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R E V I E W A R T I C L E

Phytopharmacological Profile of Moringa Oleifera Leaves a Concised Review

A. Chandrakala*, A. Venkatesh, M. Uma Devi, K. Maha Lakshmi, S. Rehana Bi, P. Lakshmi Prasanna,

S.V.U College of Pharmaceutical Sciences, Tirupathi, Andhra Pradesh, India

A B S T R A C T

Moringa oleifera is a well-known herb due to its pharmacological and therapeutic properties currently, it is used as substitutes in soups, lentils, and other preparations in Southeast Asia. It has many bio-active components which provide additional health benefits beyond the essential needs. Due to its high nutritional bio availability and medicinal properties it aids against different aliment such as diabetes, elevated blood pressure, cancer, antioxidant activity of disease prevention, such as: cardiac attack, obesity, Parkinson's disease and Alzheimer's disease. Moreover, it can be utilized to make foods that could be a step towards curbing malnutrition. The published literature gives the total scenario of the chemical constituents, nutritional content, potential uses, and pharmacological activities of the plant. The identification, isolation, and standardization of plant extracts may be considered for detailed studies which can be useful for the further development of the promising food products with health benefits and nutrients to cure different life style-related diseases as well as malnutrition. *Moringa oleifera* is a notable spice because of its pharmacological and remedial properties presently, it is utilized as substitutes in soups, lentils, and different arrangements in Southeast Asia. It has numerous bio-dynamic parts which give extra medical advantages past the fundamental requirements. Because of its high wholesome bio accessibility and restorative properties it helps against various nourishment, for example, diabetes, raised circulatory strain, malignant growth, cell reinforcement action of sickness anticipation, for example, cardiovascular assault, corpulence, Parkinson's infection and Alzheimer's illness

Keywords: *Moringa oleifera*, Alzheimer's disease, Parkinson's infection, cancer, antioxidant activity.

A R T I C L E I N F O

Corresponding Author
A. Chandrakala
S V U College of Pharmaceutical Sciences,
S.V University, Andhra Pradesh, India

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C O N T E N T S

1. Introduction

Moringa oleifera is an Angiospermic plant, commonly known as the 'drumstick' or Munaga or 'horseradish' in India, "Shiferaw" in Ethiopia and 'Sitalchini', Munga, Sahijan or Saijan in Nepal, belonging to the family *Moringaceae*. It is a native of Pakistan, India, Nepal, Asia, Bangladesh, Arabian region, Africa, West Indies, Florida,

South America, Peru, Paraguay, and Brazil and Afghanistan. It belongs to genus *Moringa* having 13 different species *M.oleifera*, *M.arborea*, *M.drouhardii*, *M. ovalifolia*, *M. longituba*, *M. rivae*, *M. borziana*, *M. corcanensis*, *M. hildebrandtii*, *M. ruspoliana*, *M. stenopetala*, *M. peregrine*, *M .pygmaea*.. Among them, *Moringa oleifera* is the most widely cultivated species native to tropical and sub-tropical region of world, is a fast growing drought-resistant. It is broadly developed for the enhanced utilization of its young seed units and green leaves as vegetables and for medication. It is considered as a generally excellent enhancement in light of its high protein esteem. It is a supplement rich seeds, palatable leaves and blossoms that can be utilized as food, medicine, restorative oil or animals feed. Different experiments have been demonstrated positive effects on health (James and Zikankuba, 2017). According to Zauba.com, India exported *Moringa* leaf powder worth USD 4,746,132, equivalent to 836,806 kg for the period June 2013 up to July 2015. Of the total amount, the United States is the largest single buyer of *Moringa* leaf powder accounting for USD 3,303,870 followed by Germany and the United Kingdom which imported *Moringa* leaf powder worth USD 364,170 and USD 162,365, respectively whereas Netherlands imported worth USD 12,594 over the same period. Herbal drugs and their constituents play an important role in different medicinal system like unani, siddha, yoga, homeopathy, naturopathy and ayurveda. In ayurvedic medication (conventional and elective medication of India) ascribed properties for the treatment of certain infections, for example, asthma, epilepsy, eye, skin and hair care illnesses [4].

Additionally utilized for against diabetic, hepatoprotective, diuretic and cholesterol bringing down limit, hostile to dangerous specialists, fever and hemorrhoids [5–7.[2]*Moring*a is having high biotechnological potential due to its high content of minerals, vitamins, proteins, lipids, secondary metabolites and other various phytochemicals like sterols, tannins, flavonoids, terpenoids, saponins, alkaloids anthraquinones, carbohydrates and reducing sugar along withTruth be told, it is a restorative plant generally known in the way to deal with ailing health and different illnesses [8 Over 70% people uses this non-allopathic game plan of prescription *Moringa*. It contains 36 antiinflammatory compounds, more than 90 recognized nutrients and 46 antioxidants. Scientific report states that *M. oleifera* consists of 539 bio-chemical activities which are much more beneficial to human being. Leaves of this plant contain all the essential amino acids which are very much useful to human being. Since 1998, WHO has promoted *Moringa* as an alternative to imported food supplies to treat malnutrition, and hence so it can be called as “Mothers best friend.

It is known as the miracle tree because of its diversified beneficial features The *Moringa* tree grows quickly, and they grow from seeds or cuttings of branch of trees. The tree leaves are something more than amazing though they grow quickly in poor soil within a very short period. Moreover, the tree is sustainable at dry and hot climates and is resistant to drought. *Moringa* is rich in nutrition owing to the presence of a variety of essential phytochemicals present in its leaves, pods, and seeds. In fact, *Moringa* is said to provide 7 times more vitamin C than oranges, 10 times more vitamin A than carrots, 17 times more calcium than milk, 9 times more protein than yoghurt, 15 times more potassium than bananas, and 25 times more iron than spinach [3]. In addition, it helps to increase the blood antioxidant level [4] and reduce the blood sugar level [5] and sustained inflammation [6].The small leaves of *Moringa* pack a full punch of nutrients which contain more protein than eggs, more iron than spinach, more vitamin A than carrots, and more calcium than milk. The *Moringa* plant is found as a good source of energy with potential as pharmaceuticals and cosmetics (oils from seeds for hair and skin care) benefits. Seed extracts show antibacterial activity and are also usedas a water purifying agent. *Moringa* seeds are also rich in vitamins and minerals.

