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Moringa Oleifera Multipurpose Traditional Medicinal Plant: A Systematic Review

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Abstract

The genus Moringa encompasses 13 distinct species, commonly referred to as the miracle tree due to its diverse phytotherapeutic and nutraceutical properties. Additionally, it serves as a valuable resource for vegetarians, providing a low-cost nutritional supplement, and is widely distributed across Asia and Africa for various applications.Moringa oleifera represents one of the 13 species within the Moringa genus, commonly known as Moringa, drumstick tree, benzoil tree, ben oil tree, or horseradish tree.specifically present in India and widely cultivated in subtropicaland tropic regions.M. olieferais a 5-10mheight tree with both nutritional as well as medicinal potential. It is a potential source of proteins, fats, vitamins, minerals, and various phytochemicals. It was reported that M. oleiferacontained calcium,iron,potassium, magnesium, phosphorus, vitamins A and D, essential amino acids, and antioxidants like β-carotene, vitamin C, and flavonoids, different polyphenols, and phenolic acids,glucosinolates, a well as alkaloids.M. oleifera hasversatile pharmacological and nutritional benefits, including antimicrobial, cardio-protective, hepatoprotective,analgesic, antiulcer, anti-urolithiatic, antihypertensive,antiviral,radioprotective,antihelmintic, immunomodulation potential, etc. Its extract is used to treat disorders like malnutrition, inflammation, cancer, oxidative stress, and diabetes. Its various parts, such as bark, seed, fruit, leaves, roots, and flowers, contain phytochemicals that are used to treat diseases.This systematic review compiles current evidence on the distribution, phytochemical composition, pharmacological activities, and safety profile ofof M. oleifera.

INTRODUCTION

*Moringa oleifera*belongs to the family *Moringaceae*, and *Moringa has*13 species(1), andits components have been used in India since 5000 years due to its various pharmaceutical and nutritional benefits(2-4). *M. oleifera* grows in hot and dry land and could survive in tough climate situations, and drought does not affect this plant (5). It can bear rain of 250mm-3000mm and a pH of 5-9(6). It has a soft trunk and gummy

bark with small leaf legs in leaves. It has white flowers. Its taste was pungent and bitter, and it was thought ofas an energetic diet and heating compound. The immature seed pod of *M. oleifera is*used like asparagus in India. It is commonly known as drumstick, marango, sohanjna, kelor, moonga, sajna, and mulangy(3, 7). In Pakistan, itis known as sohanjna(2, 8).

It is believed that the origin of *Moringa* trees occurs in northern India, with evidence suggesting their presence in the region for approximately 5,000 years. These trees have been utilized in traditional Indian medicine for centuries. Furthermore, they have also been employed by the Egyptians, Greeks, and Romans. Multiple names were awarded to this tree in ancient times, such as 'The Wonder Tree,''The Miracle Tree,' and 'The Divine Tree.' To increase the yield of corn, the nutrient-rich formula is made from its leaves,whichare used in South America. By the blessing of God, *M. oleifera* almost 5% to 35% in those regions where malnutrition is at its peak. (9, 10).It is well reported that all parts ofthe *Moringa* tree-like seeds, leaves, roots, flowers, and green pods, have multipurpose applications, including pharmacological, nutraceutical, functional food preparations, purification of water, and production of biodiesel (11). Culinary applications throughout the world are obtained fromflowers, foliage, and immature pods (12).

It was found that a significantly large amount of phenolics and glucosinolates(13), minerals (14), tocopherols (15), carotenoids (16), polyunsaturated fatty acids (17), ascorbic acid (11), and folate (18) are present in the foliage of *M. oleifera* (MO). Monounsaturated fatty acids like oleic acid (C18:1) are present in high amountsinthe seeds of this plant, which made industrial plants for biodiesel production (19). Several proteins, including chitin-binding protein isoforms (Mo-CBP3), low molecular weight

cationic proteins (MOCP), mabinlins, napins, and lectins, have been isolated from *Moringa oleifera* seeds. These proteins possess significant coagulant and antimicrobial properties, enabling their application in water purification and water hardness removal industries.(19). .

Further, the benefits of MO on health have also been well reported, and found that MO can be used to treat more than 300 different diseases. The moringa containsabout seven times higher concentration of Vitamin C is present in oranges, and 17 times higher concentration of calcium than in milk. The drumstick tree (*Moringa oleifera*) is rich in nutrients, with vitamin A content being ten times higher than that found in carrots. Additionally, its protein content is nine times higher than in yogurt, and it contains 25 times more iron than spinach. Furthermore, the potassium content in the drumstick tree is ten times higher than that present in bananas. *M. oleifera* leaves were used to treat pains and stress during the war by enhancing the energy of consumers (20). It further had applications in the healing of skin infections, wounds, asthma, anxiety, fever, gastrointestinal disorders, hepatic diseases, modulate immune system, to treat a viral infection, sore throats, to enhance milk production in lactating females, antimicrobial and antiviral potentials, etc.(21). This systematic review specifically focuses on the botanical properties, phytochemical constituents, their importance as medicinal as well as nutraceuticals characteristics and safety concerns from M. oleifera.

