



Moringa

The "miracle" tree of India

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Native to India, *Moringa oleifera* grows in the tropical and subtropical regions of the world. It is commonly known as "drumstick tree", "horseradish tree" or the "Miracle Tree". Moringa can withstand both severe drought and mild frost conditions and hence is widely cultivated across the world. With its high nutritive values, every part of the tree is suitable for either nutritional or commercial purposes. The leaves are rich in minerals, vitamins and other essential phytochemicals. Extracts from the leaves are used to treat malnutrition and augment breast milk in lactating mothers. It is used as a potential antioxidant, anticancer, anti-inflammatory, antidiabetic and antimicrobial agent. *M. oleifera* seed, a natural coagulant, is extensively used in water treatment.

Moringa oleifera, belonging to the family of Moringaceae, is an effective remedy for malnutrition. Moringa is rich in nutrition owing to the presence of a variety of essential phytochemicals present in its leaves, pods and seeds. In fact, moringa is said to provide seven

times more vitamin C than oranges, 10 times more vitamin A than carrots, 17 times more calcium than milk, nine times more protein than yoghurt, 15 times more potassium than bananas and 25 times more iron than spinach¹. About six spoonfuls of leaf powder can meet a woman's daily iron and calcium requirements during pregnancy.

Nutritive Properties

Every part of *M. oleifera* is a storehouse of important nutrients and antinutrients. The leaves of *M. oleifera* are rich in minerals like calcium, potassium, zinc, magnesium, iron and copper². Vitamins like beta-carotene of vitamin A, vitamin B such as folic acid, pyridoxine and nicotinic acid, vitamin C, D and E also present in *M. oleifera*⁸. Phytochemicals such as tannins, sterols, terpenoids, flavonoids, saponins, anthraquinones, alkaloids and reducing sugar present along with anticancerous agents like glucosinolates, isothiocyanates, glycoside



compounds and glycerol-1-9-octadecanoate⁹. Moringa leaves also have a low calorific value and can be used in the diet of the obese. The pods are fibrous and are valuable to treat digestive problems and thwart colon cancer^{10,62}. Research shows that immature pods contain around 46.78 per cent fibre and around 20.66 per cent protein content. Pods have 30 per cent amino acid content, the leaves have 44 per cent and flowers have 31 per cent. The immature pods and flowers showed similar amounts of palmitic, linolenic, linoleic and oleic acids¹¹.

Moringa has lot of minerals that are essential for growth and development, among which is calcium, considered as one of the important minerals for human growth. While eight ounces of milk can provide 300–400 mg, moringa leaves can provide 1,000 mg and moringa powder can provide more than 4,000 mg. Moringa powder can be used as a substitute for iron tablets, hence as a treatment for anaemia. Beef has only 2 mg of iron while moringa leaf powder has 28 mg of iron. It has been reported that moringa contains more iron than spinach¹². A good dietary intake of zinc is essential for proper growth of sperm cells and is also necessary for the synthesis of DNA and RNA. *M. oleifera* leaves show around 25.5–31.03 mg of zinc/kg, which is the daily requirement of zinc in the diet¹³.

Polyunsaturated fatty acids (PUFAs) are linoleic acid, linolenic acid and oleic acid; these PUFAs have the ability to control cholesterol. Research shows that moringa seed oil contains around 76 per cent PUFA, making it ideal for use as a substitute for olive oil¹⁴. A point to note is that the nutrient composition varies depending on the location. Fuglie¹² revealed that seasons influence the nutrient content. It was shown that vitamin A was found abundantly in the hot-wet season, while vitamin C and iron were more in the cool-dry season¹⁵. The difference in results can be attributed to the fact that the location, climate and the environmental factors significantly influence nutrient content of the tree¹⁶.

