic diseases such as obesity, diabetes and can be used as a medicine against these diseases. *Moringa* spp. has a good concentration of Vitamin A and other compounds in the extract, playing a good role in the prevention of ocular diseases. Though it has various nutritional, therapeutic, and health promotional effects, still much of its benefits are hidden and are yet to be discovered for the welfare of mankind.

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Introduction

Since the beginning of life, plants have always had a vital role in the life of humans around the globe. Plants have nutritional, cultural, religious, environmental, and therapeutic importance. In old ages, plants were categorized as poisonous and beneficial plants. Those plants were considered beneficial and had some therapeutic effect or were

edible. Even after the advancements in biology and the introduction of new medicines, herbal medicines did not lose their importance. In developing countries, where people have malnutrition, poor health, unemployment, poverty, and international trade isolation, herbal medicines play a key role in the lifestyle of people (Gaikwad 2021)

According to WHO, 80% of the rural population present throughout the world depends upon medicinal herbs as their primary healthcare system (Ambu et al. 2020). In the last few decades, it has been observed that the trade of herbal products has increased beyond expectations. Pakistan is one of the major importers as well as exporters of herbal things. Pakistan ranks ninth in terms of imports and tenth in terms of exports in the global herbal market. There are many plants in Pakistan, that have great medicinal importance and can bring prosperity to the country, but we are unaware of their uses (Jan et al. 2020).

"*M. oleifera*" is commonly known as "Horseradish tree", "Mother's best friend" or "drumstick" and can be cultivated in Northeast Africa, South Africa, Tropical Asia, Latin America, and Southwest Asia, but Northwest India is the main producer of this plant (Hedaoo et al. 2022). *Moringa oleifera* contains good nutritional values and serves as an antioxidant, antipyretic, antibacterial, anti-hypertensive, wound healing, and antiretroviral lead molecule which have been used to enhance the immune system function. *M. oleifera* is considered being a "Miracle Tree" because of its solid immune-boosting and antibacterial properties (Gupta 2022). In Pakistan "Suhanjna" is the common name used for *M. oleifera*. It is only used as a food source in Pakistan, but it has lots of uses concerning a medicinal point of view in developed countries. In rural areas where conventional water treatment is not accessible, it is vital to replace alum with a safe, simple-to-apply, affordable flocculant to improve and increase the water quality (Rasheed et al. 2023). *M. oleifera* is a well-known and studied *Moringaceae* species with human and animal use. The leaves, flowers, seeds, pods, bark, and roots of this plant are all edible and used as a traditional medicine to cure a variety of ailments. *M. oleifera* can thrive in both humid and dry hot regions, as well as on poor soil (Palada 2019). This nutrient-dense plant is often used to cure malnutrition in underdeveloped countries (Sokhela et al. 2023). *M. oleifera* extract contains Flavonoids, which have been used against many respiratory disease-causing viruses, such as respiratory syncytial virus and corona virus (Das et al. 2020). Dry leaves of *M. oleifera* contain 17 times higher calcium content than milk, 10 times more vitamin A concentration than carrots, 7 times more vitamin C values than oranges, 15 times higher potassium than bananas, 9 times greater protein than yogurt, and 25 times more iron than spinach as per 100 grams (Islam et al. 2021). The nutritional profile for the palatable components of raw pods and leaves is shown in Table 1.

Moringa oleifera is one of the most nutrient-rich and useful plants on this Earth. Nutritional research about *Moringa* spp. has been started since the 1970s. It has most rare combination of anti-aging compounds, antioxidants, amino acids, and anti-

inflammatory compounds. *Moringa* is considered a good source of isothiocyanate, rhamnase and glucosinolate (Lopez-Rodriguez et al. 2020). Different uses of this beneficial plant are as Average values and standard deviation reported by (Debnath et al. 2021)

Table 1. Nutritional values per 100 g of the edible portion of *M. oleifera* pods and leaves.

