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Research Paper

The Miracle Tree: Unveiling the Nutritional Medicinal Wonders of Moringa oleifera

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ABSTRACT

Moringa plant is native to India which is also known as the Moringa Oleifera, Moringa trees thrive in subtropical and tropical regions globally, as validated by scientific research, showcasing the extraordinary capabilities of Moringa Oleifera. All over the scientific analysis performed on the moringa proves the miraculous potential of the Moringa Oleifera. Moringa tree is also considered as the Natures Gold after the scientific research performed. Moringa is still unknown for its potential nutritional and medicinal importance of its leaves and pods in some regions. It is also considered as a vegetable fruit by the majority of the population. Leaves of Moringa contains the almost all required essential nutritional components such as amino acids, vitamins, proteins, growth factors, metal ions and the essential minerals, potassium and zinc. Although these properties nowadays, moringa tree leaves may be used in the preparation of various nutritional nutraceutical as supplement and medicine. Extracts from Moringa leaves are employed to enhance breast milk production in nursing mothers and combat malnutrition, contributing to their overall well-being. Leaves of the moringa plant has potential health benefits which includes the exhibit the anti-tumor, protecting abdominal constipation, anti-inflammatory, anti-ulcer effectively eliminating various intestinal worms, acting as an anti-atherosclerotic agent, stimulating appetite, and providing relief for respiratory ailments like influenza and bronchitis, Moringa presents a versatile natural remedy. because moringa leaves potent in the biologically active phytochemicals.

INTRODUCTION

Belonging to the Moringaceae family, Moringa oleifera stands out as a potent solution for nutritional deficiencies. Its leaves, pods, and seeds harbor a rich array of vital phytochemicals, making it a valuable source of essential nutrients. In general consideration of nutritional analysis

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moringa contains the vitamin A ten times more than carrots, protein content nine times more than yoghurt, calcium content seventeen times than milk, vitamin C content seven times than orange, iron content twenty-five more than spinach and potassium content fifteen more than bananas (1)

Also the general consideration that *Moringa oleifera* tree is easily grown and it is suitable remedy for the nutritional deficiency. Nations like Senegal and Benin utilize Moringa to address child health, recognizing its potential benefits in promoting well-being and nutritional support for children (2). Children which not consumed breast milk of mother may prone to malnutrition Lactogogues are frequently administered to breastfeeding mothers to enhance milk production effectively. Phytosterols such as campesterol and sitosterol stigmasterol majorly found in moringa which are predecessor of hormones. These components boost estrogen production, facilitating the enlargement of mammary gland ducts to promote milk stimulation. also used in the treatment of nutritional deficiency in child's more than 3 years old(3). Nearly 6 table spoons of moringa leaves powder can satisfy the woman's iron and calcium requirement of one day, during the period of pregnancy. This review study provides a compressive overview on medicinal activity's, cultivation for marketed use, nutritional values and pharmacological activities of leaf powder of moringa.

2. Soil Quality and Cultivation

Moringa oleifera flourishes in global tropical and subtropical climates, where temperatures range between 25 and 35 degrees Celsius. It flourishes in soil characterized by a loamy or sandy texture, with a pH level ranging thriving in environments ranging from slightly acidic to slightly alkaline, Moringa oleifera thrives best with an ideal rainfall between 250–3000 mm.(4) To achieve optimal germination rates, the direct seeding method is employed for moringa. Anticipating germination within 5–12 days post-seeding, the plant seeds at a depth of 2 cm in loamy or sandy soil for traditional cultivation, or opt for container cultivation for a versatile approach to growing moringa, placing samples in plastic bags filled with the specified soil type. Once it reaches a height of approximately 30 cm, transplantation is possible, but caution is essential due to the delicate nature of tap roots. Propagation from cuttings is another method, with cuttings typically measuring 4–5 cm in diameter and 1 m in length; however, such plants may lack an ideal deep root system, making them susceptible to drought and winds. Commercially, one can choose between large-scale intensive and semi-intensive plantation methods for cultivating moringa. Proper spacing is crucial in commercial cultivation, facilitating effective plant management and harvest. It's worth noting that the nutrient composition of Moringa oleifera may vary across different locations.(5) A tree cultivated in the Indian region exhibits distinct nutritional components compared to one grown in Nigeria(6).