Globally, there is increased scientific research, commercialization, utilization and demand for *M. oleifera*. A review of existing literature also indicates commensurate studies on animal models to support and confirm the pharmacological properties and safety of *M. oleifera*. However, safety reports on human studies with no adverse effects are few (40). Herbal extracts and products are limited in use and adoption probably due to the uncertainty surrounding their toxicity level and safety (41). In addition, several reports have shown that toxicity studies are necessary to validate the safety limits of many herbal preparations (42,43). From our observation and market surveys, *Moringa*-based products and supplements are becoming increasingly available in the open market, as well as online portals without commensurate toxicity assessment tests to establish their safe consumption. Also, different degrees of toxicity have been reported on various seed extracts of *M. oleifera* and thus requiring more scientific reviews and experimental trials (42,44) done . Hence, this systematic review is aimed to update existing information on the overall value of the pharmacological activities, toxicity and safety potentials of *M. oleifera* as an multipurpose medicinal plants.

Food and Supplementation from *Moringa oleifera*

In the recent world, people are conscious but compelled to take calorific foods due to their busy schedule. Such food habits result in various health-related problems such as obesity, high blood pressure, diabetes, and various chronic diseases. For a balanced life style, a proper diet with an optimum level of vitamins, minerals, and PUFAs, etc. is required. *Moringa* leaves are known as a very good food source which is easily digestible and rich in proteins [14]. According to Sultana and Anwar [19], *Moringa* leaves possess many valued compounds such as protein, vitamin, calcium, iron, ascorbic acid, and antioxidants (carotenoids, flavonoids, and phenol). Different developing or underdeveloped countries of the world feed their children with Moringa [20].Busani et al. reported that the presence of numerous minerals and vitamins helps to improve the immunity against various diseases [21]. Moreover, *Moringa*

leaves contain various amino acids. But nutrient variation is common because of climatic, location, and environmental factors [22]. Nowadays, *Moringa* leaves have diversified uses, such as medicinal coated capsules (as powder), as drinks (Ziga drinks), and tea [23]. Because of its nutritional properties, it is known as the miracle tree. Table 2 depicts proximate profiles of *Moringa* fresh leaves, dry leaves, and leaf powder.

2. Morphology

Synonyms: The plant *Moringa oleifera* is known by several names throughout the world. The synonyms are given below.

• Latin – *Moringa oleifera*
• Sanskrit – Subhanjana,
• Hindi – Saguna, Sainjna
•Gujarati – Suragavo
•Tamil – Mulaga , Munag
•Malayalam – Murinna, Sigru
•Punjabi – Sainjna, Soanjna
•Unani – Sahajan
•Ayurvedic – Haritashaaka, Raktaka, Akshiva
•Arabian – Rawag,
•French – Morungue
•Spanish – Angela, Ben, Moringa
•Chinese – La ken
•English - Drumstick tree, Horseradish tree

Fig: *Moringa oleifera*

Taxonomic position

Moringa is the only genus in the family *Moringa*ceae and *Moringa oleifera* is the most extensively studied and cultivated species.

Kingdom - Plantae
Super kingdom -Tracheobionta
Super division- Spermatophyta
Division - Magnoliophyta
Class -Magnoliopsida
Subclass -Dilleniidae
Order -Capparales
Family -Moringaceae
Genus -*Moringa*
Species -*oleifera*

MORPHOLOGY

The use of different parts of *Moringa oleifera* is described as below:

Leaves:

The leaves are bipinnate or more commonly tripinnate, upto 45cm long. These are compound leaves with leaflets of 1–2 cm long. The leaflets are finely hairy, green and almost hairless on the upper surface, paler and hairless beneath, with red-tinged midveins, with entire (not toothed) margins, and are rounded or blunt-pointed at the apex and short-pointed at the base (aestivation is opposite). The twigs are finely hairy and green, becoming brown [6, 11].

Flowers:

The fragrant, bisexual, yellowish white flowers are hairy stalks in spreading or drooping axillary panicles 10 - 25 cm long. Individual flowers are approximately 0.7 to 1 cm long and 2 cm broad and five unequal yellowish – white, thinly veined, spathulate petals, five stamens with five smaller sterile stamens and pistil composed of a 1-celled ovary and slender style.

Fruits:

Fruits are tri-lobed capsules and are frequently referred to as pods. Pods are pendulous, brown, triangular, and so splits into three parts (length wise) when dry, 30–120 cm long, 1.8cm wide. Fruits production mainly occurs in March and April. Each fruit contain around 26 seeds during their development phase. Immature pods are green in color. They turn brown on maturity and split open longitudinally

Bark and Wood:

The bark is whitish -gray, thick, soft, fissured and warty or corky, becoming rough. When wounded, the bark exudes agum which is initially white in color but change stored dish brown or brownish black on exposure. The wood is soft and light [6].

Seeds:

Seeds are round 1cm in diameter with brownish semi – permeable seed hull with 3 papery wings hulls of seed are brown to black but can be white if kernels are of low viability. Viable seed germinate within 2 weeks, each tree can produce around 15,000 to 25,000 seeds/year. Average weight is 0.3 gm/seed. The parts of plant *Moringa oleifera* is shown in Fig. 2.

Root:

The root bark of *Moringa* has potential to cure gastric ulcers and gastric mucosal lesions. It also decreases the acidity and increases the pH of gastric juice. Hence, MO possesses antiulcer and anti secretary activity and hence, can be used as a source for antiulcer drugs in future.

POD husks:

MO pod husks contain alkaloids, flavonoids, tannins, tritepenoids, diterpenoids and cardiac glycosides. MO pod husks extract show potential antimicrobial action against some gram positive *staphylococcus epidermidis*, *Enterococcus faecalis* and Gram negative Bacteria *Klebsiella pneumonie* and *Salmonellatyphimurium*.

