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(RESEARCH ARTICLE)

An exhaustive review on pharmacological potential, bioactive components and formulations of *Moringa oleifera*

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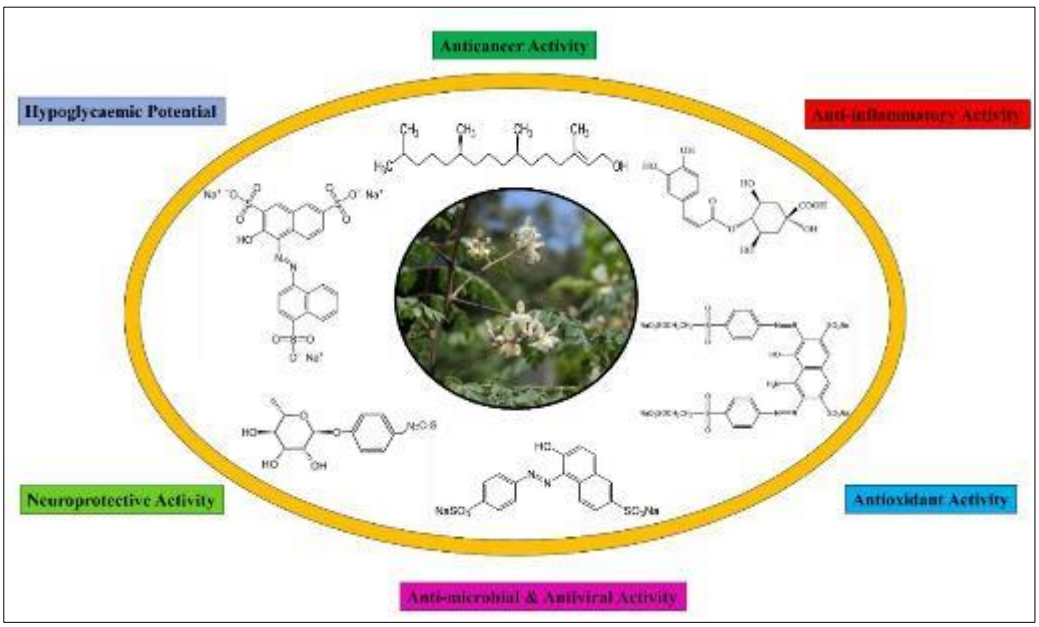
Abstract

Moringa oleifera, native to India, grows in the tropical and subtropical regions of the world. It is commonly known as 'drumstick tree' or 'horseradish tree' and has gained attention in recent years for its nutritional and medicinal properties. This review article aims to provide a comprehensive overview of the current scientific understanding of *Moringa oleifera*. The review covers the plant's botany, nutritional composition, and phytochemical content. It also discusses the plant's pharmacological and medicinal properties, including its anti-inflammatory, anti-cancer, anti-diabetic, anti-viral and anti-microbial activities. Additionally, the review examines the potential applications of *Moringa oleifera* in food and agriculture, as well as its industrial uses, such as in biofuel production. Summarizing, this review article provides a comprehensive and scientific overview of *Moringa oleifera*, highlighting its potential as a valuable plant resource with numerous applications and benefits for human health and well-being. The review article also identifies areas for future research to further explore the plant's potential and unlock its full potential as a natural resource.

Graphical Abstract



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Keywords: *Moringa oleifera*; Phytochemical Content; Pharmacological Activities; Pharmaceutical and Topical Formulations.

1. Introduction

Herbal drugs, also known as herbal medicines or botanicals, are medications made from plant extracts or whole plants. They have been used for centuries to treat various health conditions and are still widely used today [1]. Herbal drugs are a popular alternative to conventional medicine for many people. They can be effective in treating a wide range of health conditions and are often perceived as natural and safer than prescription drugs. Herbal drugs can be obtained in various forms, such as teas, tinctures, capsules, tablets, and topical ointments [2]. They are often marketed as natural alternatives to conventional medicine and are sometimes perceived as safer than prescription drugs. Some of the most commonly used herbal drugs include echinacea, ginkgo biloba, St. John's wort, and valerian root. Echinacea is believed to boost the immune system and help prevent and treat the common cold, while ginkgo biloba is thought to improve cognitive function and memory [3-6]. Herbal drugs are generally considered safe, they can still have side effects and interactions with other medications. It is important to talk to a healthcare professional before using any herbal drugs, especially if you are taking prescription medications or have a medical condition [7].

One of such good herbal agents is *Moringa oleifera*. *Moringa oleifera*, also known as the drumstick tree or the horseradish tree, is a fast-growing tree that is native to South Asia but is now widely cultivated in tropical and subtropical regions around the world [8]. Moringa is known for its many health benefits, and almost all parts of the tree are edible or have medicinal properties. The leaves, pods, seeds, and even the roots are used in traditional medicine to treat a variety of health conditions, including inflammation, infections, diabetes, and high blood pressure [9-12]. The leaves of the Moringa tree are particularly rich in nutrients, including vitamins A, C, and E, as well as calcium, potassium, and protein. This has led to Moringa being dubbed a "superfood" and its popularity has been increasing in recent years. In addition to its nutritional value, Moringa is also used in agriculture and as a source of biofuel. Its ability to grow quickly and in dry, arid regions makes it an important resource in combating food insecurity in developing countries [13-18]. Overall, *Moringa oleifera* is a versatile and valuable plant that has a wide range of uses in medicine, nutrition, and agriculture. Its many health benefits and nutritional properties make it an attractive choice for people looking to improve their overall health and well-being[19].

Moringa oleifera is native to South Asia, particularly India, Pakistan, and Afghanistan. It is also found in other parts of Asia, including Bangladesh, Nepal, and Sri Lanka. However, due to its many benefits, Moringa is now widely cultivated in other tropical and subtropical regions around the world, including Africa, the Americas, and the Caribbean [20-24].

Moringa oleifera has a variety of pharmacological potential due to its bioactive compounds. It is known for its anti-inflammatory and antioxidant effects, as well as its potential to lower blood sugar and cholesterol levels[25]. It has also been found to have antibacterial and antifungal properties, and may have neuroprotective effects. These properties make Moringa a promising candidate for further research into its potential therapeutic uses[26-27].

Table 1 Common Names of *Moringa oleifera*

Sr. No.	Language	Common Names
1.	Ayurveda	Raktaka, Akshiva, Haritashaaka
2.	Hindi	Sahjan, Saguna, Sainjna
3.	Sanskrit	Subhanjana
4.	English	Horsh reddish Tree, Drumstick tree
5.	Tamil	Mulaga, Munaga
6.	Punjabi	Soanjna
7.	Malayalam	Murinna, Sigure

2. Morphological Aspects

Moringa oleifera is a deciduous tree that belongs to the family Moringaceae. It is a fast-growing tree that can reach a height of up to 10 meters (33 feet) and has a single, upright trunk that can have a diameter of up to 45 cm (18 inches). The tree has a broad, spreading canopy with drooping branches and a rough, grey bark[28].

