

Moringa Oleifera: A Review Of Pharmacological And Phytochemical Potentials

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ABSTRACT

Moringa oleifera L. (family: Moringaceae) is a highly effective therapeutic herb with tremendous nutritional value. It is an edible herb and cheaply grows in tropical areas of India, Pakistan and Bangladesh. It considers as a super food because consists phenolic acids, zeatin, β -carotene, flavonoids, quercetin, phenolic compounds and isothiocyanates. *M. oleifera* is also a source of micro and macro nutrients like phosphorus, potassium, iron, calcium, carbohydrate, protein that helps in proper functioning of body. Various parts of moringa such as root, bark, seed buds, stem, leaves are having different biological actions described as anti-inflammatory, neuroprotective, anti-hyperlipidaemic, cytotoxic, anti-diabetic, antimicrobial effects helpful in various disorders treatment. According to largest studies *Moringa oleifera* employed as potential ingredient of food. This review emphasized on therapeutic, medicinal as well as edible properties of *Moringa oleifera* by gaining novel opinion for future researches and developments.

Key words: Drumstick, β -carotene, isothiocyanates, neuroprotective

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INTRODUCTION

The ancient Indian medical system known as Ayurveda strongly emphasis on preventive and curative properties of medicinal plants describing them both as therapeutic agents and essential dietary supplements for longevity and good health. Among these, *Moringa oleifera* Lam. (shigru) holds a prominent position (1). Low- and middle-income nations have recently shown great interest in the usage of medicinal plants. Among these, *Moringa oleifera* has become a plant with maximum potential for both industry and health. (2) *Moringa oleifera* (MO) Lam. relates to the family *Moringaceae*, is a tree having height between 5 to 10 meters found Indian subcontinents. It grows with various nutrient rich edible leaves, flowers and seeds, that can be used as food, cosmetic oil, livestock feed or medication (3). *Moringa oleifera* is rich in nutrients and has a low-fat level, with polyunsaturated fatty acids. This implies a link to coronary heart disease prevention. The plant has antibacterial qualities due to presence of isothiocyanates (4). In developing countries MO is also used as a source of edible oil, fruits, medicinal plants. All over the world functional food market is fastest growing segment.

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Moringa oleifera act as functional food itself. Commonly it is referred as versatile food due to use in all sections [3,4]. *Moringa oleifera* is a drought-resistant and fast-growing native tree of the Indian subcontinent, originates from Agra in India. It has three lobed pods (5). It is an ancient inhabitant of Pakistan, Bangladesh, India, and Afghanistan and having popular names of the field such as horseradish tree, marengo, benzolive, drumstick tree, kroll, and malunggay. Recently it has drawn socio-economic and scientific focus Eastern and Southern Asia, Asia (6). It is cultivated for the various uses of its green leaves and seed pods for medicine as well as vegetables. It consists high protein content so considered as a good supplement. It is famous because of its beneficial features explained as; 17 times more calcium than milk, 10 times more vitamins than carrots, 5 times more potassium than bananas and 7 times extra vitamin C than oranges (7). It has various qualities like to potentiate antioxidant level of blood (8) and decrease the sugar level in blood (9), replenished inflammation (10). In summers when other vegetables are scarce drumstick leaves also accessible. It boosts the milk production in lactating mothers that's why called as

mother's friend in several regions of world (11). Moringa professed as Miracle tree due to its antiulcer, hepatoprotective, cholesterol lowering capacity, diuretic and anti-diabetic activity. It has also been used in skin and hair care products. India provides maximum international trade of plant *M. oleifera* in form of oil, fresh fruits, canned product, leaf powder and seeds (12). In Bangladesh *M. oleifera* is non-commercial crop but at minimal level its leaves, pods and flowers consumption are popular (13). This review has purpose to guide daily usage of Moringa because it can provide sufficient energy and antioxidants to the body to boost immunity and evade effects of viral diseases. Study focuses on the value of *M. oleifera* to the nutraceutical and food industries and how it may help people live healthier lives. It emphasizes on the current state and potential future of *M. oleifera* as a supplement to human meals.

METHODS

Databases like EBSCO, SciHub, PubMed, Google Scholar, Science direct used to collect original scientific articles for gathering and compilation of information regarding *M. oleifera*. Articles published between 2010 to 2025 on *M. oleifera*'s pharmacological potential are included. An inclusion and exclusion process was carried out among the articles mentioned in abovesaid databases.

