



# Moringa - The Miracle Tree: An Overview of its Nutritional and Medicinal Properties

**Asma Saghir Khan <sup>a++\*</sup> and Quratulain Zulfiqar Ali <sup>a#</sup>**

<sup>a</sup> Department of Home Economics, Mirpur University of Science and Technology MUST, Pakistan.

## **Authors' contributions**

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

## **Article Information**

DOI: 10.9734/AJBGMB/2023/v15i3337

## **Open Peer Review History:**

This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: <https://www.sdiarticle5.com/review-history/107096>

**Review Article**

**Received: 07/08/2023**

**Accepted: 09/10/2023**

**Published: 17/10/2023**

## **ABSTRACT**

Moringa, scientifically known as (*Moringa oleifera Lam.*), is a multipurpose tree that has gained considerable attention due to its exceptional nutritional and medicinal properties. Native to the Indian subcontinent, Moringa is now cultivated in various tropical and subtropical regions worldwide. This article provides an overview of the nutritional composition and potential health benefits of Moringa, highlighting its role as a valuable resource for combating malnutrition and addressing various health conditions. The information presented here is based on a review of relevant research articles available on Google Scholar.

**Keywords:** Antioxidant; bioactive components; anticancer; antimicrobial.

## **1. INTRODUCTION**

Moringa, scientifically known as *Moringa oleifera*, is a tree native to the Indian subcontinent but is

now cultivated in various tropical and subtropical regions worldwide. It is highly regarded for its exceptional nutritional composition, making it a valuable dietary resource. Moringa, a drought-

<sup>++</sup> Supervisor/ senior Lecturer Food and Nutrition;

<sup>#</sup> BS scholar food and Nutrition;

\*Corresponding author: E-mail: asma.sagheer@must.edu.pk;

resistant tree, has been traditionally used for centuries in Ayurvedic medicine. Recent scientific studies have further elucidated its therapeutic potential, revealing its rich content of vitamins, minerals, and bioactive compounds [1]. This research will provide a detailed and comprehensive overview of Moringa the Miracle tree, including its origins, history, nutritional composition, medicinal uses and health benefits.

## 2. HISTORY

The history of Moringa dates back thousands of years, and the plant has been recognized for its valuable properties in various cultures around the world. Native to the Indian subcontinent, Moringa oleifera, also known as the drumstick tree or horseradish tree [2], has a rich historical significance in Ayurvedic medicine and traditional healing practices.

- **Ancient Origins:**

Moringa's origins can be traced back to ancient India, where it was highly regarded for its medicinal and nutritional properties. Historical texts and Ayurvedic scriptures mention the use of Moringa leaves, seeds, and roots in the treatment of various ailments, including digestive disorders, respiratory issues, and skin problems [3].

- **Spread across Ancient Civilizations:**

As human populations expanded and trade routes developed, Moringa spread to other parts of Asia, Africa, and the Mediterranean. It found its way into the traditional healing practices of civilizations such as the Egyptians, Greeks, and Romans [4].

- **Historical Uses:**

In ancient Egypt, Moringa oil was used in perfumes and cosmetics due to its moisturizing and emollient properties. The Greeks and Romans used Moringa leaves as a nutritious food source and for medicinal purposes, recognizing its ability to boost energy and alleviate various health conditions [5].

- **Cultural Significance:**

Moringa holds cultural significance in many regions. In Indian traditions, the tree is considered sacred and is often planted near temples and homes. Its leaves are

used in religious rituals and festivals, symbolizing fertility, abundance, and well-being [6].

- **Colonial Era:**

During the colonial era, Moringa gained attention from European botanists and explorers. Its nutritional properties were highly valued as a potential food source for European settlers and soldiers. Moringa's hardiness and ability to grow in diverse climates made it a valuable resource during long voyages and in regions with limited agricultural options [7].

- **Modern Scientific Exploration:**

In the 20th century, scientific research on Moringa began to uncover its nutritional and medicinal potential. Scientists analyzed its chemical composition and studied its bioactive compounds, leading to a deeper understanding of its health benefits and practical applications [8].

- **Contemporary Cultivation:**

Today, Moringa is cultivated in various tropical and subtropical regions worldwide, including parts of Asia, Africa, and the Americas. Its leaves, pods, and seeds are utilized for food, medicine, and commercial purposes. Moringa plantations and initiatives have been established in developing countries to combat malnutrition and address food security challenges [9].

- **Global Recognition:**

Moringa has gained recognition and popularity in recent years due to its nutrient density, adaptability to diverse environments, and potential for sustainable agriculture. It has been featured in numerous health and wellness publications, promoting its role as a "superfood" and contributing to its global demand [10].

The rich history of Moringa showcases its enduring significance in various cultures and highlights the ongoing exploration of its nutritional and medicinal potential [10]. As scientific research continues to unveil its remarkable properties, Moringa's legacy as a versatile and valuable plant persists in modern times.

### 3. NUTRITIONAL COMPOSITION OF MORINGA

Moringa leaves, pods, seeds, and roots are rich sources of essential nutrients, including proteins, vitamins (A, C, E, and B-complex), minerals (calcium, iron, and potassium), and dietary fiber. It is particularly known for its exceptional protein content and diverse range of antioxidants [11].

- **Leaves:**

Moringa leaves are the most commonly consumed part of the plant and are rich in essential nutrients. They are a good source of protein, containing all nine essential amino acids, making it a complete protein source for vegetarians and vegans. The leaves are also packed with vitamins, including vitamin A (as beta-carotene), vitamin C, vitamin E, and a range of B vitamins (such as thiamin, riboflavin, niacin, and folate). Additionally, Moringa leaves are abundant in minerals, including calcium, iron, magnesium, potassium, and zinc [12].

