

Moringa Oleifera: Nutritive and Medicinal Importance

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ABSTRACT

Moringa oleifera is likewise referred to as "Miracle Tree" and it's almost all its elements have nutritional and pharmacological residences. It's miles particularly nutritious crop cultivated often in all parts of the sector. It is a treasured food crop, that grows very rapidly or even beyond food it serves many blessings. it has been used to fight against malnutrition, specifically among younger ones and lactating moms. Its numerous plant parts are used for one-of-a-kind functions. it's by far the richest plant source of nutrients A, B, C, D, E, and okay. Minerals present in this tree encompass k, Mg, Ca, Mn, Zn, Cu, and Fe. Its various components are used for the treatment of various diseases. it is immune to drought length because of the long taproot gadget. Its cultivation is quite simple and calls for fewer efforts. It plays a crucial function in the conservation of soil, and water, and mitigating climatic exchange. This book chapter affords a quick overview approximately the nutritional importance, health blessings, and their production generation together with water purification properties.

Keywords: *Moringa oleifera*, Taxonomy, Nutritive Properties, Medicinal Uses

1. INTRODUCTION

Moringa oleifera, a member of the Moringaceae family, is a highly effective solution for addressing malnutrition. This is due to the abundance of essential phytochemicals found in its leaves, pods, and seeds, which provide a rich source of nutrients. *Moringa* is known to contain seven times more vitamin C than oranges, ten times more vitamin A than carrots, seventeen times more calcium than milk, nine times more protein than yogurt, fifteen times more potassium than bananas, and twenty-five times more iron than spinach. The fact that

Moringa is easily cultivable makes it a sustainable solution for combating malnutrition. Countries like Senegal and Benin have successfully utilized Moringa to address malnutrition in children, particularly those who are deprived of breast milk. In such cases, lactogogues, which are substances that stimulate milk production, are often prescribed to lactating mothers. Moringa contains phytosterols such as stigma sterol, sitosterol, and kampesterol, which act as precursors for the hormones necessary for reproductive growth. These compounds promote estrogen production, thereby stimulating the proliferation of the mammary gland and ducts to enhance milk production. Moringa is also used to treat malnutrition in children under the age of three. Additionally, during pregnancy, consuming approximately six spoonfuls of Moringa leaf powder can fulfill a woman's daily iron and calcium requirements. While there is limited research on the use of Moringa in treating diabetes and cancer, this study aims to bridge the existing gap by exploring its potential in these areas. In summary, this examination provides an overview of Moringa's cultivation, nutritional value, medicinal properties for commercial use, and pharmacological properties. By harnessing the power of Moringa, we can address malnutrition and potentially explore its benefits in treating other health conditions.

Table 1: Taxonomic position of *M. oleifera*

Kingdom	Planate	Order	Brassicales
Division	Magnoliphyta	Family	Moringaceae
Class	Magnoliopsida	Genus	Moringa
SubClass	Dilleniidae	Species	<i>M. oleifera</i>

Moringa, a member of the Moringaceae family, is part of a larger group of 12 species that includes various types of bushes and shrubs [2]. The Moringaceae family showcases a diverse range of tree forms, ranging from bottle-shaped to cylindrical bushes, as well as tuberous shrubs. While the Moringa tree is native to India and Pakistan [3], it is also found in several other countries such as Afghanistan, Bangladesh, Namibia, India, and Madagascar in the northwestern region of the Himalayas [4]. This genus has a wide distribution and is cultivated extensively in dry regions of the Middle East and Africa. The Moringa tree can be found in different tropical regions around the world, including Ghana, the Philippines, Ethiopia, Haiti, Uganda, Nicaragua, and many other countries [5]. These trees thrive in areas where the soil conditions are suitable for the survival and growth of Moringa.