GEOGRAPHICAL DISTRIBUTION

From ancient time Moringa species are very popular due to its traditional use. Amongst 14 species of genus Moringa, most widely utilized and known species is *M. oleifera* (14). Sri Lanka, Florida, South America, Peru, Brazil, Bangladesh, Africa, West Indies are rich heritage of these species (15). Geographical distribution described in table 1.

Table 1: Geographical distribution for different species of Moringa

Sr. no.	Name of species	Geographical distribution
1.	<i>Moringa ovalifolia</i>	Southwest Angola, Namibia
2.	<i>Moringa peregrina</i>	Arabia, Northeast-Africa, Red Sea
3.	<i>Moringa drouhardii</i>	Southern Madagascar
4.	<i>Moringa hildebrandtii</i>	Southern Madagascar
5.	<i>Moringa stenopetala</i>	Somalia, Southwest Ethiopia, Kenya
6.	<i>Moringa borziana</i>	Somalia, Kenya
7.	<i>Moringa longituba</i>	Southeast Ethiopia, Kenya, Somalia
8.	<i>Moringa oleifera</i>	India
9.	<i>Moringa arborea</i>	Kenya, Somalia
10.	<i>Moringa concanensis</i>	India
11.	<i>Moringa pygmaea</i>	North Somalia
12.	<i>Moringa rivaie</i>	Ethiopia, Kenya
13.	<i>Moringa ruspoliana</i>	Somalia, Kenya, Ethiopia

M.oleifera chosen for this study on availability basis. Since 1970s various research has been done on *M. oleifera* (16). *M. oleifera* leaves are superior than *M. drouhardii* and *M. hildebrandtii* leaves because of high amino acid and protein content (17). Recently, the medicinal and nutritional importance of this species is known to all.

MORINGA AS MIRACLE TREE

The Moringa tree grows from branch cuttings or seeds quickly. The leaves of this tree fastest grow in poor soil in short period. Edible part of tree are fruits, leaves, immature pods and flowers and became a part of traditional diets (18,19). Moringa has variety of essential phytochemicals present in its pods, seeds and leaves. In fact, Moringa provide 25 times iron than spinach (6). In pharmaceuticals and cosmetics oil obtained from Moringa acts as energy source. Moringa seeds are good source of minerals and vitamins. Various studies explained seed extracts shows diverse activities like

antibacterial, water purifying agent, as blood pressure-reducing agent, anti-inflammatory. Due to its nutritional value Moringa serves as a superfood for people suffering from poverty and malnutrition.

BIO ACTIVES OR NUTRITIONAL CONSTITUENTS

M. Oleifera is a good source of various nutrients. Various studies have revealed that every part of *Moringa oleifera* has useful metabolites like water soluble vitamin C, β -carotene and various minerals such as potassium, iron, magnesium and phosphorus were contained by the leaves of *M. oleifera* [20]. Leaves possess antioxidants (carotenoids, phenol, flavonoids) as well as protein [21,22]. It also contains amino acids like cysteine, methionine, lysine, tryptophan, isoleucine and valine [23]. *M. leaves* provided its terrific effects in drinks, medicinal coated capsules and tea [24]. Flowers give nectar for production of honey.

Table 2: Approximate nutritive content in three categories of M. leaves [25,26]

