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Moringa Oleifera: An Overall Review on Nutritive Importance and its Medicinal Application.

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ABSTRACT

Moringa oleifera, indigenous to India, grows well in the semiarid , tropical and subtropical regions of the world. It is most frequently known as 'drumstick tree' or 'horseradish tree' . It has an extensive range of soil conditions, but favors a neutral to slightly acidic (pH 6.3 to 7.0), well-drained, sandy or loamy soil. Moringa trees can withstand both severe water scarcity and mild frost conditions. Therefore, this medicinal plant is cultivated across the world. The nutritional and commercial purposes of Moringa are great in this modern world. Vitamins, minerals, micronutrients and other essential phytochemicals are rich in Moringa. Malnutrition and augmentation of breast milk in lactating mothers can be treated by using this miracle tree. It is used as a potential antidiabetic , anticancer, anti-inflammatory, antioxidant , anti-tumour and antimicrobial agent. M . Oleifera seed is a natural coagulant. Therefore, it is extensively used in water treatment. Scientific research provides the use of moringa as a cure for diabetes and cancer and it is used in commercial products. This review explores the use of moringa across disciplines of its cultivation and conditions , chemical constituents , phytoconstituents , nutritional potential , amino acids and micronutrients of leaves , pods and seeds of M. Oleifera , pharmaceutical activity, nutritional analysis of leaf powder, antidiabetic property, M. Oleifera : an apoptosis inducer in cancer cells, common applications, recent discussion, health benefits and daily source of this "Miracle Tree".

Keywords: Moringa, taxonomy, amino acids, anti-diabetic property, micronutrient, pharmaceutical activity, Moringa powder, apoptosis inducer

Introduction

The Moringaceae family consists of nearly 13 species which belong to a single genus called Moringa . This species is native to India , where it has been introduced to all warm regions of the world . They are fast growing and not very challenging as to climatic changes and soil quality. This species of Moringa oleifera is widely cultivated throughout the tropical regions of the world. The common edible parts of M.Oleifera are leaves, flowers, immature pods(which are called long green pods)and roots. In many reviews, this plant is portrayed as an attractive plant with medicinal , therapeutic and healing properties. This plant has been used as a fodder for milk-producing cattle and as an additional or supplementary feed for goats.[13] . Fever, indigestion or eye problems can be treated effectively. The anti- fungal activity of the extract has been investigated and possesses a productive action on the toxic effect of arsenic. Soap and cosmetics production uses the seed oil of this valuable tree and is also used as vegetable oil. Moringa seed oil has resistance to oxidative degradation and fuel properties. The protein press cake obtained after oil extraction has one of the best natural coagulants effectively utilized for treatment and purification of highly turbid water.

Many essential phytochemicals are present in the leaves, pods and seeds of Moringa, which are rich in nutritional value. The medical plant Moringa is easily cultivable, which makes it a solution to malnutrition. Children deprived of breast milk tend to show symptoms of malnutrition. Lactogogues are commonly advised to lactating mothers to augment milk production. The lactogogues, made of phytosterols , act as a precursor for harmones required for reproductive growth. Moringa is rich in phytosterols like stigmasterols, sitosterols and kampesterols, which are precursors to harmones. These compounds increase estrogen production, which in turn stimulates the proliferation of the mammary gland ducts to produce milk. About six tablespoons of leaf powder of Moringa can meet a woman's daily iron and calcium needs during their pregnancy. The overall review provides an overview of the plantations and conditions, nutritional values, medicinal properties for commercial and the pharmacological properties of Moringa.

Plantations and conditions

The growth of M. Oleifera is good in tropical and subtropical regions of the world, with a temperature ranging around 25- 35° C . It suits a sandy or loamy soil with a slightly acidic to slightly alkaline pH . It requires rainfall of about 250- 300 mm. The direct seeding method is followed to have a high germination rate. Therefore, Moringa seeds are able to germinate within 6-13 days after seeding and can be implanted at a depth of 2to3 cm in the soil. Moringa is cultivated commercially for various purposes. In commercial cultivation of Moringa, spacing is highly important as it helps in the harvest .