Table 2: Geographic distribution of various species

Shape of tree	Name of Species	Geographical Location
Slender shaped	<i>Moringa concanensis</i>	India
	<i>Moringa peregrina</i>	Horn of Africa, Arabia Fiori Red Sea
Bottle shaped	<i>Moringa drouhardii</i>	Madagascar
	<i>Moringa hildebrandtii</i>	Madagascar
	<i>Moringa ovalifolia</i>	S.W. Angola and Namibia
	<i>Moringa stenopetala</i>	Ethiopia and Kenya
Tuberous shrubs	<i>Moringa arborea</i>	North Eastern Kenya
	<i>Moringa borziana</i>	Somalia and Kenya
	<i>Moringa longituba</i>	Ethiopia, Kenya and Somalia
	<i>Moringa pygmaea</i>	Somalia
	<i>Moringa ruspoliana</i>	Somalia, Ethiopia, Kenya
	<i>Moringa rivae</i>	Ethiopia, Kenya

2. PRESENT STATUS IN INDIA

In India, Moringa is widely cultivated for its leaves, flowers, and pods. The pods, in particular, are a popular vegetable in the southern part of the country and are highly regarded for their delicious flavor. According to Marimuthu et al., Moringa seeds do not have dormancy, which means they can be planted immediately after maturity and remain viable for up to one year [6]. However, it is worth noting that older seeds may have lower germination rates. Moringa plants typically produce flowers and fruits once a year, although in certain regions, they may have two cycles. One of the advantages of cultivating Moringa is that it thrives in dry regions and does not require expensive irrigation techniques, making it a suitable crop for such areas. Different types of planting systems are utilized for various purposes such as direct sowing, transplanting of young seedlings, and stem cuttings. The recommended seed rate is 260-270 gm/acre, with 2 or 3 seeds sown at an intensity of 2-3 cm and spacing of 1m for leaf production. For seed, leaf, and pod production, a wider spacing of three to 5 m is advised. Moringa has been found to yield better results with direct sowing and can be easily grown in different ecological settings, playing a significant role in the vegetable industry. In Southern India, the ideal sowing time is in September to avoid overlapping with monsoon rains which could lead to flower loss. It is crucial to pinch the plant when it reaches a height of 75 cm to stimulate the growth of lateral branches and limit the height of the tree. Pinching at 60 days after sowing seeds is more effective than pinching at 90 days. Fruits should be harvested before they develop fiber, and in Tamil Nadu, Moringa trees have been successfully cultivated as an intercrop in old coconut gardens [6].

3. NUTRITIVE PROPERTIES

Table 3 highlights the fact that every part of *M. oleifera* is a rich source of essential vitamins and nutrients. Specifically, the leaves of *M. oleifera* are abundant in minerals such as calcium, potassium, zinc, magnesium, iron, and copper [7]. Moreover, *M. oleifera* contains a variety of nutrients including beta-carotene (a precursor to vitamin A), vitamin B (including folic acid, pyridoxine, and nicotinic acid), vitamin C, vitamin D, and vitamin E [8]. Additionally, *M. oleifera* is packed with phytochemicals like tannins, sterols, terpenoids, flavonoids, saponins, anthraquinones, alkaloids, and reducing sugar. These phytochemicals are accompanied by anti-cancerous agents such as glucosinolates, isothiocyanates, glycoside compounds, and glycerol-1-nine-octadecanoate [9]. The low calorific value of Moringa leaves makes them suitable for inclusion in the diet of individuals who are overweight. Furthermore, the fibrous pods of *M. oleifera* are beneficial in treating digestive issues and preventing colon cancer [10]. A study revealed that immature pods contain approximately 46.78% fiber and 20.66% protein content. Additionally, the pods have a 30% amino acid content, while the leaves and flowers contain 44% and 31% amino acids, respectively. Moreover, the immature pods and flowers exhibit similar amounts of palmitic, linolenic, linoleic, and oleic acids [11].

