Ethnomedicinal Properties and Pharmacological Uses of *Moringa oleifera*

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Moringa oleifera (*M. oleifera*), the “miracle tree”, thrives globally in almost all tropical and subtropical regions, but it is believed to be native to Afghanistan, Bangladesh, India, and Pakistan. The Moringa family comprises 13 species (*M. oleifera*, *M. arborea*, *M. rivae*, *M. ruspoliana*, *M. drouhardii*, *M. hildebrandtii*, *M. concanensis*, *M. borziana*, *M. longituba*, *M. pygmaea*, *M. ovalifolia*, *M. peregrina*, *M. stenopetala*), of which *M. oleifera* has become well known for its use in nutrition, biogas production, fertilizer, etc. Moringa has the unique property of tolerating drought. Studies have shown that *M. oleifera* is among the cheapest and most reliable alternatives for good nutrition. Nearly all parts of the tree are used for their essential nutrients. *M. oleifera* leaves have a high content of beta-carotene, minerals, calcium, and potassium. Dried leaves have an oleic acid content of about 70%, which makes them suitable for making moisturizers. The powdered leaves are used to make many beverages, of which “Zija” is the most popular in India. The bark of the tree is considered very useful in the treatment of different disorders such as ulcers, toothache, and hypertension. Roots, however, are found to have a role in the treatment of toothache, helminthiasis, and paralysis. The flowers are used to treat ulcers, enlarged spleen, and to produce aphrodisiac substances. The tree is believed to have incredible properties in treating malnutrition in infants and lactating mothers.

Moringa oleifera | compound | seeds | Ethanomedicinal uses

1. Ethnomedicinal/Traditional Properties

People worldwide have included *M. oleifera* in their diet since ancient times because of its vital therapeutic values (**Table 1**). Various medicines made from the plant are said to have ethnomedicinal properties for curing diseases and have been used for centuries. Approximately every part (leaf, pod, bark, gum, flower, seed, seed oil, and root) of this plant has been used to treat one disease or another [1]. Uses of *M. oleifera* are observed in pathological alterations such as antihypertensive [2], anti-anxiety [3], anti-diarrheal [4], and as a diuretic [5]. Moringa is also used to treat dysentery [6] and colitis [7]. A poultice made from Moringa leaves is a quick remedy for inflammatory conditions such as glandular inflammation, headache, and bronchitis [8]. The pods treat hepatitis and relieve joint pain [9]. The roots are conventionally used to treat kidney stones [10], liver diseases [11], inflammation [12], ulcers [13], and pain associated with the ear and tooth [14]. The bark of the stem is used to treat wounds and skin infections [15]. Indians use the gum extracted from this plant to treat fever, and it is also used to induce abortions [16]. The seeds of the plant act as a laxative and are used in the treatment of tumors, prostate, and bladder problems [17]. The seeds

show promise for the treatment of arthritis by altering oxidative stress and reducing inflammation [18]. Preparations from the plant leaves benefit nursing mothers and malnourished infants and improve the general health of the population. The leaves have been useful for patients suffering from insomnia [19] and treating wounds [20]. Moringa is used incredibly extensively in the cosmetic industry nowadays, and in ancient Egyptian history, it was similarly used for preparing dermal ointments [21].

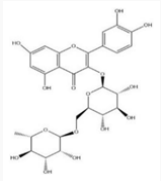
Table 1. Uses of Moringa oleifera listed in Ayurvedic medicinal textbook.

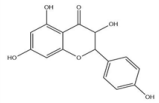
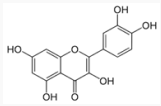
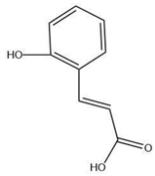
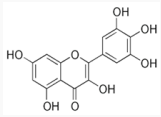
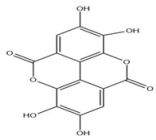
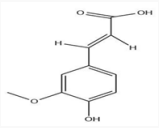
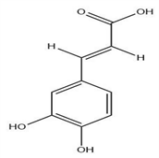
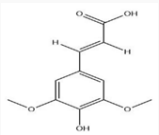
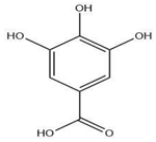
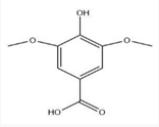
Name of Ayurvedic Text	Form of Plant Used	Treatment	References
Charaka Samhita (1000 BC- 4th Cent. AD)	Powder Decoction	Used for treatment of worms and headache, Ascites, edema Hiccough and asthma, deafness, tinnitus in the ear, worm's manifestation.	[22]
Ashtanga Hridaya (7th Cent. AD)	Oil	Ear ache, deafness, and tinnitus in the ear	[23]
Kashyapa Samhita (6–7th Cent AD)	Decoction Oil	Puerperal disorder, sleeplessness Edema	[24]
Sharangadhara Samhita (13 Cent. AD)	Decoction	Conjunctivitis	[25]
Yogaratnakara (17th Cent. A.D.)	Decoction	Enlargement of spleen, worm edema, Ascites, fever, abscess.	[26]

