REVIEW ARTICLE

Phytonutrient and Pharmacological Significance of *Moringa oleifera*

Mownica Udikala[1*], Yashodhara Verma[2], Sushma[3], Sapna Lal[4]

[1]Research Scholar, Department of Biochemistry and Biochemical Engineering, SHUATS, Allahabad, India
[2]Assistant Professor, Department of Biochemistry and Biochemical Engineering, SHUATS, Allahabad, India
[3]Assistant Professor, Department of Biochemistry and Biochemical Engineering, SHUATS, Allahabad, India
[4]Assistant Professor, Department of Health Sciences, SHUATS, Allahabad, India

[*]***Address for Correspondence: Dr. Yashodhara Verma, Asst. Professor, Department of Biochemistry and Biochemical Engineering, SHUATS, Allahabad, Uttar Pradesh, India***

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ABSTRACT- *Moringa oleifera* is a small, fast growing evergreen or deciduous tree. *Moringa* is rich in nutrition owing the presence of a variety of essential phytochemicals present in its leaves, pods and seeds. In fact, phytonutrient content of *Moringa* leaves (weight per weight) provides 7 times more vitamin C than in oranges, 10 times more vitamin A than carrots, 17 times more calcium content than milk, 9 times more protein than yoghurt, 15 times more potassium than bananas and 25 times more iron than in spinach. As numerous parts of *Moringa oleifera* plant such as roots, seed, bark, leaves, fruit, and immature pods, flowers act as cardiac and circulatory drugs, anti-pyretic, anti-ulcer, anti-inflammatory, antiepileptic properties *Moringa* is called as Multipurpose Tree or "The Miracle Tree of Life". *Moringa* also contains phytochemicals such as tannins, sterols, terpenoids, flavonoids, saponins, anthraquinones, alkaloids and reducing sugar present along with anti-cancerous agents like glucosinolates, isothiocyanates, glycoside compounds, and glycerol-1-9-octadecanoate respectively. The other chief medicinal properties of the plant include antispasmodic, diuretic, antihypertensive, cholesterol lowering hepatoprotective, antioxidant, antidiabetic, antibacterial and antifungal activities.

Key-words- Anti-pyretic, Anti-ulcer, Anti-inflammatory, Anti-epileptic, Anti-oxidant, Anti-diabetic

INTRODUCTION

Moringa oleifera Lam. (Family: Moringaceae) *Moringa oleifera* is a medium sized tree, growing in Asia, Africa and tropical areas of the world as a valuable food source [1]. *Moringa* is a fast growing tree with about 10m in height and a diameter of 2.04m at chest height [2]. It has a soft trunk, white corky; and a gummy bark bearing branches with each twice or thrice pinnate-compound leaf bearing small leaf leg. The flowers are pleasantly fragrant, white in color whereas the three wing seeds are scattered by the winds. The flowers, tenders leaves and pods are eaten as vegetables [3]. India being the largest producer of *Moringa* has an annual production of 1.1 to 1.3 million tones of tender fruits from an area of 380 km² [4]. The various parts of *Moringa oleifera* tree have been studied for several pharmacological actions. Many reports have described its leaves have antifungal, antimicrobial, anti-atherosclerotic, anti-fertility, relieving pain, central nervous system depressant, anti-inflammatory, diuretic and regulating hypothyroidism.

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Botanical description of *Moringa oleifera*

The taxonomic description includes:

Kingdom: Plantae
Subkingdom: Tracheobionta
Super division: Spermatophyta
Division: Magnoliophyte
Class: Magnoliopsida
Subclass: Dilleniidae
Order: Brassicales
Family: Moringaceae
Genus: Moringa
Species: oleifera

All *Moringa* species are native to Asia, from where they have been introduced into other warm countries, such as Malaysia and other tropical countries. The tree can tolerate temperatures from 19^0C to 28^0C, and has height from 5 to 10 m and can be cultured throughout the plains. It tolerates a wide range of rainfall annually from 250 mm [5]. It has nutritive and pharmacological potentials like antimicrobial, anticancer, anti-hyperlipidemia, anti-diabetic, antiulcer, analgesic, anti-fertility, anticonvulsant, hepatoprotective and just about all parts (leaves, roots, barks, flowers, pods and seeds) of *Moringa oleifera* have been tested for the treatment of diabetes.