*M. OLEIFERA*BOTANICAL, DISTRIBUTION, AND PRODUCTION CHARACTERISTICS

NUTRITIONAL AND FORTIFYING VALUEOF *M. OLEIFERA*

*Moringa oleifera*exhibits a broad spectrum of health benefits. Unlike many commercially available organic products, which often contain impurities, M. oleifera is naturally free of contaminants and is rich in essential vitamins and minerals, including vitamin D, vitamin

E, B-complex vitamins such as nicotinic acid, folic acid, and pyridoxine, as well as vitamin A in the form of β-carotene.(22). Minerals include copper, zinc, potassium, iron, calcium, and magnesium(23). In the case of obese persons, moringa leaves can be used as a diet because they contain fewer calories as compared to other diets. In the case of colon cancer and digestive problems, Moringa pods can be used because they contain fibers which can treat them(24)

Other phytoconstituents are flavonoids, terpenoids, alkaloids, saponins, anthraquinones, tannins, and sterols. *Moringa oleifera*also contains reducing sugar along with anti-cancerous agents such as glycosidecompounds, glucosinolates, isothiocyanates, and glycerol-1-9-octadecanoate(25). According to research, and are two types of pods first, immature pods and second, mature pods, immature pods contain 20.66% protein and 46.78% fiber, and mature pods contain 30 % amino acids. Amino acids are also present in flowers and leaves; flowers contain 31%, and leaves contain 44% amino acids. Fatty acids are also present in flowers and immature pods such as oleic acid, linolenic acid, linoleic acid, and palmitic acid, etc. (26) Due to the presence of a large amount of minerals, Moringa is essential for growth such as 8 ounces of milk provide 300-400mg calcium, and moringa leaves provide 1000mg.Moringa powder provides more than 4000mg of calcium. Moringa leaves powder can be used to treat anemia because the powder contains 28mg of iron, as compared to beef, which has 2mg of iron, and Moringa also contains more iron than spinach(27). Zinc is involved in the enhancement of sperm cell growth and synthesis of RNA and DNA, and Moringa leaves have 25.5-31.03 mg zinc/kg (it is the daily diet requirement) (28).

Moringa seed oil has 76% PUFA (linoleic acid, oleic acid, and linolenic acid), which can control the cholesterol level, and this level is higher compared to olive oil(29).Mainly in infants and nursing mothers, moringa tree leaves are used for nutrition. Moringa leaves can be eaten after cooking or fresh and can be stored in dried form in the refrigerator for several months without a nutritional loss. In tropical regions,Moringa is the best source of diet in the dry season, mainly at the time when other food sources are in a lesser amount.

The drumstick tree (*Moringa oleifera*) is nutritionally abundant, with calcium content being four times higher than in milk(30). It also contains potassium three times more than bananas and iron in greater quantities than spinach.Furthermore, it provides four times the vitamin A found in milk and twice the protein content compared to milk. The tree's nutritional profile includes calcium (Ca), magnesium (Mg), manganese (Mn), zinc (Zn), potassium (K), phosphorus (P), copper (Cu), sodium (Na), and iron (Fe)(31). The composition of the tree varies with its geographical location. (32). Additionally, it contains seven times more vitamin C than oranges, ten times more vitamin A than carrots, and 17 times more calcium than milk, nine times more protein than yogurt, 15 times more potassium than bananas, and 25 times more iron than spinach. (21).It is used in the treatment of children in Senegal and Benin(23).If children have less breastfeeding, it may lead to malnutrition, and Moringacan act as a lactogogue, which results in increasing breast milk production and ejaculation. It has a phytosterol that is a precursor of growth. It contains the campesterol,sitosterol, and stigmasterol that enhance the level of estrogen, and it also increases the production of milk. It treats malnutrition in children younger than the age of 3 years (33).

Food fortification is a process aimed at enhancing the nutritional value of food by adding essential nutrients, such as minerals, vitamins, and essential macronutrients. This practice primarily focuses on improving micronutrient levels in the food supply. When implementing food fortification, it is crucial to ensure that the added nutrients are safe, easily accessible, and readily available. Additionally, the fortification process should be designed to maintain the homogeneity of the food without inducing sensory changes that may adversely affect its taste, appearance, or texture.(34).*M. oleifera,*as a fortificant is becoming popular in various parts of the world, including Africa, and leaves of MO, as fresh and dried both inAfrican countries like Nigeria,Malawi, Ghana, East Africa, and Ethiopia, are added tomeals(35). Further, several food preparations like soups (36),herbal biscuits (37),cake (38), bread (39),amala, stiff doughmade from yam and plantain flour (40, 41), yoghurt(42)and weaning foods (43), fortified with different parts of *M. Oleifera* as fortificant are gaining much attention to enhance the nutritional value

PHYTOCHEMICAL PERSPECTIVE OF *MORINGA* SPP

The leaves of this plant are a rich source of iron, calcium, magnesium, zinc, and sodium. Pterygospermin is an active constituent of this plant that shows antifungal and antibacterial properties. *Moringa oleifera* contains various bioactive compounds, including anthronine and spirochin, which are derived from the root of the plant. Niazimicin is another important constituent of this tree, exhibiting potential anti-cancerous activities (71).