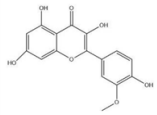
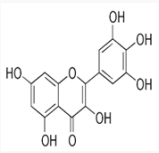
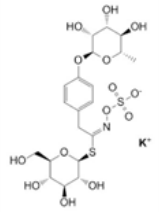
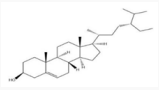
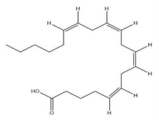
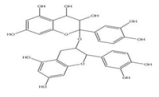
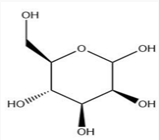
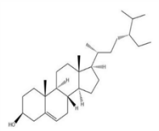
2. Pharmacological Uses

Recent pharmacological studies have revealed that different extracts of *M. oleifera* exhibit different pharmacological activities, such as antimicrobial [27], antifungal [28], anti-inflammatory [29], antioxidant [30], anticancer [31], fertility [32], wound healing [27], and other pharmacological activities mentioned below (**Table 2**).

Table 2. Phytoconstituents of Moringa and their relevant therapeutic effects.

Plant Part	Compound	Class	Structure	Therapeutic Activity	References
Leaves	Rutin (555.6 µg/g)	Flavonoid		Found to have maximum affinity and interaction towards BRAC-1 gene.	[33][34]

Leaves	Kaempferol (197.6 µg/g)	Flavonoid		Oxidative damage protective activity.	[35]
Leaves	Quercetin (2030.9 µmol/100 g)	Flavonoid		Exerts an excellent effect as anti-diabetic agent.	[36]
Leaves	O coumaric acid (0.536 mg/g)	Phenolic acid		Antioxidant and anti-microbial	[37][38]
Leaves	Myricetin (5.804 mg/g)	Flavonoid		Potential prevention of diabetes mellitus and other diabetic complications	[38]
Leaves	Ellagic acid (0.078 to 0.128 mg/g)	Polyphenol		Prevents viral and bacterial infections, potential antioxidant	[38][39]
Leaves	Ferulic acid (0.078 to 0.128 mg/g)	Phenol		Promising results as anti-cancer, antioxidant, antithrombotic, anti-arrhythmic, and anti-inflammatory.	[38][40]
Leaves	Caffeic acid (0.409 mg/g)	Phenol		Boosts athletic performance, reduces fatigue, helps weight loss, protects against herpes, HIV, cancer.	[38][41]
Leaves	Sinapic acid (trace amount)	Phenol		Cardioprotective, renoprotective, anxiolytic, neuroprotective.	[38][42]
Leaves	Gallic acid (1.034 mg/g)	Phenol		Anti-inflammatory, anti-neoplastic, anti-oxidant	[38][43]
Leaves	Syringic acid (trace amount)	Phenol		Anti-oxidant, antimicrobial.	[38][44]

Leaves	Isorhamnetin (0.118 mg/g)	Flavonoid		Anti-oxidant	[38][45]
Seeds	Myricetin (5.804 mg/g)	Flavonoid		Potential prevention of diabetes mellitus and other diabetic complications	[38]
Seeds	Glucomoringin	Glucosinolates		Anti-inflammatory, pain relieving, anti-oxidant, antihypertensive.	[46]
Seeds	β-sitosterol	Phytosterol [53]		Anti-inflammatory	[47]
Seeds	Arachidic acid	Fatty acid		Increased breast milk production	[48]
Seeds	Oleic acid (70% *w*/*w*)	Fatty acid	 [28]	Reduces blood pressure and reduces free radical damage to the cell.	[49]
Seeds	Myristic acid	Fatty acid	[27]	Anxiolytic effect, used in membrane [55] localization of the enzyme.	[50]
Seeds	Palmitic acid	Fatty acid		Trypanocidal and anti-leukemic effect	[51]
Seeds	Procyaniadin [56]	Flavonoid		Cardioprotective	[52]
Flower	D-mannose	Carbohydrate [57]		Treatment of deficiency caused by genetic defects, and acute urinary tract infections. [58]	[53]
Stem	β-sitosterol	Phytosterol		Anti-oxidant, cardiovascular, immunomodulatory	[47]