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Fig. 1: Leaves of *Moringa oleifera* plant

Nutritional properties: The leaves of *Moringa oleifera* are rich in minerals like calcium, potassium, zinc, magnesium, iron and copper [6]. Vitamins like beta-carotene of vitamin A, vitamin B such as folic acid, pyridoxine and nicotinic acid, vitamin C, D and E are also present in *Moringa oleifera* [7]. *Moringa* contains phytochemicals such as tannins, sterols, terpenoids, flavonoids, saponins, anthraquinones, and alkaloids. The leaves of *Moringa* also have a low calorific value and can be used in the diet of the obese and has lot of minerals that are essential for growth and development among which, calcium is considered as one of the important minerals for human growth. While 8 ounces of milk can provide of 300-400 mg of calcium, *Moringa* leaves can provide 1000 mg and *Moringa* powder can provide more than 4000 mg of calcium respectively. *Moringa* powder can be used as a substitute for iron tablets, hence as a treatment for anemia. Beef has only 2 mg of iron while *Moringa* leaf powder has 28 mg of iron. It has been reported that *Moringa* contains more iron than spinach. [8-11]

A good dietary intake of zinc is essential for proper growth of sperm cells and is also necessary for the synthesis of DNA and RNA [12]. *Moringa oleifera* leaves show around 25.5–31.03 mg of zinc/kg, which is the daily requirement of zinc in the diet [13-14]. Besides, the pods, leaves of *Moringa* contains high amount of Ca, Mg, K, MN, P, Zn, Na, Cu, and Fe [15]. *Moringa* leaves contain fiber, fat proteins and minerals like K, Cu, Fe, and S and as well as vitamins like vitamin-A (Beta-carotene), vitamin B-choline, vitamin B_1-thiamine, riboflavin, nicotinic acid and ascorbic acid. The leaves of *Moringa* contain various amino acids like Arg, His, Lys, Trp, Phe, Thr, Leu, Met, Ile, Val along with bio nutrients like tannins, sterols, saponins, trepenoids, phenols, alkaloids and flavonoids like quercetin, isoquercitin, kaemfericitin, isothiocyanates and glycosides respectively. Latest research from two agro ecological zones in Ghana concluded that agro ecological zonation had no significant effect on the levels of most nutrients in MO leaves [16].

Alkaloids in *Moringa* leaves often have pharmacological effects and are used as medications and recreational drugs whereas, flavonoids enhance the effects of vitamins and function as antioxidants. They are also known to be biologically active against liver toxins, tumors, viruses and other microbes. Saponins in *Moringa* causes hemolysis of red blood cells, tannins are specified with antiviral, antibacterial and antiparasitic effects. The presence of flavonoids gives leaves the antidiabetic and antioxidant properties where as isothiocyanates exhibit anticancer properties and flavonoids like quercetin act as anti-proliferative, anticancer agent. The presence of minerals and vitamins help in boosting the immune system and cure a myriad of diseases [1].

Flavonoids and phenolic acids are collectively referred as phenolic compounds. They are classified into several subgroups including: flavone, flavanone, flavonol, isoflavonoid, anthocyanin, and chaconnes.The high performance liquid chromatography analysis also indicated the presence of phenolic acids (Gallic, elegiac, chlorogenic and ferulic acid) and flavonoids: kaempferol, quercetin, isoquercetin, astragalin and rutin whereas Quercetin and kaempferol, in their as 3-O-glycoside forms were the predominant flavones in *Moringa* leaves. The leaves are well enclosed with niazirin, niazirinin, 4-[(40-O-acetyl-Lrhamnosyloxy) benzyl] isothiocyanate, niaziminin A and B, quercetin-3-O-(600-malonylglucoside), kaempferol-3-O-glucoside and kaempferol-3-O-(600- malonic-glucoside), 3-caffeoylquinic, and 5-caffeoylquinic acid. It was also reported that the leaves had enough amount of carotenoids, epicatechin and o-coumaric acid [17].

Preservation Methods of *Moringa*: *Moringa* can also be preserved for a long time without loss of nutrients. Drying or freezing can be done to store the leaves reported by Yang [18] shown that a low temperature oven used to dehydrate the leaves retained more nutrients except vitamin C than freeze-dried leaves. Hence, drying can be done using economical household appliance like stove to retain a continuous supply of nutrients in the leaves whereas Preservation by dehydration improves the shelf life of *Moringa* without change in nutritional value. An overdose of *Moringa* may cause high accumulation of iron, high iron can cause gastrointestinal distress and hemochromatosis. Hence, a daily dose of 70 g of *Moringa* is suggested to be good and prevents over accumulation of nutrients.

Medicinal Uses: *Moringa* leaves are used to treat asthma, hyperglycemia, Dyslipidemia, flu, heart burn, syphilis, malaria, pneumonia, diarrhea, headaches, scurvy, skin diseases and bronchitis, eye and ear infections. It also used in reducing blood pressure and cholesterol, and acts as an anticancer, antimicrobial, antioxidant, anti-diabetic and anti-atherosclerotic, neuroprotection agent [19-20].