Figure 1 Morphological Aspects of *Moringa oleifera* Plant, leaves, seeds and flowers.

2.1. Leaves

The leaves of *Moringa oleifera* are compound, meaning that they are composed of multiple leaflets that are arranged in a pinnate pattern. Each leaf is about 30-60 cm (12-24 inches) long and has 3-5 pairs of leaflets that are lanceolate or elliptical in shape. The leaflets are about 1-2 cm (0.4-0.8 inches) wide and 3-4 cm (1.2-1.6 inches) long. The leaves are dark green and have a slightly bitter taste[29-32].

2.2. Flowers

The flowers of *Moringa oleifera* are small and white or cream-colored, with five petals that are about 1 cm (0.4 inches) long. They are arranged in clusters or panicles that can be up to 25 cm (10 inches) long. The flowers are fragrant and attract pollinators such as bees and butterflies [33].

2.3. Fruit

The fruit of *Moringa oleifera* is a long, slender pod that is about 30-60 cm (12-24 inches) in length and 1-2 cm (0.4-0.8 inches) in diameter. The pod is green when young and turns brown as it matures. It contains many small, round seeds that are about 1 cm (0.4 inches) in diameter [34-36].

2.4. Roots

The roots of *Moringa oleifera* are shallow and wide-spreading, allowing the tree to tolerate a wide range of soil types and conditions. The roots can grow up to twice the height of the tree and can reach depths of up to 10 meters (33 feet) in search of water [37].

Overall, *Moringa oleifera* is a hardy and adaptable tree with many uses in medicine, nutrition, and agriculture. Its unique morphology allows it to thrive in a variety of environments and make it a valuable resource for communities around the world.

3. Microscopic Aspects

Microscopic examination of *Moringa oleifera* can provide further insight into the structure and composition of its various parts. Here is a brief overview of the microscopic features of *Moringa oleifera*:

3.1. Leaf

The leaf of *Moringa oleifera* is dorsiventral, meaning that it has two distinct sides: an upper adaxial surface and a lower abaxial surface [38]. The adaxial surface is covered by a waxy cuticle layer and has a layer of epidermal cells with stomata, which are specialized pores that allow for gas exchange [39-40]. The abaxial surface has a layer of loosely packed cells and lacks a cuticle layer. The leaflets of *Moringa oleifera* are composed of three main layers: the upper epidermis, the mesophyll, and the lower epidermis [41-44]. The mesophyll is divided into two layers: the palisade mesophyll, which is composed of elongated cells that are oriented perpendicular to the leaf surface, and the spongy mesophyll, which is composed of loosely packed cells with many intercellular spaces.

3.2. Stem

The stem of *Moringa oleifera* is covered by a thin layer of epidermal cells with occasional stomata. Beneath the epidermis is a layer of cortical cells, which make up the majority of the stem. The cortical cells contain chloroplasts, which give the stem a green color. The central core of the stem, known as the pith, is composed of large, parenchyma cells with thin cell walls [45].

3.3. Root

The root of *Moringa oleifera* has a similar structure to the stem, with an outer layer of epidermal cells, a layer of cortical cells, and a central pith. However, the root also has root hairs, which are specialized structures that increase the surface area for water and nutrient absorption [46].

4. Phytochemistry

Moringa oleifera is a rich source of various phytochemicals, including alkaloids, flavonoids, phenolic acids, terpenoids, and steroids. Here is a detailed overview of the phytochemicals found in *Moringa oleifera*:

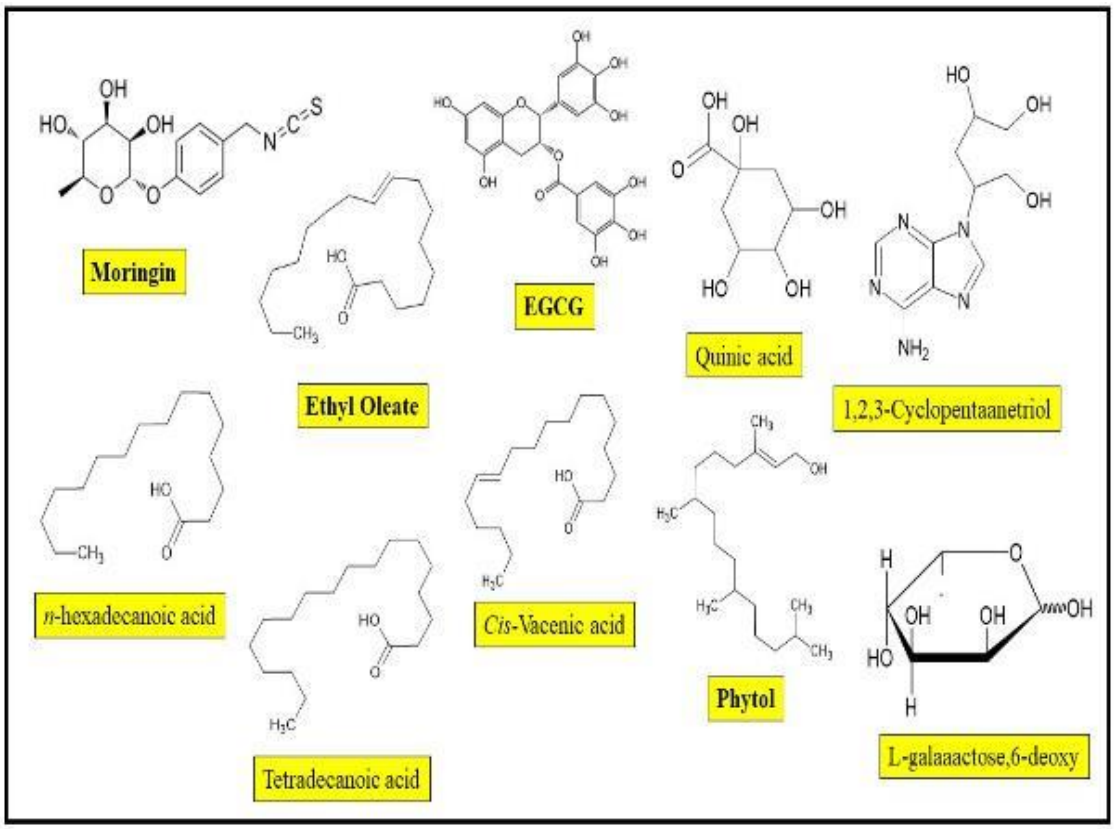

Figure 2 Majorly found Chemical Ingredients of *Moringa oleifera*

4.1. Alkaloids

Moringa oleifera contains several alkaloids, including moringine, moringinine, and moringanidine. These alkaloids have been shown to have antihypertensive, anti-inflammatory, and antispasmodic properties[47].

4.2. Flavonoids

Moringa oleifera is also rich in flavonoids, including quercetin, kaempferol, and rutin. These flavonoids have been shown to have antioxidant, anti-inflammatory, and anticancer properties[48].

4.3. Phenolic acids

Moringa oleifera contains several phenolic acids, including chlorogenic acid, caffeic acid, and ferulic acid. These phenolic acids have been shown to have antioxidant, anti-inflammatory, and anticancer properties[49].