Components	Raw pods	Raw leaves	Dried leaves
Energy (Kcal)	42	65	250 ± 60
Moisture (g)	67.1	79.55	0.0065 ± 0.0023
Protein (g)	1.50	8.30	31 ± 4.5
Total fat (g)	0.30	2.10	5 ± 3.7
Carbohydrate, by difference (g)	9.33	7.35	41 ± 8.21
Cholesterol (mg)	0	0	-
Vitamin A (Retinol; (µg)	4.25	389	3671±1935.7
Vitamin B-6 (pyridoxine) (mg)	0.240	1.800	2.7
Vitamin B-12 (Cobalamin) (µg)	0.00	0.00	-
Vitamin D (D2+D3) (calciferol) (µg)	0.00	0.00	-
Vitamin E (mg)	-	-	55 ± 123
Vitamin C, total ascorbic acid (mg)	210	49.9	182 ± 31.6
Calcium (mg)	33	169	1890 ± 744.5
Magnesium (mg)	56	38	455 ± 420.6
Phosphorus (mg)	39	135	288 ± 155.0
Iron (mg)	0.42	6.00	38.4 ± 9.79
Sodium (mg)	48	7	230 ± 185.0

Benefits and uses

Anti-cancerous effect

The use of herbal products as anticancer agents has a very long history that started with folk medicine. Several drugs used in chemotherapy have a plant origin. The leading cause of mortality, as well as morbidity round around the globe, is cancer. Deaths due to cancer are about 63% in developing nations all over the world. Cancer can be defined as uninhibited cell growth that can evade apoptosis.

Researchers are also trying to develop new medicines that can somehow slow down the aging process of cancerous cells. According to this viewpoint, aging is the primary risk factor for

several medical illnesses as well as some malignancies (Benhamü et al. 2022). Numerous human malignancies have been linked to plant cytotoxicity and some of its ingredients, including (4'-Oacetyl-L-rhamnopyranosyloxy) benzyl isothiocyanate and niazimicin for the control of caspase 9 activity. Crude aqueous Moringa leaf extract (166.7 mg/ml extract (IC50)) was tested on the A549 lung cancer cell lines for 24 hours. Increased oxidative stress, apoptotic induction, and DNA fragmentation were indicators of the antiproliferative impact. The leaves, flowers, seeds, pods, bark, and roots of this plant contain different concentrations of these compounds. According to the literature, the highest concentration of these chemicals is present in leaves. These compounds are used as a treatment to stop the growth of cancer cells (Arora and Arora 2021). Niazimicin, which is a thiocarbamate has been proven as a chemopreventive agent. Leaves also have quercetin-3-O-glucoside and kaempferol-3-O-glucoside which is a scavenger for the free radicals. It is the major antioxidant compound present in the leaf extract. It also induces apoptosis in the cancer cells (Salhab et al. 2023).

Nutritional importance

Moringa spp. is a good source of nutrients. It has some essential components that enhance the growth of living organisms. Leaves of the *Moringa oleifera* have high levels of calcium, potassium, iron, vitamins, and protein (Patil et al. 2022). This plant also contains flavonoids, alkaloids, carotenoids, and several essential amino acids (Chhikara et al. 2021). Currently, silage of *Moringa* is being used all over the world. According to a study, leaves of *Moringa* were added to the feed supplement of dairy as well as beef cattle. The daily body weight growth of beef cattle was boosted by 32%. For monogastric animals (such as pigs, rabbits, and chickens), ruminants (such as cattle and sheep), and aquatic species, moringa leaves have frequently been used as substitutes for traditional protein meals. In dairy cattle, this practice increased daily average milk production by 43%.