- **Pods:**

The immature green pods of Moringa, often referred to as drumsticks, are consumed as a vegetable. They are low in calories but rich in nutrients. Moringa pods are a good source of vitamin C, vitamin A, and vitamin B-complex, particularly niacin and vitamin B6. They also provide dietary fiber, which aids digestion and promotes a healthy gut [13].

- **Seeds:**

Moringa seeds are contained within the pods and have a unique nutritional profile. They are rich in healthy fats, including monounsaturated and polyunsaturated fats. These fats contribute to the maintenance of healthy cholesterol levels. Moringa seeds are also a good source of protein, containing significant amounts of essential amino acids. Moreover, they contain beneficial compounds like antioxidants and phenolic compounds, which provide various health benefits [14].

- **Roots:**

While less commonly consumed than the leaves and pods, Moringa roots are also

utilized for their nutritional properties. The roots are a good source of vitamins, particularly vitamin C, and minerals like potassium and iron. They are also known to contain alkaloids, flavonoids, and other bioactive compounds with potential health benefits including but not limited to anti-inflammatory effects [15].

#### **Nutritional Density:**

Moringa's exceptional nutritional composition has led to its classification as a "superfood" [16]. It is considered one of the most nutrient-dense plants on the planet, containing high levels of vitamins, minerals, and antioxidants. The combination of its protein content, essential amino acids, and diverse range of nutrients makes Moringa a valuable addition to a balanced diet [17].

In summary, Moringa is a nutritionally-rich tree that offers a wide array of essential nutrients. Its leaves, pods, seeds, and roots provide a diverse range of vitamins, minerals, proteins, and antioxidants, making it an excellent dietary resource. Incorporating Moringa into one's diet can contribute to overall nutrition and promote well-being [18].

### 4. ROLE OF MORINGA IN MALNUTRITION

The role of Moringa in addressing malnutrition has gained significant attention, particularly in developing countries where malnutrition is a pressing issue. Moringa's nutritional density and availability make it a valuable resource in combating malnutrition [19]. Here are some key aspects of Moringa's role in addressing malnutrition:

- **Nutrient-Rich Composition:**

Moringa is packed with essential nutrients, including proteins, vitamins, minerals, and antioxidants. Its leaves, pods, and seeds contain a wide range of vitamins, such as vitamin A, vitamin C, and various B vitamins. It also provides important minerals like calcium, iron, potassium, and zinc. These nutrients are crucial for overall growth, development, and maintenance of the human body [20].

- **Protein Source:**

Moringa leaves are known to contain high-quality proteins with all nine essential

amino acids. Proteins are essential for building and repairing tissues, supporting immune function, and producing enzymes and hormones. Incorporating Moringa into diets can help address protein deficiencies, particularly in regions where animal protein sources are limited [5]

- **Addressing Micronutrient Deficiencies:**

Moringa's nutrient profile makes it a valuable tool in combating micronutrient deficiencies, such as vitamin A, iron, and zinc deficiencies. These deficiencies can lead to impaired growth, compromised immune function, and increased susceptibility to diseases. Regular consumption of Moringa can help supplement these essential micronutrients, promoting optimal health and reducing the risk of associated deficiencies[21].

- **Accessible and Culturally Acceptable:**

Moringa is often available and accessible in areas where malnutrition is prevalent. It is relatively easy to cultivate, even in arid and semi-arid regions, and its parts (leaves, pods, and seeds) can be easily incorporated into local diets. Moringa's cultural acceptance and familiarity in certain regions make it more likely to be embraced as a food source [6].

- **Sustainable Agriculture:**

Moringa is known for its resilience and ability to grow in diverse environmental conditions. It requires minimal water and can withstand dry spells, making it suitable for regions with water scarcity. The cultivation of Moringa trees can contribute to sustainable agriculture practices, providing a renewable source of nutrition to combat malnutrition in communities [22].

- **Community Empowerment:**

Moringa cultivation and utilization can also contribute to community empowerment. Small-scale farming and processing of Moringa products, such as leaf powder or seed oil, can provide income-generating opportunities for local communities. This not only improves nutrition but also enhances livelihoods and economic stability [23].

While Moringa alone cannot solve the complex issue of malnutrition, it can play a valuable role in supplementing diets with essential nutrients and addressing specific nutritional deficiencies. Its availability, nutritional density, and adaptability make it a promising resource in the fight against malnutrition, particularly in resource-constrained settings. However, it is essential to consider Moringa's integration into broader nutrition programs and ensure that its consumption is part of a diversified and balanced diet for long-term impact [24].

## 5. ANTI-INFLAMMATORY AND IMMUNOMODULATORY EFFECTS OF MORINGA

Moringa exhibits notable anti-inflammatory and immunomodulatory effects, which contribute to its potential therapeutic applications.

### 5.1 Anti-Inflammatory Effects

Moringa possesses several bioactive compounds, including flavonoids, phenolic acids, and isothiocyanates, which contribute to its anti-inflammatory properties. These compounds help to reduce inflammation in the body through various mechanisms [25]:

- **Inhibition of Inflammatory Mediators:**

Moringa compounds, such as quercetin and kaempferol, have been shown to inhibit the production and release of pro-inflammatory mediators, such as cytokines (e.g., TNF-alpha and interleukins) and prostaglandins. By reducing the production of these inflammatory molecules, Moringa helps to modulate the inflammatory response [26].

- **Suppression of Inflammatory Pathways:**

Moringa can inhibit the activation of nuclear factor-kappa B (NF-κB), a key transcription factor involved in the regulation of inflammation. NF-κB activation triggers the expression of inflammatory genes. By inhibiting NF-κB, Moringa helps to downregulate the inflammatory signaling pathways [27].

- **Antioxidant Activity:**

Oxidative stress plays a role in promoting inflammation. Moringa is rich in antioxidants, including vitamin C, vitamin

E, and various phenolic compounds, which help to neutralize harmful free radicals and reduce oxidative stress. By reducing oxidative stress, Moringa indirectly mitigates inflammation [28].