4.4. Terpenoids

Moringa oleifera contains several terpenoids, including β-sitosterol, campesterol, and stigmasterol. These terpenoids have been shown to have anti-inflammatory, antitumor, and cholesterol-lowering properties[50].

4.5. Steroids

Moringa oleifera contains several steroids, including stigmasterol, β-sitosterol, and campesterol. These steroids have been shown to have anti-inflammatory, antitumor, and cholesterol-lowering properties[51].

4.6. Carotenoids

Moringa oleifera contains several carotenoids, including β-carotene, lutein, and zeaxanthin. These carotenoids have been shown to have antioxidant properties and may help to protect against age-related macular degeneration[52].

4.7. Vitamins and minerals

Moringa oleifera is also a rich source of vitamins and minerals, including vitamin C, vitamin A, iron, calcium, and potassium. These nutrients are essential for maintaining good health and can help to prevent nutrient deficiencies[53].

5. Pharmacological uses of *Moringa oleifera*

Moringa oleifera has been extensively studied for its pharmacological properties, and the bioactive compounds present in the plant are responsible for its various therapeutic effects. Here is a detailed pharmacology of *Moringa oleifera*:

Figure 3 Pharmacological Applications of *Moringa oleifera*

5.1. Anti-inflammatory effects

Moringa oleifera has been shown to have significant anti-inflammatory effects due to its high content of bioactive compounds like flavonoids, phenolic acids, and alkaloids. These compounds help to reduce inflammation by inhibiting the production of inflammatory mediators like cytokines and prostaglandins. Studies have shown that *Moringa oleifera* extract can inhibit the production of inflammatory cytokines like TNF-α and IL-6 in animal models[52].

5.2. Antiviral activity of *Moringa oleifera*

The antiviral activity of *Moringa oleifera* is attributed to its bioactive compounds such as flavonoids, phenolic acids, and alkaloids. These compounds have been shown to inhibit viral replication by interfering with viral entry, viral replication, and virion release. *Moringa oleifera* has demonstrated promising antiviral activity against a range of viruses, including influenza virus, herpes simplex virus, dengue virus, HIV, and hepatitis B virus. However, more studies are needed to determine the clinical efficacy and safety of *Moringa oleifera* as an antiviral agent[52]. Here are some examples of the antiviral activity of *Moringa oleifera*:

5.2.1. Influenza virus

Moringa oleifera extract has been shown to inhibit the replication of influenza virus in vitro. A study reported that *Moringa oleifera* leaf extract significantly reduced the viral load in mice infected with influenza virus.

5.2.2. Herpes simplex virus

Moringa oleifera extract has been shown to inhibit the replication of herpes simplex virus type 1 (HSV-1) and type 2 (HSV-2) in vitro. A study reported that *Moringa oleifera* leaf extract significantly reduced the viral load in mice infected with HSV-1.

5.2.3. Dengue virus

Moringa oleifera extract has been shown to inhibit the replication of dengue virus in vitro. A study reported that *Moringa oleifera* leaf extract reduced the viral load in mice infected with dengue virus.

5.2.4. Human immunodeficiency virus (HIV)

Moringa oleifera extract has been shown to inhibit the replication of HIV in vitro. A study reported that *Moringa oleifera* leaf extract inhibited the reverse transcriptase activity of HIV-1.

5.2.5. Hepatitis B virus (HBV)

Moringa oleifera extract has been shown to inhibit the replication of HBV in vitro. A study reported that *Moringa oleifera* leaf extract inhibited the surface antigen expression of HBV in HepG2.2.15 cells.

5.3. Antioxidant effects

Moringa oleifera has potent antioxidant properties due to its high content of phenolic compounds and vitamin C. These compounds help to scavenge free radicals and reduce oxidative stress, which is associated with various chronic diseases like cancer, diabetes, and cardiovascular diseases. Studies have shown that *Moringa oleifera* extract can increase the activity of antioxidant enzymes like superoxide dismutase (SOD) and catalase in animal models[53].

5.4. Hypoglycemic effects

Moringa oleifera has been shown to have hypoglycemic effects, which make it useful in managing diabetes. The bioactive compounds in *Moringa oleifera* help to regulate blood sugar levels by increasing insulin sensitivity and reducing glucose absorption in the intestines. Studies have shown that *Moringa oleifera* extract can lower blood glucose levels in animal models and humans[54].

5.5. Anti-cancer effects

Moringa oleifera has been shown to have anti-cancer effects due to its high content of bioactive compounds like flavonoids, phenolic acids, and terpenoids. These compounds help to inhibit the growth and spread of cancer cells by inducing apoptosis (programmed cell death) and inhibiting angiogenesis (formation of new blood vessels). Studies have shown that *Moringa oleifera* extract can inhibit the growth of various cancer cells like breast cancer, colon cancer, and prostate cancer in vitro and in animal models[55].

5.6. Anti-microbial effects

Moringa oleifera has been traditionally used for its anti-microbial properties. Studies have shown that the bioactive compounds in *Moringa oleifera* have potent anti-bacterial, anti-viral, and anti-fungal effects, which make it useful in treating various infections. *Moringa oleifera* extract has been shown to inhibit the growth of various bacteria like Escherichia coli, Staphylococcus aureus, and Salmonella typhimurium in vitro and in animal models[56].

5.7. Neuroprotective effect

Moringa oleifera has been reported to possess neuroprotective effects, which means it has the potential to protect the brain and nervous system from damage caused by various factors. The neuroprotective effects of *Moringa oleifera* are attributed to its bioactive compounds such as flavonoids, phenolic acids, and alkaloids. These compounds have been shown to protect against oxidative stress, reduce inflammation, and improve cognitive function. *Moringa oleifera* has demonstrated promising neuroprotective effects, which may have potential therapeutic implications in the prevention and treatment of various neurological disorders. However, more studies are needed to determine the clinical efficacy

and safety of *Moringa oleifera* as a neuroprotective agent[57]. Here are some examples of the neuroprotective effects of *Moringa oleifera*:

5.7.1. Oxidative stress

Moringa oleifera has antioxidant properties that can help to reduce oxidative stress in the brain. A study reported that *Moringa oleifera* leaf extract significantly reduced the levels of oxidative stress markers in the brain of rats exposed to lead.

5.7.2. Neuroinflammation

Moringa oleifera has anti-inflammatory properties that can help to reduce neuroinflammation in the brain. A study reported that *Moringa oleifera* leaf extract significantly reduced the levels of inflammatory markers in the brain of rats exposed to lead.

5.7.3. Neurodegenerative diseases

Moringa oleifera has been shown to protect against neurodegenerative diseases such as Alzheimer's and Parkinson's. A study reported that *Moringa oleifera* leaf extract reduced cognitive impairment and oxidative stress in rats with Alzheimer's disease.

5.7.4. Cerebral ischemia

Moringa oleifera has been shown to protect against cerebral ischemia, which is a condition that occurs when there is a shortage of blood supply to the brain. A study reported that *Moringa oleifera* leaf extract reduced brain damage and improved neurological function in rats with cerebral ischemia[58].