MEDICINAL PROPERTIES AND USES

This plant shows different activities like antiulcer, anti-epileptic, antixiolytic, antifungal, and anti-obesity activities. The seed extract of this plant has coagulant properties (44). It

is used in the Unani and Ayurvedic medicine (45). It's all parts, such as seeds, bark, roots, leaves, flowers, gum, and fruit used in medicines (46).

This plant possesses a range of therapeutic properties, with its dried leaves being particularly effective in treating various ailments. These include the treatment of diarrhea, bronchitis, and ear infections.. The leaves of this plant are a rich source of iron. The juice of this plant, which is obtained from the extract of flowers, also has thepotential to improve the quality of milk. If we use seeds of this plant with coconut oil, then it can treat jointproblems, STIs, and cramps. The oil extracted from the drumstick tree (*Moringa oleifera*) has been found to be highly effective in treating scurvy, hysteria, and prostate-related issues.This plant is the richest source of minerals, vitamins. It improves our cognitive ability and boosts the immune system. It also to treat liver problems like cirrhosis and protect from damage and toxicity. By increasing protein level in the liver and by avoiding oxidative stress, it prevents liver damage.The seed, leaf, and root of this plant tend to improve healing properties by decreasing clotting time.

ANTIMICROBIAL ACTIVITY

*Moringa oleifera*is used to treat bacterial infections. It inhibits the activity of *S.aureus, B.subtilis, E.coli,* and *P.aeruginosa*. It is also effective against *Mycobacterium phlei*and *Bacillus subtilis* It maintains the level of *Basidiobolushaptosporus* and *B.ranarums*fungus(47-48).It has antifungal potential(49).It has an antimicrobial activity due to the presence of cations that influenceinhibition on *F.solani,R.solani*, fungus, bacteria, *P.multocida, E.coli, B.subtilis, S.aureus, P.multicoda*and *B.subtilis*(50). It also inhibits the effect of *Aspergillusniger, A.terreus,* and *A.nidulans*(51).It has activity against *E.coli, P.aeruginosa, Salmonella typhi, K.pneumonia, C.albicans*, *Enterobacter,*and *Streptococcus*species (52).These activities are due to the presence of *Moringa*

pterygosperma -pterygospermin(53) and *Pheritimaposthuma*(54).Anthonine inhibits the *V. cholerae* (47).It has anthelmintic potential (55).

ANTI-INFLAMMATORY ACTIVITY

The extract of the root has anti-inflammatory activity in rat paw edema, which is induced by carrageenan (56) . Its methanol extract also inhibits carrageenan in rats.Its n-butanol extract has anti-inflammatory potential against ovalbumin-induced inflammation in guinea pigs (57).It shows activity in chronic disease by improving inflammation(58). The anti-inflammatory activity of *Moringaoleifera* has been associated with the presence of several glycosides. It was proven that four of the important glycosides are associated with anti-inflammatory activities and include 4-[(2' -O-acetyla-L-rhamnosyloxy)benzyl]isothiocyanate (compound 1), 4-[(3' -O-acetyl-a-L-rhamnosyloxy)benzyl]isothiocyanate (compound 2), 4-[(4' -O-acetyl-a-L-rhamnosyloxy)-benzyl]isothiocyanate (compound 4) and 4-[(a-L-rhamnosyloxy)benzyl]isothiocyanate (compound 5). These glycosides were separated from the fruit of *Moringaoleifera,* and an ethyl acetate extract was made, which inhibits nitric oxide at an IC50 value of 0.136 lg/mL. Compound 1 was determined to exhibit an anti-inflammatory effect by inhibiting the release of nitric oxide induced by lipopolysaccharide, with an IC50 value of 1.67 µM. Compound 5 showed the same effect at an IC50 value of 14.43 µM(59). Similarly, in another study, the anti-inflammatory property of the plant was observed through the observation of inhibition of nitric oxide production in RAW 264.7 macrophage cells. Three samples were prepared using moringa plants collected from different parts of Zambia and at various times. They showed different anti-inflammatory potential with the extract of the plant PKM-1 variety collected from Lusaka, Zambia, in July showed maximum anti-inflammatory potential by strongly inhibiting nitric oxide(60). An extract

of *Moringa oleifera*flowers at concentrations of 100-500 mg/ml showed significant inhibition of protein denaturation and the effect was comparable to Diclofenac sodium, which is a commonly used NSAID(61).

ANTI-ASTHMATIC ACTIVITY

The drumstick tree (Moringa oleifera) contains an alkaloid that exhibits bronchodilatory properties, which can be beneficial in treating bronchial asthma(8),when the seed kernel is utilized. Plant extracts derived from this tree have been shown to alleviate severe symptoms associated with asthma, such as dyspnoea, chest tightness, wheezing, and cough.(62).

ANALGESIC ACTIVITY

The ethanolic extract of the fruit is analgesic (63). The extract of seeds and leaves is also analgesic, and the analgesic effect of this extract can be detected by the tail Immersion method (64).