## 5.2 Immunomodulatory Effects

Moringa also exhibits immunomodulatory effects, meaning it can regulate and modulate the immune response. These effects are mediated by several bioactive compounds present in Moringa, such as phenolic acids, flavonoids, and alkaloids [29]. Here's how Moringa's immunomodulatory properties work:

- **Enhancing Immune Function:**

Moringa extracts have been found to enhance the activity and proliferation of immune cells, including T cells, B cells, and natural killer (NK) cells. These immune cells play crucial roles in combating infections, defending against pathogens, and maintaining immune system balance [30].

- **Anti-Allergic Effects:**

Moringa has shown potential in reducing allergic reactions. It can suppress the release of histamine, a key mediator involved in allergic responses, and inhibit the activation of mast cells, which play a central role in allergic inflammation [31].

- **Balancing the Immune Response:**

Moringa compounds can modulate the immune response by promoting a balanced immune reaction. They have been shown to regulate the production of pro-inflammatory and anti-inflammatory cytokines, helping to maintain immune homeostasis [32].

- **Antimicrobial Defense:**

Moringa's immunomodulatory effects also include antimicrobial activity. By enhancing immune function, Moringa supports the body's natural defense mechanisms against infections caused by bacteria, viruses, and fungi [33].

The anti-inflammatory and immunomodulatory effects of Moringa contribute to its potential therapeutic applications in various inflammatory

and immune-related conditions [25]. However, it's important to note that further research is needed to fully understand the underlying mechanisms and optimize the use of Moringa in clinical settings.

## 6. ANTIDIABETIC PROPERTIES OF MORINGA

Moringa possesses antidiabetic properties, which have been attributed to various bioactive compounds present in the plant [34]. Here's an explanation of the antidiabetic effects of Moringa:

- **Regulation of Blood Glucose Levels:**

Moringa has been found to have hypoglycemic properties, meaning it helps to lower blood glucose levels. This effect is particularly beneficial for individuals with diabetes [35]. The antidiabetic properties of Moringa are attributed to several mechanisms:

- **Increased Insulin Secretion:**

Studies have shown that Moringa extracts can stimulate insulin secretion from pancreatic beta cells. Insulin is a hormone responsible for regulating blood sugar levels by facilitating the uptake of glucose into cells. By promoting insulin secretion, Moringa helps to enhance glucose utilization and reduce blood glucose levels [36].

- **Enhanced Insulin Sensitivity:**

Moringa has been shown to improve insulin sensitivity, which is the ability of cells to respond to insulin effectively. Improved insulin sensitivity allows for better glucose uptake by cells, thereby reducing blood glucose levels. This effect is beneficial for individuals with insulin resistance, a condition often associated with type 2 diabetes [37].

- **Inhibition of Glucose Absorption:**

Moringa contains compounds, such as chlorogenic acid and quercetin, which have been found to inhibit the enzymes responsible for breaking down carbohydrates into glucose. By inhibiting these enzymes, Moringa can reduce the

absorption of glucose from the digestive system, leading to lower blood sugar levels [38].

- **Antioxidant Activity:**

Oxidative stress plays a significant role in the development and progression of diabetes. Moringa is rich in antioxidants, such as vitamin C, vitamin E, and various phenolic compounds, which help to neutralize harmful free radicals and reduce oxidative stress. By reducing oxidative stress, Moringa protects pancreatic beta cells and improves their function, contributing to better glucose regulation [39].

- **Anti-Inflammatory Effects:**

Chronic inflammation is closely associated with insulin resistance and the development of type 2 diabetes [40]. Moringa's anti-inflammatory properties, as discussed earlier, help to reduce systemic inflammation. By mitigating inflammation, Moringa supports insulin sensitivity and improves overall glucose control.

- **Lipid Profile Regulation:**

Diabetes is often accompanied by abnormalities in lipid metabolism, leading to dyslipidemia (elevated levels of cholesterol and triglycerides) [41]. Moringa has been shown to help regulate lipid profiles by reducing total cholesterol, LDL cholesterol, and triglyceride levels while increasing HDL cholesterol levels. These effects contribute to better cardiovascular health and help manage the complications associated with diabetes [42].

It's important to note that while Moringa shows promise as an antidiabetic agent, it should not replace conventional diabetes management strategies. Moringa can be incorporated into a balanced diet and lifestyle changes recommended for diabetes management, under the guidance of a healthcare professional [35].

## 7. ANTIMICROBIAL ACTIVITY OF MORINGA

Moringa exhibits notable antimicrobial activity against a wide range of microorganisms, including bacteria, viruses, and fungi. The

antimicrobial properties of Moringa can be attributed to various bioactive compounds present in the plant [33]. Here's an explanation of the antimicrobial activity of Moringa:

### 7.1 Antibacterial Effects

Moringa extracts have demonstrated significant antibacterial activity against both gram-positive and gram-negative bacteria [43]. The antibacterial effects are attributed to multiple mechanisms:

- **Disruption of Cell Membrane:**

Certain bioactive compounds in Moringa, such as isothiocyanates, have been shown to disrupt the cell membrane integrity of bacteria. This disrupts their structural integrity and function, leading to bacterial cell death [44].

- **Inhibition of Bacterial Growth:**

Moringa extracts have been found to inhibit the growth of various bacteria by interfering with their metabolic pathways. These include enzymes involved in cell wall synthesis, DNA replication, and protein synthesis, among others [45].

- **Antioxidant Activity:**

Moringa's antioxidant properties, attributed to compounds like phenolic acids and flavonoids, contribute to its antibacterial effects. Antioxidants help neutralize harmful free radicals and oxidative stress, which can weaken bacterial cells and inhibit their growth [46].

### 7.2 Antiviral Effects

Moringa exhibits antiviral activity against several types of viruses [47]. The antiviral effects of Moringa can be attributed to the following mechanisms:

- **Viral Replication Inhibition:**

Moringa extracts have been found to inhibit the replication of certain viruses by interfering with their viral enzymes and inhibiting the expression of viral proteins. This prevents viral replication and the spread of infection [48].

