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Moringa: Natural gift as a miraculous tree

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Abstract
The Moringa species having much more health benefits. It consists of large amount of vitamins, amino acids and minerals. Moringa species contain various phytoconstituents such as alkaloids, saponins, tannins, steroids, phenolic acids, glucosinolates, flavonoids, and terpenes. This review mainly focuses on various species of Moringa along with its pharmacological activity. It also emphasize on the species of Moringa available throughout the world. The species of Moringa having several activities like antiviral, antitrypanosomal, antileishmanial, anticancer, antihyperlipidemic, antihyperglycemic, antimicrobial, antifertility, antispasmodic, antihypertensive and anti inflammatory activity.

Keywords: *Moringa oleifera*, Mother's Best friend, anticancer, miracle tree

Introduction
The Moringa genus has traditionally been widely wont to improve health. Kings and queens used Moringa to enhance their awareness and to uphold healthy skin. Indian warriors were fed *M. oleifera* leaves to reinforce their energy and help to relieve their pain and stress during war [1]. Other conventional uses of the species are in curing skin infections, anxiety, asthma, wounds, fever, diarrhea, and sore throats. *M. oleifera*, which is additionally known as the "Miracle Tree" and "Mother's Best Friend," has been named the massive amount nutrient rich plant. aside from having a high concentration of vitamin A, vitamin C, potassium, and calcium, the plant contains all the essential amino acids and minerals.
Currently, it's well-known that the plant has anti-inflammatory, antioxidant, anticancer, and antidiabetic activities. Recently, more research has been conducted on other species like *M. concanensis*, *M. stenopetala*, and M. peregrina. However, no reflective research on other species has been found [1]. Following figure shows various species of Moringa throughout world are as follows:

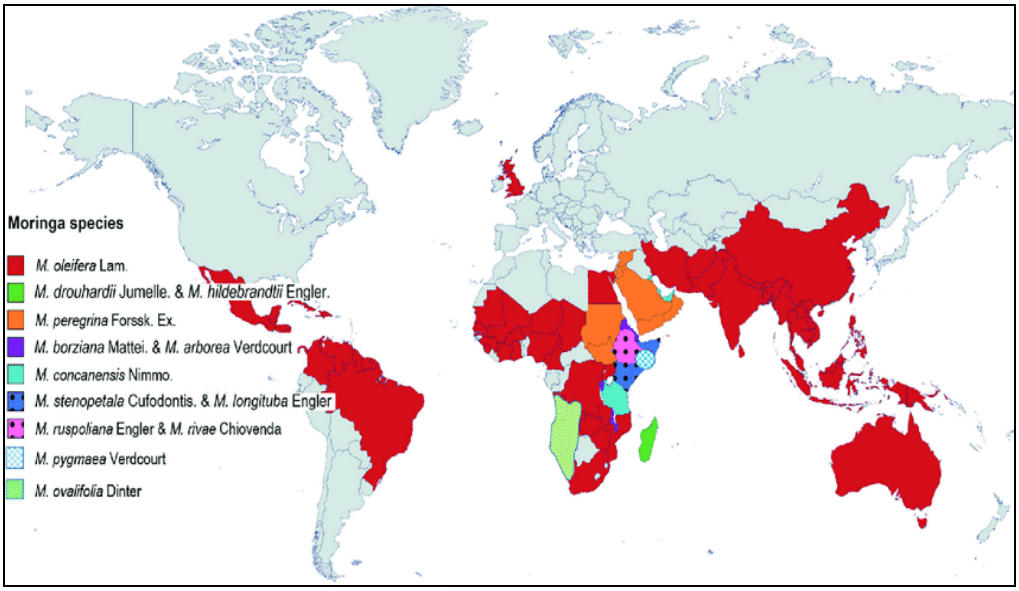

Fig 1: Various species of Moringa throughout the world: [2]

Botanical Description of the Moringa

M. oleifera can be taxonomically identified according to the most up-to-date classification of APG IV (Angiosperm Phylogeny Group), which is based on phylogenetic criteria. The taxonomic classification of *Moringa* would be as follows:

- Class *Eudicotyledoneae*
- Subclass *Magnoliidae*
- Clado *Malvidae*
- Order *Brassicales*
- Family *Moringaceae*
- Genus *Moringa*
- Species *Moringa oleifera* (3)

Phytochemistry

Moringa species contain various phytoconstituents like alkaloids, saponins, tannins, steroids, phenolic acids, glucosinolates, flavonoids, and terpenes. The range of these phytochemicals in the genus contributes to its numerous pharmacological uses. About 110 compounds were identified from the genus of Moringa. A number of these compounds showed positive results when tested for various biological activities. Additionally to these 110 compounds, the genus contains more compounds as detected by GC-MS. No matter the high phytochemical contents of the genus, the constituents of only specific species had been explored, namely *M. concanensis*, M. peregrina, *M. stenopetala*, and *M. oleifera*, and most of the studies focused on the leaves of the plants.