Propagation:

Moringa oleifera can be propagated either from seeds, cuttings or both. Due to its high germination rate, direct seeding is possible. *Moringa* seeds can be germinated year-round in well-draining soil. For vegetative propagation, cuttings of 1 m length and at least 4 cm diameter can be used. For intensive leaf production, "the spacing of plants should be 15 x 15 cm or 20 x 10 cm, with conveniently spaced alleys (for example: every 4 m) to facilitate plantation management and harvests. Now and then, because of high thickness weeding and sickness

anticipation are very troublesome. The plants are dispersed at 50 cm* 1 m separated during semi-serious creation. This gives great outcomes with less upkeep. *Moringa* trees have enormous advantage as a characteristic wall since it tends to be planted in back streets and furthermore connected with different harvests. In agro-ranger service development the distance between *Moringa* lines is generally 2m and 4m.

Harvesting

Moringa trees can be reaped in the wake of arriving at a stature of 1.5m and 2 m during high thickness development. The leaves ought to be reaped by cutting the leaf stems with a sharp blade or snapping leaf comes from branches at 20 cm to 45 cm over the ground. This technique advances the improvement of new shoots [4]. It very well may be reaped up to 35 to 40 days. However, in the event of grain collecting, the tree ought to be gathered at regular intervals. The collected leaves ought not be loaded together, since they will ruin without any problem. Early Morning is the best time for collecting which forestall overabundance loss of water. For selling the new leaves, they ought to be sold that very day since they lose dampness rapidly in the wake of reaping. Moringa can likewise be reaped at a tallness of 50 cm over the ground level, which works with mechanical collecting[5].

Origin and distribution

M. oleifera is native of the western and sub- Himalayan, India, Pakistan, Asia Minor, Africa and Arabia [6]. But it is now distributed in the Philippines, Cambodia, Central America, North and South America and the Caribbean Islands [7]. For a variety of purposes, it is now cultivated in the whole tropical and sub-tropical regions of the world.

Cultivation condition

Moringa oleifera is a small to medium-sized, deciduous or evergreen tree mostly common in tropical, foot hills and some midhill region of Nepal [8]. It grows upto 25-30 ft and the mid-hill, the siwalik and teraiarea is best for its cultivation [9]. It grows best in direct sunlight up to 0-1000 meter above sea level. Moranga can tolerates high range of soil conditions, but prefers neutral to slightly acidic (pH. 6.3-7.0). This shows its preferences towards well-drained sandy or loamy soil. The Minimum annual rainfall requirements is about 250mm with maximum at over 3,000mm, but in waterlogged soil the roots have a tendency to rot. In order to encourage water run-of, trees can be planted on small hills in heavy rainfall prone area.

The Presence of a long taproot makes the plant resistant to severe periods of drought. The best temperature range from 12-40 degree Celsius, but the tree will tolerate up to 48 degrees in the shade and it can survive a light frost [10]. It promptly colonizes stream banks and savannah regions where the dirts are all around depleted and the water table remaining parts genuinely high all the all year. Albeit, the plant is dry season lenient, it yields considerably less foliage when it is constantly submerged pressure. It isn't hurt by ice, however can be killed back to ground level by a freeze. It rapidly conveys new development from the storage compartment when cut, or starting from the earliest stage frozen[4].

Present status in India

Nutritional properties

The Leaves of *Moringa oleifera* are rich source of minerals like calcium, potassium, zinc, magnesium, iron and copper. The Leaves has low calorific value so can be used in the diet of obese. The leaves also contain all essential amino acids and are rich in protein and minerals [11]. Pods contains around 46.78% fiber, 20.66% protein and are highly valued for curing digestive problem and colon cancer [12]. Vitamins like vitamin A, Vitamin B, Beta-carotene, pyridoxine, nicotinic acid, vitamin C, Vitamin D and E also present in abundant amount in *Moringaoleifera*. *Moringa oleifera* also contains major phytochemicals such as: tannin, sterols, terpenoids, flavonoids, saponins, anthraquinones, alkaloids and reducing sugar is also present along with anti-cancerous agents like glucosinolates, isothio cyanates, glycoside compounds and glycerol-1-9-octadecanoate. Oligosaccharides and oxalate were reported as anti-nutrient factor in *Moringa* leaves [13]. The Dried leaves (*M. oleifera*) retained 87.5% and 50% of β-carotene after 4 and 3 month storage, respectively, and could therefore be processed for convenient use [14].

Vitamins and Minerals Besides macronutrients (carbohydrates, protein, and lipids), the animal body requires various micronutrients for survival. These micronutrients are very important for the body which act as a carrier or participate in the breakdown process of macronutrients. Vitamins are important which play a great role in energy processing of the animal body. Beriberi, rickets, scurvy, etc. are very common diseases which occur due to the deficiency of vitamins. Vitamins, such as vitamin A (beta-carotene), vitamin B (folic acid, pyridoxine, and nicotinic acid), vitamin C, vitamin D, and vitamin E, are found in *Moringa oleifera* [36]. Therefore, *Moringa* leaf powder or processed food derived from *Moringa* could be a good source of vitamins. Apart from various vitamins, *Moringa* contains lot of minerals, which are essential for physiological growth and development. Calcium is considered as one of the most important minerals, where dried *Moringa* powder is a great source of that element. It possesses 17 times more calcium than milk [22]. Without that, it contains 2 mg/100 g iron and 25.5-31.03 mg/kg zinc [22]. It is well enough to fulfill the daily requirement of zinc in the diet [37]. Table 6 depicts a list of vitamins and minerals found in leaf pods and seeds [24, 38].