ANTIPYRETIC ACTIVITY

Moringa also has an antipyretic activity, which is due to ethanol, ether, and ethyl acetate extract of seeds. Its ethanol and ethyl acetate extractstreat the fever in rats (65).Ethanolic extract of *Moringa oleifera*leaves at doses of 100 mg/kg, 200 mg/kg, and 400 mg/kg has been found to produce significant antipyretic effects which were comparable to that of paracetamol. It was found that a dose of 100 mg/kg administration produced antipyretic effects within 2 hours while doses of 200 and 400 mg/kg produced their effects within 30 minutes, and the effect for all three doses lasted for up to12 hours, which was similar to that of paracetamol(66).

ANTIHYPERTENSIVE, DIURETIC, AND CHOLESTEROL-LOWERING ACTIVITY

The drumstick tree *(Moringa oleifera)* is employed in the treatment of hypertension due to its blood pressure-lowering properties. The leaves of this tree contain nitrile, glycoside, and thiocarbamate glycoside compounds, which contribute to the reduction of blood pressure. Additionally, various parts of the tree, including flowers, roots, gum, leaves, and seeds, exhibit diuretic activity, aiding in the management of high blood pressure(5).Its cholesterol-lowering activity is due to beta-sitosterol, and it lowers the lipid or cholesterol in the serum of rats fed a fat diet(67).

ANTIDIABETIC ACTIVITY

Moringaoleifera lowers the blood glucose level in type 2 diabetes in Wistar rats and Goto-Kakizaki rats (68).Its leaf extract lowers the blood glucose in three hours after consumption (69).It has antidiabetic activity due to dark chocolate polyphenols (70)and more many polyphenols(71, 72).It also has rutin, kaempferol, glycosides, quercetin-3-glycoside and polyphenols (68).*Moringa oleifera* has been extensively studied for its potential to produce antidiabetic effects in patients suffering from diabetes. Research has demonstrated that this plant can be effective in treating both type 1 and type 2 diabetes mellitus. Type 1 diabetes is characterized by the pancreas' inability to produce insulin, leading to elevated blood glucose levels. In contrast, type 2 diabetes is an insulin-resistant condition where the body produces insulin but fails to utilize it effectively to combat high glucose levels, often due to impaired glucose sensing by pancreatic beta cells. The leaves of the *Moringa oleifera* tree have been used to lower blood sugar levels, and aqueous extracts of the plant leaves have been employed to reduce glucose levels in diabetic rats. A recent study conducted on diabetic male albino Wistar rats investigated the antidiabetic potential of *Moringa oleifera*.. The study

determined that aqueous extract of *Moringa oleifera*at a dose of 200 mg/kg of body weight besidesdecreasing the glucose levels in diabetic rats of both type 1 and type 2 diabetes butalso increase the insulin production but also prevents diabetes in normal and non-diabetic rats. It was observed that the plant's extract at adose of 200 mg/kg of body weight lowered the fasting plasma glucose level considerably. Another study performed recently also supports the antidiabetic potential of *Moringa oleifera*plant. In a recent study, the seeds of the drumstick tree (*Moringa oleifera*) were utilized instead of the leaves to investigate their potential antidiabetic effects. The seeds were administered to diabetic male albino Wistar rats in powdered form at low doses of 50 mg/kg and 100 mg/kg of body weight. The study demonstrated that the seed powder not only effectively lowered the fasting plasma glucose levels but also reduced glycosylated hemoglobin (HbA1c), an indicator of long-term blood glucose control. Furthermore, the research revealed the potential of the plant's seed powder to reverse diabetic nephropathy by reducing the levels of creatinine, uric acid, albumin, and glucosuria in diabetic patients.

HEPATOPROTECTIVE ACTIVITY

*Moringa oleifera*leaves ethanolic extract has a hepatoprotective effect, which is induced by isoniazid, pyrazinamide, and rifampicin in rats. Its leaves have activity on aspartate and alanine aminotransferases, alkaline phosphatase,serum bilirubin, and peroxidation in the liver(73).In albino rats, it protects against CCl4.Its activity is also due to quercetin(74, 75).It protects against CCl4 if serum globulin and aminotransferase levels rise (76). Experiments support that *Moringa oleifera*is effective in lowering the inflammatory cytokines IL-6, chemokine MCP-1, and TNF-α, in diabetic rats treated with methanolic extract of the plant leaves at a dose of 250 mg/kg for 42 days, as well as

seeds powder of *Moringaoleifera* at low doses of 50 to 100 mg/kg of body weight. A separate study was conducted on diabetic rats to assess the impact of *Moringa* species on hepatic and renal markers. In diabetic rats, the levels of bilirubin, ALT, GGT, AST, and ALP were found to increase. However, when these rats were treated with an extract of *Moringa stenopetala* leaves, the levels of these markers were significantly reduced. Additionally, the plant extract restored protein levels to normal levels in diabetic rats. The studies demonstrated that both *Moringa oleifera* and *Moringa stenopetala* possess hepatoprotective properties and can protect against diabetes-induced hepatic dysfunction and nephropathy in diabetic rats..