Table 1: Various species of Moringa including its part of plant used and traditional uses:

Sr. No.	Species	Part	Traditional uses	References
1	*M. concanensis*	Bark	Reduce pain, abortifacient	Patil *et al*., 2005 [4]
		Leaves	External tumors	Chitravadivu *et al*., 2009 [5]
		Resin	Fire burn wounds	
2	*M. drouhardii*	Bark	Cold and cough	Olson *et al*., 1999 [6]
3	*M. peregrina*	Leaves	Skin rashes, paralysis	Odee *et al*., 2002 [7]
		Bark	Disinfectant to speed up wound healing	Marwah *et al*., 2007 [20]
		Pods	Infantile paralysis or convulsions	Miller *et al*., 1988 [9]
		Leaves and roots	Malaria, hypertension, stomach disorder, expel retained placenta, asthma, diabetes	Mekonnen *et al*., 1999 [20]
4	*M. rivae*	Leaves	Weakness of thigh and calf muscles	Forest Department, 2016 [11]
		Gums	Arthritis	
5	*M. ruspoliana*	Aerial part or sometimes leaves	Eye and throat infections, tsetse fly bites, livestock diseases, abdominal pains, sexually transmitted diseases	Odee *et al*., 2002 [7]
6	*M. stenopetala*	Leaves	Flu	Teklehaymanot and Giday, 2010 [12]
			Diabetes and disorders associated	Habtemariam, 2016 [13]
			Malaria, hypertension, expel retained placenta, stomach pain, visceral leishmanial, diabetes, wound healing, common cold	
		Root	Malaria, stomach pain, diabetes	Mekonnen, 2002 [20]
			Epilepsy, help during labor	
		Bark	Cough	Teklehaymanot and Giday, 2010 [12]
7	*M. oleifera*	Leaves	Cardiac stimulants, malaria, arthritis, diseases of the skin, hypertension, typhoid fevers, swellings, parasitic diseases, diabetes, cuts, contraceptive remedy, genio-urinary ailments, boost immune system, elicit lactation	Anwar *et al*., 2007 [14]
			Antibacterial, antimalarial	Parrotta, 1993 [15]
			Diarrheal, dysentery, colitis, sores, skin infection, anemia, cuts, scrapes, rashes, sign of aging	Silver, 2017 [22]
		Gums	Fevers, dysentery, asthma, dental decay	
		Seeds	Warts	
		Oil	Gout and acute rheumatism	
		Roots	Toothache, anthelmintic, ant paralytic	Anwar *et al*., 2007 [14]
		Flowers	Tumor, inflammation, hysteria, enlargement of spleen, muscle diseases, aphrodisiac substances	Anwar *et al*., 2007 [14]