Phytochemical analysis *M. oleifera* has shown the presence of a range of unique compounds with several medicinal, nutraceutical and pharmaceutical properties. The ethanolic

extract of leaves contain two nitrile glycosides, three mustard oil glycosides niazirin, niazirinin, niaziminin A and B and 4-[(4'-o acetyl-α-L-rhamnosyloxy) benzyl] isothiocyanate [19]. They also contain 4-(α-L-rhamnopyranosyloxy)-benzylglucosin olate and three monoacetyl-isomers of glucosinolate. Quercetin which is one of the most biologically active flavonoids is found as quercetin-3-o glucoside and quercetin-3-o-(6-malonyl glucoside). It acts as a potent polyphenol antioxidant and immune system modulator. Its immune support attributes are enhanced by its synergisti association with vitamin C. Quercetin is the natural compound that assists optimal bone health, scavenge free radicals in the body which damage cell membranes, alter the DNA, and even cause cell death. Quercetin appears to protect against the damage caused by LDL cholesterol and may help prevent death from heart disease. By its anti - inflammatory action it helps to stabilize the cells that release histamine in the body. They also contain 3- caffeoylquinic acid, 5-caffeolquinic acid and kaemferol is found as Kaemferol-3-o-(6"-malonyl-glucoside [20]. The caffeoylquinic acid has anti-hypertensive and anti-cancer properties while kaemferol exhibits anti-diabetic, anti- bacterial, anti-viral anti-cancer and cardio-protective properties. Moringa stem is a source of vanillin, 4- hydroxymellein, β-sitosterol, β-sitisterone and octaconic acid and the bark contains 4-(α-L-rhamnopyranosyloxy)- benzylglucosinolate [20]. The exudates (gum) of Moringa plant contain D-mannose, D-xylose, D-galactose, D- glucuronic acid, L-arabinose and L-rhamnose. A new compound (leucoanthocyanin) leucodelphinidin-3-o-β-D- galactopyranosyl (1-4)-o-β-D glucopyranoside, has been reported in gum [21]. The roots of M. oleifera have high concentrations of both 4-(α-L-rhamnopyranosyloxy) benzylglucosinolate and bezylglucosinolate which are supposed to be possess anti-cancer properties [20].

3. Pharmacological Actions

Anticancer and Antitumor Activity

There is a direct connection of Reactive Oxygen Species (ROS) with cell death. Various environmental stresses lead to excessive production of ROS causing progressive oxidative damage and ultimately cell death [58]. The compounds of the leaves that are held responsible for the anticancer activities are glucosinolates, niazimicin, and benzyl isothiocyanate. “Niazimicin” a bioactive compound from Moringa leaves showed potential anticancer activity [59]. Seven bioactive compounds, namely, 4(*α*-L-rhamnosyloxy)-benzyl isothiocyanate, niazimicin, 3- O-(6′-oleoyl-*β*-D-glucopyranoyl)-*β*-sitosterol, *β*-sitosterol- 3-O-*β*-D-glucopyranoside, niazirin, *β*-sitosterol, and glycerol- 1-(9-octadecnoate) had been isolated from the ethanol extract of the *Moringa* seed [60]. Benzyl isothiocyanate has been shown to be linked with cancer. Research showed that BITC causes intracellular ROS, which leads to cell death. This could be one of the reasons for *Moringa* to be a good anticancer agent [61–63]. *Moringa* contains an antiaging compound called Zeatin, which is a naturally occurring cytokinin [64] which has antitumor activities, effective against prostate and skin cancers, and is a strong antioxidant. The *Moringa* leaves also showed a significant cytotoxic effect on human myeloma cell lines [65].

Antimicrobial and Anthelmintic Activities. Extracts from leaf, flower root bark, and stem bark of *Moringa oleifera* have antimicrobial and anthelmintic properties. Pterygospermin has powerful antibacterial and fungicidal activities [51] found by Das et al. and Rao et al. in the leaf and flower, respectively [52, 53]. Ethanolic extract of seeds, leaves, and flowers revealed the antimicrobial activity against *E. coli, P. aeruginosa, Enterobacter species, K. pneumoniae, S. aureus, Proteus mirabilis, Salmonella typhi A, Streptococcus,* and *Candida albicans [54]*. *Moringa oleifera* flower and leaves have been demonstrated for their anthelmintic activity during several studies [55], for example, ethanolic extracts from *Moringa oleifera* leaves to inhibit Indian earthworm *Pheretima posthuma* [56].

hepato-protective effects

Moringa leaves methanol extract providing a hepatoprotective effect, which may be attributed to the existence of quercetin presence. *Moringa oleifera* leaves has significant effects on levels of alkaline phosphatase (ALP), aspartate amino transferase (AST), alanine amino transferase (ALT), plus lipid reduction and lipid peroxidation concentration in rat liver. Its leaves have been discovered to minimize plasma ALT, AST, ALP, creatinine and to alleviate drug-induced hepatic and kidney damage. Related findings were found in a rabbits were taken as sample and treated with MO leaves and NiS04 for nephrotoxicity induction (Miltonprabu *et al*., 2017). Another experimental study was done on guinea pigs in which it was proved that Non-alcoholic fatty liver disease (NAFLD) can be prevented by treating MO leaves as a mod of liver steatosis, as demonstrated by reducing liver cholesterol and triglyceride concentrations. This reduction in liver lipids is associated with decrease inflammation and expression of genes included in lipid assimilation and inflammation (Ali *et al*., 2018).

Lipid peroxidation (LPO)

LPO takes an essential role of body metabolism. It may inflict harm to cells and to the nerves if it disrupts the internal and external equilibrium, In-vivo study was done and observed that with the use of *Moringa* leaves for fifteen days, leaves effectively restore the rate of glutathione (GSH) and prevent liver peroxidation (Sinha *et al*., 2016). Due to the presences of phytochemicals like ascorbic acid and phenols (catechin, epicatechin, ferulic acid, ellagic acid and myricetin), leaves play a major role in the elimination of free- radicals. In fact, the pre-administrstion of MO hydro-ethanol extract has an effective result on hepatotoxicity trial. The levels of lipid peroxidation, glutathione-S transferase (GST), glutathione peroxidase (GPx), and glutathione peptide reductase (GR) were similar to standard values, comparable to positive values. It was also observed through histopathological changes that liver

toxicity caused by high fat diet and anti-tubercular drugs such as pyrazinamide, rifampicin, or isoniazid due to the low level of ALP, AST, ALT, LPO, and bilirubin, *Morinaga* plays an important role to protect liver from toxicity and damage (Giacoppo *et al*., 2015).

Antioxidant activity: Aqueous and alcoholic extracts (methanolic & ethanolic) of leaves and roots of *Moringa oleifera* exhibit strong *in-vitro* anti-oxidant and radical scavenging activity. Its leaves are rich source of antioxidant compounds; they could protect the animals against diseases induced by oxidative stress. Administration of *Moringa oleifera* leaves extract seems to prevent oxidative damage caused by high-fat diet [5].