M .oleifera differs in nutrient composition at different locations. During summer and in some hot areas, the chemical structure and composition of proteins and enzymes get denatured and so the nutrient content differs. The major factor that defines the nutritive content of this plant is the quality of the soil. Fertilizer, when applied solely or in combination with others, results in different nutrient compositions in plant parts. Moringa plants are resistant to various pests and diseases. Termites are the major problem in the well-defined growth of Moringa. [14] . The armyworms , cutworms , stem borers , aphids and fruitflies are also attracked to Moringa.

Chemical constituents

The chemical constituents of *M. Oleifera* stems , leaves , flowers , pods and seeds have been analyzed for the presence of bioactive compounds , demonstrating the predominance of secondary metabolites, such as phenolic acid, gallic acid , ellagix acid , chlorogenic acid , ferulic acid , glucosinolates , flavonoids , quercetin , vanillin and kaempferol , which have nutritional , pharmaceutical and antimicrobial properties. The effectiveness of these extracts of this valuable tree varies depending on the different geographic location , quality of the soil and changes in climate conditions.[1] . Many phytoconstituents of *M. Oleifera* have been isolated and studied. Main phytochemicals obtained from the plant include : tannins, saponins , alkaloids , glycosides , quercetin and terpenoids from flowers ; gallic acid , catechins , epicatechin , ferulic acid , vanillin , caffeic acid , protocateuric acid , cinnamic acid , phytosterol , quercetin , glycosides and phenols from seeds ; procyanidins , quercetin glycoside , rhamnoglucoside quercetin and chlorogenic acid from roots ; procyanidin , sterols , triterpenoids , glycosides, tannis , alkaloids , β- sitosterols and octacosanoic acid from stem bark.[3]

Taxonomical classification

- Kingdom – Plantae
- Sub kingdom – Tracheobionta
- Super Division – Spermatophyta
- Division – Magnoliophyta
- Class – Magnoliopsida
- Sub class – Dilleniidae
- Order – Capparales
- Family – Moringceae
- Genus – Moringa
- Species – oleifera [8]

Plant part	**Phytochemicals**	**Group**
Seeds	B- sitosterols	Phytosterols
Leaves, stem and roots	4- α- L – rhamnopyranosyloxy-benzylglucosinolate	Glucosinolates
Leaves	4-o-glycopyranosylcaffeoyl quinic acid	Caffeoylquinic acid
Seeds	Glycerol-1-(9-octadecanote)	Glycoside
Seeds and roots	Kampferol	Flavonoid
Leaves and seeds	Niazimicin	Glycoside
Leaves	((α-L-rhamnosyloxy) benzyl)carbamate)	Glucosinolate
Seeds, leaves, stem and roots	Quercetin	Flavonoid
Roots and flowers	Pterygospermin	Glycoside

Nutritional potential

M. Oleifera contains about 85 to 95 nutritional chemical compounds , including a variety of proteins, vitamins, lipids, carbohydrates and fibers . It is used as a nutritive resource to overcome malnutrition, specifically in children and infants.

Nutrients in *M. Oleifera* (g/100g of plant)

Nutrients	**Leaves**	**Pods**	**Seeds**
Proteins	25.0 - 30.3	6.7 - 43.5	29.4 - 38.3
Lipids	0.1 - 10.6	0.1 - 5.1	30.8 - 41.2
Carbohydrates	0.1 - 43.9	0.1 - 38.2	0.1 - 21.1
Fibers	0.1 - 28.5	0.1 - 27.0	0.1 - 7.2

Analyzing the various nutrients present in this valuable plant , protein is the most abundant chemical substance, accounting for approx. 25% of the dry weight and a minimum of about 19 amino acids have been identified in this plant. M. Oleifera also contains several minerals and vitamins. The liquid (lipidic) compounds linolelic acid and palmitic acid are the main constitution of M. Oleifera leaves .