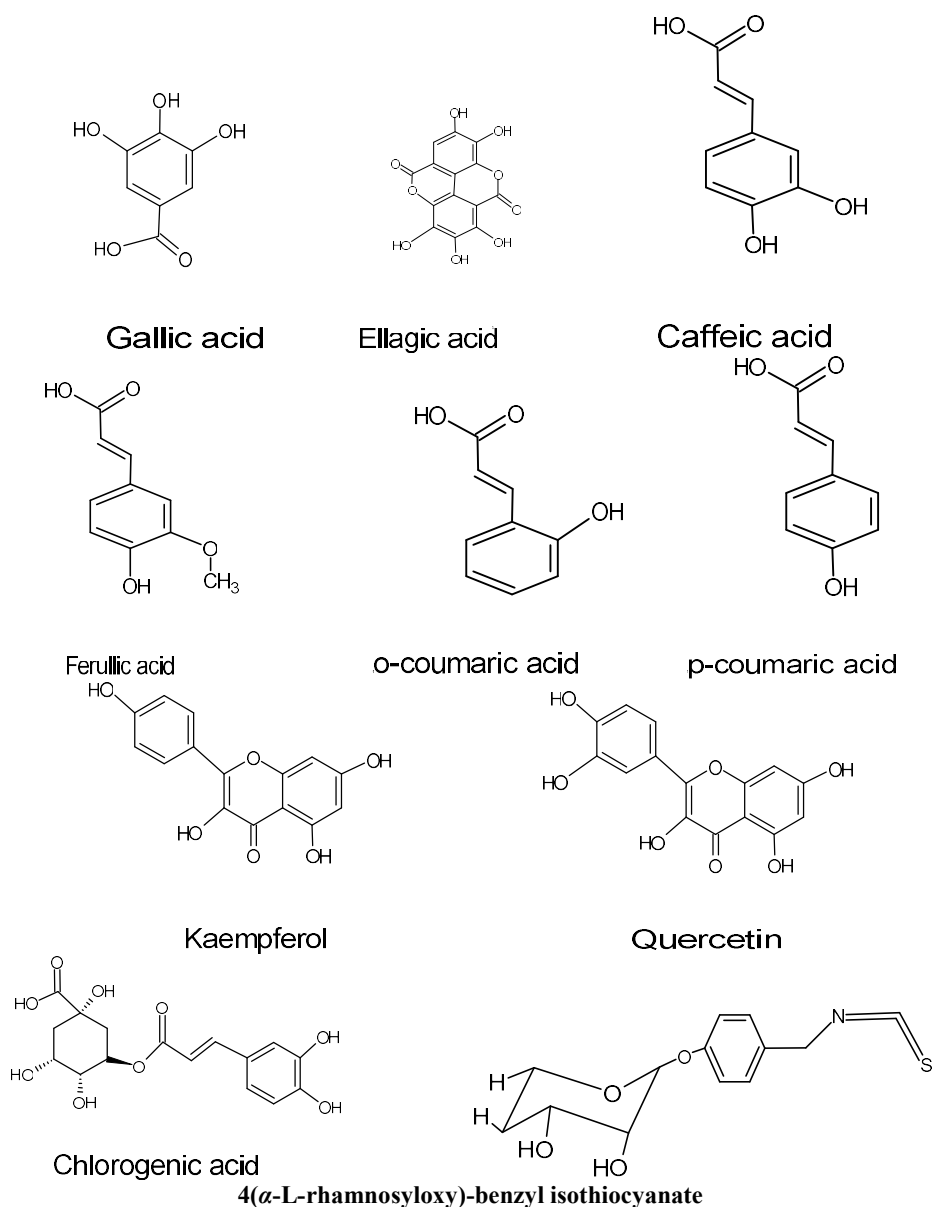
Sr. no	Components	g/100 g of plant material Leaves
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	Fresh	Dry	Leaf powder (Dry)
1. Fat(g)	1.7	5.2	2.3
2. Carbohydrates(g)	12.5	41.2	38.2
3. Protein(g)	6.7	29.4	27.1
4. Fiber(g)	0.9	12.5	19.2

Moringa leaf powder composed of high content of amino acids compared to other consumable leaf powders like mulberry leaves (*Morus alba*) (27,28). It also contains vitamin B (nicotinic acid, folic acid, and pyridoxine,) (29).

Pods are good source of fatty acids and carbohydrates like d-galactose, D-galacturonic acid, l-arabinose, l-rhamnose, 6-O-Me-D-galactose and thiocarbamates (30). Seeds composed of vitamin A, vitamin

E(tocopherol) and also produce seed oil known as ‘ben oil’ consists of fatty acid composition (17). The most studied plant parts are seeds and important constituents of these are 4(α -L-rhamnosyloxy)-benzyl isothiocyanate, β -sitosterol, niaziridin, 3-O-(6'-oleoyl- β -D-glucopyranoyl)- β -sitosterol, β -sitosterol-3-O- β -D-glucopyranoside, niazirin, glycerol-1-(9-octadecenoate) and niazimicin (13). Chemical structures of various constituents shown in figure 1.