- **Immunomodulatory Effects:**

Moringa's immunomodulatory properties, as mentioned earlier, can contribute to its antiviral effects. By enhancing immune function, Moringa aids in the body's defense against viral infections, promoting the clearance of viruses [30].

### 7.3 Antifungal Effects

Moringa extracts have shown antifungal activity against various fungal species, including *Candida* and *Aspergillus* [48]. The antifungal effects are attributed to:

- **Disruption of Fungal Cell Membrane:**

Similar to its antibacterial effects, certain bioactive compounds in Moringa can disrupt the cell membrane of fungal cells, leading to their death [49].

- **Inhibition of Fungal Growth:**

Moringa extracts have been found to inhibit the growth of fungi by interfering with their metabolic processes, such as ergosterol synthesis, which is crucial for fungal cell membrane integrity [50].

- **Antioxidant and Immunomodulatory Effects:**

Moringa's antioxidant and immunomodulatory properties also contribute to its antifungal effects. By reducing oxidative stress and enhancing immune function, Moringa helps the body combat fungal infections [51].

## 8. MEDICINAL PROPERTIES OF MORINGA

Moringa possesses various medicinal properties, which have been recognized and studied for their potential therapeutic applications [52]. Here's an explanation of the medicinal properties of Moringa:

- **Cholesterol-Lowering Effects:**

Moringa has shown promise in reducing cholesterol levels, particularly LDL (low-density lipoprotein) cholesterol, also known as "bad" cholesterol. This effect is attributed to compounds like beta-sitosterol

and quercetin, which help inhibit cholesterol absorption and promote its elimination from the body. By improving lipid profiles, Moringa may contribute to cardiovascular health [53].

- **Hepatoprotective Properties:**

Research suggests that Moringa has hepatoprotective effects, meaning it can protect the liver from damage. Its antioxidant and anti-inflammatory properties play a role in reducing liver inflammation and oxidative stress. Moringa may also support liver function by promoting the detoxification process and enhancing the production of enzymes involved in liver metabolism [54].

- **Wound Healing and Skin Benefits:**

Moringa contains bioactive compounds that promote wound healing, including anti-inflammatory and antimicrobial properties. It may help accelerate the healing process, reduce inflammation, and prevent infection [55]. Additionally, Moringa oil is rich in nutrients and antioxidants, making it a potential ingredient for skincare products to nourish and protect the skin [56].

- **Cardiovascular Health:**

Certain components of Moringa, such as flavonoids and polyphenols, have been associated with potential cardiovascular benefits. They may help lower blood pressure, reduce cholesterol levels, prevent plaque formation in blood vessels, and improve overall heart health. These properties suggest that Moringa could have a protective effect against cardiovascular diseases [57].

- **Antioxidant Activity:**

Moringa is rich in antioxidants, including vitamins C and E, flavonoids, and phenolic compounds. These antioxidants help neutralize harmful free radicals, which can cause oxidative stress and damage cells. The antioxidant activity of Moringa contributes to its potential benefits in reducing inflammation, preventing chronic diseases, and supporting overall cellular health [46].

- **Anti-inflammatory Effects:**

Moringa exhibits significant anti-inflammatory properties. It contains compounds like flavonoids, isothiocyanates, and phenolic acids, which can help reduce inflammation in the body. Chronic inflammation is linked to various health conditions, including cardiovascular diseases, diabetes, and certain cancers. The anti-inflammatory effects of Moringa make it beneficial for managing and preventing such conditions [25].

- **Antimicrobial Activity:**

Moringa possesses antimicrobial properties against bacteria, viruses, and fungi. The bioactive compounds in Moringa, such as isothiocyanates and phenolic acids, contribute to its antimicrobial activity. These properties make Moringa potentially useful in combatting bacterial and fungal infections and supporting immune function against viral pathogens [48].

- **Anticancer Potential:**

Several studies have suggested that Moringa exhibits anticancer properties. Its bioactive compounds, such as quercetin, kaempferol, and glucosinolates, have shown potential in inhibiting the growth of cancer cells and inducing apoptosis (programmed cell death) in various types of cancer. However, further research is needed to better understand the mechanisms and potential applications of Moringa in cancer treatment [58].

- **Nutritional Supplementation:**

In addition to its medicinal properties, Moringa is highly nutritious and contains essential vitamins, minerals, proteins, and antioxidants. It can serve as a valuable dietary supplement to address nutrient deficiencies and support overall health and well-being [59].

## 9. SAFETY AND POTENTIAL SIDE EFFECTS OF MORINGA

Moringa is generally considered safe for consumption when used in appropriate amounts

[5]. However, like any dietary supplement or natural product, it is essential to be aware of potential side effects and consider individual circumstances. Here's an explanation of the safety and potential side effects of Moringa:

- **Allergic Reactions:**

Some individuals may be allergic to Moringa. Allergic reactions can range from mild symptoms, such as skin rash and itching, to more severe reactions like difficulty breathing or anaphylaxis. If you have a known allergy to plants in the Moringaceae family, it is advisable to avoid Moringa [60].

- **Interference with Medications:**

Moringa may interact with certain medications. It contains compounds that can potentially affect the metabolism of drugs processed by the liver's cytochrome P450 enzymes [61]. If you are taking any medications, especially those with narrow therapeutic indices, it is advisable to consult a healthcare professional before using Moringa as a dietary supplement.

- **Blood Sugar Regulation:**

Moringa has hypoglycemic properties and may lower blood sugar levels. Individuals with diabetes or hypoglycemia should monitor their blood sugar levels closely when incorporating Moringa into their diet to prevent hypoglycemia. Adjustments to diabetes medication may be necessary under the guidance of a healthcare professional [39].