Amino acids of leaves , pods , seeds, of *M. Oleifera*

Amino acids	**Leaves**	**Pods**	**Seeds**
Essential:			
Arginine	0.4 – 1.8	0.36	4.5
Histidine	0.1 -0.7	0.11	2.3
Leucine	0.4 – 2.2	0.65	6.7
Lysine	0.3 - 1.4	0.15	1.5
Methionine	0.1 – 0.5	0.15	2.4
Phenylalanine	0.2 - 1.6	0.43	4.0
Threonine	0.1 – 1.3	0.39	3.1
Tryptophan	0.1 – 5.2	ND	1.6
Valine	0.4 - 1.4	0.54	4.3
Non-essential :			
Alanine	1.8 - 3.0	ND	6.9
Aspartate	1.4 – 2.2	ND	5.0
Cysteine	0.01 -0.10	ND	2.0
Glutamate	2.5 – 3.5	ND	20.9
Glycine	1.3 – 1.5	ND	10.9
Proline	1.2 – 1.4	ND	4.5
Serine	1.0 - 1.2	ND	4.4
Tyrosine	0.01 – 2.6	0.08	1.6

Note: ND – Not Determined

Micronutrient present in various parts of *M. Oleifera*

(mg per 100 g of the plant)

Micronutrients	**Leaves**	**Pods**	**Seeds**
Minerals:			
Calcium	440 - 3650	30.0 – 237.7	263.5
Magnesium	24 - 1050	9.6 – 83.4	78.4
Sulphur	137 - 925	137	ND
Sodium	164.0 – 272.1	210.5	ND
Potassium	259 - 20616	259 – 2097.2	ND
Phosphorous	70 - 300	110.0 – 194.3	ND
Iron	0.85 – 126.20	4.4 – 15.5	44.8
Zinc	0.16 – 3.30	ND	ND
Copper	0.6 – 1.1	2.7 – 3.5	1.3
Vitamins:			
A	6.78 – 18.90	ND	ND
B2	0.05 – 20.50	ND	ND
B3	0.8 – 8.2	ND	ND
B7	423	ND	ND
C	17.3 – 220.0	ND	ND
E	77	ND	ND