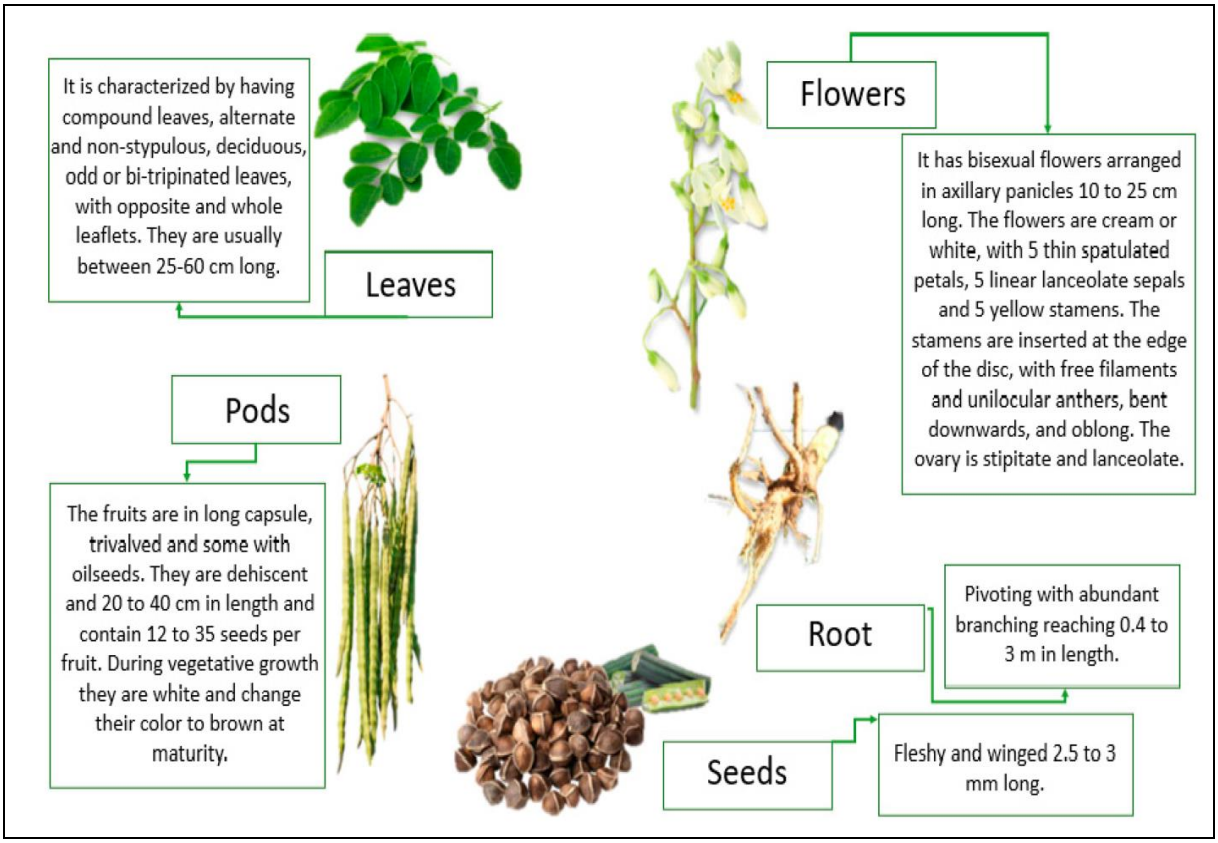

Fig 2: *M. oleifera* plant parts: [3]