5.8. Wound healing effects

Moringa oleifera has been shown to have wound healing effects due to its high content of vitamin C and bioactive compounds like phenolic acids and flavonoids. These compounds help to promote tissue repair and regeneration and reduce inflammation, which is essential for wound healing. Studies have shown that *Moringa oleifera* extract can enhance wound healing and reduce inflammation in animal models[59].

Table 2 Pre-clinical Studies of *Moringa oleifera*

Plant Part	Species/Cells	Protocol of Treatment	Reported Results	Reference
Leaves	50 male Albino Wistar rats	Dose of 250 mg/kg or 500 mg/kg administered for 60 days	Significant decrease in the total CHO, TG, LDL-C, and VLDL-C levels, and significant increase in the HDL-C level	[60]
Leaves	24 adult Wistar Albino rats	Rats fed with HFD and orally administrated 200 or 400 mg/kg/ day of extract for 3 weeks	Improved the lipid profile (decrease in CHO, TG, VLDL, and LDL, and increase in HDL), reducing waist size, Lee index, BMI, and food intake. It also reversed HFD-induced endothelium dysfunction	[61]
Leaves and arial parts	40 adult male Albino Wistar rats	Administrated with 20% leaf extract and HFD	Gain in body weight and BMI while levels of CHO, TC, and LDL decreased significantly. HLD levels increased in the test group	[62]
Leaves extract in gelatin capsules	15 female overweight or obese participants (aged 44–55 years)	1 capsule per day containing 400 mg of extract for 8 weeks	The BMI, TC, and LDL decreased significantly after 8 weeks	[63]

Leaves	3T3-L1 cells	Measurement of apoptosis and adipoogenesis	Induced apoptosis by upregulating BAX and down- regulating BCL-2 expression, enhanced caspase-3 activity, and showed nuclear condensation while inhibited adipogenesis by decreasing triglyceride content and suppressing adipogenesis marks (C/EBPβ, adiponectin, FABP4, and PPARγ)	[64]
Leaves	3T3-L1 preadipocytes	Glucose activity	Extract showed insulin-induced glucose activity at a concentration of 50 μg/mL	[65]
Dried Leaves	17 Saharawi diabetic and 10 healthy people in refugee camps	meal supplemented with 20 g of MO leaves powder	A lower increment of the postprandial blood glucose in diabetic participants	[66]
Arial Parts	42 male Albino rats	Rats with HFD-induced obesity orally administered with 200 or 400 mg/kg body wt of extract for one month	Significantly decreased the levels of glucose, insulin, and HOMA-IR	[67]
Arial Parts	32 adult female Wistar rats	Rats were fed with HCD and extract of 600 mg/kg body wt for 12 weeks	Down-regulated mRNA expression of leptin and resistin, while upregulated adiponectin genes expression, decrease in body weight, enhanced atherogenic index, coronary artery index, glucose level, and insulin level	[68]
Leaves	51 female Sprague Dawley rats	Rats with HFRD were administered with 400 mg/kg extract for 10 weeks	No prevention of fructose-induced hypertriglyceridemia	[69]

In summary, the pharmacological properties of *Moringa oleifera* are diverse and make it a valuable natural resource for managing various diseases and promoting good health. The bioactive compounds present in *Moringa oleifera* have been shown to have significant anti-inflammatory, antioxidant, hypoglycemic, anti-cancer, anti-microbial, and wound healing effects. However, more research is needed to fully understand the pharmacological potential of *Moringa oleifera* and its mechanisms of action.

6. Pharmaceutical Formulations of *Moringa oleifera*

Moringa oleifera is a popular medicinal plant and has been used in various traditional medicine systems for centuries. Today, it is available in various market formulations such as:

6.1. *Moringa oleifera* powder

This is the most common form of *Moringa oleifera* available in the market. The leaves are dried and then ground into a fine powder. It can be added to smoothies, juices, and other beverages, or used as a seasoning in cooking[70].

6.2. *Moringa oleifera* capsules

Moringa oleifera is also available in the form of capsules, which contain dried leaf powder or extracts. Capsules are a convenient way to consume *Moringa oleifera* as a dietary supplement [71].

6.3. *Moringa oleifera* tea

Moringa oleifera leaves can also be used to make tea, which is a popular way to consume it. The leaves are dried and then steeped in hot water to make a flavorful and healthy tea.

6.4. *Moringa oleifera* oil

The seeds of *Moringa oleifera* can be pressed to extract oil, which is rich in antioxidants and has numerous health benefits. *Moringa oleifera* oil is used in cooking and as a skincare ingredient.

6.5. *Moringa oleifera* supplements

Moringa oleifera supplements are available in various forms such as tablets, gummies, and liquid extracts. They are formulated to provide a concentrated dose of *Moringa oleifera*'s bioactive compounds[72].

In addition to these market formulations, *Moringa oleifera* is also used in the food industry to fortify food products and as an ingredient in cosmetic and personal care products.It is important to note that the quality and efficacy of *Moringa oleifera* products can vary depending on the source and manufacturing process. It is recommended to choose products from reputable manufacturers and to consult with a healthcare professional before adding *Moringa oleifera* supplements to your diet.

7. Topical Formulations of *Moringa oleifera*

Moringa oleifera is a versatile plant that has been used for various medicinal purposes. Topical formulations of *Moringa oleifera* are also available in the market, discussed below:

7.1. *Moringa oleifera* oil

Moringa oleifera oil is extracted from the seeds of the plant and has been used for centuries in traditional medicine. It is rich in antioxidants and has anti-inflammatory properties, making it an effective ingredient in skincare products. *Moringa oleifera* oil is used in creams, lotions, and serums to hydrate, soothe, and protect the skin[73].

7.2. *Moringa oleifera* leaf extract

The leaves of the *Moringa oleifera* plant are rich in bioactive compounds such as flavonoids and phenolic acids, which have antioxidant and anti-inflammatory properties. *Moringa oleifera* leaf extract is used in skincare products to protect the skin from environmental stressors and promote a healthy complexion.

7.3. *Moringa oleifera* soap

Moringa oleifera soap is made with *Moringa oleifera* oil and other natural ingredients such as coconut oil and shea butter. It is a gentle and moisturizing soap that is suitable for all skin types. *Moringa oleifera* soap is used to cleanse and nourish the skin while providing antioxidant protection [74].

7.4. *Moringa oleifera* face mask

Moringa oleifera face masks are made with *Moringa oleifera* leaf powder and other natural ingredients such as honey and yogurt. They are used to exfoliate, hydrate, and brighten the skin. *Moringa oleifera* face masks are suitable for all skin types and are an effective way to incorporate the benefits of *Moringa oleifera* into your skincare routine[75].

7.5. *Moringa oleifera* lip balm

Moringa oleifera lip balms are made with *Moringa oleifera* oil and other natural ingredients such as beeswax and coconut oil. They are used to moisturize and protect the lips from environmental stressors. *Moringa oleifera* lip balms are suitable for all skin types and are an effective way to keep your lips soft and healthy [76].