Dietary supplementation with *M. oleifera* leaves enhanced milk fat content and altered the composition and variety of methanogens in nursing cows (Su and Chen 2020). Further research showed that adding 2 kg of dry moringa matter to the diet raised milk production by 58% while adding 3 kg of dry moringa matter increased milk production by up to 64%. This increased milk production is very helpful in the profitable dairy business and fulfills the milk requirement in the world. Better nutritional digestibility, appropriate rumen fermentation levels, and even higher milk output and quality in terms of fat, protein, and lactose content were seen in animals given mixes enriched with *M. oleifera* leaves. An increase in the animal immune system's activity and a decrease in

susceptibility to dangerous bacterial infections were linked to the production metrics' considerable improvement. (Bakowski and Kiczorowska 2021)

Moringa oil effects

Out of 13 species in genus "Moringaceae" the one most prominent is *Moringa oleifera*. During the last decades it is known as an emerging plant. *M. oleifera* oil is used for different purposes in the world like edible, perfume, and skin lotion. *Moringa* seed oil is produced in tribal and wild areas of Pakistan to showing its physiochemical properties and exported to Europe for lubrication of different machines in 19th century. These physiochemical properties also shows that *M. oleifera* oil must be used for edible purpose (Trigo et al. 2021)

Water purification

Billions of people on the Earth do not have any access to clean, pure, and safe drinking water. People living in parts of Asia, Latin America, and Africa rely on the surface water to fulfill their needs, which is not safe for drinking at all. This untreated water is the major cause of water borne diseases in the developing world. It is the leading cause of death in children of age less than five years (Maizuwo et al. 2017). Seeds of *M. oleifera* are involved for water purification purposes. It can bind the pollutants present in raw water. Seeds powder can even clarify the most turbid water. This powder joins the solid particles and settles down to the bottom. This method can remove 90-99% of bacteria from the water (Hoa and Hue 2018). Only two grams of *Moringa* seeds powder can treat about twenty liters of water. Two grams of seed powdered are mixed well in a cup of water, shake well and then mixed in the remaining water. Stir the water for 25 to 10 minutes. Leave the bucket undisturbed for about one hour. Filter the water and water is ready for drinking purpose. This method is widely used to purify the raw water in the whole world (Elsargany 2023).

Antimicrobial and anti-diabetic effects

Many bacteria like *Staphylococcus aureus*, *Escherichia coli*, *Pseudomonas*, and *Bacillus* species that are considered as major pathogens of different diseases were found susceptible to the *Moringa* spp. extracts (Elsayed et al. 2016). This plant also shows inhibitory effect against *Mycobacterium* spp. *Scenedesmus obliquus* (green algae) was also found susceptible to *Moringa* seed extracts (Farooq et al. 2012). Diabetes mellitus is a chronic disease associated with insulin production or its effect on target cells in the body. This disease is a pre-disposing factor in different health-related problems like heart problems, liver damage, and stroke (Lin et al. 2018). In both insulin-resistant and insulin-deficient bioassays, *Moringa* seed powder demonstrated antidiabetic activity with decreased glucose and improved levels of lipid peroxide, as well as decreased levels of IL6, and immunoglobulins A in comparison to diabetic

positive control animals (Villarruel-López et al. 2018).

Hypolipidemic effects

The leaves of the *Moringa oleifera* tree contain chemicals that activate the lipid homeostasis phenomena. Some compounds like phenolic and flavonoids play a vital role in lipid regulation. Extracts of *M. oleifera* play an important role in inhibiting both cholesterol esterase and lipase, so this extract is used for the prevention and treatment of hyperlipidemia. The process of cholesterol homeostasis depends upon two things e.g., Cholesterol synthesis and cholesterol absorption. The bioactive substance B-sitosterol is found in *M. oleifera* leaves, and studies have shown that it lowers plasma cholesterol levels in rats given high-fat diets (Ansari et al. 2020). Another compound known as saponins, also prevent the cholesterol absorption by circulating bile acid and increases its fecal excretion, these saponins are also present in *M. oleifera* leaves. Bile acid synthesis increases from cholesterol when bile acid excretion is enhanced. so it leads to decrease the overall plasma cholesterol (Vergara-Jimenez et al. 2017).