A significant anti-inflammatory effect was observed in different parts of *M. oleifera* (leaf, pods, flowers, and roots). It was observed that the isolated compound (4-[2-o-Acetyl-alpha -l-rahamnoslyloxy) benzyl] thiocynate from Moringa possessed nitric oxide inhibitory activity and was subsequently found to be effective in Raw264.7 cell lines [59]. A compound derived from *M. oleifera* roots, known as aurnatiamide acetate and 1,3-dibenzylurea, inhibited TNF-α

production [60]. Active compounds such as tannins, phenols, alkaloids, flavanoids, carotenoids β-sitosterol, vanillin, and moringin have anti-inflammatory properties [16]. The *M. oleifera* fruit extract blocked nuclear factor kappa B (NF κB) translocation, and the chloroform extract was found to be cytotoxic at high concentrations (500–1000 µg/mL) [61]. *M. oleifera* leaves extract was used in mice for treating atopic dermatitis in human keratinocytes and was found to be effective in reducing the expression of mannose receptor mRNA, thymic stromal lymphopoietin, and retinoic acid-related orphan receptor γT in ear tissues (**Figure 1**) [62].

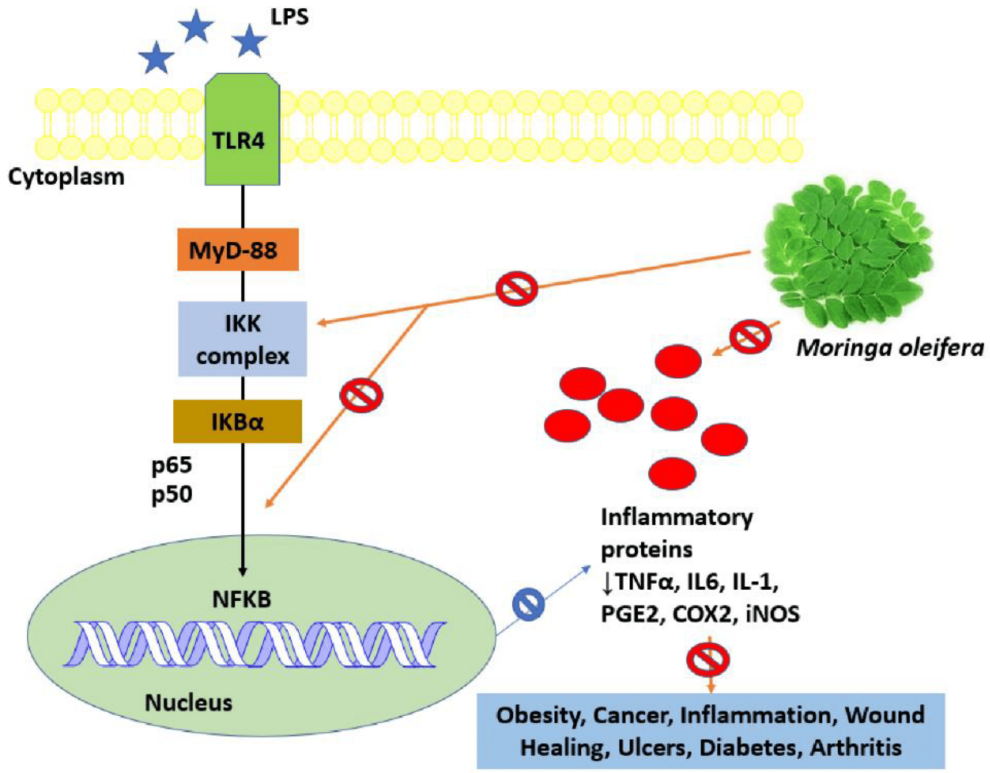


Figure 1. *M. oleifera*, as an oxidative and inflammatory marker, inhibits IKBα phosphorylation, thereby preventing NFKB (nuclear factor kappa B) inhibition. It prevents the nuclear translocation and dimerization of IkBα and NFKB, thereby inhibiting the formation of inflammatory proteins such as TNFα(tumor necrosis factor), COX-2(cyclooxygenase-2), IL6(interleukin -6), and iNos(inducible nitric oxide synthase) and thereby reducing the inflammation and curing other disorders like obesity, arthritis, cancer, diabetes, and ulcer.