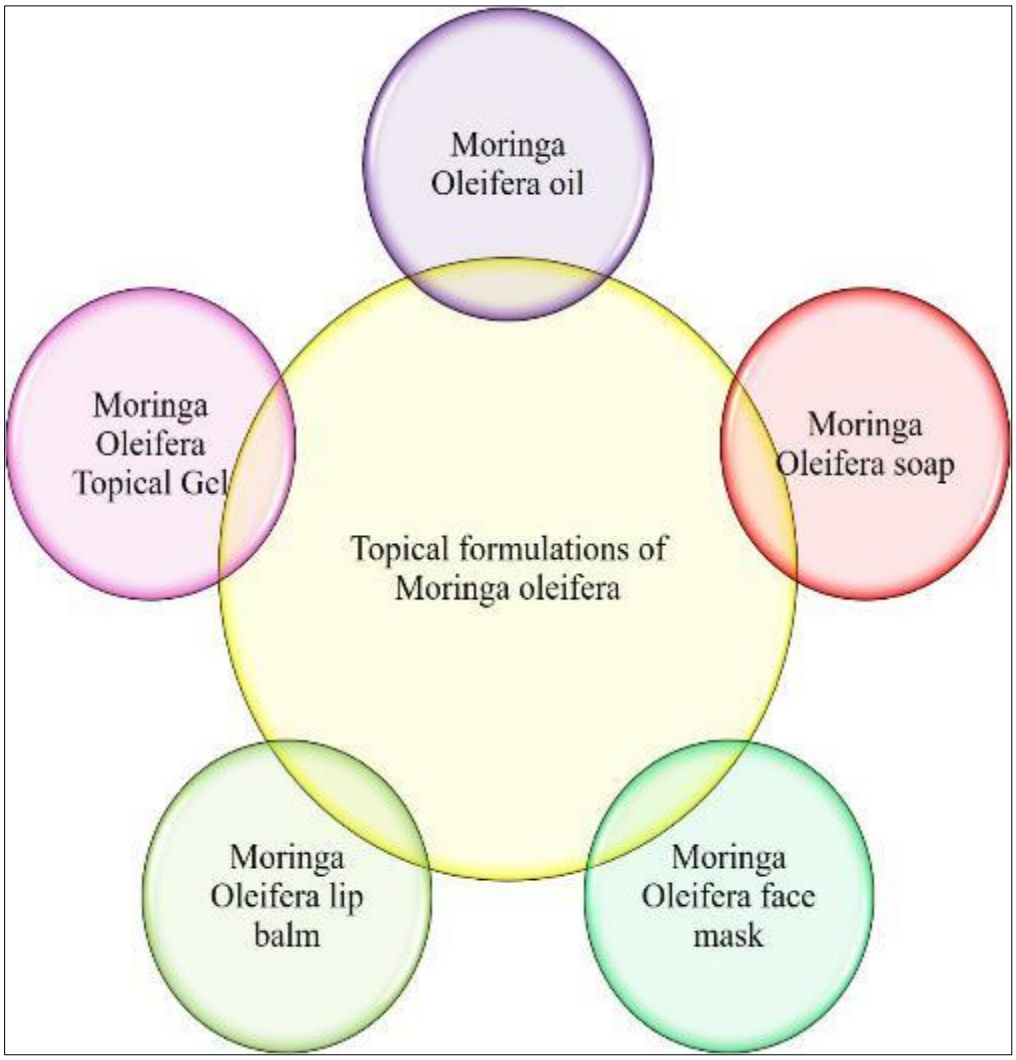

Figure 4 Different Topical Formulations of *Moringa oleifera*

Summarisingly, *Moringa oleifera* is a versatile plant that has numerous medicinal benefits. Topical formulations of *Moringa oleifera* are available in the market and are effective in promoting healthy skin and hair. It is important to choose products from reputable manufacturers and to consult with a healthcare professional before adding *Moringa oleifera* supplements or topical formulations to your daily routine.

8. Marketed Formulations of *Moringa oleifera*

There are various *Moringa oleifera* topical gel formulations available in the market. Some of the popular brands are:

8.1. Moringa-O2 Herbal Moisturizing Lotion

This lotion contains *Moringa oleifera*, olive oil, and omega from sunflower oil. It claims to nourish and moisturize the skin, improve skin elasticity, and protect against UV rays[75].

8.2. Pure *Moringa oleifera* Oil

This oil is cold-pressed from *Moringa oleifera* seeds and claims to have anti-aging and anti-inflammatory properties. It is suitable for all skin types and can be used as a moisturizer or as a base for DIY skincare formulations [76].

8.3. Organic Veda Moringa Oil

This oil is made from *Moringa oleifera* seeds and claims to have moisturizing, anti-inflammatory, and antioxidant properties. It can be used for hair and skin care and can also be ingested as a dietary supplement.

8.4. Moringa Infused Face & Body Lotion

This lotion contains *Moringa oleifera*, shea butter, and aloe vera. It claims to deeply moisturize and nourish the skin, while also protecting against environmental stressors[77].

9. Conclusion

In conclusion, *Moringa oleifera* is a versatile plant that has been used for centuries as a traditional medicine and food source in various cultures. As a rich source of vitamins, minerals, and antioxidants, *Moringa oleifera* has been found to have a variety of health benefits, including improving blood sugar control, reducing inflammation, and supporting heart health.The various parts of the *Moringa oleifera* plant, including the leaves, seeds, and roots, have been studied extensively for their potential therapeutic properties. Research suggests that the plant's bioactive compounds, such as flavonoids and phenolic acids, may play a role in these health benefits.Additionally, *Moringa oleifera* has been found to have a range of potential applications in agriculture and water purification due to its ability to remove pollutants from soil and water.

While further research is needed to fully understand the health benefits and potential uses of *Moringa oleifera*, the existing evidence suggests that it may be a valuable addition to the diet and traditional medicine practices of many cultures. Its ability to grow in a variety of environments and its numerous potential uses make it a plant with great potential for improving both human health and the health of the planet.

Compliance with ethical standards

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Disclosure of conflict of interest

Authors declare no conflicts of interest.