Note : ND – Not Determined

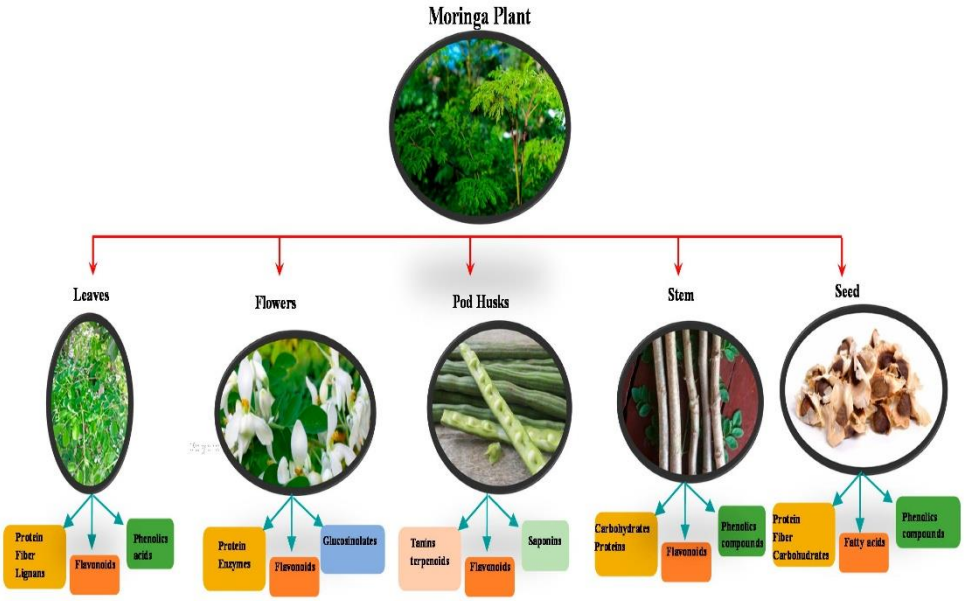
Pharmaceutical activity

Plant parts	**Pharmaceutical activity**
Leaves	Anti- inflammatory Anti-cancer Anti- microbial Anti- oxidant Antiatherosclerotic Hepatoprotective Hypocholesterolemic Hypoglycaemic Immunomodulatory Nephroprotective Neuroprotective
Roots	Anti- inflammatory Anti- microbial Hepatoprotective Nephroprotective
Flowers	Anti- microbial Hepatoprotective Nephroprotective
Pods	Anti- cancer Anti- inflammatory Anti- microbial Anti- oxidant Hypocholesteromic
Seeds	Anti- inflammatory Anti- cancer Anti- microbial Anti- oxidant Anti- tumour Immunomodulatory

Nutritional analysis of *moringa* leaf powder

For a child aged 1- 3, a 100g serving of fresh leaves would provide all his daily requirements of calcium, about 75% of his iron and half of his protein needs, as well as an important amount of potassium, vitamin B , copper and all the essential amino acids. As little as 20g of leaves would provide a child with all the vitamin A and C they need. Moringa seeds and leaves are playing a major role in improving the health of pregnant and breast-feeding women. For pregnant and breast-feeding women and passing on strength to the foetus or nourishing child.[11]

One 100g portion of leaves of this plant can supply a woman with over a third of her daily requirement of calcium and also provide iron , protein, copper , sulphur and some vitamins.



Anti- diabetic properties

Moringa is recommended for diabetic patients to cure both type 1 and type 2 diabetes. Type 1 diabetes is one where patients suffer from non- production of insulin, which is a harmone that maintains the blood glucose level at the required normal value . Type 2 diabetes is associated with resistance to insulin. Type 3 diabetes might also be due to beta cell dysfunction, which fails to sense glucose levels ,hence reducing the signalling to insulin, resulting in high blood glucose levels. Several studies have shown that Moringa can act as an anti – diabetic agent. A research study has proven that the extracts of M. Oleifera can cure streptozotocin – induced type 1 diabetes in rats . In another study, the researchers fed the STZ – induced diabetes rats with Moringa seed powder and noticed that the fasting blood dropped .

This research says that the antioxidant present in the Moringa could bring down the ROS caused in the Beta – cells due to STZ induction. STZ causes ATP dephosphorylation reactions and helps xanthine oxidase in the formation of superoxide and reactive oxygen species (ROS) in Beta cells . The beta cells get destroyed in hyperglycemic patients. Reactive oxygen species are released when glucose enters the mitochondria. Only a low number of antioxidants are present in the beta cells. This in turn causes apoptosis of the beta cells . This reduces the insulin secretion leading to hyperglycemia and, in turn, diabetes mellitus type- 2. The flavonoids like quercilin and phenolics have been attributed as antioxidants that bring about a scavenging effect on ROS . It can be hypothesized that the flavonoids in Moringa scavange the ROS released from mitochondria , thereby protecting the beta cells and in turn keeping hyperglycemia under control.