Examined the nutritional variances in leaves between two ecological settings Savannah regions and semi-deciduous areas. Findings revealed that the latter exhibited lower nutritional value than the former, with the disparity attributed to elevated temperatures in the Savannah regions. The higher temperatures are believed to lead to the denaturation of proteins and enzymes, potentially accounting for the observed differences in nutrient content. It's important to note that soil quality serves as a pivotal factor, representing the plant's strength and influencing nutrient content(7). Illustrated that the application of fertilizers, either individually or in combination, led to diverse nutrient compositions in different plant parts. Through the provision of poultry manure, NPK fertilizer, and organic base fertilizer, the study

examined their impact on nutrient content, revealing that poultry manure yielded the most significant results, particularly in terms of phosphorus, sodium, potassium, and manganese. Moreover, the incorporation of chicken waste resulted in an increase in stem diameter and overall vegetative development of moringa. Despite fluctuations in nutrient concentrations, the plant maintained a consistently balanced nutrient profile. This trait positions moringa as a potential undiscovered nutraceutical with worldwide relevance.

3. Nutrient Characteristics-

Virtually every segment of Moringa oleifera acts as a repository of vital nutrients. From which, the plant leaves are the most abundant source of minerals, encompassing zinc, magnesium, calcium, potassium, iron, and copper. Moringa oleifera is rich in a diverse range of vitamins, encompassing beta-carotene, a precursor to vitamin A, B-complex vitamins like folic acid, cobalamin, pyridoxine, and nicotinic acid, in addition to vitamins C, D, and E.(8) Moringa oleifera contains a phytochemical, including but not limited to saponins, anthraquinones, alkaloids, tannins, sterols, terpenoids, flavonoids, and reducing sugars. Additionally, it has antineoplastic agents such as isothiocyanates, glucosinolates, glycoside compounds, and glycerol-1-9-octadecanoate.(9) leafs possess a low calories content, making them suitable for inclusion in the diet of individuals dealing with obesity. The fibrous nature of the pods is advantageous for addressing gastrointestinal problems and preventing colon cancer(10). The study suggest that unripe pods exhibit near protein about 20.66% and fiber 46.78% content, with amino acids 30% in pods, 31% in flowers, and 44% in leaves. Moreover, premature pods and blossoms exhibited similar concentrations of linolenic, linoleic, palmitic, and oleic acids(11). Plant, rich in essential variety minerals for growth, such as calcium, exceed conventional sources. With over 4000 mg in moringa powder and 1000 mg in leaves, it exceeds the calcium content of 8 ounces of milk. Moreover, moringa serves as an effective alternative to iron tablets, boasting 28 mg of iron in its leaf powder, outperforming beef's 2 mg. Analytical study highlight moringa's superior iron content compared to spinach(12). Sufficient zinc intake is essential for DNA and RNA synthesis, as well as essential for the sufficient development of sperm cells; Moringa leaves, constituent near about 24.5–30.03 mg of zinc/kg, meet the daily dietary requirement for zinc (13,14). Linolenic acid, linoleic acid, and oleic acid constitute polyunsaturated fatty acids (PUFAs), identified for their cholesterol-regulating properties. Analysis have demonstrated that moringa seed oil, with a composition of near about 76% PUFAs, serves favorable alternative of olive oil. It's essential to considered that the nutritional status of Moringa oleifera changes based on different location and is influenced by seasonal changes(15). Research indicates that in the hot-wet season, vitamin A is crucial, while during the cool-dry season, emphasis shifts to the significance of vitamin C and iron content(16). Differentiation in outcomes can be resulted to the substantial influence of the nutrient composition of the tree is influenced by climatic conditions, geographical location, and environmental factors, highlighting the interplay of these elements on its nutritional profile in an authentic(17). Refer to Table 1 for a comprehensive breakdown of nutrient composition in leaves, pods, and seeds.

