"Exploring the Multifaceted benefits of *Moringa oleifera* Pods"

A comprehensive review of their phytochemistry, pharmacological and medicinal qualities

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***Abstract*—*Moringa oleifera* pods, well-known for its abundance of vitamins, minerals, flavonoids, and polyphenols. *Moringa* has been shown in traditional medicine to be effective in treating a number of illnesses, especially cardiovascular disorder, skin disorders and diabetes. Examining its pharmacological actions reveals that phenolic compounds have strong antioxidant qualities that help fight inflammation and oxidative stress. Increased levels of biochemical markers, such as glutathione peroxidase and superoxide dismutase, support the cardioprotective effects of the lyophilized hydroalcoholic extract, which suggest potential in reducing myocardial infarction-induced disruptions. Furthermore, Moringa pods have spasmolytic and hypotensive properties, suggesting a potential role in blood pressure regulation. The anti-diabetic effects are also emphasized, showing that it can control blood glucose levels and enhance glycemic control in animal models.**

***Index Terms*—Moringa pods, antioxidant activity, cardioprotective effects, polyphenols, pharmacological activity.**

I. INTRODUCTION

Traditional herbal medicine (also known as alternative medicine) as a primary source of healthcare for many people worldwide, has been playing an essential role for the treatment and prevention of diseases. For thousands of years, it has maintained the health of many people with a unique medical system that relies on empirical and accumulated information. Both primary and secondary metabolites are found in plants, in which secondary metabolites has a therapeutic potential. Plants include many different kinds of phytoconstituents, like glycosides, bitter substances, flavonoids, alkaloids, saponins, coumarins, phenols, carboxylic acids and terpenes. These phytoconstituents provide plants with specific characteristics and properties.(1) Therefore, the analysis of these components would aid in the determination of various biological activities of plants. Natural products, whether used as pure substances or as standardized plant extracts, offer limitless opportunities for the development of novel pharmaceuticals.(2) Moringa oliefera, (M. oleifera) also known as miracle tree. It has been utilized for centuries in traditional medicine and cooking across the globe. Moringa is a nutrient-dense, antioxidant-rich, and numerous bioactive phytoconstituents, including alkaloids, tannins, phenolic acids, glucosinolates, terpenes, and saponins, are found in *Moringa* species that offers a host of health advantages.(3) Originating from the Indian subcontinent, Asia, Africa, and Latin America are among the tropical and subtropical regions where the tree is widely grown.(4) *Moringa* pods, from the *Moringa* tree, belong to the Moringaceae family and are known as "drumstick tree" or "miracle tree". Other common names include "horseradish tree," "African moringa," and "radish tree," among others.(6,7)

Numerous illnesses, including cancer, diabetes, hypertension, cardiovascular disease, neurological diseases, inflammatory diseases, infectious diseases, digestive problems, respiratory diseases, and skin diseases, have been treated with *Moringa*.(8) A variety of antioxidant and anti-inflammatory compounds, including polyphenol and flavonoids, are found in Moringa pods and may help safeguard cardiovascular health. Polyphenol may aid in preventing inflammation and lipid buildup, two factors that can exacerbate heart disease. Additionally, moringa may lower cholesterol.(9,10)

II. Overview of Moringa pods:-

Moringa oleifera pods are a wholesome and adaptable food that has been utilized for decades in both traditional medicine and cooking. They have a smooth, fragile texture, are green in color, and have a long, thin, triangular shape. Nutrients including as protein, fiber, vitamins, minerals, and antioxidants like ascorbic acid, 1.Fresh moringa pods 2.Dried moringa pods phenolic acids, and flavonoids are abundant pods.[11,12]

III. TAXONOMICAL CLASSIFICATION :- [13,14]

Kingdom: Plantae (Plants)
Subkingdom: Tracheobionta (Vascular plants)
Superdivision: Spermatophyta (Seed plants)
Division: Magnoliophyta (Flowering plants)
Class: Magnoliopsida (Dicotyledons)
Subclass: Dilleniidae
Order: Capparales
Family: Moringaceae (Horse-radish tree family)
Genus: Moringa Adans
Species Moringa oleifera Lam.