- **Pregnancy and Breastfeeding:**

There is limited scientific evidence regarding the safety of Moringa during pregnancy and breastfeeding. It is advisable for pregnant and breastfeeding women to consult their healthcare provider before using Moringa as a dietary supplement [62].

- **Contaminants:**

As with any plant-based product, there is a possibility of contamination with microbes, heavy metals, or other pollutants [63]. It is



important to choose Moringa products from reputable sources that adhere to quality control standards to minimize the risk of contamination.

It's worth noting that the side effects and safety considerations mentioned above are based on limited scientific studies. Moringa has been consumed as a food source for centuries in many cultures without reported significant adverse effects. However, individual responses may vary, and it's always prudent to exercise caution and seek professional advice when considering any dietary supplement. If you have any specific health concerns or are considering using Moringa for a specific medical condition, it is recommended to consult a healthcare professional for personalized guidance and to ensure its safe use [64].

## 10. CONCLUSION

This article presents an overview of Moringa's nutritional makeup and potential health advantages, emphasizing its role as a significant resource for confronting malnutrition and managing a variety of health issues. Moringa leaves are the most commonly consumed part of the plant and are rich in essential nutrients. Moringa has significant antibacterial activity against a variety of pathogens, including bacteria, viruses, and fungi. In conclusion, Moringa is a nutrient-dense tree that provides a wide range of vital elements.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

## REFERENCES

1. Bk S, Patel P. Moringa Oleifera-Nature's Gold. Imperial Journal of Interdisciplinary Research (IJIR). 2017;3(5).
2. Drumstick (Moringa oleifera): A Multipurpose Indian Vegetable on JSTOR. (n.d.). Retrieved October 8, 2023. Available: <https://www.jstor.org/stable/4254186>
3. Mallenakuppe R, Homabalegowda H, Gouri MD, Basavaraju PS, Chandrashekharaiyah UB. History, Taxonomy and Propagation of Moringa oleifera-A Review. SSR Institute of International Journal of Life Sciences, 2019;5(3): 2322–2327.

- DOI:<https://doi.org/10.21276/ssr-ijls.2019.5.3.7>
4. S GZ, SE, A AT, AK. Moringa oleifera: An underutilized tree in Nigeria with amazing versatility: A review. African Journal of Food Science. 2015;9(9):456–461. DOI:<https://doi.org/10.5897/ajfs2015.1346>
  5. Mahmood K, Mugal T, Pharmaceutical IHJ. of, undefined. (n.d.). Moringa oleifera: a natural gift-A review. Search. Proquest. Com. Retrieved; October 8, 2023. Available:<https://search.proquest.com/openview/a957454d42c5b806f298f9f385114dae/1?pq-origsite=gscholar&cbl=54977>
  6. Hedhili A, Akinyemi BE, Otunola GA, Ashie-Nikoi PA, Kulkarni M, Husson F, Valentin D. Moringa oleifera Lam.: A comparative survey on consumer knowledge, usage, attitude and belief in Africa and India. South African Journal of Botany. 2022;147:153–162. DOI:<https://doi.org/10.1016/J.SAJB.2022.01.009>
  7. Tahir Mahmood K, Mugal T, Haq IU (n.d.). Moringa oleifera: A natural gift-A review.
  8. The Miraculous Moringa: Exploring the Wonders of the Moringa Leaf - Tresno Saras - Google Books. (n.d.). Retrieved October 8, 2023. Available:[https://books.google.com.pk/books?hl=en&lr=&id=qKzQEAAQBAJ&oi=fnd&pg=PA1&dq=Moringa+modern+scientific+exploration&ots=OGB8\\_U5oyi&sig=c\\_Cq3rITRQOSIbe2vhnUM2oTF7E&redir\\_esc=y#v=onepage&q=Moringa%20modern%20scientific%20exploration&f=false](https://books.google.com.pk/books?hl=en&lr=&id=qKzQEAAQBAJ&oi=fnd&pg=PA1&dq=Moringa+modern+scientific+exploration&ots=OGB8_U5oyi&sig=c_Cq3rITRQOSIbe2vhnUM2oTF7E&redir_esc=y#v=onepage&q=Moringa%20modern%20scientific%20exploration&f=false)
  9. Leone A, Spada A, Battezzati A, Schiraldi A, Aristil J, Bertoli S. Cultivation, Genetic, Ethnopharmacology, Phytochemistry and Pharmacology of Moringa oleifera Leaves: An Overview. International Journal of Molecular Sciences. 2015;16:12791-12835. 2015;16(6):12791–12835. DOI:<https://doi.org/10.3390/IJMS160612791>
  10. Boopathi NM, Raveendran M, Moringa and Its Importance. 2021;1–9. DOI:[https://doi.org/10.1007/978-3-030-80956-0\\_1](https://doi.org/10.1007/978-3-030-80956-0_1)
  11. Oviedo AG, Güemes-Vera N, Acevedo O, Godinez-Oviedo A, Guemes-Vera N, Acevedo-Sandoval OA. Nutritional and Phytochemical Composition of Moringa oleifera Lam and its Potential Use as Nutraceutical Plant: A Review. Article in Pakistan Journal of Nutrition. 2016;15(4): 397–405.