Table 3: Composition of various nutrients*

Nutrients	Fresh Leaves	Dry Leaves	Leaf Powder	Seed	Pod
Protein (gm)	6.7	29.4	27.1	35.97±0.19	2.5
Carbohydrate (gm)	12.5	41.2	38.2	8.87±0.12	3.7
Fat(gm)	1.7	5.2	2.3	38.67±0.03	0.1
Fibre(gm)	0.9	12.5	19.2	2.87±0.03	4.8
VitaminB1(mg)	0.06	2.02	2.64	0.05	0.05
VitaminB2 (mg)	0.05	21.3	20.5	0.06	0.07
VitaminB3 (mg)	0.8	7.6	8.2	0.2	0.2
Vitamin C(mg)	220	15.8	17.3	4.5±0.17	120
Vitamin E (mg)	448	10.8	113	751.67±4.41	----
Calcium (mg)	440	2185	2003	45	30
Magnesium (mg)	42	448	368	635±8.66	24
Phosphorous (mg)	70	252	204	75	110
Potassium (mg)	259	1236	1324	----	259
Copper (mg)	0.07	0.49	0.57	5.20±0.15	3.1
Iron (mg)	0.85	25.6	28.2	----	5.3
Sulphur (mg)	----	----	870	0.05	137

*All values are 100gm/plant material [<http://www.moringaleafpowder.co.za/analysis.html>]
Moringa is rich in essential minerals that play a crucial role in supporting growth and development, with calcium being highlighted as a particularly important mineral for human health. While 8 ounces of milk can provide 300-400 mg of calcium, Moringa leaves offer a significant amount of 1000 mg, and Moringa powder surpasses this by providing more than 4000 mg. Moreover, Moringa powder can serve as a natural alternative to iron supplements, making it a potential remedy for anemia. In comparison, beef contains only 2 mg of iron, whereas Moringa leaf powder boasts a much higher iron content of 28 mg. Studies have shown that Moringa contains more iron than spinach [12], further emphasizing its nutritional value. Additionally, zinc is another vital mineral necessary for various bodily functions, including the proper growth of sperm cells and the synthesis of DNA and RNA. Moringa oleifera leaves are found to contain approximately 25.5-31.03 mg of zinc per kilogram, meeting the daily requirement of zinc in a balanced diet. This highlights the diverse range of essential minerals present in Moringa, making it a valuable addition to a healthy diet [13].

4. MEDICINAL PROPERTIES

Various health issues such as sore throat, ear infections, sprains, hypertension, cough, tension, headaches, skin infections, epilepsy, intestinal worms, respiratory problems, joint pain, anemia, blackheads, pimples, cholera, diarrhea, bronchitis, lactation issues, diabetes, abnormal blood pressure, chest congestion, conjunctivitis, bronchial asthma, fever, scurvy, tuberculosis, and semen deficiency [14] can be treated using these remedies. Moringa trees have been found to contain a variety of chemicals that possess beneficial pharmacological properties, which can potentially be used for medicinal purposes (Table 4). These chemicals include compounds that can lower cholesterol levels, treat ulcers, lower blood sugar, heal infectious skin conditions, reduce hypertension, relieve spasms, and even have anticancer effects. The medicinal applications of Moringa trees are diverse and promising, offering a natural and potentially effective way to address various health concerns. The presence of these beneficial compounds in Moringa highlights the potential for using natural remedies derived from plants to improve health and well-being [15].