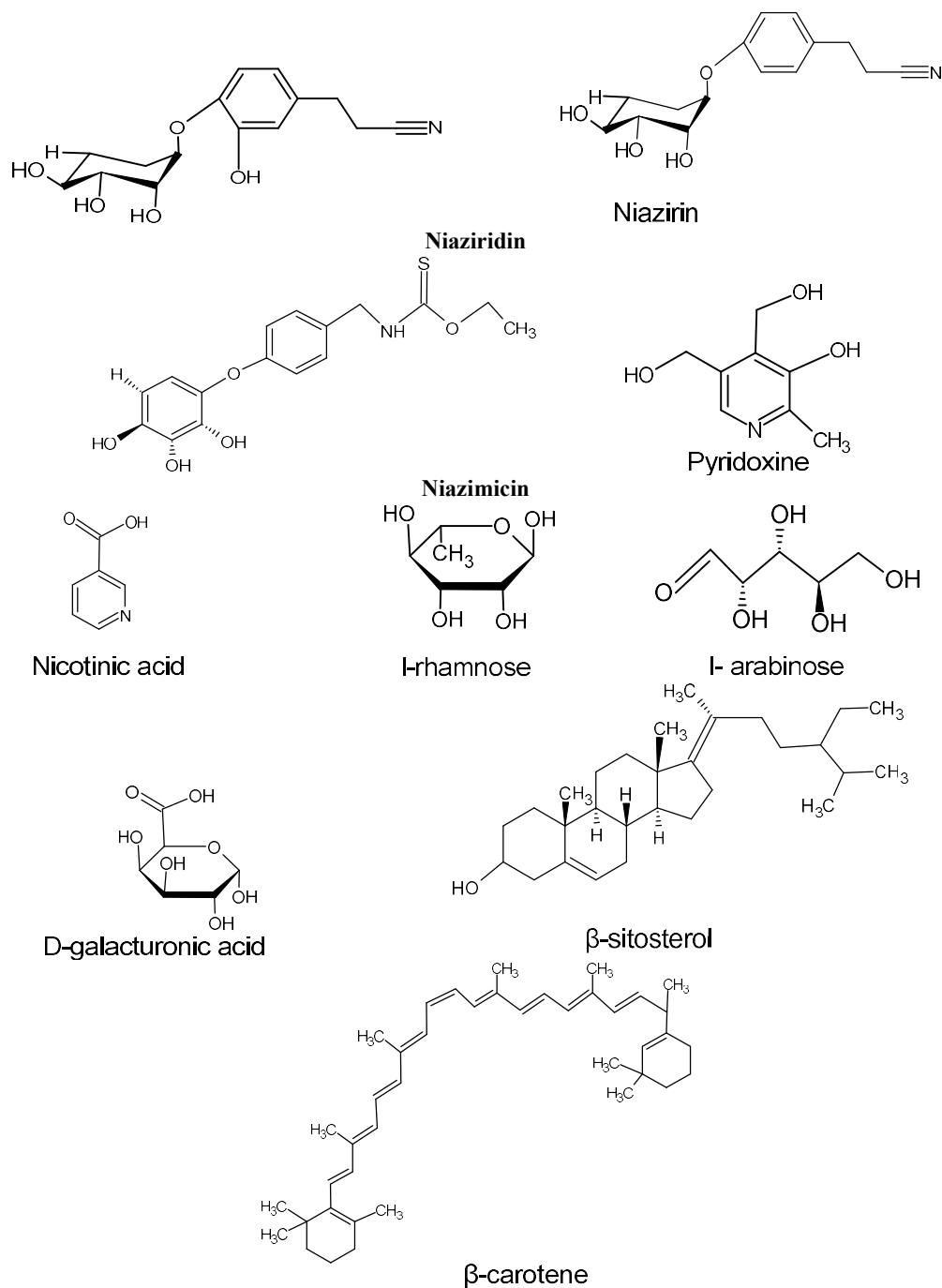


Figure 1: chemical structures of different constituents

PHARMACOLOGICAL THERAPEUTIC USES

It considered as most useful plant because almost all parts include seed oil, bark, flowers, seed, root, leaf have major industrial, agriculture as well as therapeutic usage (4).

Antibacterial activity

Antibacterial effects possessed by the chloroform, ethanolic and methanolic extract of Moringa leaf against the Gram negative and Gram-positive bacteria named as *Pseudomonas aeruginosa*, *Enterobacter aerogenes*, *E.*

ACTIVITIES/

coli, *Bacillus subtilis*, *Salmonella typhi*. Ethanolic extract was found effective for fungus strains like *Fusarium sp* (30) Aqueous extract of seed shows effectiveness against *Staphylococcus aureus* and *Pseudomonas aeruginosa* (31). Plant activity was compared with standard antibiotic kanamycin (32).