Cardiac Stimulant and Antidiuretic Activities. The bioactive compound alkaloids from Moringa trees act as a cardiac stimulant [68] which are evident to stabilize blood pressure [60] influence on diuretic activity [13] and reduce fat and cholesterol [69] to prevent hyperlipidemia [70] and reduce serum triglyceride and serum cholesterols [71].

Antiepileptic activity: Methanolic extract of *Moringa oleifera* leaves exhibit potent anti-convulsant activity against pentylenetetrazole and maximal electroshock induced convulsions at the dose levels of 200 mg/kg and 400 mg/kg administered intraperitonially. Diazepam and phenytoin were used as reference standard. Methanolic extract significantly delayed the onset of seizures in Ptz induced convulsions and significantly reduced duration of hind limb extension in MES test at both the dose levels. This may be because of the presence of alkaloids, flavonoids and tannins present in the extract [6]. Studies were performed to determine the *in-vivo* anti-convulsant effect of ethanolic extract of *Moringa concanensis* leaves (200 mg/kg, i.p) on MES and PTZ-induced seizures in Swiss albino mice. Observation revealed MES seizures, suppression of tonic hind limb extension. In PTZ seizures, abolition of the convulsions was noted. The ethanolic extract of *Moringa concanensis* leaves may produce its anti-convulsant effects via multiple mechanisms since it abolished the hind limb extension induced by MES as well as abolished seizures produced by PTZ [7]

Anti-fertility activity: Aqueous extract of *Moringa oleifera* roots was found to be effective as anti-fertility in presence or absence of estradiol dipropionate and progesterone. The *in-vivo* antifertility activity and histopathology study was done using aqueous extract to investigate the effect on histoarchitecture of the uterus during pre and post–implantation stages [12].

Antiurolithiatic activity: The *in-vitro* anti-urolithiatic activity was performed in aqueous and alcoholic extract of bark of *Moringa oleifera*. It showed reduction in weight of stone produced using ethylene glycol induced urothiasis. It also possesses both preventive and curative property [13]

CNS activity: *Moringa oleifera* leaves extract restores mono amine levels of brain, which may be useful in Alzheimer's disease. *In-vitro* anticonvulsant activity from the aqueous extract of *Moringa oleifera* roots and ethanolic extract of leaves was studied on penicillin induced convulsion, locomotor behaviour, brain serotonin (5-HT), dopamine and norepinephrine level and evaluated [22]. The pharmacological activity of *Moringa oleifera* is listed in tabular form in Table 2.

Effect of MO on body weight, lipid content and lipid profile
One of the most common anti-obesity mechanisms of herbs is through modifying the lipid profile of the individual, it is usually associated with reduction of total cholesterol (CHO), triglycerides (TG), low-density lipoprotein (LDL-C), very low-density lipoprotein (VLDL-C), and enhancement of high-density lipoprotein (HDL) (or high-density lipoprotein cholesterol (HDL-C)) levels. The effect of MO on lipid profile was the subject of several studies as summarized in Table 1. The effect of MO on lipid content was evaluated based on the lipid profile which included measurement of CHO, TG, LDL-C, VLDL-C, and HDL/HDL-C. A study considered the administration of methanolic MO extract to 50 male Albino Wistar rats at a dose of 250 mg/kg or 500 mg/ kg for 60 days, the extract was helpful in significantly decreasing the total CHO, TG, LDL-C, and VLDL-C levels, and significantly increasing the levels of HDL-C (Saleem, Al-Dujaily, & Al-Murshidi, 2016). Besides, several studies evaluated the potential of MO extract on the lipid profile of animals fed with high-fat diet (HFD). A study reported that the male C57BL/6J mice that were fed with HFD diet containing 0.1% leaf powder for 7 weeks, experienced a reduction in the increased levels of CHO, TG, and LDL-C due to HFD, and prevented hypercholesterolemia and fat deposition in the mice (Kim & Kim, 2019). In addition, another study also considered mice fed with HFD to evaluate the effect of petroleum ether MO extract on the lipid profile (Xie et al., 2018). The male C57BL/6J mice that were fed with HDF were administered with 0.125, 0.25, or 0.5 g/kg of MO extract and their lipid profile was analyzed. MO extract was successful in reducing the body weight, relative epididymal, perirenal, mesenteric fat weight and fat tissue size, hepatic fat accumulation, and levels of TC, LDL-C, and aspartate aminotransferase (AST) of the tested animals. Furthermore, it was also reported that MO extract helped significantly in decreasing the levels of CHO, TG, VLDL, and LDL, and increasing HDL levels in Albino Wistar rats that were fed with HFD and orally administrated with 200 or 400 mg/kg/day of methanolic MO extract for 3 weeks (Madkhali et al., 2019). In fact, the same study also suggested that the MO extract was efficient in decreasing the waist size, Lee index, BMI, and food intake, and reversing HFD-induced endothelium dysfunction. Moreover, a recent study also proved the capability of MO oil extract (dosage of 400 mg/kg) in reducing the body weight and the levels of CHO, TG, VLDL, and LDL, in

diet-induced obesity in Albino Wistar rats fed with HFD for 12 weeks (Greish et al., 2021). In fact, MO oil extract helped in increasing the level of HDL. The study also proved that MO oil extract can improve oxidative stress and male fertility markers in the diet-induced obesity of male rats.

Anti-ulcer *M. oleifera* seed extracts was studied for its antiulcer activity in the dose level of 150 and 200 mg/kg orally in pylorus ligation and compared with standard drug, omeprazole (20 mg/kg). The results have shown a significant ($P< 0.05$) reduction in the ulcer index such as reduction in gastric volume and decrease in free and total acidity which was comparable with the standard [48]. Das et al., investigated the protective effects of *M. oleifera* (200 mg/kg and 400 mg/kg body weight) on pyloric ligation gastric ulcers induced experimentally by ibuprofen in rats, famotidine (3.6 mg/kg) was used as a standard drug. Results revealed that *M. oleifera* extract show significant ($P<0.001$) reduction of the free and total acidity of gastric juice[49]. Further Verma et al., performed the antioxidant activity and antiulcer of *M. oleifera* leaves against ethanol and aspirin-induced gastric ulcer in rats which demonstrated that the alcoholic leaf extract of *M. oleifera* Lam. have shown a dose dependent protective effect against cold restraint stress, ethanol, pylorus-ligation and aspirin-induced gastric ulcer in rats[50]. Extracts of root-bark, stem bark and seed showed antiulcer activity against the ethanol-induced gastric ulcer in rats[48,51,52]. Several investigations suggested that the secondary metabolites such as flavonoids (quercetin) and tannins has antiulcer activity, steroids such as β-carotene and β-sitosterol reduces the gastric ulcer development, alkaloids such as moringine and moringinine in the root-bark treats ulcer. The antiulcer activity of *M. oleifera* is based on the stimulation of mucous membrane protective factors and antioxidant defense mechanism probably by metabolizing lipid peroxides and scavenging endogenous H2O2[48,50,51,53].
Anti-nephrotoxicity.