4. Clarification of Moringa-

Processed plants often lose nutritional value; however, in a comparison of germinated, raw, and fermented moringa seed flour, raw seed flour exhibited higher phytochemicals, while fermented and germinated seed flour showed elevated amino

acid content(18). While summarizing the biochemical processes in germination and fermentation. Surprisingly, boiling emerged as the most effective method, significantly reducing oxalate, cyanide, and phytate contents compared to the other techniques. These findings underscore the importance of processing to enhance the bioavailability of essential nutrients from seeds and leaves(19). The research indicates that boiling enhances antioxidant and iron levels in moringa seed flour, making it a viable solution for addressing nutritional deficiencies. Despite this, some studies suggest that children may resist consuming moringa due to its mild bitterness(20). Moringa noodles were crafted using three cooking methods—baking, steaming, and boiling. Subsequent rat testing revealed that baked noodles had a notably positive impact on mammary glands, enhancing milk production. The baking process also improved lacto gum values due to the sterol-rich oil used. Additionally, Moringa oleifera was infused into chocolates, with a recent study determining that a 20% moringa blend in cocoa powder yielded optimal results. Similarly, incorporating moringa into halwa tahini increased the nutritional value of this delicacy in halva and tahini(21). Various fortification methods involving moringa can be employed to ensure children receive sufficient nutrient intake.

4.1. Conservation Techniques-

Moringa maintains its nutritional content for an extended period through methods like freezing or drying. Using a low-temperature oven for drying preserves more nutrients, excluding vitamin C compared to freeze-drying. Everyday appliances like a stove can be employed for cost-effective drying, ensuring a constant nutrient supply. Dehumidification enhances Moringa's shelf life without altering its nutritional value. To avoid potential adverse effects, a recommended daily dose of 70g is advised to prevent nutrient over-aggregation, especially regarding iron(22).

Table 1. The nutritional status of leaf powder, newly harvested leaves, and dried leaves vary in their nutrient compositions.

Nutrients	unit	Leaf Powder	Newly Harvested Leaves	Dried Leaves
Calorie	Cal.	205	91	328
Protein	g.	27.1	6.7	29.4
Fat	g.	2.3	1.7	5.2
Carbohydrate	g.	38.2	12.5	41.2
Fiber	g.	19.2	0.8	11.5
Thiamine	mg	2.64	0.05	2.03
Riboflavin	mg	20.5	0.06	21.5
Niacin	mg	8.2	0.9	7.4
Ascorbic acid	mg	17	222	14.8
Tocopherol	mg	111	448	10.8
Calcium	mg	2000	440	2185
Magnesium	mg	360	42	448
Phosphorus	mg	200	70	252
Potassium	mg	1324	259	1236
Iron	mg	28.2	0.8	25

5. Disease Fighting abilities-

Moringa oleifera is commonly acknowledged for its potential health benefits and has a history of traditional use in African and Indian herbal medicine. Rich in phytochemicals, Moringa is explored for its medicinal properties. This section reviews its impact on various health aspects, including potential effects on conditions such as cancer and diabetes.