- DOI:<https://doi.org/10.3923/pjn.2016.397.405>
12. Moyo B, Masika PJ, Hugo A, Muchenje V. Nutritional characterization of Moringa (*Moringa oleifera* Lam.) leaves. African Journal of Biotechnology. 2011;10(60):12925–12933.  
DOI:<https://doi.org/10.5897/AJB10.1599>
  13. Seshadri S, Dietetics V. NW review of nutrition and, & 2003, undefined. (n.d.). Kanjero (*Digera arvensis*) and drumstick leaves (*Moringa oleifera*): nutrient profile and potential for human consumption. Books.Google.Com. Retrieved October 8, 2023.  
Available:[https://books.google.com/books?hl=en&lr=&id=ZVSh\\_u7KxQIC&oi=fnd&pg=PA41&dq=moringa+drumstick&ots=\\_iBxyQi1kS&sig=\\_OQ3F6161FpO0dtFT12dyJuJf4E](https://books.google.com/books?hl=en&lr=&id=ZVSh_u7KxQIC&oi=fnd&pg=PA41&dq=moringa+drumstick&ots=_iBxyQi1kS&sig=_OQ3F6161FpO0dtFT12dyJuJf4E)
  14. Leone A, Spada A, Battezzati A, Schiraldi A, Aristil J, Bertoli S. Moringa oleifera Seeds and Oil: Characteristics and Uses for Human Health. International Journal of Molecular Sciences 2016;17:2141. 2016; 17(12): 2141.  
DOI:<https://doi.org/10.3390/IJMS17122141>
  15. Sashidhara KV, Rosaiah JN, Tyagi E, Shukla R, Raghubir R, Rajendran SM. Rare dipeptide and urea derivatives from roots of *Moringa oleifera* as potential anti-inflammatory and antinociceptive agents. European Journal of Medicinal Chemistry, 2009;44(1):432–436.  
DOI:<https://doi.org/10.1016/J.EJMECH.2007.12.018>
  16. Kaur S, Chauhan PN, Harwansh RK, Chakma M, Kaur S. Nutraceutical Potential and Processing Aspects of *Moringa oleifera* as a Superfood. Current Nutrition & Food Science, 2022;19(4):357–376.  
DOI:<https://doi.org/10.2174/1573401318666220517104316>
  17. (PDF) *Moringa oleifera*: a prolific herbal research front. (n.d.). Retrieved; October 8, 2023,  
Available:[https://www.researchgate.net/publication/324923950\\_Moringa\\_oleifera\\_a\\_prolific\\_herbal\\_research\\_front](https://www.researchgate.net/publication/324923950_Moringa_oleifera_a_prolific_herbal_research_front)
  18. Yang R, Chang L, JHM. leaves, undefined. (n.d.). Nutritional and functional properties of *Moringa* leaves–From germplasm, to plant, to food, to health. Formad-Environnement.Org. Retrieved; October 8, 2023,  
Available:[http://formad-environnement.org/Yang\\_ghana\\_2006.pdf](http://formad-environnement.org/Yang_ghana_2006.pdf)
  19. Products LFD. Potential for M, undefined. (n.d.). Combating malnutrition with *Moringa*. Npvital.Com. Retrieved; October 8, 2023  
Available:<https://npvital.com/npvital/artikel/moriveda/studien/bekaempfung%20mangelernaehrung.pdf>
  20. Dhakar R, Maurya S, Malnutrition BPC. undefined. (n.d.). *Moringa*: The herbal gold to combat malnutrition. Papers.Ssrn.Com. Retrieved; October 8, 2023,  
Available:[https://papers.ssrn.com/sol3/papers.cfm?abstract\\_id=3774645](https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3774645)
  21. Glover-Amengor M, Aryeetey R, EAFS, undefined. Micronutrient composition and acceptability of *Moringa oleifera* leaf-fortified dishes by children in Ada-East district, Ghana. Wiley Online Library. 2017; 5(2):317–323.  
DOI:<https://doi.org/10.1002/fsn3.395>
  22. Zayed MS. Improvement of growth and nutritional quality of *Moringa oleifera* using different biofertilizers. Annals of Agricultural Sciences. 2012;57(1):53–62.  
DOI:<https://doi.org/10.1016/J.AOAS.2012.03.004>
  23. Omotesho KF, Sola-Ojo FE, Fayeye TR, Babatunde RO, Otunola GA, Aliyu TH. The potential of *Moringa* tree for poverty alleviation and rural development: Review of evidences on usage and efficacy. International Journal of Development and Sustainability, 2013; 2(2):799–813.  
Available:[www.isdsnet.com/ijds](http://www.isdsnet.com/ijds)
  24. Mushtaq BS, Hussain MB, Omer R, Toor HA, Waheed M, Shariati MA, Sergey P, Heydari M. *Moringa Oleifera* in Malnutrition: A Comprehensive Review. Current Drug Discovery Technologies, 18(2), 2019;235–243.  
DOI:<https://doi.org/10.2174/1570163816666191105162722>
  25. Ndiaye M, Dieye AM, Mariko F, Tall A, Sall Diallo A, Faye B. [Contribution to the study of the anti-inflammatory activity of *Moringa oleifera* (*moringaceae*)]. Dakar Medical, 2002; 47(2):210–212.  
Available:<https://europepmc.org/article/med/15776678>
  26. Udupa SL, Udupa AL, Kulkarni DR. Studies on the anti-inflammatory and wound healing properties of *Moringa oleifera* and *Aegle marmelos*. Fitoterapia. 1994;65(2):119–123.