Anti-inflammatory activities

In herbal medicines *Moringa* is used to decrease the inflammation. Different parts of *Moringa* tree possess anti-inflammatory effects but root is significant. It has good anti-inflammatory action against the raw paw edema induced by carrageenan. N-butanol is the active ingredient present the root extract, which has considerable anti-inflammatory action. Inflammation associated with chronic diseases can be rectified using *Moringa oleifera*. Hence it has beneficial effect to decrease inflammation (Farooq et al. 2012).

Wound healing and anti-pyretic activity

Aqueous extract of *Moringa oleifera* was found very helpful in wound healing process. Significant increase in granuloma breaking strength, wound closure rate and decrease in the scar area was reported when *M. oleifera* treatment was used. 10% ointment of the leaf extract revealed the best results wound healing. *M. oleifera* ethanolic extract is considered to possess a good anti-pyretic activity. Especially the seed extracts showed significant drop in body temperature of rats (Al-Shahat et al. 2022).

Potential effective against COVID-19

Moringa oleifera phytochemical screening and extraction reveals the presence of saponins, carbohydrates, alkaloids, glycosides, flavonoids, and proteins, in various parts of the plant (Kini et al. 2017; Shinwari et al. 2017). Flavonoids are known to be antiviral, particularly against respiratory syncytial virus (Das et al. 2020). Many studies show that a substance derived from *M. oleifera* inhibits the initiation of the viral replication cycle (Tahir ul Qamar et al. 2019). Flavonoids usually have an inhibitory effect against viruses, particularly respiratory syncytial virus (Russo et al. 2020). Many studies show that a substance derived

from *M. oleifera* inhibits the beginning of the viral replication cycle (Pebam et al. 2022). *M. oleifera* extract contains the phytochemical Anthraquinone, which acts as an antiviral and antifungal agent (Behl et al. 2021). This compound has antiviral properties against the Human cytomegalovirus (HCMV) strain as well as inhibitory effects against polioviruses. It also exhibits potent antiviral activity against HIV-1 (Frecentese et al. 2016; Guo et al. 2022). Both the ethanolic and aqueous extracts of *M. oleifera* are high in anthraquinone, and flavonoids, respectively (Hamza et al. 2021). *M. oleifera* contains hydroxychloroquine (HCQ), a chloroquine derivative used to treat autoimmune illnesses and as an anti-inflammatory drug, is more pathogenic than chloroquine. HCQ is also on the trial list for COVID-19 treatment (Liu et al. 2020; Wang et al. 2020). COVID-19 is a pandemic disease and it affect the people throughout the world. it is necessary to adopt preventive measured against this fatal disease. The current situation of this pandemic in different countries is shown in (Table 2). The efficacy of HCQ in COVID-19 patients has been demonstrated in theoretical, experimental, preclinical, and clinical studies. JCQ suppresses lysosomes and reduces numerous immune cell functions, that's why it is recommended in rheumatologic circumstances and has anti-inflammatory properties. In vitro investigations show that HCQ is more effective than chloroquine in suppressing SARS CoV-2 (Yao et al. 2020).

Antioxidant effects

Antioxidants are useful against different types of diseases like cardiovascular disorders, cancer, and inflammatory conditions. These antioxidants are present in high concentrations in *M. oleifera* leaves. Beta-carotene is present in *Moringa* leaves and it possesses antioxidant effects (Khor et al. 2018). *Moringa* leaves contain more than one antioxidant and these antioxidants when used in combination then their effect is more powerful as compared to use in single form (Vijayakumar et al. 2023). Recently data was collected from a study that was performed on children which shows that vitamin A is present in *Moringa* leaves in valuable concentrations. Tannins, terpenoids, and glycosides are compounds that have been extracted from *Moringa* leaves. The antioxidants extracted from *Moringa* leaves depend upon different factors like environment temperature, soil condition, and extracting techniques. To gain the maximum antioxidant effects, these factors must be properly managed (Vergara-Jimenez et al. 2017)