5.1. Diabetes Management Properties-

Moringa oleifera exhibits promising effects in addressing Type 1 and Type 2 diabetes. For Type 1, marked by inadequate insulin production, Moringa shows potential in controlling blood sugar. In Type 2, associated with insulin resistance or pancreatic issues, Moringa may offer benefits in managing diabetes-related factors, Moringa shows promise in addressing these factors and maintaining optimal blood glucose levels(23). Numerous research articles emphasize the promising role of moringa as an anti-diabetic agent. One specific study highlights the healing attributes of aqueous extracts derived from Moringa oleifera, demonstrating efficacy in treating streptozotocin-induced Type 1 diabetes and insulin-resistant Type 2 diabetes in rat models(24). In a distinct study, scientists conducted an examination where they provided streptozotocin-induced diabetic rats with Moringa oleifera seed powder. The outcome showed a notable reduction in fasting blood glucose levels. The administration of around 500 mg of moringa seed powder per kg of body weight resulted in an elevation of antioxidant enzymes in the serum. This indicates that the antioxidants present in moringa may have the ability to alleviate reactive oxygen species (ROS) in Beta-cells induced by streptozotocin, thereby countering ATP dephosphorylation and ROS in Beta cells(25). Individuals with hyperglycaemia, destruction of beta cells occurs, leading to elevated glucose entry into mitochondria and subsequent release of reactive oxygen species (ROS). Due to limited antioxidants in beta cells, this process ultimately triggers apoptosis in beta cells(26,27). Reducing insulin production leads to hyperglycaemia and eventually Type-2 diabetes. Flavonoids such as quercetin and phenolics act as antioxidants, scavenging reactive oxygen species. Moringa's flavonoids may protect beta cells by scavenging reactive oxygen species from mitochondria, helping control hyperglycaemia(28). Diabetes contributes to issues like nephropathy, retinopathy, and atherosclerosis. Moringa shows promise in averting these conditions. Increased blood glucose levels initiate a process where they react with proteins, leading to the Creating advanced glycation end products (AGEs) leads to their binding with the receptor for advanced glycation end (RAGE), on immune cells, triggering heightened cytokine transcription(29). This supports the movement of cells through blood vessel walls, triggering artery inflammation and contributing to atherosclerosis. Moringa oleifera is recognized for its anti-atherosclerotic effects, possibly attributed to its antioxidant properties(30).

5.2. Cancer Fighting Properties-

Cancer is a prevalent ailment, contributing to one in seven deaths often caused by inadequate treatment. India witnesses approximately 2.4 million cases, with cancer development lacking specific attributions. Lifestyle factors such as insufficient physical activity, smoking, and exposure to radiation are commonly associated with the onset of this disease.(31,32) Cancer therapies such as chemotherapy, surgery, and radiation are not only costly but also accompanied by adverse effects. Moringa oleifera emerges as a natural, reliable, and safe alternative with established concentrations as an antineoplastic

agent. Numerous studies highlight its efficacy as an antiproliferative agent, impeding cancer cell growth. Extracts from Moringa leaves, both soluble and solvent-based, demonstrate effectiveness as antineoplastic agents. Further supports its potential in cancer treatment(33–35). Anticancer drugs leveraging reactive oxygen species induction are prevalent; however, it is essential for these compounds to possess the ability to counteract antioxidant enzymes(36). Moreover, extracts from *Moringa oleifera* leaves have shown antioxidant and anticancer properties by inducing reactive oxygen species. The specific interactions between the contrasting aspects of the leaves remain unexplored, with niazimicin glucosinolates and benzyl isothiocyanate identified as the responsible components for the antineoplastic effects(37). Research indicates a connection between benzyl isothiocyanate (BITC) and cancer. Studies reveal that BITC induces intracellular reactive oxygen species, resulting in cell death. This may contribute to the efficacy of moringa as a potential anticancer agent(38–40).

5.3. Other Disease Fighting abilities-

when blood circulation to the brain is obstructed Ischemia occurs, leading to repentantly and subsequent peroxidation of lipid, culminating generation of reactive of oxygen species (ROS)(41,42). Moringa plant, has its antioxidant properties, also mitigate ROS, thereby safeguarding the brain. *Moringa oleifera* is employed in dementia treatment due to its proven ability to enhance spatial memory. Extracts from moringa leaves have been shown to reduce acetylcholinesterase activity, enhancing cholinergic function and memory(43,44). Research has shown that incorporating moringa into the diet of rats enhances protein content while reducing blood levels of creatinine and urea, preventing renal dysfunction. Moreover, Moringa demonstrates a substantial decrease in acidity for gastric ulcers, registering reductions of 86.15% and 85.13% at doses of 500 mg and 350 mg, respectively, suggesting its potential as an antiulcer agent(45). Herbal practitioners often recommend moringa for AIDS patients, emphasizing its inclusion in daily diets to enhance the immune system of individuals with HIV. Nevertheless, additional studies are crucial to ascertain impact of plant of moringa on antiretroviral drugs(46). The hydro-alcoholic extract from moringa flowers exhibits promise as an effective therapy for arthritis, as evidenced by its ability to lower levels of rheumatoid factor, IL-1, and TNF-alpha in arthritic rats(47). Microbial diseases are diverse, necessitating effective antimicrobic. *Moringa oleifera* has demonstrated efficacy as a reliable antimicrobial agent. Research also demonstrated that efficacy of Moringa extracts in combating bacteria such as Staphylococcus aureus, Bacillus subtilis, and Vibrio cholerae(48). The seeds exhibit antibacterial properties due to the presence of moringine, pterygospermin, and benzyl isothiocyanate, contributing to their antimicrobial effects(49). Tables 2 and 3 provide an overview of the nutrient composition and therapeutic application of Moringa part.