2.3. Oxidative Stress

The results of *M. oleifera* were observed in methotrexate-induced mice. The study aimed to look into a probable palliative effect of *M. oleifera* extract on mice. The mice received the extract one week before administering methotrexate injection, and this treatment was continued for 12 days. The result showed that pretreatment with an extract of *M. oleifera* on mice poisoned with methotrexate could protect them from oxidative stress [63].

The antioxidant activity of ethanolic extract *M. oleifera* stems exhibited a protective effect against epidermal oxidative stress injury induced by H_2O_2 in keratinocytes. The result displayed that the stems showed antioxidant

potential, and, therefore, can be used as an excellent and preventive source in animal epidermal oxidative stress injury [64].

The research investigated the antioxidant potential of Moringa leaves against diclofenac sodium-induced liver toxicity in animals. The researchers concluded that the extract was significantly effective against diclofenac-induced liver toxicity and, therefore, can be considered liver protective [65].

2.4. Anti-Oxidant Activity

Bioactive compounds such as glycosylates [66], isothiocyanates [46], thiocarbamates [67], flavonoids [68], and certain other compounds from Moringa pods have been investigated for reactive oxygen spices. The aqueous extract has been shown to be a potent free radical scavenger against free radicles [29]. Previous studies suggest that the antioxidant potential might be due to kaempferol, which is mainly found in plant leaves [27]. The synergistic outcome of Moringa was observed with piperine and curcumin on oxidative stress induced by beryllium toxicity in Wistar rats [69]. The alcoholic extract of the plant reduced glucose-induced cataractogenesis in isolated goat eye lenses by controlling GSH levels [70]. Myricetin, derived from the Moringa seed extract, has proved to be a better antioxidant than BHT (butylated hydroxytoluene) and alpha-tocopherol. *M. oleifera* leaf extract and compounds, such as isoquercetin, astragalin, and crypto-chlorogenic acid, help lower ROS in HEK-293 cells [71]. Moringa is also helpful in reducing plasma monoaldehyde (MDA) levels in fasting plasma glucose (FPG) concentration in healthy volunteers compared to the individuals fed with warm water. A dose-dependent upsurge in GSH and reduced MDA levels were observed with alcoholic extract of the plant without toxic effect till 100 mg/kg (**Figure 1**) [30].

2.5. Anti-Cancer Activity

Several parts of moringa (fruits, leaves, flowers, stems) have been shown to be beneficial against cancer, a deadly disease. The isolated compounds thiocarbamate and isothiocyanate from moringa act as inhibitors of tumor cells [31][72]. The dichloromethane fraction was found to be cytotoxic for MCF7 breast cancer cells [73]. Niazimincin has been projected as an effective chemopreventive agent in chemical carcinogenesis [28]. Alcoholic and hydro-methanolic extracts of fruits and leaves have shown significant tumor growth retardation in the melanoma mouse model [16]. Soluble cold distilled water from Moringa inhibited tumor cell growth and reduced ROS (reactive oxygen species) in cancer cells [29]. A recent study based on computational modelling suggests that M. oleifera contains rutin with the highest binding affinity with BRAC-1 (Breast Cancer Gene-1) [33].

2.6. Fertility and Anti-Fertility Activity

Adding to the list of beneficial effects of Moringa, the various parts of the plant possess fertility and abortion-inducing properties. The aqueous extract at a 200 and 400 mg/kg dose has been found to be more abortifacient and anti-fertility effects [28]. Recent studies on hot and cold extracts of leaves of *M. oleifera* propose that ingestion of Moringa before, after, and during pregnancy may lead to adverse fetal developmental outcomes by causing rigorous contraction of the uterine wall [74].