Effects/ uses against hypotensive and ocular disease

To stabilize blood pressure, different bioactive compounds are required. These compounds are present in *M. oleifera* leaves. A study on rats showed that four different compounds like niazinin A, B, and A+B were extracted from *M. oleifera* leaves and these compounds play important roles in lowering

blood pressure. *M. oleifera* leaves exhibit significant hypotensive characteristics both in vitro and in vivo, which raises the possibility that they might someday be employed as an anti-hypertensive medication. This plant's leaf extract may reduce arterial blood pressure by encouraging the endothelium's natural relaxation response to nitric oxide (NO) generation, according to research on how it impacts mean arterial pressure and the mesenteric arterial beds in rats (Xu et al. 2023). A key contributing factor to inadequate dark adaptation and night blindness is vitamin A deficiency. High levels of vitamin A found in moringa leaves, pods, and leaf powder aid in preventing night blindness and eye issues. Consuming leaves and oil increases vitamin A levels and slows the progression of cataracts (Keshri et al. 2021).

Table 2. corrected with the subsequent information of affected people with COVID-19 in different countries of the world (as of 2021)

S. No	Country	Affected	Death	Recovered
1.	United states	46,597,003	761,865	36,476,756
2.	India	34,231,809	456,418	33,614,434
3.	France	7,140,294	117,589	5,162,757
4.	Iran	5,888,100	125,716	5,455,329
5.	Spain	5,006,675	87,289	4,861,043
6.	Italy	4,752,368	131,954	4,545,049
7.	Thailand	1,884,973	19,006	1,766,823
8.	Pakistan	1,271,027	28,414	1,219,174
8.	South Korea	358,412	2808	330,853
9.	Singapore	184,419	349	151,580
10.	Afghanistan	156,124	7,266	128,274
11	China	96,934	4636	91,634

Herbal medicines effective against different virus

Disperse of infection while epidemic can be restrained with effective antiviral herbal intervention. Pakistan has a rich and unique group of plants an expected 700-800 species of plants have been used in conventional medical systems. The therapeutic characteristics of plants were examined by different types of researchers in Pakistan (Jan et al. 2020). It is for the documentation and gives wide data concerning the medicinal plant from conventional healers to

preserve the fact of plant usage. We consider the evolving role of plants and fungi in global healthcare as new challenges to human health and biodiversity arise. We present current and emerging scientific approaches to uncover and preserve nature-based health solutions for the future, through harmonization with biodiversity conservation strategies (Howes et al. 2020). A mainstream of the global society in developing and developed countries rely upon primary health care using conventional medicine. To enhance their health, 80% of the population turns to traditional medicine based on plants. Herbal remedies include herbs, herbal components, herbal preparations, and completed herbal goods that have active plant components, other plant materials, or mixtures as their main constituents (Nsagha et al. 2020). A huge collection of pharmaceutical studies has been shown in plants widely. People have been used remedial plants to treat critical diseases. Antigenic proteins obtained from plants provide hope for widespread immunization against viral diseases. Plant-based vaccines are being assessed in clinical trials against different diseases like hepatitis B, influenza etc. Tumor-associated antigens (TAAs) generated from plants are a recent breakthrough that may open up new treatment options for cancer. There are now several plant-based anti-cancer vaccines being researched (Rahimian et al. 2021). It is emphasized necessitates more examination and association towards modern plant-based medications (Table 3).