4.1. Anti-Diabetic Properties

Moringa, known for its anti-diabetic properties, has been found effective in treating both Type 1 and Type 2 diabetes. Type 1 diabetes is characterized by the body's inability to produce insulin, a hormone crucial for regulating blood glucose levels. On the other hand, Type 2 diabetes is linked to insulin resistance, often caused by Beta cell dysfunction leading to elevated blood sugar levels due to reduced insulin signaling. Various studies have highlighted Moringa's potential as an anti-diabetic agent. Research has demonstrated that aqueous extracts of Moringa oleifera can effectively manage streptozotocin-induced Type 1 diabetes and insulin-resistant Type 2 diabetes in rats. In a separate study, rats with STZ-induced diabetes were fed Moringa seed powder, resulting in a significant decrease in fasting blood glucose levels. Moreover, administering around 500 mg of Moringa seed powder per kg of body weight to the rats led to an increase in antioxidant enzymes in the serum. The presence of antioxidants in Moringa has been shown to have a significant impact on reducing the reactive oxygen species (ROS) levels within Beta-cells that are induced by STZ. STZ is known to trigger ATP dephosphorylation reactions, leading to the activation of xanthine oxidase and the subsequent formation of superoxides and ROS within the Beta cells. In patients with hyperglycemia, the destruction of beta cells results in an influx of excessive glucose into the mitochondria, leading to the release of reactive oxygen species. Due to the low levels of antioxidants in beta cells, this process ultimately leads to the apoptosis of beta cells, resulting in reduced insulin secretion, hyperglycemia, and the development of type-2 diabetes. Flavonoids such as quercetin and phenolics have been identified as antioxidants that possess scavenging properties against ROS. It is believed that the flavonoids present in Moringa play a crucial role in scavenging the ROS released from the mitochondria, thereby protecting the beta cells and helping to regulate hyperglycemia. The mechanism by which excessive glucose leads to the development of diabetes involves the entry of glucose into glycolysis within the mitochondria of beta cells, leading to the formation of reactive oxygen species. This process ultimately triggers the apoptosis of beta cells, resulting in decreased insulin secretion, hyperglycemia, and the onset of type-2 diabetes.

4.2. Anticancer Properties

Cancer is a prevalent disease that is responsible for a significant number of deaths, with one in seven deaths being attributed to incorrect medication. In India alone, there are approximately 2.4 million cases of cancer, and the causes of cancer are not specific. Factors such as smoking, lack of exercise, and radiation exposure can contribute to the development of the disease [16]. However, the treatments available for cancer, such as surgery, chemotherapy, and radiation, are expensive and often come with side effects. Fortunately, M. oleifera, also known as Moringa, has shown promise as an anticancer agent. It is a natural and reliable option that is considered safe when used at appropriate concentrations. Research has demonstrated that Moringa can act as an anti-neoproliferative agent, meaning it can inhibit the growth of cancer cells. The soluble and solvent extracts derived from Moringa leaves have been particularly effective as anticancer agents. One of the reasons Moringa is effective against cancer is its ability to induce reactive oxygen species (ROS) within cancer cells. Studies have shown that the ROS generated by Moringa leads to apoptosis, or programmed cell death, in cancer cells. This is further supported by the upregulation of caspase 3 and caspase 9, which are key components of the apoptotic pathway [17,18]. Importantly, the production of ROS by Moringa is selective and specifically targets cancer cells, making it an ideal anticancer agent. Additionally, research has indicated that Moringa extracts can enhance

the expression of glutathione-S-transferase, which inhibits the expression of antioxidants. This further contributes to the effectiveness of Moringa as an anticancer agent [17].

The development of atherosclerosis as a result of diabetes involves a complex mechanism where excessive blood glucose triggers the release of reactive oxygen species (ROS) through glycolysis. These ROS then interact with lipids, particularly LDLs, forming a harmful combination that can directly lead to inflammation within the body. Additionally, the formation of advanced glycation end products (AGE) when combined with the receptor for AGE (RAGE) expressed on cell surfaces can activate NF-κB, a transcription factor that further promotes the expression of inflammatory cytokines, exacerbating the inflammatory response. The inflammatory process initiated by the interaction of ROS, LDLs, AGE, and RAGE can ultimately lead to the trans-endothelial migration of immune cells and LDLs, contributing to the progression of atherosclerosis. However, the impact of Moringa on this process is significant as it has been shown to possess antioxidant properties that enable it to scavenge ROS, preventing their harmful effects. Furthermore, Moringa can inhibit the formation of AGE and LDL, acting as an anti-atherosclerotic agent by impeding the cascade of events that lead to atherosclerosis.