Processing of Moringa

Most plants lose their nutritive properties when processed. When compared, the nutritive content of raw, germinated and fermented moringa seed flour, it was found that phytochemicals were higher in raw seed flour and amino acid content was at its peak in fermented and germinated seed flour^{17,59}. This can be a result of the biochemical activities during germination and microbial activity during fermentation. However, a study reviewed the effect of boiling, simmering and blanching to see the retention of nutrient content of moringa leaves. Interestingly, boiling was the most effective of all the techniques as it reduced the cyanide, oxalate and phytate contents more significantly than the other two methods. The presence of phytate and other anti-nutrients can reduce the bioavailability of certain nutrients and processing can hence be done for maximum utilisation of required nutrients from the seeds and leaves^{18,63}. Yang et al.¹⁵ reported that boiling increased the availability of iron and antioxidant content. Hence, the processed moringa seed flour can be used to treat malnutrition problems.

Preservation Methods

Moringa can also be preserved for a long time without loss of nutrients. Drying or freezing can be done to store the leaves. A report by Yang et al.¹⁵ shows that a low-temperature oven used to dehydrate the leaves retained more nutrients except vitamin C than freeze-dried leaves. Hence, drying can be done using economical household appliances, such as a stove, to retain a continuous supply of nutrients in the leaves. Preservation by dehydration improves the shelf life of moringa without change in nutritional value.

An overdose of moringa may cause high accumulation of iron. High iron can cause gastrointestinal distress and haemochromatosis. Hence, a daily dose of 70g of moringa is suggested to be good and prevents overaccumulation of nutrients²¹.

Medicinal Properties

M. oleifera is often referred to as a panacea and can be used to cure more than 300 diseases. Moringa has long been used in herbal medicine by Indians and Africans. The presence of phytochemicals makes it a good medicinal agent. In this section, the effect of moringa on diseases like diabetes and cancer are reviewed.

• Antidiabetic Properties

Moringa has been shown to cure both Type 1 and Type 2 diabetes. Type 1 diabetes is where the patient suffers from non-production of insulin, which is a hormone that maintains the blood glucose level at the required normal value. Type 2 diabetes is associated with insulin resistance. Type 2 diabetes might also be due to beta cell

Nutritional Compositions and Medicinal Uses of Different Parts of Moringa

TREE PART	MEDICINAL USES	NUTRITIVE PROPERTIES	SUGGESTION
Leaves	Moringa leaves treat asthma, hyperglycemia, dyslipidemia, flu, heart burn, syphilis, malaria, pneumonia, diarrhoea, headaches, scurvy, skin diseases, bronchitis, eye and ear infections. Also reduces blood pressure and cholesterol and acts as an anticancer, antimicrobial, antioxidant, antidiabetic and anti-atherosclerotic agents, neuroprotectant.	Leaves contain fibre, fat proteins and minerals like Ca, Mg, P, K, Cu, Fe, and S. Vitamins like vitamin A (beta carotene), vitamin B (choline), vitamin B1 (thiamine), riboflavin, nicotinic acid and ascorbic acid are present. Various amino acids like Arg, His, Lys, Trp, Phe, Thr, Leu, Met, Ile, Val are present. Phytochemicals like tannins, sterols, saponins, terpenoids, phenolics, alkaloids and flavonoids like quercetin, isoquercetin, kaemfericetin, isothiocyanates and glycoside compounds are present.	The presence of flavonoids gives leaves the antidiabetic and antioxidant properties. The isothiocyanates are anticancer agents. Flavonoids like quercetin and others are known for antiproliferative, anticancer agent. The presence of minerals and vitamins help in boosting the immune system and cure a myriad of diseases. (References 1,8,12,17,31,40)
Seeds	Seeds of moringa help in treating hyperthyroidism, Crohn's disease, antiherpes-simplex virus arthritis, rheumatism, gout, cramp, epilepsy and sexually transmitted diseases, can act as antimicrobial and anti-inflammatory agents.	Contains oleic acid (Ben oil), antibiotic called pterygospermin, and fatty acids like linoleic acid, linolenic acid, behenic acid, phytochemicals like tannins, saponin, phenolics, phytate, flavonoids, terpenoids and lectins. Apart from these, fats, fibre, proteins, minerals, vitamins like A, B, C and amino acids.	The presence of flavonoids gives its anti-inflammatory property. The antibiotic pterygospermin is responsible for antimicrobial properties. The other phyto-chemicals help in treating various diseases. (References 1,2,4,38,61)
Root Bark	Root bark acts as a cardiac stimulant, anti-ulcer and anti-inflammatory agent	Alkaloids like morphine, moriginine, minerals like calcium, magnesium and sodium.	The alkaloid helps the bark to be antiulcer, a cardiac stimulant and helps to relax the muscles. (References 39,41)
Flower	Moringa flowers act as hypocholesterolemic, anti-arthritic agents can cure urinary problems and cold.	Flower contains calcium and potassium and amino acids. Also contains nectar.	The presence of nectar makes them viable for use by beekeepers. (References 12,38)
Pods	Moringa pods treat diarrhoea, liver and spleen problems, and joint pain.	Fatty acids like oleic acid, linoleic acid, palmitic acid and linolenic acid are also present. Rich in fibre, lipids, non-structural carbohydrates, protein and ash.	The presence of PUFA in the pods can be used in the diet of the obese. (Reference 12)