IV. GEOGRAPHICAL DISTRIBUTION:

The drumstick tree is native to the foothills of the Himalayas in South Asia, extending from northern West Bengal State in India to northeastern Pakistan, it is grown and naturalised in Afghanistan, Bangladesh, Sri Lanka, Southeast Asia, West Asia, and other

regions of Pakistan, India, and Nepal. East and West Africa, the Arabian Peninsula, the West Indies, southern Florida, Central and South America, spanning from Mexico to Peru, Brazil, and Paraguay.[15]

V. COMMON AND VERNACULAR NAMES:- [16]

English: Horseradish tree,Drumstick tree
Marathi: Shevga
Hindi: Shajna
Sanskrit: Sigru
Gujarati: Saragavo
Tamil: Murungai
Urdu: Sahajna
Bengali: Sajina
Kannada: Nugge

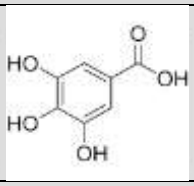
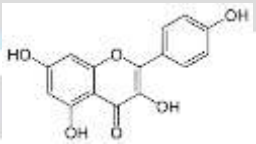
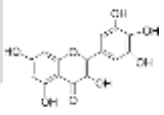
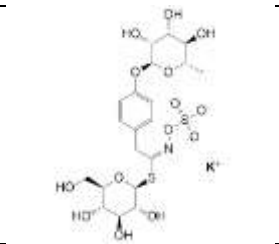
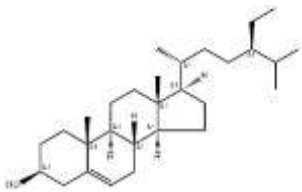
VI. PHARMACOGNOSTIC FEATURES:

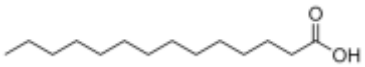
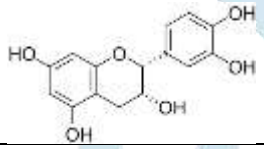
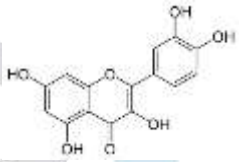
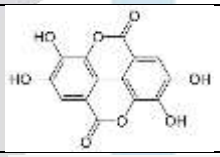
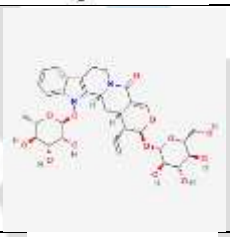
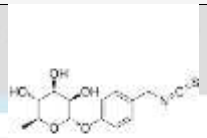
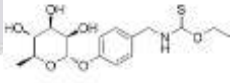
A] Macroscopy- Fruits are trilobed capsules, also known as pods. They are pendulous, brown, triangular, and, when dry, split into three lengthwise parts that are 30 to 120 cm long and 1.8 cm wide. March and April are the months when most fruits are produced. Approximately 26 seeds are present in fruit at this stage of development. Pods are green when they are immature and turn brown when they mature.[17]

B] Microscopy- Young vascular bundles had a horseshoe configuration, but as they matured, they were dispersed throughout the area. The vascular bundles were round and distributed radially. There were seeds in the parenchymatous center area. The thick integument covering the seed is made up of papillae-like outer epidermal layer cells, up to two layers of parenchymatous exotesta cells, and anisodiametric tiny inner integument cells. Below the integument are the parenchymatous cells of the cotyledons, which are packed with starch grains and oil droplets (Plate 6. C-H). [18]

VII. PHYTOCHEMISTRY:

Moringa pods, are a rich source of various phytochemicals. The pods contain a range of bioactive compounds, including alkaloids, flavonoids, phenolic acids, saponins, tannins, and glycosides. In addition, the pods are a good source of vitamin C, vitamin B1 (thiamin), vitamin B2 (riboflavin), vitamin B3 (niacin), and vitamin B6. Minerals such as calcium, copper, iron, magnesium, manganese, phosphorus, potassium, sodium, and zinc are also present in them. With all of the essential amino acids present, Moringa pods have an impressive amino acid profile. Moringa pods are a valuable source of nutrients and bioactive compounds with potential health benefits due to their phytochemical profile. Numerous phytochemicals found in Moringa pods have been linked to their therapeutic benefits, which include antimicrobial, anti-inflammatory, antioxidant, and cardiovascular protection.[19,20,21]
A closer look at the phytochemicals present in Moringa pods is provided below [22,23,24]:

Sr. No.	Compound	Class	Structure	Therapeutic activity
1.	Gallic acid	Phenol		Antioxidant, anti-inflammatory, and anti-neoplastic
2.	Kaempferol	Flavonoid		Protection against oxidative damage.
3.	Myricetin	Flavonoid		Possible prevention of diabetic complications, including diabetes mellitus
4.	Glucomoringin	Glucosinolate		ain-relieving, anti-inflammatory, antioxidant, and antihypertensive
5.	β-sitosterol	Phytosterol		Anti- inflammatory activity