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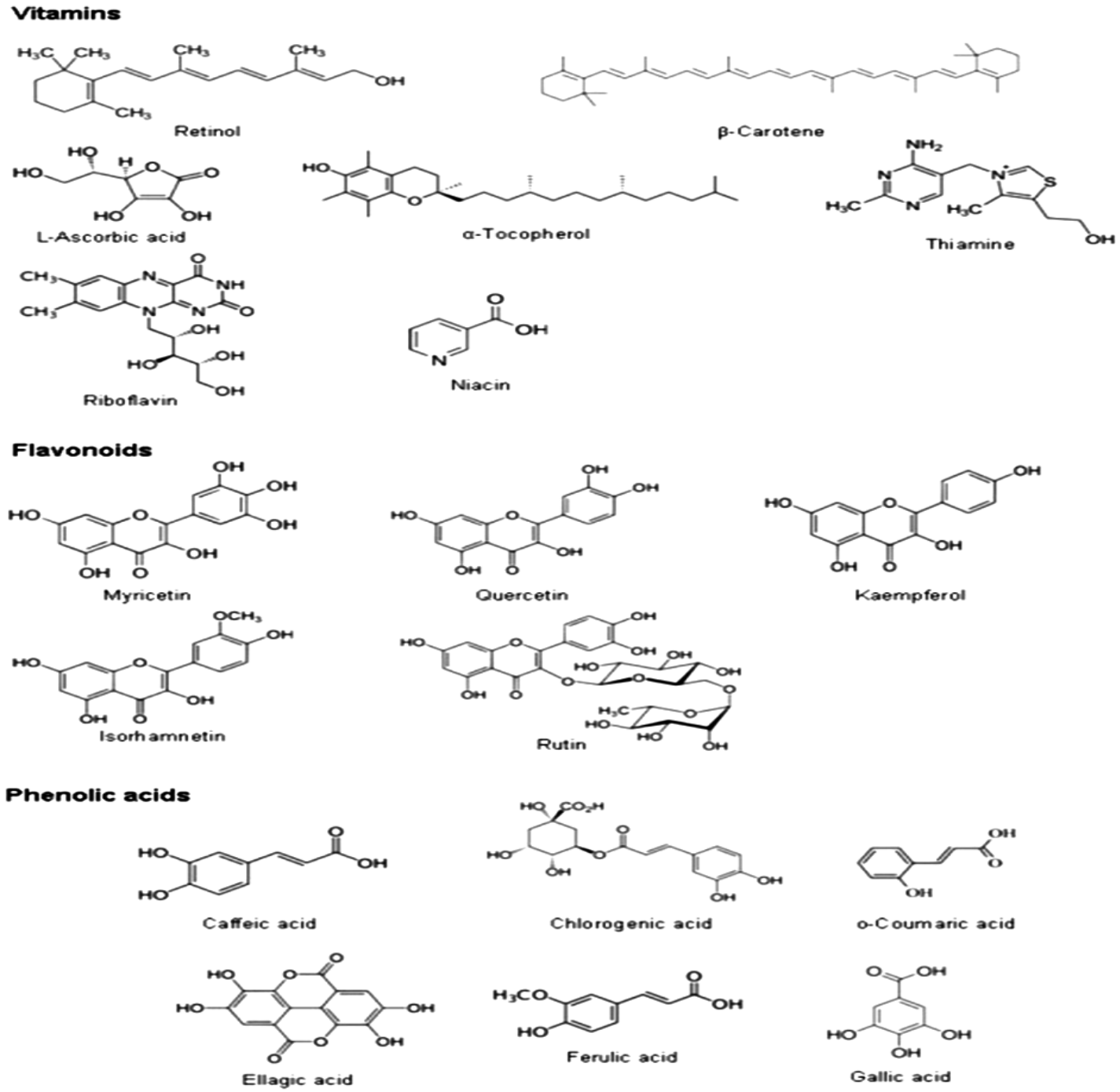