Free radical scavenging activity

Leaves and flowers extract of *M. oleifera* showed scavenging activity compared to selected vegetables such as cauliflower, cabbage, peas and spinach. Pakade et. Al observed that total flavonoid and phenolic content

was almost three times of selected vegetables. That study proved that Moringa possessed greater scavenging activity. Scavenging activity is more in mature leaves than tender (33).

Anti-gastric activity

Methanolic extracts of fruits/leaves of *M. oleifera* prevents chronic gastric ulcers induced by acetic acid (34).

Anti-inflammatory activity

It is reported that aqueous extract of root of *M. oleifera* have shown effectiveness against inflammation (35). Flavanoids and phenolic content of Moringa plant shown anti-inflammatory effect (36). Anti-inflammatory activities were shown by n-butanol extract of seeds in guinea pigs i.e inflammation induced with Ovalbumin (37).

Anthelmintic activities

Various studies revealed anthelmintic effect of extracts (ethanolic) of root, stem, flower, bark of Moringa oleifera against Pheretima posthuman earthworm (38).

Antifungal activities

Rao et al. and Das et al. concluded antifungal activity by Pterygospermin found in flower and leaf extracts respectively against Candida albicans (39-41).

Anti-asthmatic activity

Improved effects shown in asthmatic patients with seeds of *M. oleifera* without any adverse symptoms (42).

Chemo preventive effects

Reactive oxygen species (ROS) and cell death are closely related. Increased production of ROS due to different environmental pressures leads to cell death (43). Niazimicin obtained from ethanolic extract of leaves shown antitumor activity (44). Ethanolic extract of moringa seeds provide various bio actives like β -sitosterol, niazirin, benzyl isothiocyanate, glycerol-1-(9-octadecnoate), 4(α -L-rhamnosyloxy)-benzyl isothiocyanate etc. causes cell death due to intracellular ROS (45-47). Zeatin (antiaging agent) found in moringa shown anticancer activity against skin and prostate cancer (48). Against human myeloma cell lines antitumour effects showed by leaves of *M. oleifera* (49). Root extracts of *M. oleifera* exhibited anticancer activity to treat ovarian cancers (50).

Antidiabetic activity

Aqueous extract of moringa leaves showed antidiabetic effect by reducing blood glucose level (51-52). Recent research has demonstrated that administering *M. oleifera* leaf extract for six weeks is crucial in lowering diabetic

complications by preventing diabetes-induced kidney damage and inflammation.

Cardioprotective and antidiuretic activity

Alkaloids found in moringa tree stabilizes blood pressure and acts as cardiac stimulant and antidiuretic (53) also decrease cholesterol (54).

Analgesic activity

Analgesic effect showed by extract (methanolic) of *M. oleifera* leaves and root in guinea pig and frog by tail immersion method (55-56).

Antipyretic activity

Ethyl acetate, petroleum ether and ethanol extract of moringa shows an antipyretic activity against yeast induced pyrexia in rats (57).

Hepatoprotective effects

Moringa leaf extracts reported effectiveness against hepatotoxicity and liver fibrosis reduction (58).

Antiviral effects

It is reported that extract (hydroalcoholic) of fruits (*M. oleifera*) have been shown effectiveness for anti-hepatitis B virus (HBV) (59).

Neuroprotective effects

Dementia is a progressive neurological condition that is proliferating globally due to an ageing population. The most common cause of dementia is Alzheimer disease. According to earlier research, oxidative stress is thought to be a major contributing element to neurodegenerative illnesses including Parkinson's and Alzheimer diseases. Despite several efforts to novel treatments for AD, none of the current therapies have been demonstrated to reduce the disease's progression. Natural substances having flavonoids have attracted more attention as potential options for treatment or prevention of neurodegenerative disorder as synthetic anti-dementia drugs are expensive. In fact, in a rat model of AD caused by cholchicine, the alcoholic extract of *M. oleifera* leaves can counteract oxidative stress. It has been demonstrated *M. oleifera* promotes neuronal survival and expansion under challenging treatment environments. The extract from *M. oleifera* leaves is believed to demonstrate antioxidant properties and nootropic effects. This shows that combination of *M. oleifera* and fluoxetine or other SSRI medications seems to have intriguing potential (60).