M. Oleifera: An apoptosis inducer in cancer cells

Aqueous and solvent extracts of M. Oleifera leaves have been reported to have significant antiproliferative effects on alveolar and pancreatic cancer cells and induce apoptosis in KB cells and other cancer cells. Apoptosis, which is a programmed cell death, is an energy required and highly regulated process essential for normal homeostasis, and it is regarded as the hallmark of cancer . Apoptotic cells are characterized by certain morphological properties at different stages of the apoptosis process. At early stages of apoptosis, microscopic view of the cell reveals chromatin condensation ,nuclear fragmentation, pyknosis, rounding up of cells and pseudopods retraction, while late apoptosis is marked by cell membrane blebbing , cellular shrinkage , exposure of internal phosphatidylserine to the outside surface of the cell, and formation of apoptotic bodies. Apoptosis is carried out via two major pathways; death receptor pathway (extrinsic pathway) and the mitochondrial pathway (intrinsic pathway). Extrinsic pathway starts binding of death receptors (e.g. Fas (CD95), TNFR1,DR4 and DR5) with their specific ligands (e.g. TRAIL and TNF α ligands). This binding causes trimeterization of the receptors and clustering of their cytosolic death domains , which in turn , permits the recruitment of adaptor molecules by the receptors. The complex formed by the

attachment of ligands on the cell surface and adaptor molecules in cell cytoplasm to death receptors is referred to as the death inducing signalling complex (DISC). DISC recruits and binds to inhibitor caspases upon binding. The caspases are activated by cleaving due to induced proximity .

The activated inhibitor caspases execute downstream cleavage and activation of effector caspase 3 , followed by apoptosis cell death . DNA damage, oxidative stress , high concentration of cytosolic Ca2+ and growth factor deprivation are part of internal stimuli that trigger and initiate activation of the intrinsic pathway . When activated , the permeability of the mitochondrial membrane is compromised by the release of pro – apoptotic proteins cytochrome c, SMAC , DIABLO, among others. SMAC and DIABLO proteins act by interacting and binding to IAPs(inhibitors of apoptosis)in order to prevent them from binding with effector caspases and inhibiting their apoptotic actions. The release of these proteins is controlled by members of the Bcl2 (B-cell lymphoma 2) protein family. Bcl2 family proteins include Bax , Bad , Bid, Bcl2 , Bcl- xo, Bak etc .. and are different into pro-apoptotic proteins based on their respective roles in the process of apoptosis. The release of cytochrome c is promoted by pro-apoptotic proteins from the intermembrane space of mitochondria to the cell cytoplasm, while the anti – apoptotic proteins act by preventing the release to inhibit apoptotic cell death . The release of cytochrome c from the mitochondria to the cytoplasm depends on the resultant effect of the balance of pro-apoptotic and anti – apoptotic proteins of the Bcl2 family. .

Common applications

Rheumatoid arthritis: Fluid swelling, redness, and pain can be reduced by the leaf extract of Moringa.

Diabetes: Moringa helps to lower the blood glucose level as some of the studies have proven the presence of insulin-like proteins in this plant. The leaves of Moringa contain plant chemicals that help the body to process sugar better and it affects how the body releases Insulin.

Cancer: Some of the lab tests show that the growth of pancreatic cancer cells is slowed by the leaf extracts of Moringa and helped chemotherapy to work better.

Memory: Various parts of Moringa contain tryptophan, a protein which is highly essential to maintain the serotonin levels in the body, which acts as a calming agent. It has the ability to reduce the oxidative stress that is responsible for neurological conditions.

Recent discussions

- Cholesterol
- Arthritis
- High blood pressure
- Liver damage caused by medicines
- Stomach ulcers
- Asthma
- Wound healing
- Ulcerative colitis
- Diarrhea

- Anemia
- Weight Loss

Health Benefits

- Protecting and nourishing skin and hair
- Treating edema
- Protecting the liver
- Preventing and treating cancer
- Treating stomach complaints
- Fighting against bacterial diseases
- Making bones healthier

Daily source of *Moringa*

Moringa capsules

Moringa powder

Moringa honey

Moringa food

Conclusion

M. Oleifera has great anti-diabetic, anti-cancer properties and it act as an apoptosis inducer in cancer cells. This plant can be easily grown without having any high level of maintenance. Various chemical constituents of Moringa are studied and taken into futuristic applications. Every part of this plant such as seeds, leaves, stem, roots and flowers contains different kind of phytochemicals. Leaf powder of Moringa plays a major role in the improvement of children's health. The various medicinal properties of Moringa are taken into consideration for pharmaceutical applications.

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