Paliwal and his research team investigated the *M. oleifera* pods extract for its antinephrotoxicity in 7,12 Dimethylbenz[a]anthracene (DMBA)-induced renal carcinogenesis of Swiss albino mice for 14 days, and assessed the altered renal oxidative stress parameters like superoxide dismutase, lipid peroxidation, and catalase in the kidney of mice. Altered renal oxidative stress parameters results were restored near to the normal values, after extract treatment [107]. The mechanism for its anti-nephrotoxicity is induction of antioxidant profile by the phytoconstituents such as β-carotene, vitamin A and C, also the oxidative free radical scavenging activities by the other phytoconstituents like phenolic, flavonoid and alkaloids. Mansour et al., evaluated the antihepatotoxicity and antinephrotoxicity activity of aqueous extract of M. oleifera leaves in rat. Hepatotoxicity and nephrotoxicity were induced by γ-radiation. Induction by γ-radiation showed significant modification in different biochemical parameters such as malondialdehyde, total nitrate/nitrite levels, superoxide dismutase, catalase, glutathione content, aminotransferase, alanine, aspartate aminotransferase, level of creatinine and urea nitrogen in serum. The treatment restored the modified biochemical parameters. The above study results demonstrated that free radical scavenging activity might be attributed for its nephroprotective effect[108].

It fights against free radicals

The antioxidants are popular due to the fact as they fight against free radicals that cause oxidative stress, cell damage, and inflammation. In addition to this, *Moringa* contains antioxidants called flavonoids, polyphenols, and ascorbic acid in the leaves, flowers, and seeds which are beneficial in many ways. A study found that leaf extracts has higher antioxidant activity, free-radical-scavenging capacity, and higher inhibition of lipid, protein, and DNA oxidation than flowers and seeds. This means it prevents the damage and degradation that free radicals cause in the cells of different organs in the body, keeping them healthy and functioning at their best [19].

Anti- inflammatory

The most promising uses of *Moringa* extract is in the treatment of many types of chronic and acute inflammations. Inflammation can lead to chronic diseases like diabetes, respiratory problems, cardiovascular disease, arthritis, and obesity. *Moringa* reduces inflammation by suppressing inflammatory enzymes and proteins in the body, and leaf concentrate can significantly lower inflammation in the cells [20].

Supports brain health

Moringa strongly support for brain health and boost cognitive power due to its antioxidant and neuro-enhancer activities. It has shown several preliminary result as a treatment of Alzheimer's disease. The high amount of vitamin C and E helps to improve brain function and also normalize the neurotransmitters serotonin, dopamine and noradrenalin in the brain which play a key role in memory, mood, organ function, responses to stimulus such as stress and pleasure, and mental health like depression and psychosis.

Enhances wound healing

Moringa has blood-clotting properties in its leaves, roots, and seeds that benefit wound healing and can reduce clotting time, which means it reduces the time it takes for scratches, cuts, or wounds to stop bleeding. Antipyretic and wound healing properties from the ethyl acetate and ethanolic extracts of *Moringa oleifera* leaves were described by V.I. Hukkeri. The ethanolic and ethyl acetate extracts of seeds defines significant antipyretic activity in rats, where ethyl acetate extract of dried leaves presents wound healing activity (10% extracts in the form of ointment) on excision, incision and dead space (granuloma) wound models in rats [22].

Anti-diabetic and anti-obesity activities

People around the world have exploited herbal medicine to solve their health challenges and ultimately for a healthier living (96). Diabetes, being a protracted metabolic malady of the endocrine system, is characterized by abnormalities in carbohydrates, protein, and fat metabolism (97,98). The

incidence of diabetes is increasing at an alarming rate with the attendant high cost of management/treatment and its related complications (96,99-101). In 2012 alone, diabetes caused 1.5 million deaths with an increased projection estimated in recent years (99,101). Stroke, heart attack, overweight, kidney failure, obesity, leg amputation, vision loss, and nerve damage are some of the complications of diabetes. Obesity in Africa is also on the increase, being associated with various medical conditions that may lead to death. An imbalance in the intestinal flora is one of the main factors related to obesity and metabolic disorders. The human gut microbiome undertakes a variety of metabolic functions such as the breakdown of complex organic substances into easily digestible sources of energy. *M. oleifera* possesses antidiabetic, hypo- and hyperglycemia effects (1,102). Consequently, the antidiabetic therapeutic effect of *M. oleifera* has been attributed to its polyphenols content to reduce blood glucose and lipids concentration after ingestion (96). According to the investigation of Abd Eldaim et al (103), *M. oleifera* leaves aqueous extract significantly ameliorated hepatotoxicity and reduced hyperglycemia in alloxan-induced diabetic rats. In another study designed to demonstrate the efficacy of *M. oleifera* ethanolic extract in rats induced with high-fat diet obesity, body weight was significantly reduced in rats treated with the extracts (104). Potential hypoglycemic activity of phenolic glycosides from *M. oleifera* seed also showed significant therapeutic properties in reducing blood pressure, blood sugar and enhancing the immune system in humans (105). *M. oleifera* leaves extract was thus confirmed to exhibit hypolipidemic and antiobesity potentials with the capacity to protect the body against negative effects of high fat diet-induced obesity.