6.	Arachidic acid	Fatty acid		A boost in the production of breast milk.
7.	Oleic acid	Fatty acid		Lowers blood pressure and cell damage caused by free radicals.
8.	Myristic acid	Fatty acid		Anxiolytic action, which helps in the enzyme's membrane localization
9.	Procyanidin	Flavonoid		Cardioprotection property
10.	Quercetin	Flavonoid		Exhibits remarkable anti-diabetic activity
11.	Ellagic acid	Polyphenol		prevents bacterial and viral infections and may have antioxidant properties
12.	N-α-L Rhamnopyranosy vincosamide	Alkaloid		Antioxidant activity and Cardiovascular protection
13.	Moringine	Alkaloid		Anti-inflammatory activities and antioxidant activity
14.	Niazimicin	Alkaloid		Antibacterial activity and antifungal activity.

VIII. TRADITIONAL USES:

Around 5000 years ago, the Indian Vedic literature first recorded moringa and its therapeutic properties. In the Sultanate of Oman, its pods are most frequently used to treat diabetes. In the Indian subcontinent, it is also successfully used to treat diabetes-related symptoms such hyperlipidemia and hyperglycemia. This plant's oil has long been used to cure skin conditions like scabies, freckles, and itching.[24]. The plant has long been used as a diuretic, expectorant, stimulant, and antispasmodic. In addition, the plant has antibacterial and heart circulatory tonic properties. Fried pods are used to treat diabetes; they also have antipyretic and anthelmintic properties. The traditional use of Moringa oleifera are in tabulated form. [25]

Plant parts	Traditional uses
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
Flower	Tumor, inflammation, hysteria, enlargement of spleen, muscle diseases, aphrodisiac substances
Gum	Fevers, dysentery, asthma, dental decay
Oil	Gout, acute rheumatism
Root	Toothache, anthelmintic, ant paralytic
Pod	Infantile paralysis or convulsions
Bark	Aiding digestion, stomach pain, poor vision, ulcer, hypertension, joint pain, anemia, diabetes
Gum	Fevers, dysentery, asthma, dental decay

IX. PHARMACOLOGICAL ACTIVITY:

Antioxidant Property: According to phytochemical analysis, phenolic substances may be the cause of moringa's antioxidant qualities. The hydro-ethanolic extract is screened. Important bioactive substances such as glucosinolates, isothiocyanates, thiocarbamates, and flavonoids are found in Moringa pods. These substances replenish membrane-bound antioxidants, chelate metal ions, and quench ROS. The primary component identified in plant drumsticks, β-carotene, and the vitamins A and C found in *M. oleifera* provide a rationale for their manner of contribution to the current investigation's induction of antioxidant profiles. The extract's constituents' synergistic effect and the stimulation of Phase II enzymes (GSTs) and antioxidant enzymes, which may be linked to the anticarcinogenic activity, provide the biochemical basis for M. oleifera extract's chemopreventive potency.[26]

Cardioprotective Activity: lyophilized hydroalcoholic extract of *M. oleifera* cardioprotective activity in the myocardial infarction model produced by isoproterenol (ISP). It was shown that long-term *M. oleifera* treatment reduced the hemodynamic [HR, (+) LV dP/dt, (-) LV dP/dt, and LVEDP] disturbances brought on by ISP. In contrast to the ISP control group, chronic *M. oleifera* treatment produced a notable positive modulation of the biochemical enzymes superoxide dismutase, catalase, glutathione peroxidase, lactate dehydrogenase, and creatine kinase-MB, but it did not show any discernible impact on decreased glutathione. Myocardial tissue's increased lipid peroxidation was considerably inhibited by *Moringa* therapy.[27]

Spasmolytic and Hypotensive Activities: The hypotensive properties of the ethanolic and aqueous extracts of *M. oleifera* whole pods and their components—coat, pulp, and seed—were also examined by Faizi et al. at a dosage of 30 mg/kg, the ethanolic extracts of the seeds and pods had comparable levels of activity. At the same dosage, the most potent part of the pods' ethanolic extract was discovered to be the ethyl acetate phase.Thiocarbamate and isothiocyanate glycosides, which were likewise the pods' hypotensive principles as seen in the case of Moringa leaves, were isolated using its bioassay-directed fractionation.[27,28]