dysfunction, which fails to sense glucose levels, hence reduces the signalling to insulin, resulting in high blood glucose levels²². Several studies have shown that moringa can act as an antidiabetic agent. A study has shown that the aqueous extracts of *M. oleifera* can cure

streptozotocin-induced Type 1 diabetes and also insulin-resistant Type 2 diabetes in rats²³. In another study, the researchers fed the streptozotocin (STZ)-induced diabetes rats with Moringa seed powder and noticed that the fasting blood glucose dropped⁵⁰. Also, when the rats



Left: A moringa orchard in Maharashtra, India. (Photo: Crops for the Future)

were treated with about 500 mg of moringa seed powder/kg body weight, the antioxidant enzymes increased in the serum. This shows that the antioxidants present in moringa can bring down the reactive oxygen species (ROS) caused in the Beta-cells due to the STZ induction⁸. STZ causes ATP dephosphorylation reactions and helps xanthine oxidase in the formation of superoxides and reactive oxygen species (ROS) in Beta cells²⁴. In hyperglycaemic patients, the beta cells get destroyed. Therefore, high glucose enters the mitochondria and releases reactive oxygen species. Since beta cells have low number of antioxidants, this in turn causes apoptosis of the beta cells^{25,26}. This reduces insulin secretion leading to hyperglycaemia and in turn diabetes mellitus Type 2. The flavonoids like quercetin and phenolics have been attributed as antioxidants that bring about a scavenging effect on ROS. It can be hypothesised that the flavonoids in moringa scavenge the ROS released from mitochondria, thereby protecting the beta cells and in turn keeping hyperglycaemia under control^{27,50}.

• Anticancer Properties

Cancer treatments like surgery, chemotherapy and radiation are expensive and have side effects. *M. oleifera* can be used as an anticancer agent as it is natural, reliable and safe, at established concentrations. Studies have shown that moringa can be used as an anti-neoproliferative agent, thereby inhibiting the growth of cancer cells. Soluble and solvent extracts of leaves have been proven effective as anticancer agents. Furthermore, research papers suggest that the anti-proliferative effect of cancer may be due to its ability to induce reactive oxygen species in the cancer cells. Research shows that the reactive oxygen species induced in the cells leads to apoptosis. This is further proved by the up regulation of caspase-3 and caspase-9, which are part of the apoptotic pathway^{30,31,64}. Moreover, the ROS production by moringa is specific and targets only cancer cells, making it an ideal

anticancer agent. Tiloke et al.³⁰ also showed that the extracts increased the expression of glutathione-S-transferase, which inhibits the express of antioxidants.