- Available:<https://researcher.manipal.edu/en/publications/studies-on-the-anti-inflammatory-and-wound-healing-properties-of->
27. Mundkar M, Bijalwan A, Soni D, Kumar P. Neuroprotective potential of *Moringa oleifera* mediated by NF-kB/Nrf2/HO-1 signaling pathway: A review. *Journal of Food Biochemistry*, 2022;46(12):e14451. DOI:<https://doi.org/10.1111/JFBC.14451>
  28. Sreelatha S, Padma PR. Antioxidant activity and total phenolic content of *Moringa oleifera* leaves in two stages of maturity. *Plant Foods for Human Nutrition*, 64(4), 2009;303–311. DOI:<https://doi.org/10.1007/S11130-009-0141-0/METRICS>
  29. Mehwish HM, Riaz Rajoka MS, Xiong Y, Zheng K, Xiao H, Anjin T, Liu Z, Zhu Q, He Z. *Moringa oleifera* – A Functional Food and Its Potential Immunomodulatory Effects. *Food Reviews International*. 2022; 38(7):1533–1552. DOI:<https://doi.org/10.1080/87559129.2020.1825479>
  30. Li C, Dong Z, Zhang B, Huang Q, Liu G, Fu X. Structural characterization and immune enhancement activity of a novel polysaccharide from *Moringa oleifera* leaves. *Carbohydrate Polymers*. 2020;234: 115897. DOI:<https://doi.org/10.1016/J.CARBPOL.2020.115897>
  31. Mahajan SG, Mehta AA. Immunosuppressive activity of ethanolic extract of seeds of *Moringa oleifera* Lam. in experimental immune inflammation. *Journal of Ethnopharmacology*. 2010; 130(1):183–186. DOI:<https://doi.org/10.1016/J.JEP.2010.04.024>
  32. Xiao X, Wang J, Meng C, Liang W, Wang T, Zhou B, Wang Y, Luo X, Gao L, Zhang L. *Moringa oleifera* Lam and its Therapeutic Effects in Immune Disorders. *Frontiers in Pharmacology*. 2020;11: 566783. DOI:<https://doi.org/10.3389/FPHAR.2020.566783/BIBTEX>
  33. Moyo. Antimicrobial activities of *Moringa oleifera* Lam leaf extracts. *African Journal of Biotechnology*, 2012;11(11). DOI:<https://doi.org/10.5897/AJB10.686>
  34. Chhikara N, Kaur A, Mann S, Garg MK, Sofi SA, Panghal A. Bioactive compounds, associated health benefits and safety considerations of *Moringa oleifera* L.: An updated review. *Nutrition and Food Science*. 2021;51(2):255–277. DOI:<https://doi.org/10.1108/NFS-03-2020-0087/FULL/XML>
  35. BA F, BAH M, SENE M, SAMBOU JK, GUEYE MM, BA EH. Antidiabetic properties of *Moringa oleifera*: A review of the literature. *Journal of Diabetes and Endocrinology*, 2020;11(1):18–29. DOI:<https://doi.org/10.5897/JDE2019.0136>
  36. Anthanont P, Lumlerdikij Bsc N, Md A, Vannasaeng S, Sriwijitkamol A. *Moringa Oleifera* Leaf Increases Insulin Secretion after Single Dose Administration: A Preliminary Study in Healthy Subjects. *J Med Assoc Thai*. 2016;99(3);308–321.
  37. Ahmad J, Khan I, Blundell R. *Moringa oleifera* and glycemic control: A review of current evidence and possible mechanisms. *Phytotherapy Research*, 2019;33(11):2841–2848. DOI:<https://doi.org/10.1002/PTR.6473>
  38. Owens FS, Dada O, Cyrus JW, Adedoyin OO, Adunlin G. The effects of *Moringa oleifera* on blood glucose levels: A scoping review of the literature. *Complementary Therapies in Medicine*, 2020;50:102362. DOI:<https://doi.org/10.1016/J.CTIM.2020.102362>
  39. Gupta R, Mathur M, Bajaj VK, Katariya P, Yadav S, Kamal R, Gupta RS. Evaluation of antidiabetic and antioxidant activity of *Moringa oleifera* in experimental diabetes. *Journal of Diabetes*, 2012;4(2):164–171. DOI:<https://doi.org/10.1111/J.1753-0407.2011.00173.X>
  40. Chen L, Chen R, Wang H, Liang F. Mechanisms Linking Inflammation to Insulin Resistance. *International Journal of Endocrinology*; 2015. DOI:<https://doi.org/10.1155/2015/508409>
  41. Ginsberg HN, Tuck C. Diabetes and Dyslipidemia. 2001;131–147. DOI:[https://doi.org/10.1007/978-1-59259-091-9\\_8](https://doi.org/10.1007/978-1-59259-091-9_8)
  42. Mehta LK, Balaraman R, Amin AH, Bafna PA, Gulati OD. Effect of fruits of *Moringa oleifera* on the lipid profile of normal and hypercholesterolaemic rabbits. *Journal of Ethnopharmacology*. 2003;86(2–3):191–195. DOI:[https://doi.org/10.1016/S0378-8741\(03\)00075-8](https://doi.org/10.1016/S0378-8741(03)00075-8)
  43. Vieira GHF, Mourão JA, Ângelo ÂM, Costa RA, Vieira RHS. dos F. Antibacterial effect