EFFECTS ON FERTILITY

xtracts from the bark and root of the drumstick tree (*Moringa oleifera*) have been found to exhibit post-coital antifertility effects in rats, as well as causing fetal resorption during late pregnancy(77).These extracts have been investigated for their estrogenic, pro-gestational, antiestrogenic, and antiprogestational activities, with the results indicating that they possess antifertility properties(78). It causes abortion at a dose of 175mg/kg(79).

Aqueous extracts of the plant seeds have been studied for their traditional use as an aphrodisiac. The aqueous extract of plant seeds was administered at different doses of 100, 200, and 500 mg/kg for a total of 21 days in a study performed by (80) on albino male rats. It was determined that the plant increases libido and sperm count in male albino rats and may be used for the treatment of male sexual disorders. The dose of 500 mg/kg was found to be most effective among all doses. The study concluded that the change in sexual behavior of the male albino rats may be associated with the presence of saponins, flavonoids, and alkaloids in the plant(80). Another study used ethanolic

extract of *Moringaoleifera* leaves at doses of 100, 200, and 400 mg/kg for thirty days in male Wistar rats with the results that the extract effectively increased testosterone, luteinizing hormone (LH), and follicle-stimulating hormone (FSH) as well asincreasedcharacteristic of semen(81). Another histopathologicalstudy, however, determines that the ethanolic extract of the moringa leaves producesan antifertility effect in male albino rats when administered at a dose of 200 mg/kg for 28 days. Histopathological slides showed that the epididymis epithelium is greatly disturbed with the presence of more than the usual number of spermatozoa in the lumen. Histopathological evaluation indicated that these spermatozoa might be abnormal, and their viability and normal function may be compromised(82). It suggests that spermatozoa may be produced in large numbers but may be inactive or functionally not compatible,whichmay lead to male infertility. Whereas, the aqueous extract of the *Moringa oleifera*leaves has also been observed to prevent electromagnetic radiation-induced testicular injury and infertility in male Wistar rats at a dose of 200 mg/kg for eight weeks daily(83).

ANTISPASMODIC ACTIVITY

The roots and leaves of the drumstick tree (*Moringa oleifera*) are employed in the treatment of muscle spasms. These parts contain 4-0-methyl thiocarbamate, a compound that modulates calcium channels and inhibits the influx of calcium ions, thereby blocking muscle contractions. Additionally, niazinin A and B, as well as niazimicin, are present in the tree and are known to lower blood pressure and alleviate bradycardic conditions. An infusion of the seeds of *Moringa oleifera* has been shown to exhibit an antispasmodic effect on AHC-induced intestinal spasms, with the effect being nearly 50%. This effect is dose-dependent and increases with higher doses. Similarly,

guinea pigs and albino mice were used as experimental models to assess the effects of *Moringa stenopetala* leaves on the smooth muscles of the guinea pig ilium and mouse duodenum. The ethanolic extract of the plant leaves was found to decrease mean smooth muscle contractions, with the effect being dependent on the dose and contact time..

ANTIULCER ACTIVITY

It treats the motility disorder of the GIT (84).It treats the gastric lesions in rats induced by indomethacin, serotonin, and acetylsalicylic acid. It treats lesionsinducedby acetic acid in chronic conditions(85).It is an antiulcer in Holtzman albino rats(86).

CARDIAC STIMULANT

Moringa bark and root are cardiac stimulantsby acting on the sympathetic nervous system due to alkaloid moringinine(4).It protects from hyperlipidaemia. It is due to deficient iron treatment forhyperlipidemia in Wistarrats(68).In a study comparing the effects of atenolol and *Moringa oleifera* extract on serum glucose, cholesterol, and triglycerides in rats, it was found that the plant extract also exhibits cardioprotective properties. The study demonstrated that the extract lowers serum cholesterol levels, reduces weight gain, and decreases the weight of the heart, indicating its potential benefits in managing cardiovascular health (87).A study comparing the antiatherosclerotic effects of *Moringa oleifera* extract and simvastatin in rats found that the plant extract exhibits comparable or superior protective effects against atherosclerosis compared to the drug(88).Additionally, the extract has been shown to protect the heart in Wistar rats induced to experience myocardial infarction (MI) using isoproterenol. The plant extract modulates various enzymes, including catalases, dismutases, glutathione peroxidase, lactate dehydrogenase, and keratin kinase-MB,

which contribute to its cardioprotective properties. Furthermore, the extract has been demonstrated to protect against heart damage caused by ischemia-reperfusion injury (ISI) in MI. (89).

INTRAOCULAR DISORDERS

Blindness is due to a deficiency of vitamin A. Its fruit, leaves, and powder contain vitaminsthat treat blindness in children. It treats the cataract (90).It is used as a food supplement due to its source of nutrition (91).