Table 2. (8,12,18,34,50)

Disease Fighting abilities	Leaves
Healing Qualities	Moringa showcase a diverse array of therapeutic applications, including treatment in hyperglycaemia, dyslipidaemia, asthma, flu, pneumonia, diarrhoea, heartburn, syphilis, malaria, scurvy, skin diseases, bronchitis, headaches, as well as addressing eye and ear infections. Additionally, they contribute to reducing cholesterol and

	blood pressure, functioning as antioxidant, antidiabetic, anticancer, antimicrobial, anti-atherosclerotic agents, and neuroprotectants.
Nutritive Properties	Moringa is a nutrient-rich source, containing essential minerals like calcium, magnesium, phosphorus, potassium, copper, iron, and sulphur. They also provide vital nutrients such as fiber, fats, proteins, and a range of vitamins including Vitamin A, B-choline, B1-thiamine, riboflavin, nicotinic acid, and ascorbic acid. Additionally, these leaves are abundant in phytochemicals like saponins, terpenoids, phenolics, alkaloids, tannins, sterols, and flavonoids such as isoquercetin, quercetin, kaempferitrin, isothiocyanates, and glycosides, along with various amino acids like Arg, His, Lys, Trp, Phe, Thr, Leu, Met, Ile, and Val.
Suggestion	Flavonoids contribute antioxidant and antidiabetic properties to the leaves, while isothiocyanates act as antineoplastic agents. Notably, flavonoids like quercetin exhibit anticancer and anti-proliferative characteristics. The abundance of vitamins and minerals in Moringa leaves plays essential role in enhancing the immune activity and addressing various diseases.

Table 3. (4,42,51–53)

Disease Fighting abilities	Seeds
Medicinal uses	Moringa seeds are renowned for their therapeutic properties, aiding in the treatment of conditions such as Crohn's disease, hyperthyroidism, arthritis, rheumatism, gout, cramps, epilepsy, and sexually transmitted infections are among the conditions these substances may help alleviate. Furthermore, their anti-inflammatory and antimicrobial properties highlight their extensive medicinal advantages.
Nutritive Properties	Abundant in oleic acid (Ben oil), containing the antibiotic pterygospermin, and rich in essential fatty acids like Linoleic Acid and linolenic acid. It encompasses flavonoids, behenic acid, and a diverse range of Phytochemicals, including tannins, phytate, terpenoids, saponin, phenolics, and lectins. Moreover, it delivers a well-balanced combination of vitamins A, B, and C, coupled with fats, fiber, proteins, minerals, and amino acids.
Suggestion	Flavonoids contribute to its anti-inflammatory nature, while the antibiotic pterygospermin imparts powerful antimicrobial properties. The array of other phytochemicals aids in the treatment of diverse diseases.

6. Industrial Applications-

Moringa oleifera seeds yield Ben oil, abundant in oleic acid, sterols, and tocopherols. Due to its resilience against oxidative rancidity, this oil is adaptable for cooking as a replacement for olive oil, in perfume production, and for lubrication purposes(54). Capsules possess the ability to assimilate natural pesticides and contaminants, while *Moringa oleifera* seeds exhibit effective coagulation properties, aiding in the precipitation of both mineral and organic particles from a solution(55,56). Chemical coagulants like ferric sulphate and aluminium sulphate, as well as