References

[1] K Sai Sandhya T, Geetha RV, Thangavelu L, et al, 2018. A survey on awareness of dengue among public. Int. J. Res. Pharm. Sci. 10(2), 1218-1221. (DOI: 10.55522/jmpas.V11I4.2907)

[2] Naresh P, Shyam Sundar P, Jubie S, 2021.Dengue virus entry/fusion inhibition by small bioactive molecules; A critical review. Mini Rev med chem. 22 (3), 484 -497. (DOI: https://doi.org/10.2174/1389557521666210805105146)

[3] Phun N, Nguyen TP, Bui TL, et al, 2019. C-reactive protein in children with dengue fever in Vietnam. Int. J. Res. Pharm. Sci. 10(3), 2525-2531. (DOI: 10.55522/jmpas.V11I4.2907)

[4] Kashyap, Piyush, et al. 2022. "Recent advances in Drumstick (*Moringa oleifera*) leaves bioactive compounds: Composition, health benefits, bioaccessibility, and dietary applications." *Antioxidants* 11.2: 402. (DOI: https://doi.org/10.3390/antiox11020402)

[5] Abdel-Latif, Hany MR, et al. 2022. "Benefits and applications of *Moringa oleifera* as a plant protein source in Aquafeed: A review." *Aquaculture* 547: 737369. (DOI: https://doi.org/10.1016/j.aquaculture.2021.737369)

[6] Sharma, Kanika, et al. 2022. "Moringa (*Moringa oleifera* Lam.) polysaccharides: Extraction, characterization, bioactivities, and industrial application." *International Journal of Biological Macromolecules*. (DOI: https://doi.org/10.1016/j.ijbiomac.2022.04.047)

[7] Ramalingam K, Varghese CS, Elias CH, et al, 2015. A retrospective study on the effect of Vitamin C in the management of dengue fever in three different states of India. Int. J. Res. Pharm. Sci. 10(4), 2670-2673. (DOI: https://doi.org/10.26452/ijrps.v10i4.1525.)

[8] Back AT, Lundkvist A, 2013. Dengue viruses-an overview. Infect Ecol Epidemiol. 3, 10. (DOI: https://doi.org/10.3402/iee.v3i0.19839)

[9] Shaheedha SM, Prasad VV, et al, 2019. Investigation for assessing dengue in children with their clinical Presentations. Int. J. Res. Pharm. Sci. 10(1), 150-154. (DOI: 10.55522/jmpas.V11I4.2907)

[10] Stiasny K, Fritz R, Pangerl K, et al, 2011. Molecular mechanisms of flavivirus membrane fusion. Amino Acids. 41(5), 1159-1163. (DOI: https://doi.org/10.1007/s00726-009-0370-4.)

[11] Roby JA, Setoh YX, Hall RA, et al, 2015. Post-translational regulation and modifications of flavivirus structural proteins. J Gen Virol. 96, 1551-1569. (DOI: https://doi.org/10.1099/vir.0.000097)

[12] Naresh P, Shyam Sundar P, Girija K, et al, 2021. Drug repurposing of Daclatasvir and Famciclovir as antivirals against dengue virus infection by in silico and in vitro techniques. Indian J. Biochem. Biophys. Vol. 58, pp. 557-564. (DOI: http://op.niscpr.res.in/index.php/IJBB/article/view/57794)

[13] Shyam Sundar P , Podila Naresh, Jawahar Natarajan,et al, 2022. Potential Coumarin Thiosemicarbazone Hybrids as BRCA-1 Mimetics for ER Positive Breast Cancer Therapy: An in-silico Approach. Journal of medical pharmaceutical and allied sciences. 10 (4), 3484-3493. (DOI: 10.55522/jmpas.V11I4.2907)

[14] Zhou Z, Madura JD, et al, 2009. Relative free energy of binding and binding mode calculations of HIV-1 RT inhibitors based on dock-MM-PB/GS, Proteins. Struct. Funct. Bioinf. 7, 493–450. (DOI: https://doi.org/10.1002/prot.20223)

[15] Sukumaran B, Tom A, Kandasamy K, et al, 2019. Review on current status of dengue and its prevention in India. International Journal of Research in Pharmaceutical Sciences. 10 (4), 2748- 2754. (DOI: https://doi.org/10.26452/ijrps.v10i4.1543)

[16] Halstead SB, Thomas JS, et al, 2013. Dengue vaccines. 6, 1042- 1051.

[17] Naresh P, Jubie S, Girija K, et al, 2020. Dengue Virus Entry/Fusion Inhibition by Small Bioactive Molecules. Current Trends in Biotechnology & Pharmacy. 2, 149-150. (DOI: https://doi.org/10.2174/1389557521666210805105146)

[18] Bibi S, Sakata K, 2017. An Integrated Computational Approach for Plant-Based Protein Tyrosine Phosphatase Non-Receptor Type1 Inhibitors. Current Computer-aided Drug Design. 13(4), 319-335. (DOI: https://doi.org/10.2174/1573409913666170406145607)

[19] Cousins KR, 2011. Chem draw ultra12.0.J. Am. Chem. Soc. 133, 8388. (DOI: 10.55522/jmpas.V11I4.2907)

[20] Yao X, Ling Y, Guo S, et al, 2018. From the Acoruscalamus L. root inhibited dengue virus proliferation and infections. Phytomedicine. 42, 258-267. (DOI: https://doi.org/10.1016/j.phymed.2018.03.018)

[21] Lalitha P, Sivakamasundri S, et al, 2010. Calculation of Molecular Lipophilicity and Drug Likeness for Few Heterocyclic. Orient J. Chem. 26(1). (DOI: hhttp://www.orientjchem.org/?p=23496)

[22] Ertl P, Rohde B, Selzer P, 2020. Fast calculation of molecular polar surface area as a sum of fragment-based contributions and its application to the prediction of drug transport properties. (DOI: https://doi.org/10.1021/jm000942e)

[23] Lipinski CA, Lombardo F, Dominy BW, et al, 1997. Experimental and computational approaches to estimate solubility and permeability in drug discovery and development settings. Adv.Drug.Delivery Rev. 23, 4-25. (DOI: https://doi.org/10.1016/j.addr.2012.09.019)

[24] Veber DF, Johnson SR, Cheng HY, et al, 2002. Molecular properties that influence the oral bioavailability of drug candidates. J.Med.Chem. 45, 2615-2623. (DOI: https://doi.org/10.1021/jm020017n)

[25] Jubie S, Jameera Begam A, Nanjan MJ, et al, 2020. Coumarinfatty acid conjugates potential ERα/AKT-1 antagonist for ER positive breast cancer. Anticancer agents in medicinal chemistry. 20, 437. (DOI: https://doi.org/10.2174/1871520619666191028104339)

[26] Masahiko Kurokawa, Ashish Wadhwani, Hisahiro Kai, et al, 2016. Activation of Cellular Immunity in Herpes Simplex Virus Type 1- Infected Mice by the Oral Administration of Aqueous Extract of *Moringa oleifera* Lam. Leaves Short title: Activation of cellular immunity by *Moringa oleifera* extract. Phytotherapy Research. 30(5), 797. (DOI: 10.55522/jmpas.V11I4.2907)

[27] Cosgrove AS, 1962. An apparently new disease of chickens, avian nephrosis, Avian Dis. 6(3), 385–389. (DOI: https://doi.org/10.2307/1587909).