• Other Diseases

Moringa can be used as a potent neuroprotectant. Cerebral ischaemia is caused due to obstruction of blood flow to the brain. This leads to reperfusion and lipid peroxidation, which in turn results in reactive oxygen species. Moringa with its antioxidants can reduce the reactive oxygen species, thereby protecting the brain^{36,37}. *M. oleifera* is used to treat dementia, as it has been shown to be a promoter of spatial memory. The leaf extracts have shown to decrease the acetylcholine esterase activity, thereby improving cholinergic function and memory³⁸.

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Adeyemi et al.³⁹ showed that moringa in the diet of rats can increase protein content and decrease levels of urea and creatinine in blood, preventing renal dysfunction.

Moringa decreased acidity in gastric ulcers by a percentage of 86.15 per cent and 85.13 per cent at doses of 500 mg and 350 mg respectively, and therefore can be used as an antiulcer agent⁴⁰.

Moringa is prescribed by herbal practitioners for patients with AIDS. Moringa is suggested to be included in the diet, with the view of boosting the immune system of HIV-positive individuals. However, more research is essential to validate the effect of moringa on anti-retroviral drugs⁴¹.

The hydro-alcoholic extract of moringa flowers reduced the levels of rheumatoid factor, TNF-alpha and IL-1 in arthritic rats. This proves that moringa can be a potent therapy for arthritis⁴².

Microbial diseases are widespread and there is a need for antimicrobial agents, *M. oleifera* has been proven as a good antimicrobial agent⁶⁶. A study by Viera et al.⁴³ has shown that the extracts of *M. oleifera* can act against bacteria like *Bacillus subtilis*, *Staphylococcus aureus* and *Vibrio cholera*. The antibacterial effects of the seeds were accounted for by the presence of pterygospermin, moringine and benzyl isothiocyanate⁶⁷.

Conclusion and Future Prospects

The research on *M. oleifera* is yet to gain importance in India or elsewhere. It is essential that the nutrients of this wonder tree are exploited for a variety of purposes. *M. oleifera* has great antidiabetic and anticancer properties. However, double blind studies are less prevalent to further substantiate these properties of moringa.

More studies are needed to corroborate the primary mechanisms of moringa as antidiabetic and anticancer agents. Several puzzling questions are unanswered. Research on the antioxidant nature of aqueous extracts on cancer cells needs further inquiry. Studies have proven that moringa causes ROS (reactive oxygen species) in

cancer cells that leads to apoptosis or necrosis. However, the aqueous extracts also have antioxidants present in them. The exact mechanism of this irony is yet to be explored. The effect of environmental factors on the nutrient levels of leaves and other parts of *M. oleifera* grown across the globe requires further analysis.

Further research to isolate endophytic fungi and identify the enzymes or proteins from *M. oleifera* that are accountable for the anticancer and antidiabetic activity may lead to development of novel therapeutic compounds. Yet another focal area is to evaluate the commercial use of *M. oleifera* as a bio-coagulant. It might be a viable alternative for water purification. The demand for snacks in the market is huge. Hence moringa fortification in snacks to eradicate malnutrition has a twin advantage.

The tree as a native to India can become a great source of income for the nation if this potential for highly nutritional food is exploited by the industries and researchers by undertaking further research to corroborate earlier studies.

Editor's Note:

Due to space constraints, we are unable to include the complete list of article references. These may be found at <https://tinyurl.com/y9nj2uhf>.

Traditional Medicinal Uses of Moringa

Antioxidant

Anti-inflammatory

UTI

Stimulate hair growth

Enhance skin health

Increase energy & endurance

Anti-cholesterol

Vision improvement

Normalises blood pressure

Anti-depressant

Strengthen immune system

Used as an aphrodisiac & promoter of libido

Anti-fungal

Reduces wrinkles/age lines

Anti-tumour

Increase mental clarity

Normalise blood sugar

Appetite suppressant

Improve wound healing

Detoxification

Anti-ulcer

Eliminate constipation

Improve digestion

Nutrition for infants from six months & pregnant & nursing mothers

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