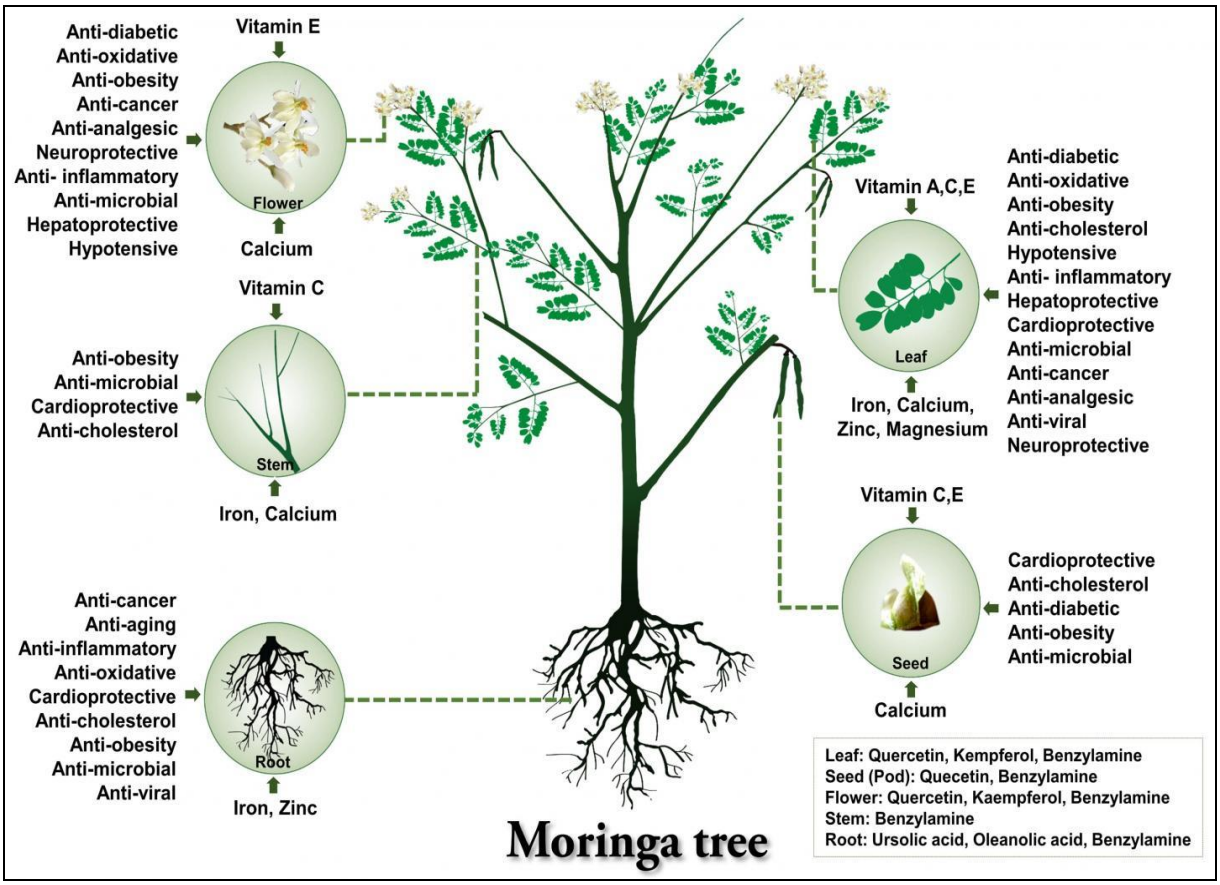

Fig 3: Different Parts (Tissues) of *Moringa oleifera*. Key Nutrients and Medicinal Values Are Marked For Each Part.

Table 2: Phytoconstituents in Moringa species

Sr. No.	Name of chemical constituents in Moringa species	Name of Phytoconstituents
1	Flavonoids And Flavanol Glycosides	Rutin, Chryseriol-7-O-rhamnoside, Quercetin, Isquercetin, Myricetin, Procyanidins, Vicenin-2, Kaempferol-3-O-glucoside
2	Glucosinolate and Isothiocyanate	4-(α-L-rhamnopyranosyloxy) benzyl glucosinolate (glucomoringin), 4-[(3′ -O-acetyl-α-L-rhamnosyloxy) benzyl] Isothiocyanate, Isobutylthiocyanate/Isothiocyanate, 4-[(β-D-glucopyranosyl-1->4-α-Lrhamnopyranosyloxy) benzyl] Isothiocyanate, Sinalbin.
3	Phenolic Acid	Gallic acid, salicylic acid, Gentisic acid, ellagic acid, ferulic acid, caffeic acid, o- coumaric acid, p-coumaric acid, cinnapic acid, chlorogenic acid
4	Terpene	E-lutein, 13-z-Lutein, 15-z-β-Carotene, β-Amyrin, α-Amyrin, E-Zeaxanthin
5	Alkaloid and Sterol	4’ -hydroxyphenylethanamide-α-L-rhamnopyranoside (marumoside A), Pyrrolemarumine-4″ -O-α-L-rhamnopyranoside, Aurantiamide acetate, Niazimicin, Campesterol, Stigmasterol, β-Sitosterol-3-O-β-D-galactopyranoside, Lupeol
6	Others	Linoleic acid, oleic acid, palmitoleic acid, myristic acid, Behenic acid, Benzylamine, 1,3-Dioleoyl-2-linolein.

Biological activities of Moringa

Anticancer activity

Moringa concanesis

Methanol crude extracts of *M. concanensis* root bark inhibited the proliferation of hepatocellular carcinoma (Hep-G2) cells

Regulating caspase 9 and caspase 3

Reducing the mitochondrial membrane potential of the cells

Moringa oleifera

A water extract of *M. oleifera* pods exhibited suppressive effects on dextran sodium sulfate- and azoxymethane-induced mouse colon carcinogenesis

|Reduced COX-2 proteins and iNOS expression in addition to reducing the PCNA index

Reduced the multiplicity and incidence of the tumors

Moringa stenopetala

Reduced Hep-G2 activity and increased LDH leakage in a dose

Anti-convulsant activity

M. concanensis

The leaf extract might block either calcium channels, sodium channels, or NMDA receptors, or has GABA agonist activity

Antimicrobial activity

Hexane and methanol seed extracts of both *M. oleifera* and *M. stenopetala* showed inhibition against waterborne pathogens, particularly against Salmonella typhii, Vibrio cholera, and Escherichia coli.

Moringa oleifera

Ethyl acetate, acetone and ethanol extracts showed inhibition of Streptococcus aureus and Streptococcus mutans with the ethanol extract and leaf extract showing the highest inhibition

M. oleifera also exhibited inhibition against the dermatophytes Trichophyton mentagrophytes, Microsporum canis, Trichophyton rubrum, and Epidermophyton floccosum

Throughout the study it was observed that the extract showed stronger inhibition against gram-positive species than gram-negative species.

M. stenopetala

Cholest-5- en-3-ol possessed the strongest antibacterial activity against E. coli.