Numerous non-diabetic and diabetic animal studies have demonstrated the antidiabetic effect of *M. oleifera* leaf extracts to reduce plasma glucose levels and increase glucose tolerance (29,106,107). A significant decrease in the level of plasma glucose was reported in rats having diabetes using *M. oleifera* leaves extract (76). The study of Jaiswal et al (107) also established the antidiabetic effect of constant consumption of the leaves of *M. oleifera* as a therapeutic means to protect diabetic patients against oxidative damage. The leaf preparation of the plant was also shown to significantly ameliorate streptozotocin-induced diabetes milletus in adult rats with the outcome of a reduction in biomarkers of diabetes (108). Alejandra Sanchez-Munoz et al (109) recently demonstrated the effect of *M. oleifera* extract on supercomplex formation, ATPase activity, ROS production, glutathione (GSH) level, lipid peroxidation, and protein carboxylation. Their findings indicated that hyperglycemia modifies oxygen consumption, supercomplexes formation, and increases ROS levels of STZ-diabetic rats while *M. oleifera* treated rats were protected against some alterations. Recently, Leone et al (110) demonstrated the potential hypoglycemic capabilities of the powdered form of the leaves of *M. oleifera* on postprandial blood glucose response on Saharawi people living in refugee camps and confirmed *M. oleifera* leaf powder as a possible hypoglycemic herbal drug. Several other reports have validated the antidiabetic activities of *M. oleifera* leaf and seed extracts in diabetic rats (62,110-112). Overall, *M. oleifera* leaves were confirmed to lower postprandial blood pressure (50).

4. Conclusion

Moringa is a well-known herb due to its pharmacological and therapeutic properties. It has many bio-active components which provide additional health benefits beyond the essential needs. Due to its high nutritional bio availability and medicinal properties it aids against different aliment such as diabetes, elevated blood pressure, cancer, antioxidant activity of disease prevention, such as: cardiac attack, obesity, Parkinson's disease and Alzheimer's disease. *Moringa* extracts controls hypercholesterolemia which leads to increase in body weight, total cholesterol, triglycerides, and reduction in the levels of HDL. It indicates that there is a significant decrease in hepatic biomarkers levels and glucose levels. *Moringa* also has a major thermogenic impact because it serves as hypolipidemic in problems related to obesity. *Moringa* still seems to be a "miracle" plant with endless advantages for mankind that’s why it was available at a very reasonable price as a high-quality nature gift.

5. References

[1] N. Z. Abd Rani, K. Husain, and E. Kumolosasi, “Moringa genus: a review of phytochemistry and pharmacology,” Frontiers in Pharmacology, vol. 9, p. 108, 2018.

[2] J. W. Fahey, “Moringa oleifera: a review of the medical evidence for its nutritional, therapeutic and prophylactic properties. Part 1,” Trees for Life Journal, vol. 1, no. 5, pp. 1–15, 2005.

[3] P. Siddhuraju and K. Becker, “Antioxidant properties of various solvent extracts of total phenolic constituents from three different agroclimatic origins of drumstick tree (Moringa oleifera Lam.) leaves,” Journal of Agricultural and Food Chemistry, vol. 51, no. 8, pp. 2144–2155, 2003.

[4] B. A. Anhwange, V. O. Ajibola, and S. J. Oniye, “Chemical studies of the seeds of Moringa oleifera (Lam) and Detarium microcarpum (Guill and Sperr),” Journal of Biological Sciences, vol. 4, no. 6, pp. 711–715, 2004.

[5] M. Busani, J. M. Patrick, H. Arnold, and M. Voster, “Nutritional characterization of Moringa (Moringa oleifera Lam) leaves,” African Journal of Biotechnology, vol. 10, no. 60, pp. 12925–12933, 2011.

[6] L. Gopalakrishnan, K. Doriya, and D. S. Kumar, “Moringa oleifera: A review on nutritive importance and its medicinal application,” Food Science and Human Wellness, vol. 5, no. 2, pp. 49–56, 2016.

[7] P. T. Olagbemide and P. C. Alikwe, “Proximate analysis and chemical composition of raw and defatted Moringa oleifera kernel,” Advances in

Life Science and Technology, vol. 24, pp. 92–99, 2014.

[8] B. Uphadek, D. M. Shinkar, P. B. Patil, and R. B. Saudagar, "Moringa oleifera as a pharmaceutical excipient," International Journal of Current Pharmaceutical Research, vol. 10, no. 2, pp. 13–16, 2018.

[9] M. D. Thurber and J. W. Fahey, "Adoption of Moringa oleifera to combat under-nutrition viewed through the lens of the "diffusion of innovations" theory," Ecology of Food and Nutrition, vol. 48, no. 3, pp. 212–225, 2009.

[10] [34] M. R. Berger, M. Habs, S. A. A. Jahn, and D. Schmalhl, "Toxicological assessment of seeds from Moringa oleifera and Moringa stenopetala, two highly efficient primary coagulants for domestic water treatment of tropical waters," East African Medical Journal, vol. 61, no. 9, pp. 712–716, 1984.

[11] M. Mbikay, "Therapeutic potential of Moringa oleifera leaves in chronic hyperglycemia and dyslipidemia: a review," Frontiers in Pharmacology, vol. 3, p. 24, 2012.

[12] J. T. Barminas, M. Charles, and D. Emmanuel, "Mineral composition of non-conventional leafy vegetables," Plant Foods for Human Nutrition, vol. 53, no. 1, pp. 29–36, 1998.

[13] L. A. Pham-Huy, H. He, and C. Pham-Huy, "Free radicals, antioxidants in disease and health," International Journal of Biomedical Sciences, vol. 4, pp. 89–96, 2008.

[14] K. K. Kattappagari, C. R. Teza, R. K. Kommalapati, C. Poosarla, S. R. Gontu, and B. V. R. Reddy, "Role of antioxidants in facilitating the body functions: a review," Journal of Orofacial Sciences, vol. 7, no. 2, pp. 71–75, 2015.

[15] S. K. Al-Taweel and I. H. Al-Anbari, "Review article Moringa olifera: a review on the phytochemical screening, proximate analysis, medicinal, nutritional, and plant biostimulants values of its leaves, pods, seeds and roots," Plant Archives, vol. 19, no. 2, pp. 1612–1622, 2019.

[16] K. Z. Khor, V. Lim, E. J. Moses, and N. A. Samad, "The in vitro and in vivo anticancer properties of Moringa oleifera," International Journal of Food Science 9 Evidence-Based Complementary and Alternative Medicine, vol. 2018, Article ID 1071243, 14 pages, 2018.