[28] Adamu J, Owoade AA, Abdu PA, Kazeem HM, Fatihu MY, 2013. Characterization of field and vaccine infectious bursal disease viruses from Nigeria revealing possible virulence and regional markers in the VP2 minor hydrophilic peaks, Avian Pathol. 42(5), 420-433. (DOI: https://doi.org/10.1080/03079457.2013.822055)

[29] Chettle NJ, Stuart JC, Wyeth PJ, 1989. Outbreaks of virulent infectious bursal disease in East Anglia, Vet Rec, 125,271-272. (DOI: https://doi.org/10.1136/vr.125.10.271)

[30] Van den Berg TP, 2000. Acute infectious bursal disease in poultry, a review, Avian Pathol. 29(1), 175-194. (DOI: https://doi.org/10.1080/03079450050045431)

[31] Kundu P, Narang G, Mahajan NK, Yadav P, Jindal N, 2018. Retrospective Study on Epidemiology of Infectious Bursal Disease in Broiler Chickens in Haryana, India, Int J Curr Microbiol App Sci. 7(06),1279-1290. (DOI: https://doi.org/10.20546/ijcmas.2018.706.150)

[32] Van Den Berg TP, Gonze M, Meulemans G, 1991. Acute infectious bursal disease in poultry, isolation and characterization of a highly virulent strain, Avian Pathol. 20(1), 133–143. (DOI: https://doi.org/10.1080/03079459108418748)

[33] Eterradossi N, Arnauld C, Toquin D, Rivallan G, 1998. Critical amino acid changes in VP2 variable domain are associated with typical and atypical antigenicity in very virulent infectious bursal disease viruses, Arch Virol, 143(8), 1627–1636.

[34] Dey S, Chellappa M, Pathak D, 2017. Newcastle disease virus vectored bivalent vaccine against virulent infectious bursal disease and newcastle disease of chickens, Vaccines. 5(4), 31. (DOI: https://doi.org/10.3390/vaccines5040031)

[35] Dobos P, Hill BJ, Hallett R, Kells DT, Becht H, Teninges D, 1979. Biophysical and biochemical characterization of five animal viruses with bisegmented double-stranded RNA genomes, J Virol. 32(2), 93–605. (DOI: https://doi.org/10.1128/jvi.32.2.593-605.1979)

[36] Jindal N, Mahajan NK, Mittal D, Gupta SL, Khokar RS, 2004. Some Epidemiological Studies on Infectious Bursal Disease in Broiler Chickens in Parts of Haryana, India, International Journal of Poultry Science. 3(7), 478-482. (DOI: https://doi.org/10.3923/IJPS.2005.239.243)

[37] Muller H, Kaufer I, Reinacher M, Weiss E, 1979. Immunofluorescent studies of early virus propagation after oral infection with infectious bursal disease virus (IBDV), Zbl, Vet. 26, 345–352. 13. Jackwood DJ, Sommer-Wagner SE, 2011. Amino acids contributing to antigenic drift in the infectious bursal disease Birnavirus (IBDV), Virology. 409(1), 33–37. (DOI: https://doi.org/10.1111/j.1439-0450.1979.tb00823.x)

[38] Nandha Kumar D, Rajasekhar R, Logeshwaran G, 2020. Identification and genetic analysis of infectious bursal disease viruses from field outbreaks in Kerala, India, Tropical Animal Health and Production, 52,989–997. (DOI: https://doi.org/10.1136/vr.125.10.271)

[39] Kataria RS, Tiwari AK, Nantha Kumar T, Goswami PP, 2001. One-step RT-PCR for the detection of infectious bursal disease virus in clinical samples, Veterinary Research Communication. 25, 429-36. (DOI: https://doi.org/10.1023/a:1010607229688)

[40] Mittal D, Jindal N, Gupta SL, Kataria RS, Tiwari AK, 2005. Detection of Infectious Bursal Disease Virus in field outbreaks in broiler chickens by reverse transcription polymerase chain reaction, International Journal of Poultry Science. 4,239-43. (DOI: https://doi.org/10.3923/IJPS.2005.239.243)

[41] Pahar B, Rai A, 1997. Immunogenicity of Infectious Bursal Disease Virus Strains Isolated in India, Journal of Applied Animal Research. 12,137-144. (DOI: 10.55522/jmpas.V11I2.2312)

[42] Jeurissen SH, Janse EM, Lehrbach PR, 1998. The working mechanism of an immune complex vaccine that protects chickens against infectious bursal disease, Immunology. 95(3), 494. (DOI: https://doi.org/10.1046%2Fj.1365-2567.1998.00617.x)

[43] Rautenschlein S, Yeh HY, Sharma JM, 2002. The role of T cells in protection by an inactivated infectious bursal disease virus vaccine, Vet Immunol Immunopathol. 89(3–4), 159–167. (DOI: https://doi.org/10.1016/S0165-2427(02)00202-7)

[44] Vakharia VN, He J, Ahamed B, Snyder DB, 1994. Molecular basis of antigenic variation in infectious bursal disease virus, Virus research. 31, 265–273. (DOI: https://doi.org/10.1016/0168-1702(94)90009-4)

[45] Mundt E, Beyer J, Muller H, 1995. Identification of a novel viral protein in infectious bursal disease virus-infected cells, Journal of General Virology. 76, 437–443. (DOI: https://doi.org/10.1099/0022-1317-76-2-437)

[46] Saif YM, 1991. Immunosuppression induced by infectious bursal disease virus, Vet Immunol Immunopathol. 30,45-50. (DOI: https://doi.org/10.1016/0165-2427(91)90007-Y)

[47] Kumar S, Stecher G, Tamura K, 2016. MEGA7, molecular evolutionary genetics analysis version 7.0 for bigger datasets, Mol Biol Evol. 33, 870–1874. (DOI: https://doi.org/10.1093/molbev/msw054)

[48] Sharma, Vikas, et al. 2021. "Development of herbal ayurvedic formulation as digestive tablets, evaluation of it's pharmaceutical, pharmacognostic parameters and screening of its antioxidant potential." *Research Journal of Pharmacy and Technology* 14.11: 5849-5855. (DOI: http://dx.doi.org/10.52711/0974-360X.2021.01018)

[49] Lesk, AM. Bogdanchikov A, Zhaparov M, Suliyev R, 2019. Bioinformatics, Encyclopedia Britannica. Python to learn programming Science. (DOI: 10.1088/1742-6596/423/1/012027)

[50] National Center for Biotechnology Information (NCBI), 1988. Bethesda (MD), National Library of Medicine (US), National Center for Biotechnology Information. (DOI: https://doi.org/10.1093%2Fnar%2Fgkr1184)

[51] Saini, Ramesh Kumar, Nandini Prasad Shetty et al. 2014. "Carotenoid content in vegetative and reproductive parts of commercially grown *Moringa oleifera* Lam. cultivars from India by LC–APCI–MS." *European Food Research and Technology* 238: 971-978.