ANTI-HYPERTENSION PROPERTIES

The drumstick tree (*Moringa oleifera*) contains important bioactive compounds, such as niaziminin and isothiocyanate, which have been shown to reduce arterial thickening and improve blood pressure. The leaves of this tree also contain alkaloids that have been linked to lowering blood pressure in experimental models. An alcoholic extract of *Moringa oleifera* leaves has been demonstrated to exhibit antihypertensive properties in mongrel cats and dogs.11. A study was conducted to investigate the effects of the aqueous extract of *Moringa oleifera* leaves on the frog heart. Alkaloids were isolated from the leaves extract and used as active constituents. The alkaloidal salts were found to inhibit the effects of calcium in the frog heart, suggesting the presence of a calcium channel blocker or calcium antagonist in the alkaloids. This hypothesis was further confirmed by conducting an experiment on guinea-pig taenia coli, a preferred model for studying calcium antagonists. The results confirmed that the total alkaloidal salts of *Moringa oleifera* leaves possess calcium channel blocking activity. Calcium channel blockers have been used widely for the treatment of hypertension and arrhythmic heart conditions 12. This confirms that *Moringaoleifera* contains blood pressure-lowering tendencies.

ANTI-HYPERLIPIDEMIC PROPERTIES

*Moringa oleifera*has shown strong anti-hyperlipidemic activity in diabetic rats as determined in several studies at a dose of 200 mg/kg of body weight of the plant's leaves aqueous extract (3, 6). A recent study specifically investigated the anti-hyperlipidemic effects of *Moringa oleifera*. The methanolic extract of *Moringa oleifera* leaves was administered to diabetic adult male rats at a dose of 250 mg/kg of body weight for 42 days. The results demonstrated that the extract improved the overall lipid profile parameters in the rats and normalized the hepatic enzyme markers, including AST, ALT, and ALP. The treated group showed a reduction in LDL and cholesterol levels, while HDL levels were increased compared to both the diabetic non-treated group and the normal control (8). Another study was carried out on alloxan-induced diabetic male Wistar albino rats. A total of 24 rats were divided into three groups, each consisting of eight rats, and were labeled as normal control, diabetic control, and diabetic treated with aqueous extract of *Moringa oleifera* at a dose of 400 mg/kg. The results showed a significant decrease in the total cholesterol, LDL, and triglyceride levels in the blood of diabetic rats treated with the plant's extract (9). Other studies also support similar results, as shown in a study whereaqueous ethanol and n-butanol extracts of *Moringastenopetala* leaves were used in diabetic rats at a dose of 500 mg/kg body weight. In a study examining the lipid profile of rats, it was observed that the levels of total cholesterol and triglycerides were significantly lower in the group treated with *Moringa stenopetala* extract compared to the diabetic control group. Additionally, after 14 days of treatment with the same extract, the HDL level was found to increase significantly at the same dose (10).

ANTIOXIDANT ACTIVITY

*Moringa oleifera*has antioxidant activity(88).Its leaf, seeds, and fruit are extracted and are antioxidant in nature(92).Methanol and ethanol extractsof leaves are antioxidants by 65.1% and 66.8%(29, 93).It has antioxidant properties due to the presence of kaempferol and quercetin (93, 94).It has activity in hepatocyte growth factors, which induce protein phosphorylation with IC50 value for 12 and 6 uM/L.Its seeds are protective against radicals(95).

Methanolic extract of *Moringa oleifera*is found to be a good antioxidant against DPPH radical. Methanolic extract of *M. oleifera* is soluble in chloroform, petroleum ether, and ethyl acetate along with ascorbic acid,whichare found to be antioxidants against nitric oxide radical with an IC50 of 65.12, 93.32, 54.83, and 12.59 microg/mL, respectively(96). Similarly, another study justifies that the ethanolic extract of *Moringaoleifera* leaf tissue shows strong radical scavenging activity due to the presence of flavonoids in the leaves. Three types of flavonoids were found to be present in the ethanolic extract of the plant leaves and stems. It was found that the ethanolic extract showed stronger antioxidant potential as compared to the saline extract of similar plant parts and reacted slowly with the DPPH radical(97). A study investigated the antioxidant potential of *Moringa oleifera* by comparing the acetone extract with the aqueous extract of the plant. The acetone extract was found to contain higher levels of total flavonoids, followed by flavonols, phenolics, and proanthocyanidins, compared to the aqueous extract. Furthermore, the acetone extract demonstrated a strong radical scavenging potential against ABTS, DPPH, and nitric oxide radicals(98).

MORINGA POTENTIALS IN TREATING TUMOR CELLS

*Moringa oleifera*has thiocarbamate that is helpful in the treatment of tumors (99).Niazimicin inhibits the teleocidin B-4, which inducesEBV activation(100).It has a toxicity effect on the cell line of myeloma(101, 102).It has antitumor activity by effects on carcinogen metabolizing enzymes and is antioxidant(103).A549 lung cancer cell line has been used for a study in which the apoptotic effect of *Moringa oleifera*was checked and confirmed. It was established during the result that quantities above 300 µg/mL of the *Moringa oleifera*leaf extract soluble in coldwater (4°C) showed antiproliferative properties on A549 lung cancer cell line(104). The antioxidant properties of *Moringa oleifera* play a crucial role in cancer prevention, as the free radical scavenging activity of the plant helps prevent free radical-induced mutations. Free radicals can cause DNA damage and mutations in genes, leading to uncontrolled and abnormal cancerous growths(105) The endogenous antioxidant system of the body can be effectively controlled by administering antioxidants from the outside.(106). *Moringa oleifera*extracts are found to contain polyphenol that is recognized as powerful antioxidants. Apart from this, leaves of the plant also contain flavonoids thatexhibit strong antioxidant activities. Methanolic extract of the plant has shown that the important polyphenols present in the plant include quercetin, gallic acid, and kaempferol. Moreover, methanolic extracts are found to contain a higher polyphenolic content as compared to dichlorophenolic extract (107).