polymers, Neutralizing the electrical charges of water particles to effectively remove suspended particles in wastewater and enhance water purification, forming flocs that can be easily filtered. *Moringa oleifera* seeds, containing a cationic protein, serve as a natural coagulant, effectively clarifying turbid water. The increasing research interest in *Moringa oleifera* stems from its cost-effective alternative to other coagulants like activated carbon, alum, and ferric chloride, which are both expensive and limited in availability(50,57). Created a dual-phase clarifier for the purification of tapioca starch wastewater, incorporating coconut fiber in the first stage and a sand media layer infused with powdered *Moringa oleifera* in the second stage. This innovation enhanced both chemical and physical properties, stabilizing the pH value. Significantly, the extract from *Moringa oleifera* seeds demonstrated the ability to efficiently remove heavy metals such as cadmium, chromium, lead, copper, and arsenic from water(58). Research findings indicate that the utilization of magnetic nanoparticles, specifically iron oxide, enhances the efficacy of *Moringa oleifera* on upper layer water treatment(32). *Moringa oleifera* seeds exhibit potent antimicrobial properties, thwarting bacterial growth and mitigating waterborne diseases. This attribute holds substantial importance in disease prevention, especially in rural areas where Moringa is abundantly available, enhancing overall quality of life. Additionally, these versatile seeds find applications in cosmetics, serve as a biodiesel source, and their cakes make effective organic fertilizer. *M. oleifera* blossom, known for hypocholesterolaemia property, also brewed in herbal tea. when fried, they are said to resemble the taste of mushrooms(59). Moringa flowers serve as excellent nectar sources for beekeepers. Additionally, the medicinal value of Moringa extends to its root bark, which is employed in treating conditions such as eye infection, dyspepsia, and heart diseases(60). Furthermore, the roots and gum exhibit notable properties, including antifungal, anti-inflammatory, and antibacterial attributes(61). The growth hormone Zeatin, extracted from Moringa leaves, proves to be an exceptional leaf nutrient, potentially boosting crop yields by 25%–30%. Incorporating Moringa in fortification efforts and various food products, including snacks, holds promise in addressing malnutrition and nutrient deficiencies, as supported by ongoing research(12,62). Conducting a sensory assessment on cookies infused with a combination of maize flour and moringa seed flour, revealing optimal acceptance at a ratio of 7.5% moringa and 92.5% maize seed flour. This combination garnered praise for its appealing aroma, taste, crispness, and colour. Moringa leaves have also been employed to enhance protein and energy content in cereal gruels. Notably, a blend of 35% moringa leaves and 65% popcorn, subjected to blanching and fermentation, resulted in heightened energy and protein levels, while the blanched cereal exhibited higher mineral content(63,64). Moringa was innovatively employed in the manufacturing fortified butter crackers and cream alongside Ipomoea batatas, aiming to enhance the nutritional profile of snacks. The sensory evaluation indicated widespread acceptance and approval of the cream crackers. Moreover, incorporating *Moringa oleifera* leaves into the diet of layers and hens presents a valuable protein source, offering a cost-effective alternative to pricier ingredients like groundnut cake and soybean meal(65,66). After considering various fortification perspectives, it is recommended to extend such additions to a variety of snacks. Incorporating *Moringa oleifera* into snacks has the potential to enhance their nutritional value. Numerous studies highlight the positive impact of adding Moringa to maize flour-based snacks, contributing to increased energy, protein, and mineral content.

7. Summary and Potential Outcomes-

The analysis performed in Moringa is currently underappreciated in India, despite its immense potential. Exploiting the nutritional content of this remarkable tree could have various applications. *Moringa oleifera* is recognized for its notable anti-cancer and anti-diabetic properties, although further double-blind research is required for conclusive evidence. Exploring the antioxidative properties of aqueous extracts in relation to cancer cell activity and understanding the paradoxical presence of both reactive oxygen species and antioxidants demands deeper exploration. Moreover, studying the impact of environmental factors on nutrient levels in M. oleifera across different regions is crucial. Isolating endophytic fungi and identifying specific enzymes or proteins responsible for antineoplastic and antidiabetic activity could pave the way for therapeutic development. Evaluating *Moringa oleifera* commercial use as a bio coagulant for water purification is another promising avenue. Fortifying snacks with Moringa to address nutritional deficiencies not only meets market demand but also holds economic potential for India. With further research validation, Moringa has the opportunity to emerge as a lucrative source of highly nutritious food, benefiting both industries and the nation.

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