FOOD APPLICATION OF DIFFERENT PARTS OF *M. OLEIFERA*

Moringa is abundant source of natural nutrition in subtropical area. Various studies revealed the potential of *M. oleifera* in food products (61).

Table 3: Food application of *M. oleifera*

Product	Mix with or inclusion	Blessings	Reference
Soup	Melon and spinach leaves alongwith MO leaves	Enhance nutritional content	61
Paneer	<i>M. oleifera</i> leaf	Nutritional values found greater than normal value	62

Cakes & herbal biscuits	5% w/w of leaf powder	Enhance 14% protein content of herbal biscuits	63,64
Bread	5% of moringa seed and leaves powder	↑ 88% and 14% of fibre and protein content respectively	64
Icey milk	Dry leaf powder and leaves	oil of <i>M. oleifera</i> Reinforced milk obtained; sensory as well as nutritional parameters also enhanced	65
Yoghurt	Leaves of <i>M. oleifera</i>	Observed negative effect on lactobacillus growth	66
Muffin	Added dried leaf powder of moringa (concentration 12%)	increase in mineral content of <i>moringa muffin</i>	67
Khakhra	Added 2,4,6,8and 10% proportion of leaves	Increase content of ash, carbohydrate, protein, moisture and fat/ antioxidant activity also improved	68

Table 4: List of various extracts of *Moringa oleifera*

Sr. no	Part used	Model	Extract	Dose	Uses	Reference
1.	Leaves	Rat	Aqueous extract	5%	Lower blood sugar level, decrease hyperglycaemia	69
2.	Fruit	Rat	Chloroform extract	500 µg/ml	Cytotoxic	70
3.	Leaf powder	Rat	Emulsion	4 g	Increase insulin secretion	71
4.	Leaves	Wistar albino rats	Aqueous extract	640 mg/kg	Anti-inflammatory	72,73
5.	Seed	Rat	Ethanol extract	----	Cardioprotective	74
6.	Seed	Ileum	Aqueous extract	65.6 mg/ml	Anti-spasmodic	75
7.	Leaves	Rabbits	Alcoholic extract	-----	Nephrotoxicity	76
8.	Flower	Rat	Ethanol extract	100-300 mg/kg	Anti-inflammatory	77
9.	Seed	Rat	Ethanol extract	100 µg/ml	Antihyperglycemic activity	53,78
10.	Leaf	---	Hydroethanolic extract	2.5 to 10 mg/ml	Anti-diabetic	79
11.	Seed	Rat	Hydroalcoholic extract	50,100 & 200 mg/kg	Anti-inflammatory	70
12.	Leaf	Wistar rats	Hydroalcoholic extract	125 mg/kg	Anti-depressant, ↑ humoral immune response	68
13.	Leaves	Mice	-----	13.2- 20.6 g/kg	Anti-dyslipidaemia	50, 80
14.	Leaf	Rat	Ethyl acetate extract	125 µg/ml	Anti-inflammatory	37,81

CONCLUSION

Moringa oleifera reveals various pharmacological activities as chemical constituents contain therapeutic effects. It is a good source of antioxidants. Bio active nutrients present in it provide extra health benefits. Sometimes leafy vegetables like fenugreek, spinach is replaced by *moringa oleifera* leaves in lentil dish, soups etc. in eastern and southern India. Regarding potential applications of *Moringa oleifera* there found knowledge gap. Still, it is a wonder or miracle tree for humanity at affordable price. Overview of nutritional content, chemical composition, therapeutic uses and effects are provided by available Literature. Least of literature found regarding toxic behaviour of moringa oleifera plant.

Abbreviations

MO-Moringa oleifera, AD-Alzheimer disease, ROS-Reactive oxygen species

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Author Contributions

The design, concept and manuscript compiled by all authors combinedly. All authors have read and agreed to the submitted version of the paper and consent to be accountable for all aspects of the work.

Conflict of Interest

The authors have no conflict of interest.

Declaration of Artificial Intelligence (AI) Assistance

The authors declare that they did not use AI assisted tools (ChatGPT, OpenAI) during the writing process.

Ethics Approval

Not Applicable

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