[52] Koheil, Mahmoud A., et al. 2011. "Anti-inflammatory and antioxidant activities of Moringa peregrina seeds." *Free Radicals and Antioxidants* 1.2: 49-61. (DOI: https://doi.org/10.5530/ax.2011.2.10)

[53] Shanker, Karuna, et al. 2007. "Determination of bioactive nitrile glycoside (s) in drumstick (*Moringa oleifera*) by reverse phase HPLC." *Food chemistry* 105.1: 376-382. (DOI: https://doi.org/10.1016/j.foodchem.2006.12.034)

[54] Sharma, Vikas, Rahul Kaushik et al. 2020. "Comparative Study of Herbal Formulation and Marketed Formulation of Triphala Churna." *Int J Pharm Edu Res* 2.1: 21-29. (DOI: 10.37021/ijper.v2i1.4)

[55] Rakesh, Sharma, and Vaghela Jai Singh. 2011. "Anti-inflammatory activity of *Moringa oleifera* leaf and pod extracts against carrageenan induced paw edema in albino mice." *J. Pharm. Sci. Innov* 1: 22-24. (DOI: https://doi.org/10.22270/ajprd.v9i1.889)

[56] Islam, Zahidul, et al. 2021. "*Moringa oleifera* is a prominent source of nutrients with potential health benefits." *International Journal of Food Science*. (DOI: https://doi.org/10.1155/2021/6627265)

[57] Milla, Paula García, Rocío Peñalver et al. 2022. "Health benefits of uses and applications of *Moringa oleifera* in bakery products." *Plants* 10.2: 318. (DOI: https://doi.org/10.3390/plants10020318)

[58] Ndhlala AR, Mulaudzi R, et al. 2014. J. Antioxidant, antimicrobial and phytochemical variations in thirteen *Moringa oleifera* Lam. cultivars. Molecules. Jul;19(7):10480-94. (DOI: https://doi.org/10.3390/molecules190710480)

[59] Gupta A, Rao, CV et al. 2010. Immunomodulatory effect of *Moringa oleifera* Lam. extract on cyclophosphamide induced toxicity in mice. Indian J. Exp. Biol.; 48:1157–1160. (DOI: http://nopr.niscpr.res.in/handle/123456789/10472)

[60] Al-Malki AL, El Rabey HA. et al. 2021. The antidiabetic effect of low doses of *Moringa oleifera* Lam. seeds on streptozotocin induced diabetes and diabetic nephropathy in male rats. BioMed research international. Oct; 1–13. (DOI: https://doi.org/10.1155/2015/381040)

[61] Shukla S, Mathur R, Prakash AO. 1988. Antifertility profile of the aqueous extract of *Moringa oleifera* roots. Journal of Ethnopharmacology. Jan 1;22(1):51-62. (DOI: https://doi.org/10.1016/0378-8741(88)90230-9)

[62] Fahad JF, Kumar MS. 2010. Antiurolithiatic activity of aqueous extract of bark of *Moringa oleifera* (Lam.) in rats. Health.;2(4):352-5. (DOI:10.4236/health.2010.24053)

[63] Agrawal ND, Nirala SK et al. 2015. Co-administration of adjuvants along with *Moringa oleifera* attenuates beryllium-induced oxidative stress and histopathological alterations in rats. Pharmaceutical biology. Oct 3;53(10):1465-73. (DOI: https://doi.org/10.3109/13880209.2014.986685).

[64] Agrawal B, Mehta A. 2008. Antiasthmatic activity of *Moringa oleifera* Lam: A clinical study. Indian Journal of pharmacology. Jan; 40(1):28. (DOI: https://doi.org/10.4103%2F0253-7613.40486)

[65] Mehta A, Agrawal B. 2008. Investigation into the mechanism of action *Moringa oleifera* for its anti- asthmatic activity. Orient Pharm Exp Med.;8(1):24-31. (DOI: 10.3742/OPEM.2008.8.1.024)

[66] Elsayed EA, Wadaan M. et al. 2015. In vitro evaluation of cytotoxic activities of essential oil from *Moringa oleifera* seeds on HeLa, HepG2, MCF-7, CACO-2 and L929 cell lines. Asian Pacific Journal of Cancer Prevention.;16(11):4671-5. (DOI: http://dx.doi.org/10.7314/APJCP.2015.16.11.467)

[67] Budda S, Butryee C et al. 2011. Suppressive effects of *Moringa oleifera* Lam pod against mouse colon carcinogenesis induced by azoxymethane and dextran sodium sulfate. Asian Pac J Cancer Prev. Jan 1;12(12):3221-8. (DOI: https://doi.org/10.3389/fphar.2018.00108)

[68] Bharali R, Tabassum J et al. 2003. Chemomodulatory effect of *Moringa oleifera*, Lam, on hepatic carcinogen metabolising enzymes, antioxidant parameters and skin papillomagenesis in mice. Asian Pacific Journal of Cancer Prevention. 24;4(2):131-40. (DOI: https://doi.org/10.5530/ax.2011.2.10)

[69] Elgamily H, Moussa A. et al. 2016 Microbiological assessment of *Moringa oleifera* extracts and its incorporation in novel dental remedies against some oral pathogens. Open access Macedonian journal of medical sciences. 15;4(4):585. (DOI: https://doi.org/10.3889/oamjms.2016.132)

[70] Saadabi AM, Zaid IA. 2011. An in vitro antimicrobial activity of *Moringa oleifera* L. seed extracts against different groups of microorganisms. Australian Journal of Basic and Applied Sciences.;5(5):129-34.

[71] Chuang PH, Lee CW et al. 2007. Anti-fungal activity of crude extracts and essential oil of *Moringa oleifera* Lam. Bioresource technology. 1;98(1):232-6. (DOI: https://doi.org/10.1016/j.biortech.2005.11.003)

[72] Rahman MM, Rahman MM et al. 2010. Control of coliform bacteria detected from diarrhea associated patients by extracts of *Moringa oleifera*. Nepal Med Coll J. 1;12(1):12-9. (DOI: https://doi.org/10.1016/S0166-3542(03)00152-9)

[73] Peixoto JR, Silva GC et al. 2011. In vitro antibacterial effect of aqueous and ethanolic Moringa leaf extracts. Asian Pacific journal of tropical medicine. 1;4(3):201-4. (DOI: https://doi.org/10.1016/S1995-7645(11)60069-2)

[74] Torondel B, Opare D. et al. 2014. Efficacy of *Moringa oleifera* leaf powder as a hand-washing product: a crossover controlled study among healthy volunteers. BMC complementary and alternative medicine.;14(1):1-7. (DOI: https://doi.org/10.1016/0165-2427(91)90007-Y)

[75] Lipipun V, Kurokawa M et al. 2003. Efficacy of Thai medicinal plant extracts against herpes simplex virus type 1 infection in vitro and in vivo. Antiviral research. 1; 60(3):175-80. (DOI: https://doi.org/10.1016/S0166-3542(03)00152-9)

[76] Kurokawa M, Wadhwani A et al. 2016. Activation of cellular immunity in herpes simplex virus type 1-infected mice by the oral administration of aqueous extract of *Moringa oleifera* Lam. leaves. Phytotherapy Research. 30(5):797-804. (DOI: https://doi.org/10.1021/jm020017n)

[77] Younus I, Siddiq A et al. 2016. Evaluation of antiviral activity of plant extracts against foot and mouth disease virus in vitro. Pak. J. Pharm. Sci. 1;29(4):1263-8. (DOI: https://doi.org/10.1046%2Fj.1365-2567.1998.00617.x)