Fig. 2: Structures of Phytochemical constituents of *Moringa oleifera*

Pharmacological studies of *Moringa oleifera*

Anti-diabetic activity

In randomized control design study, 18–55 years old individuals with low density lipoprotein (LDL) greater than 100 mg/dL were given *Moringa oleifera* leaves as commercial 350 mg capsule (2 capsules tid for 30 days). A significant reduction of 13.76 mg/dL LDL concentration verses control was observed and prevents the rise in serum glucose 2 hrs. after 75 g oral glucose. Moringa leaves significantly decrease blood glucose concentration in Wistar rats and Goto-Kakizaki (GK) rats, modeled type 2 diabetes was reported by Ndong [21]. According to another study Mittal [22] reported that the extract from Moringa leaf is effective in lowering blood sugar levels within 3 hrs after ingestion As a mechanistic model for anti-diabetic activity of Moringa, it has been indicated that dark chocolate polyphenols and other polyphenols. [23] are responsible for hypoglycemic activity. In general, Diabetes leads to several complications such as retinopathy, nephropathy and atherosclerosis etc. *Moringa* can be used to prevent such ailments, when there is hyperglycemia, the blood glucose reacts with proteins and causes advanced glycated end products (AGEs). These AGEs bind to RAGE which gets expressed on the surface of immune cells. This interaction leads to increased transcription of cytokines like interleukin-6 and interferons. At the same time, the cell adhesion molecules are expressed on the surface endothelium of arteries. This facilitates trans endothelial migration, which causes inflammation in the arteries and leads to atherosclerosis. *Moringa* is used as an anti-atherosclerotic agent [24]. The anti-atherogenic nature

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can be accounted by the antioxidant properties of *Moringa.*

Anticancer Activity: *Moringa* has several bioactive compounds showing antitumor activity. Niazimicin, is a bioactive compound found in *Moringa* leaves, has anticancer activity [25]. *Moringa oleifera* leaf extract have shown potential cytotoxic effects on human multiple myeloma cell [26]. Also, *Moringa* seed extracts have effects on hepatic carcinogen metabolizing enzymes. Another study involving 11 plants used in Bangladeshi folk medicine, *Moringa* was considered as potential source of anticancer compounds. During this study, the plant extract were analyzed for cytotoxicity through brine shrimp lethality assay, sea urchin eggs assay, hemolysis assay and MTT assay using tumor cell lines. Beside leaves, *Moringa* seed extracts also have anticancer activity through its effects on hepatic carcinogen metabolizing enzymes, and antioxidant property [27].

Antioxidant Activity: The extracts of freeze-dried leaves showed radical scavenging and antioxidant activities. All the extracts were capable of scavenging proxy and superoxyl radicals. The major bioactive compounds of phenols were found to be flavonoid groups such as quercetin and kaempferol. The drumstick leaves are found to be a potential source of natural antioxidants. During a study reporting antioxidant property of freeze dried *Moringa* leaves from different extraction procedures, it was found that methanol and ethanol extracts of Indian origin *Moringa* have the highest antioxidant activity with 65.1 and 66.8%, respectively [28]. It was also reported that the major bioactive compounds of phenolic, such as quercetin, and kaempferol are responsible for antioxidant activity [29]. During another study, quercetin, and kaempferol have shown good antioxidant activity on hepatocyte growth factor (HGF) induced Met phosphorylation with IC_{50} value for 12 and ~6 μM/L respectively [30].

Antibacterial Activity: The antibacterial activity of chloroform extract of *Moringa oleifera* showed maximum zone of inhibition (6 mm) against *Escherichia coli* and *Salmonella typhus*. The antibacterial activity of chloroform extract of *Moringa oleifera* showed no zone of inhibition against *Pseudomonas aeruginosa, Staphylococcus aureus.* The antibacterial activity of ethanol extract of *Moringa oleifera* showed maximum zone of inhibition (14 mm) against *Salmonella typhus* showed the minimum inhibitory zone (8 mm) against *Escherichia coli.* The antibacterial activity of aqueous extract of *Moringa* leaves showed maximum inhibitory zone (8 mm) against *Staphylococcus aureus*. The antibacterial activity of aqueous extract of leaves showed no inhibitory zone against *Salmonella typhus, Pseudomonas aeruginosa* and *Escherichia coli.* Bukar [31] reported that *Moringa oleifera* ethanoic extract had the broadest spectrum of activity on the test bacteria. The results showed that activity against four bacterial isolates *Enterobacter* spp. (7mm), *Staphylococcus aureus*(8mm), *Pseudomonas aeruginosa* (7 mm) and *Escherichia coli* (7 mm) were sensitive at concentration of 200 mg/ml. while *shigella* spp. and *Salmonella typhus* were not sensitive at all concentrations.

CONCLUSIONS

Moringa oleifera leaves due to presence of phytochemicals indicated that it has all the possible preventive and curative properties. Although many bioactive compounds have been discovered from *Moringa* still the knowledge is in infancy in term of its total reserve. Perhaps, future rigorous studies directed towards the detection and commercialization of bioactive compounds to the development of remedies for several ailments. The pharmacological studies reported in the present review confirm the therapeutic value of drumstick leaves.

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