[17] Somali M., *et al*. "Chemical composition and characteristics of Moringa peregrina seeds and seeds oil". *Journal of American oil Chemist's Society* (1984): 85-86.

[18] Morton FJ. "The Horseradish Tree, Moringa pterygosperma (Moringaceae): A boon to arid lands". *Economic botany* (1991): 318-333.

[19] Leone A., *et al*. "Cultivation, Genetic, Ethnopharmacology, Phytochemestry and Pharmacology of Moringa oleifera Leaves: An Overview". *International Journal of Molecular Science* (2015).

[20] Janick J and Paull R. The Encyclipedia of Fruits and Nuts. Walling ford, United Kingdom: Cabi Publishing (2018).

[21] Gopalkrishan L., *et al*. "Moringa oleifera: A review on nutritional importance and its medicinal application". *Food Science and Human Wellness* 8 (2016).

[22] Freiberger C., *et al*. "Nutrient content of edible leaves of seven wild plants from Niger". In Plants Food for human Nutrition (1998): 57-69.

[23] Glover AM and F M. "Nutritional evaluation of Moringa oleifera Leaves using three drying methods". *Journal of Resistant Biology* (2012): 469-473.

[24] Daba, M. "Miracle tree: A review on multipurpose of Moringa oleifera and its Implication for climate change mitigation". *Earth Science Climate Change* (2016).

[25] Gandhi K., *et al*. "Status and Utilization of Moringa oleifera Lam: A review". *African crop science Journal* 26 (2018): 137-156.

[26] Dixit S., *et al*. "Medicinal properties of Moringa oleifera: A Review". *International Journal of Education and Science Research Review* (2016).

[27] Chaudhary K and Chaurasia, S. "Neutraceutical Properties of Moringa oleifera : A Review". *European journal of Pharmaceutical and medical research* (2017): 646-655.

[28] Khor Z., *et al*. "The in- vivo and in-vitro anticancer properties of Moringa". *Hindawi* (2018).

[29] Alegbeleye OO. 2018. How functional is *Moringa oleifera*. A review of its nutritive, medicinal, and socioeconomic potential. Food and nutrition bulletin 39(1), 149-70.

[30] Ali M, Khan T, Fatima K, Ali QU, Ovais M, Khalil AT, Idrees M. 2018. Selected hepatoprotective herbal medicines: evidence from ethnomedicinal applications, animal models, and possible mechanism of actions. Phytotherapy Research 32(2), 199-215.

[31] Christianto V, Smarandache F. 2019. On the Efficacy of *Moringa oleifera* as Anticancer Treatment: A Literature Survey. BAOJ Cancer Research & Therapy 5, 69-71.

[32] Fakurazi S, Sharifudin SA, Arulselvan P. 2012. *Moringa oleifera* hydroethanolic extracts effectively alleviate acetaminophen-induced hepatotoxicity in experimental rats through their antioxidant nature. Molecules 17(7), 8334-8350.

[33] Helmy SA, Morsy NF, Elaby SM, Ghaly MA. 2017. Hypolipidemic effect of *Moringa oleifera* Lam leaf powder and its extract in diet-induced hypercholesterolemic rats. Journal of medicinal Food, 20(8), 755-762.

[34] Kooltheat N, Sranujit RP, Chumark P, Potup P, Laytragoon-Lewin N, Usuwanthim K. 2014. An ethyl acetate fraction of *Moringa oleifera* Lam. inhibits human macrophage cytokine production

induced by cigarette smoke. Nutrients, 6(2), 697-710.

[35] Kou X, Li B, Olayanju B, Drake JM, Chen N. 2018. Nutraceutical or pharmacological potential of *Moringa oleifera* Lam. Nutrients 10(3), 343.

[36] Sharma VR. Paliwal R, Sharma S. Phytochemical analysis and evaluation of antioxidant activities of hydro-ethanolic extract of *Moringa oleifera Lam*. J Pharm Res. 2011; 4(2):554-7.

[37] Amrutia J, Lala M, Srinivasa, Moses RS. Anticonvulsant activity of *Moringa oleifera* leaf. International Research Journal of Pharmacy. 2011, 2(7): 160-2.

[38] Joy AE, Kunhikatta SB, Manikkoth S. Anti-convulsant activity of ethanolic extract of *Moringa concanensis* leaves in Swiss albino mice. Arch Med Health Sci. 2013, 1(1):6-9.

[39] 8. Ndong M, Uehara M, Katsumata S, Suzuki K. Effects of oral administration of *Moringa oleifera* Lam on glucose tolerance in gotokakizaki and wistar rats. J of Clin Biochem and Nutri. 2007;40:229-33.

[40] Gupta R, Mathur M, Bajaj VK, Katariya P, Yadav S, Kamal R, *et al*. Evaluation of antidiabetic and antioxidant activity of *Moringa oleifera* in experimental diabetes. J Diabetes. 2012, 4(2):164-71.

[41] Gilani AH, Aftab K, Suria A, Siddiqui S, Salem R, Siddiqui BS, *et al*. Pharmacological studies on hypotensive and spasmolytic activities of pure compounds from *Moringa oleifera*. Phytother Res. 1994, 8(2): 87-91.

[42] Shukla S, Mathur R, Prakash AO. Antifertility profile of the aqueous extract of *Moringa oleifera* roots. J Ethnopharmacol. 1998, 22(1): 51-62.

[43] Fahad J, Vijayalakshmi, Satish Kumar MC, Sanjeeva, Kodancha GP, Adarsh B, *et al*. Antiurolithiatic activity of aqueous extract of bark of *Moringa oleifera* (lam.) in rats. Health. 2010, 2(4): 352-5.

[44] Agrawal B, Mehta A. Antiasthmatic activity of *Moringa oleifera Lam*: a clinical study. Indian J Pharmacol. 2008, 40(1): 28–31.

[45] Mishra G, Singh P, Verma R, Kumar S, Srivastav S, Jha KK, *et al*. Traditional uses, phytochemistry and pharmacological properties of *Moringa oleifera* plant: an overview. Scholars Research Library. 2011, 3(2):141-64.