CYTOTOXICITY OF *MORINGA OLEIFERA*

Cytotoxicity refers to the toxic effects of substances on cells, which can result in different cellular fates. This may include necrosis or apoptosis. In necrosis, cells lose their membrane integrity, release their contents into the surrounding area, and cease

metabolic activity, leading to rapid cell death without initiating apoptotic machinery. In contrast, apoptosis is a programmed, well-defined cell death process that occurs through the activation of the genetic program of cell death, and cells display apoptotic markers. The drumstick tree (*Moringa oleifera*) is a medium-sized plant commonly found in northeastern India, tropical regions, and various parts of the world. It is considered one of the most effective medicinal plants, and its oil has numerous therapeutic applications.. The seed extract of *M. oleifera* also shows antimicrobial activity (Ali., 2004). The cytotoxic activity of *Moringaoleifera* is against cancerous cells. The seeds of this plant contain wsmol, cmol and lectins(72). The seeds of the plant are highly effective in treating infections caused by protozoa and bacteria, as well as possessing antitumor and anti-inflammatory activities. The seeds contain a lectin that exhibits cytotoxic effects on murine melanoma cells.

A study was conducted using the leaves and callus of *Moringa oleifera* to assess the cytotoxic activity of the plant. Ethanolic extract of callus of *Moringaoleifera* reduced the viability of HeLacells by 50 percent at a dose of 2000µg/ml, while the leaf extract of the plant reduced HeLaviability at all doses above 260 µg/ml renderingthe leaf extract more potent in showing cytotoxicity(108). The cytotoxic potential of *Moringa oleifera* can be effectively utilized in reducing cancerous cell growths, supporting the plant's traditional use for such purposes. However, human trials are required to confirm the clinical administration of the plant as an anticancer agent. Human pulmonary mucoepidermoid carcinoma, HEp-2 (human larynx epidermoid carcinoma), and HT-29 (human colon adenocarcinoma) cell lines have been used in a study to determine the cytotoxic activity of seeds of *Moringaoleifera*. The seeds of the plant contain WSMol (water-soluble *Moringaoleifera*lectin) and cmol (coagulant *Moringa oleifera lectin*),

which are associated with various useful properties of the plant such as antibacterial(109), insecticidal (110, 111), and coagulant properties for reducing water turbidity (109, 111), etc. These lectins also contain cytotoxic properties at different concentrations. It was determined that the aqueous seed extract of the plant was cytotoxic at a 50 percent inhibition concentration of 34.3 ± 2.31 µg/mL while cMol was cytotoxic at IC50 of 11.72µg/mL. However, WSMol did not affect the viability of the cells at different concentrations. Similarly, diluted seed extract at an IC50 of 144 µg/mL did not show any cytotoxic effect either. The study had concluded that aqueous seed extract of *Moringaoleifera* was not safe for reducing the turbidity of water, as it may show cytotoxic effects when administered in the human body(112).

Moreover, isothiocyanatesare present in seeds of the plant and are found to be toxic to normal human cells(113). The drumstick tree *(Moringa oleifera)* possesses numerous beneficial properties, and research data supports its traditional uses,including its cytotoxic effect, which designates the plant as a potent anticancer agent. However, further research is required to determine safe doses of the plant that can be administered clinically using various parts, such as leaves, flowers, fruits, and seeds.

CLINICAL CONSEQUENCES OF *M. OLEIFERA* ON THE HUMAN BODY

CONSEQUENCES OF *MORINGA OLEIFERA*ON BLOOD PRESSURE

NiazininA, andniazinin B also exhibit the blood pressure-lowering effects on rats because they act as an antagonist for calcium channels(84). The study revealed that *Moringa oleifera* (MO) only decreases blood pressure within two hours, with no further reduction observed in the subsequent four hours. This indicates that the MO dose has a short-term effect on blood pressure. As a result, the study found that MO decreases systolic and diastolic blood pressure within the normal range..

CONSEQUENCES OF *MORINGA OLEIFERA*ON PULSE RATE

Study-based results show that MO slows down the pulse rate. Because alkaloid contents (114) of MO which obstruct the heart contractions that are persuaded by potassium(84)

CONSEQUENCES OF *MORINGA OLEIFERA*ON BODYTEMPERATURE

An experiment was conducted in adult rabbits to induce high body temperature through *E. coli* infection. The body temperature was measured using the rectal method every four to five hours, and it was observed that the temperature decreased significantly within the first four hours.. The same experiment was performed on rats (64). They also showed a decline in body temperature withinthe first 4 hours after taking of MO seeds. This antipyretic activity of Moringa is attributed to its constituents such as moringinine, glycosides, and alkaloids found in the leaf. These phytochemicals lowers the body temperature by obstructing the production of inflammatory mediators like prostaglandins which mainly elevates the temperature setpoint during pyrexia(65). Moreover, it is indicated that lowering body temperature occurs due to the vasodilation of peripheral blood vessels.