Table 4: Medicinal uses and nutritional compositions of Moringa

Leaves	Medicinal usages: Treat headaches, hyperglycemia, scurvy, skin diseases, dyslipidemia, asthma, flu, syphilis, pneumonia, heartburn, malaria, ear infections, bronchitis, diarrhoea, governs cholesterol and blood pressure, acts as an anti-atherosclerotic agent, neuroprotectant, antioxidant, antimicrobial, anticancer and antidiabetic [8, 12, 19, 20]
	Nutritional properties: Contains proteins, fiber, and various minerals like Mg, Ca, S, K, and Fe and Vitamins like A, B-choline, B1-thiamine, riboflavin, ascorbic acid and nicotinic acid. Amino acids, Various phytochemicals like saponins, phenolics, sterols, quercetin, tannins, terpenoids, alkaloids besides flavanoids like, glycoside, isothiocyanates and isoquercitrin, kaemfericitin etc.
	Benefit: Antidiabetic and anticancer agents, anti-proliferative properties and antioxidant. Vitamins and minerals help in improving the immune system.
Seeds	Medicinal usages: Help in treating Crohn's disease, STDs, epilepsy cramp rheumatism simplex virus arthritis hyperthyroidism, anti-herpes, gout, and acts as anti-inflammatory and antimicrobial agents [17,19,21,22]
	Nutritional properties: Comprises oleic acid and antibiotics termed as pterygospermin, along with several fatty acids like linolenic acid, behenic acid, and Linoleic acid. Some phytochemicals like phytate flavonoids tannins lectins, saponins, terpenoids, and phenolics. In addition to it some minerals, proteins, vitamins like A, and B, and amino acids and fats.
	Benefit: Anti-inflammatory and antimicrobial properties
Root Bark	Medicinal usages: Contains cardiac stimulant compound, anti-inflammatory and anti-ulcer properties [23, 24].
	Nutritional properties: Some alkaloid substances like moriginine morphine and minerals like magnesium, sodium, and calcium.
	Benefit: Antiulcer and a cardiac stimulant
Flower	Medicinal usages: Anti-arthritic agents and hypocholesterolemic properties that can cure urinary diseases [12, 25,]

	Nutritional properties: Contains Ca, K, and amino acids.
	Benefit: Feasible for use by beekeepers due to nectar
Pods	Medicinal usages: Helps in the treatment of joint pain, liver or spleen problems, and diarrhoea [12]
	Nutritional properties: Rich in lipids non-structural carbohydrates, protein, fiber, and ash. Various fatty acids like linoleic acid etc. are present.
	Benefit: In the diet of obese because of Polyunsaturated fatty acid (PUFA).

4.3. Water Purification Properties

The powdered form of Moringa seeds contains cationic polyelectrolytes that act as a natural flocculent, aiding in the clarification of highly turbid water. By binding with the suspended solids in the water, this powder effectively settles them down, resulting in the removal of up to 99% of microorganisms present in the water [26]. An interesting discovery from the use of Moringa oleifera as a coagulant is its ability to significantly reduce primary levels of turbidity at a concentration of 15 mg/lit, achieving a remarkable 91.17% removal efficiency. This is particularly noteworthy as it surpasses the performance of aluminum sulfate, which required a higher dosage of 55 mg/lit to achieve a slightly lower removal rate of 85.46%.