M. peregrine

Higher inhibition toward bacteria than toward fungi

Antitrypanosomal activity

M. stenopetala

Leaf acetone extract and root ethanol extract inhibited the infective stages of Trypanosoma brucei

Antileishmanial activity

M. stenopetala

Changed Leishmania donovani promastigotes’ shape

Result in the loss to their flagella

M. oleifera

Ethyl acetate fraction of a methanolic extract inhibited leishmaniasis with an IC50

Leaf extract shows antileishmanial activity against L. donovani promastigotes.

Antiviral activity

M. oleifera

The extract inhibited phosphonoacetate-resistant HSV-1 and kinase deficient HSV-1 strains

It possessed antiviral activity against the herpes simplex virus type 1 (HSV-1).

Antihyperglycemic, Antihyperlipidemic, and Hypocholesterolemic activity

M. oleifera

Leaf hydroethanolic extract reduced the mRNA expression of PPARα1, PPAR-γ, and HMG-CoAR

(Responsible for lipid homeostasis) Aqueous leaf extract also inhibited formation of both nonfluorescent and fluorescent advanced glycation end products.

By reducing monosaccharide, in addition to reducing the oxidation of thiols and protein carbonyl content

Antifertility activity

M. stenopetala

The extract increased the smooth muscle contraction

|By inducing smooth muscle contraction it inhibit the implantation by inducing oxytocic activity

Other activity

Including all of above activity Moringa species also having anti- inflammatory activity, anti- hypertension activity and anti- spasmodic activity also [18].

Table 3: Pharmaceutical formulations of Moringa species available in Market: [19]

Tree parts	Brand/Product	Product information
Leaves	Naturinga	
	Moringa capsules	Regulates the gastrointestinal transit; natural anti-inflammatory; lowers cholesterol levels; improves diabetic condition
	Moringa tea	Delays the ageing process; ensures proper digestion; high antioxidant power; helps healing process; tonifies body and mind
	Moringa kids multivitamin complex	Strengthens the immune system; rich in vitamins and minerals; stimulates natural defenses
	Moringa powder	Adds nutritional value; source of fiber, protein, vitamins and minerals; improves physical condition
	Bio-hera	
Dried seeds extract	Moringa capsules	Strengthens the immune system; helps to reverse the aging process; beautifies the skin; reduces the appearance of wrinkles and fine lines; maintains the normal glucose level; stimulates brain function and concentration; increases libido
Leaves	Moringa syrup	It is a nutritionally complex whole food naturally rich in vitamins, minerals and amino acids. Daily use of Moringa can help to restore your imbalances in your diet
Leaves	Moringa organic tea	
Leaves	Moringa powder organic	The Moringa leaf boasts a vast array of beneficial nutrients, making this tree one of the highest plant sources of vitamins and minerals around
Leaves, dry extract	Nutrabasics—Moringa	The richness of its active ingredients helps maintain blood glucose levels. Provides Flavonoids (2.5%) and Polyphenols (5%)
Leaves	Anti-wrinkle face cream Anti-aging moisturizer face cream Hand cream	Purifying and protective action against environmental stress, such as smoke and pollution
M. pterygosperma oil	African paradise (body conditioner)	Moisturizing, nourishing
M. pterygosperma powder	Twinkle toes (foot powder)	Deodorizing
M. pterygosperma oil	Moringa range (Shower gel, oil, body butter, body milk, body sorbet, hand cream, soap, body scrub)	Skin feels smooth and restored
M. oleifera seeds and oil	Moringa soap	High antioxidant value slowing skin ageing; exfoliate dead cells by regenerating the tissue
M. oleifera leaf extract/oil	Herbal moisturizing lotion/facial toner/soap	Rejuvenate, nourish and protects skin
	herbal shampoo/conditioner	Repairs, strengthens, reduces hair fall
M. pterygosperma seed extract	Anti-Oxi + pollutant and dullness clarifying cleansing oil	Enhanced power to remove micro impurities and stubborn make-up; anti-pollution breakthrough
M. oleifera seed extract	Anti-pollution micellar cleansing water/gentle cleansing foam/cleansing oil gel/gentle exfoliating gel	Removes makeup, pollution particles and excess sebum, while leaving the skin well moisturized. The Seed of Moringa extract selected contains purifying peptides which, on the surface, limit the adhesion of the pollution particles and, in depth, activate their elimination.

Conclusion

The Moringa genus has traditionally been widely used to improve health. The leaves of Moringa contain vitamins like A, C, E and minerals like iron, calcium, zinc and magnesium. Likewise seed, roots, stem and flower of Moringa also contains minerals and vitamins. The plant has anti-inflammatory, antioxidant, anticancer, and antidiabetic activities. Recently, more research has been conducted on other species like *M. concanensis*, *M. stenopetala*, and M. peregrina.

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