FUTURE PERSPECTIVE AND CONCLUSION

The drumstick tree *(Moringa oleifera),* also known as the Miracle Tree, is renowned for its multipurpose, nutritious, and medicinal plant applications. It is one of the 13 species of Moringa, commonly referred to as the drumstick tree, benzoil tree, ben oil tree, or horseradish tree, and is particularly prevalent in India, with widespread cultivation in subtropical and tropical regions. Moringa oleifera is a 5-10m tall tree that serves as a potential source of proteins, fats, vitamins, minerals, and various phytochemicals. Although a wealth of research data is available, more specific studies are needed to

identify and isolate the phytocompounds responsible for its pharmacological applications at a deeper level.

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TABLE 1: Phytochemical constituents and their therapeutic and nutritional activities in different parts of *M. oleifera* (18, 115-117)

Parts	Phytochemicals	Activities
Leaves	Niazirin, Niazirinin, Niazimicin,niaziminin, Niaziminin A, NiaziminB,nitrile glycosides,4-[(4'-O-acetylalpha-L-rhamnosyloxy) benzyl isothiocyanate, and three mustard oil glycosides, α thiocarbamate,4-(alpha-1-rhamnopyranosyloxy)-benzylglucosinolate,quercetin-3-O-glucoside and quercetin-3-O-(6''- Malonyl-glucoside),. Pyrrolealkaloid(pyrrolemarumine400-O-a-L-rhamnopyranoside) and 40-hydroxyphenylethanamide (marumoside A andB) 4.alpha and gamma-tocopherol.2, Minerals like Ca, Mg, P, K, Cu, Fe,and S., fats, proteins	Skin infection, scrapes, rashes, cuts, Antibacterial,Dysentery,Diarrhea l, colitis, sores, anemia,sign of aging, parasitic diseases, antimalarial, arthritis, typhoid fevers, hypertension, Cardiac stimulants, diabetes, Anti-inflammatory agents, immune-stimulants, contraceptive remedy, reproductive and UTI treatment, elicitlactation Nutritional potential
Stem	Vanillin, beta-sitosterone and beta-sitosterol, 4-hydroxyl mellein,octacosanoicacid	Dysentery,Dental decay, Fevers, asthma, Nutritional potential
Seeds	Niazirin, niazimicin, cysteine,Methionine,4-	Anti-inflammatory activity,

	(alpha-L-rhamnopyranosyloxy) benzylglucosinolate,benzylglucosinolate, Moringin	Warts treatment, antioxidant, Anti-asthma, Nutritional potential
Oil	Linoleic acid, Linolenic acid,Oleic acid, Palmitoleic acid, Stearic acid,Myristic acid, Palmitic acid, Arachidic acid, Paullinic acid, α-Phellandrene,Behenic acid, p-Cymene,	acute rheumatism,Gout, anti-inflammatory, antioxidant, nutritional, Nutritional potential
Flowers	Quercetin,isoquercetin,ascorbic acid, D-glucose, D-mannose, kaempferol, and protein	Anti-cancer, anti-inflammation, hysteria, plenomegaly, muscular disorders, aphrodisiac substances, infertility, Nutritional potential
Roots	Deoxy-niazimicine,Aurantiamide acetate, Procyanidins, S-ethylthioformate,N-benzyl, 1, 3-Dibenzyl urea,1,3-dibenzyl urea, alpha-phellandrene,moringinine,Moringine,Arachidic acid, spirachin, p-cymene,4-(alpha-L-rhamnopyranosyloxy)benzylglucosinolate, minerals like Ca, Ma, Na	Anti-inflammatory, anti-paralytic, Toothache,anthelmintic, Nutritional potential
Barks	N-benzyl, 4-(alpha-L- rhamnopyranosyloxy) benzylgiucosinolate, Procyanidins,S-ethylthioformate, 15-z-Carotene,minerals like Ca, Ma, Na	Improve digestion, stomach pain, ulcer,hypertension, diabetes, anti-rheumatism, anemia,poorvision,Nutritional potential

Pods	Niaziridin,Nitrites, All-E-Zeaxanthin, All-E-luteoxanthin,All-E-lutein, 13-z-Lutein, 15-z-Carotene, thiocarbamates,O-(1heptenyloxy) propyl undecanoate, Isothiocyanate,O-ethyl-4-(alpha-L-rhamnosyloxy) benzyl carbamate, methyl- p-hydroxybenzoate, β-sitosterol, Vanillin, Rich in non-structural carbohydrates, lipids,fibers	Anti-inflammatory, hypertensive treatment, Anti-oxidant, antimicrobial, poor vision,Nutritional potential