Zand and Hoveidi, have highlighted the importance of coagulant dosages on turbidity [27]. Enhanced dosages could potentially increase the effectiveness of water treatment, but this approach is not feasible due to the risks involved. Overdosing should be avoided at all costs to prevent any adverse effects. The saturation of the polymer bridge could lead to the re-stabilization of the diluted particles, creating a potential for the appearance of unwanted outcomes. A study indicated that a change in the concentration of seed powder from 0.016 to 0.08 g/l increased turbidity levels. This occurrence can be attributed to the presence of free positively charged particles from the flocculants resisting and causing the flocks to settle in the water. Pritchard et al. found that seed extracts from Moringa reduced turbidity levels significantly, leading to a clear supernatant and a substantial decrease in bacterial load in the sludge [28]. Adejumo et al.'s research suggested that treating water samples with varying concentrations of Moringa leaf powder did not show a significant difference in coliform count [29]. This could be due to variations in compound concentrations, which aid in reducing coliform count. The efficacy of water treated with Moringa seed powder is enhanced by proteins that facilitate the coagulation process, along with the presence of compounds like tannins and polyphenols that exhibit antibacterial properties [30]. Additionally, Moringa seeds are utilized by individuals to regulate pH levels and control microbial contamination in water treatment processes for consumption [15]. Various studies have highlighted the superiority and cost-effectiveness of Moringa tree seeds over aluminum sulfate in reducing turbidity in polluted water. The use of Moringa seeds as coagulants has shown promising results in reducing turbidity, microbial load, and microparticle content, serving as a sustainable alternative to chemical coagulants that pose risks to human, animal, and environmental health [31].

Moringa plants are rich in over 90 essential nutrients, including lipids, proteins, carbohydrates, and dietary fibers. These nutrient-packed plants serve as a valuable food source, especially in tropical regions, where they play a crucial role in combating malnutrition, particularly among children and infants.

5. CURRENT STATUS

Moringa, a plant known for its versatility and numerous benefits, has shown great potential in various pharmacological activities, biomedical applications, and livestock, poultry, and fish production. Recent research conducted in countries like India, Nigeria, Brazil, and China from 2019 to 2022 has provided valuable insights for researchers globally. Through in-depth studies on *Moringa oleifera*, it has been discovered that this plant offers a wide range of advantages for both humans and animals. The abundance of nutrients and phytoconstituents present in *Moringa* makes it a suitable dietary option for consumption. Its strong antioxidant properties have led to its use in pharmaceutical formulations such as wound healing, anti-cancer, and anti-aging products. Not only is *Moringa* beneficial for human consumption, but it also serves as a valuable fertilizer extracted from the plant itself. However, despite its numerous advantages, it is important to note that *Moringa* can have severe toxic and abortifacient effects if consumed in large quantities. This highlights the importance of using *Moringa* responsibly and in moderation to fully reap its benefits.

6. SUMMARY

Moringa oleifera has the potential to address a wide range of health issues, diseases, vitamin deficiencies, and malnutrition, and serve as a valuable natural resource for both the population and industry. Recent studies have focused on identifying the proteins of *M. oleifera* and their functions, emphasizing the importance of utilizing the vitamins present in this remarkable tree for various purposes. The anti-diabetic and anti-cancer properties of *M. oleifera* have been highlighted, although there is a need for more double-blind studies to validate these claims. Further research is necessary to understand the underlying mechanisms of *Moringa's* effectiveness as an anti-diabetic and anti-cancer agent, as well as to explore its antioxidant properties on cancer cells. Unanswered questions persist regarding the impact of environmental factors on the nutrient content of *M. oleifera* leaves grown worldwide, requiring additional investigation. Research efforts to isolate entophytic fungi and identify specific enzymes or proteins responsible for the anticancer and anti-diabetic effects of *M. oleifera* could lead to the development of innovative therapeutic compounds. Another area of interest lies in exploring the commercial potential of *M. oleifera* as a bio-coagulant for water purification, offering a promising alternative for addressing water quality issues. Additionally, incorporating *Moringa* fortification in snacks to combat malnutrition presents a dual benefit, especially considering the high demand for such products in the market. Leveraging the nutritional benefits of *Moringa*, particularly from trees native to India, could not only contribute to the nation's income but also offer a sustainable solution for providing highly nutritious food. By encouraging further research and collaboration between industries and researchers, the full potential of *M. oleifera* can be harnessed to benefit both health and economic sectors. To fully comprehend the energetic categorization and actions of traditional Asian medicine and paradigm-based medicine, future research studies must be conducted to validate and understand their mechanisms. These studies will not only open up new ideas and horizons but also shed light on the effects of diseases like COVID-19, leading to a more accurate, scientific, and clinically applicable use of *M. oleifera*.

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