Hypolipidaemic and Antiatherosclerotic Activities: *Albino Wistar* rats were given a hyperlipidemic diet for 30 days along with simvastatin (4 mg/kg, p.o.) and methanolic extract of M. oleifera (150, 300, and 600 mg/kg, p.o.) to detect the hypolipidemic impact. Simvastatin and *M. oleifera* were observed to raise HDL levels while decreasing serum cholesterol, triacylglycerides, VLDL, LDL, and the atherogenic index when compared to the matching high-fed cholesterol diet group (control). Additionally, it was discovered that *M. oleifera* increased fecal cholesterol excretion. Therefore, it can be said that *M. oleifera* has a hypolipidemic effect.[29]

Antibacterial and Antifungal Efficacy: The distillate of *M. oleifera* showed a significant decrease in test bacterial growth, indicating an antibacterial activity. *E. coli* showed the highest level of inhibition among the studied microorganisms, followed by *S. aureus, K. pneumoniae, P. aeruginosa, and B. subtilis.* The inhibition of fungus was also demonstrated by the smaller colony diameter in distillate-poisoned plates relative to control plates. A. niger showed the highest level of inhibition, followed by *A. oryzae, A. terreus, and A. nidulans*. The essential oil percentage of the plant material contained in the distillate fraction may be the cause of the steam distillate of *M. oleifera's* antibacterial and antifungal properties.[30]

Anti- cancer activity: Mice's hindpaw inflammation caused by carrageenan was reduced by the crude ethanol extract of dried seeds. In addition to the butanol and water fractions, the hexane fractions of the dried seeds' crude ethanol extract also reduced inflammation. Conversely, the ethyl acetate fraction was hazardous and increased inflammation. Following oral delivery of the fraction, the mice passed away. Additionally, the crude ethanol extract prevented TPA from forming Epstein-Barr virus early antigen (EBV-EA), indicating that it has antitumor-promoting properties.[31,32]

Gastroprotective activity/ Anti-ulcer activity: The model of stomach ulcers caused by ibuprofen; bisphenols and flavonoids present in *Moringa l*eaves shown a decreased incidence of ulcer index, duodenal ulcer, and stress ulcer.[17] Moringa extract has been demonstrated to neutralize the acidic environment and drastically lower free radicals. behavior of gastric juice and have a preventive effect on the formation of gastric ulcer. The presence of flavonoids in the plant has been demonstrated to have a preventive impact on ulcer formation by strengthening capillary resistance and boosting microcirculation, resulting in less cell harm.[33,34]

Anti-Diabetic Activity: Wistar and GotoKakizaki rats' glucose tolerance and blood glucose levels were both significantly improved by moringa leaves. By regulating hemoglobin, protein, sugar, and blood glucose levels, the aqueous extract demonstrated an antidiabetic activity in rats.[19] Within three hours of consumption, the plant's leaves were found to reduce blood glucose levels,

although not more than the common medication glibenclamide. After being given *Moringa* seeds,include insulin-like proteins with antigenic epitopes similar to insulin that have antihyperglycemic properties when taken orally.[35,36]

X. CONCLUSION:

The review of *Moringa oleifera* pods demonstrates both their significant nutritional value and therapeutic potential. Along with bioactive phytochemicals like flavonoids, phenolic acids, and other secondary metabolites, the pods are distinguished by their rich composition of vital vitamins and minerals. These substances have strong antioxidant qualities that are essential for reducing inflammation and oxidative stress, which helps to produce cardioprotective effects. Studies support *Moringa oleifera* pods' anti-diabetic qualities by showing that they can control blood glucose levels and glycemic control in a variety of models. These pods' historical medicinal significance has been established by the fact that they have been used in many cultures to treat a variety of illnesses, such as metabolic disorders and dermatological conditions.The review of *Moringa oleifera* pods demonstrates both their significant nutritional value and therapeutic potential. Along with bioactive phytochemicals like flavonoids, phenolic acids, and other secondary metabolites, the pods are distinguished by their rich composition of vital vitamins and minerals. These substances have strong antioxidant qualities that are essential for reducing inflammation and oxidative stress, which helps to produce cardioprotective effects. Studies support Moringa oleifera pods' anti-diabetic qualities by showing that they can control blood glucose levels and glycemic control in a variety of models. These pods' historical medicinal significance has been established by the fact that they have been used in many cultures to treat a variety of illnesses, such as cardiovascular diseases, metabolic disorders and dermatological conditions.

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