Effect on obesity

Obesity is the accumulation of excessive fats in different body parts. It is a major problem in the world. According to a WHO report about 39% of the men and 40% of women in the world are obese. Many factors are associated with obesity, diet is the most important of all. According to a study methanol extract of leaves of *Moringa* was given to high fat rats that resulted in decreased the cholesterol level. *Moringa* also results in less lipid accumulation in liver and prevents lipid toxicity. It has also a therapeutic effect against lacto-bacillary infection. Improved lipid profiles (levels of total cholesterol, triglycerides, low-density lipoprotein, very low-density lipoprotein, high-density lipoprotein, and high-density lipoprotein cholesterol) and body weight, along with significant gene regulation of adipogenesis, glucose uptake, insulin resistance, and hormones like leptin, vaspin, resistin, and insulin, were the main anti-obesity mechanisms of MO (Redha et al. 2021).

Conclusion

Moringa oleifera is a plant of great importance and many uses. It is found extensively in different parts of Pakistan. It is a miracle tree with beneficial effects in treatment of cancer, obesity, diabetes, inflammation, Covid-19, and different microbial

infections. Still, there is need to pay attention in researching more beneficial uses of *Moringa*. Moreover, as it is a native plant there will never be any shortage of raw material for pharmaceutical companies. It also has a good effect on the economy of the country as it is a cheap source of edible oil, and its flowers and leaves can be used for food purposes. Indeed, it is a gift of nature that provides

us with plenty of benefits at very low prices. Different phytochemical components of *M. oleifera* are used against different viral diseases. In the future, it is recommended that these compounds should be clinically observed against antiviral diseases especially COVID-19.

Table 3. List of south Indian medicinal plants inhibits several types of viruses.

Plant Names	Virus	Effectiveness	Reference
<i>Azadirachta indica</i>	Dengue virus	Leaf extract (Aqueous) inhibits DEN-2 <i>in vivo</i>	(Ali et al. 2021)
<i>Hippophae rhamnoides</i>	Dengue virus	Leaf extract has significant anti-dengue activity	(Singh and Rawat 2017)
<i>Andrographis paniculata</i>	Dengue virus Chikungunya virus (CHIKV)	NVK provides protection against DENV and CHIKV	(Mohanty et al. 2023)
<i>Glycine max</i> (black)	Human adenovirus (type 1)	Inhibits human ADV-1 in dose dependent manner	(Marques et al. 2020)
<i>Ficus religiosa</i>	Human rhino virus (HRV) & Respiratory syncytial virus (RSV)	Bark extract endowed with antiviral activity against HRV & RSV	(Cagno et al. 2015)
<i>Sesbania grandiflora</i>	Herpes simplex virus	Extract possesses strong antiviral against HSV	(Walimbe et al. 2022)
<i>Carissa edulis</i>	Herpes simplex virus	Exhibits anti HSV-1&2 <i>in vitro</i> and <i>in vivo</i> strongly	(Tolo et al. 2006)
<i>Achyranthus aspera</i>	Herpes simplex virus	Inhibits earlier stages of HSV multiplications	(Mukherjee et al. 2013)
<i>Guazuma ulmifolia Lam</i>	Polio virus	Extracts inhibits polio replications	(Felipe et al. 2006)
<i>Punica granatum L</i>	Human herpes virus 3	Phytochemical extract exhibits potential anti-viral activity	(El-Aguel et al. 2022)
<i>Phyllanthus niruri L</i>	Human immuno deficiency virus	Inhibits hepatitis B virus replication	(Liu et al. 2014)
<i>Moringa oleifera</i>	HIV	Leaves used to inhibit viral replication	(Ndlovu et al. 2022)
<i>Moringa oleifera</i>	Epstein bar virus (EBV)	Leaves and seeds inhibit activity against EBV activation	(Khor et al. 2018)

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Ethical statement

No Ethical permissions were required for this article.

Availability of data and material

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Consent to participate

All the authors gave their consent for equal participation.

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Competing Interest

The authors declare that they have no relevant financial or non-financial interests to disclose.

Author Contribution

AS, AT, MK, and MA wrote the manuscript. AN and MA managed the data and references.

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