- (*in vitro*) of *Moringa oleifera* and *Annona muricata* against Gram positive and Gram negative bacteria. *Revista Do Instituto de Medicina Tropical de São Paulo*, 2010;52(3):129–132.  
DOI:<https://doi.org/10.1590/S0036-46652010000300003>
44. Padla EP, Solis LT, Levida RM, Ragasa CY, Shen CC. Antimicrobial Isothiocyanates from the Seeds of *Moringa oleifera* Lam. *Zeitschrift Fur Naturforschung - Section C Journal of Biosciences*, 2012;67(11–12):557–564.  
DOI:<https://doi.org/10.1515/ZNC-2012-11-1205/MACHINEREADABLECITATION/RIS>
  45. Peixoto JRO, Silva GC, Costa RA, de Sousa Fontenelle J res L, Vieira GHF, Filho AAF, Vieira RHS, dos F. *In vitro* antibacterial effect of aqueous and ethanolic *Moringa* leaf extracts. *Asian Pacific Journal of Tropical Medicine*. 2011; 4(3):201–204.  
DOI:[https://doi.org/10.1016/S1995-7645\(11\)60069-2](https://doi.org/10.1016/S1995-7645(11)60069-2)
  46. Farooq B, Koul B. Comparative analysis of the antioxidant, antibacterial and plant growth promoting potential of five Indian varieties of *Moringa oleifera* L. *South African Journal of Botany*. 2020;129:47–55.  
DOI:<https://doi.org/10.1016/J.SAJB.2018.12.014>
  47. Biswas D, Nandy S, Mukherjee A, Pandey DK, Dey A. *Moringa oleifera* Lam. and derived phytochemicals as promising antiviral agents: A review. *South African Journal of Botany*. 2020;129:272–282.  
DOI:<https://doi.org/10.1016/J.SAJB.2019.07.049>
  48. Raj A, Gopalakrishnan V, S YJ of P. undefined. Antimicrobial activity of *Moringa oleifera* (Lam.) root extract. *Citeseer*. 2011;4(5):1426–14270.  
Available:<https://citeseerx.ist.psu.edu/document?repid=rep1&type=pdf&doi=b0748d9a2681f6dab94fbc7a48f5c4e100a28a61>
  49. Zaffer M, Ahmad Ganie S, Singh Gulia S, Singh Yadav S, Singh R, Ganguly S (n.d.). Antifungal Efficacy of *Moringa oleifera* Lam. Retrieved; October 8, 2023.  
Available:[www.ajpct.org](http://www.ajpct.org)
  50. Bhatia M, Karnekar N, Halingale O, Arvindekar S. Glycosylated heterocycles emulsified with antifungal fraction of *Moringa oleifera* for potentiation of mycolytic activity. *Natural Product Research*; 2023.  
DOI:<https://doi.org/10.1080/14786419.2023.2222432>
  51. Majali I, Althunibat O, Qaralleh H. Antimicrobial and immunomodulatory activities of *Moringa peregrine*- minireview. *Journal of Basic and Applied Research in Biomedicine*. 2015;1(2):55–61.  
Available:<https://jbarbiomed.com/index.php/home/article/view/41>
  52. Farooq F, Rai M, Tiwari A, A KJ of M, undefined. (n.d.). Medicinal properties of *Moringa oleifera*: An overview of promising healer. *Fengshuilondon.Net*. Retrieved; October 8, 2023.  
Available:<http://www.fengshuilondon.net/wp-content/uploads/2014/02/MEDICINAL-PROPERTIES-OF-MORINGA-OLEIFERA.pdf>
  53. Reddy V, Urooj A, Sairam S, Ahmed F, Nn P (n.d.). Hypocholesterolemic Effect of *Moringa oleifera* Polyphenols in Rats Fed High Fat-Cholesterol Diet 473 Hypocholesterolemic Effect of *Moringa oleifera* Polyphenols in Rats Fed High Fat-Cholesterol Diet.
  54. Muzumbukilwa WT, Kadima MG, Nloto M, Owira PMO. Mapping the evidence of hepatoprotective properties of *Moringa oleifera* from sub-Saharan African countries: A systematic review protocol. *Systematic Reviews*. 2019;8(1):1–6.  
DOI:<https://doi.org/10.1186/S13643-019-1117-2/PEER-REVIEW>
  55. Mohammad Shafie N, Raja Shahrman Shah RNI, Krishnan P, Abdul Haleem N, Tan TYC. Scoping Review: Evaluation of *Moringa oleifera* (Lam.) for Potential Wound Healing in *In Vivo* Studies. *Molecules*. 2022;27(17):5541.  
DOI:<https://doi.org/10.3390/MOLECULES27175541/S1>
  56. Nadeem M, Imran M. Promising features of *Moringa oleifera* oil: Recent updates and perspectives. *Lipids in Health and Disease*. 2016;15(1):1–8.  
DOI:<https://doi.org/10.1186/S12944-016-0379-0/TABLES/9>
  57. Alia F, Putri M, Anggraeni N, Syamsunarno MRAA. The Potency of *Moringa oleifera* Lam. as Protective Agent in Cardiac Damage and Vascular Dysfunction. *Frontiers in Pharmacology*. 2022;12: 724439.  
DOI:<https://doi.org/10.3389/FPHAR.2021.724439/BIBTEX>

58. Charoensin S. Antioxidant and anticancer activities of Moringa oleifera leaves. 2014;8(7): 318–325. DOI:<https://doi.org/10.5897/JMPR2013.5353>
59. Patil SV, Mohite BV, Marathe KR, Salunkhe NS, Marathe V, Patil VS. Moringa Tree, Gift of Nature: a Review on Nutritional and Industrial Potential. Current Pharmacology Reports, 2022;8(4):262–280. DOI:<https://doi.org/10.1007/S40495-022-00288-7/FIGURES/6>
60. Olson ME. Moringa frequently asked questions. Acta Horticulturae. 2017;1158: 19–32. DOI:<https://doi.org/10.17660/ACTAHORTIC.2017.1158.4>
61. Karthivashan G, Arulselvan P, Tan SW, Fakurazi S. The molecular mechanism underlying the hepatoprotective potential of Moringa oleifera leaves extract against acetaminophen induced hepatotoxicity in mice. Journal of Functional Foods, 2015;17:115–126. DOI:<https://doi.org/10.1016/J.JFF.2015.05.007>
62. Ulmy M, Tahir A, Arsunan A, Clínica BBE, undefined. (n.d.). Effect of moringa leaves during pregnancy on growth and morbidity in 0–5 months. Elsevier. Retrieved; October 8, 2023. Available:<https://www.sciencedirect.com/science/article/pii/S1130862120301388>
63. Grosshagauer S, Pirkwieser P, Kraemer K, Somoza V. The Future of Moringa Foods: A Food Chemistry Perspective. Frontiers in Nutrition, 2021;8: 751076. DOI:<https://doi.org/10.3389/FNUT.2021.751076/BIBTEX>
64. Stohs SJ, Hartman MJ. Review of the Safety and Efficacy of Moringa oleifera. Phytotherapy Research. 2015;29(6):796–804. DOI:<https://doi.org/10.1002/PTR.5325>

© 2023 Sagheer and Ali; This is an Open Access article distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

*Peer-review history:*  
*The peer review history for this paper can be accessed here:*  
<https://www.sdiarticle5.com/review-history/107096>