2.7. Hepatoprotective Activity

Among the numerous flavonoids (quercetin, kaempferol, isoquercetin, rhamnetin, etc.,) present in Moringa, quercetin in Moringa flowers is thought to be accountable for the hepatoprotective effect [28]. Methanolic extract at low dose showed changes in hepato-renal and hematological profile with significant changes in serum aminotransferase concentration, plasma cholesterol level, alkaline phosphate, bilirubin, and serum LPO levels. However, the higher dose of the extract altered total bilirubin, blood urea nitrogen, and non-protein nitrogen levels and decreased the clotting time [27]. Liver injuries induced by acetaminophen in Sprague-Dawley rats, where the standard drug taken was silymarin, Moringa showed similar hepatoprotective properties in these rats by dropping the levels of AST, ALT, and ALP [75]. The seeds were also found to be effective against carbon tetrachloride-induced liver fibrosis, as evidenced by a reduction in serum aminotransferase activity and globulin levels [76]. Treatment with this plant extract for about 21 days regularly as diet significantly reduced liver injury, and this effect was found due to alkaloid, quercetin, kaempferol, flavonoids, ascorbic acid, and benzyl glucosinolates in this plant [16].

2.8. Cardiovascular Activity

The freeze-dried aqueous and alcoholic extract of *M. oleifera* showed cardioprotective activity in animals induced with myocardial infarction by isoproterenol [77]. Chronic treatment of *M. oleifera* was effective on isoproterenol-induced hemodynamics and improved the levels of enzymes such as SOD, catalase, lactase dehydrogenase, glutathione peroxidase, and creatine kinase [77]. Butanolic extract has been proven to be a rich antioxidant source in rats with cardiac necrosis induced with isoproterenol. Moreover, it was found to significantly reduce inflammatory levels and myocardial necrosis due to the presence of the compound N-α-rhamnopyranosyl vincosamide [78]. Moringa leaves significantly lowered cholesterol levels by showing a protective effect on hypertensive rats. The active constituents believed to be responsible for this activity were identified as niazirmin A, niazirimin B, and niazimincin [16].

2.9. Anti-Ulcer/Gastroprotective Activity

Bisphenols and flavonoids found in moringa leaves showed a reduced level of ulcer index, duodenal ulcer, and stress ulcer in the ibuprofen-induced gastric ulcer model [16]. Moringa extract was shown to significantly reduce free radicals and neutralize the acidic behavior of gastric juice and have a protective effect on the development of gastric ulcer [79]. The presence of flavonoids in the plant has been shown to have a protective effect on ulcer formation by increasing capillary resistance and improving microcirculation, resulting in less cell injury [80].

2.10. Analgesic/Antipyretic Activity

Moringa leaf extract shows analgesic activity in almost all tree parts in central and peripheral animal models [16]. Multiple factions of alcoholic extracts such as petroleum ether, n-butanol, ethyl acetate, and dimethyl ether were found to have potent analgesic activity compared to standard aspirin [81]. At a dosage of 30–300 mg/kg, the polar and non-polar extract of leaves showed a remarkable drop in prostaglandin and bradykinin levels compared to the seed and root extract in a nociceptive study of formalin-induced paw edema [81]. The ether and ethyl acetate

fractions of the seeds were studied in a hyperpyrexia model [82], keeping paracetamol as standard 200 mg/kg, and the extract proved to have the best antipyretic activity among all [29].

2.11. Neuropharmacological Activity

Previous results have proved that leaves extract reestablishes levels of monoamine in the brain and is very helpful in Alzheimer's disease, while the in vitro activity of the ethanolic extract of the leaves showed an anticonvulsant effect on dopamine and norepinephrine levels, locomotor activity, and serotonin (5HT) in the brain in penicillin-induced convulsions [83][84]. The methanolic root extract in mice induced by pentobarbital sodium and diazepam has remarkable sedative effects on the CNS by improving sleep duration [19]. The toluene acetate fraction of the methanolic extract proved its potency as a possible nootropic agent [82]. The leaves have shown good anticonvulsant activity in a phenyl tetrazoline and maximal electric shock-induced model using male albino mice [83]. The aqueous extract of the roots blocked the epileptic seizures induced by penicillin in adult albino rats [84]. The ethanolic leaves extract exhibited anxiolytic properties, which were confirmed in behavioral experiments using the actophotometer and the rotarod device, respectively (**Figure 2**) [16].

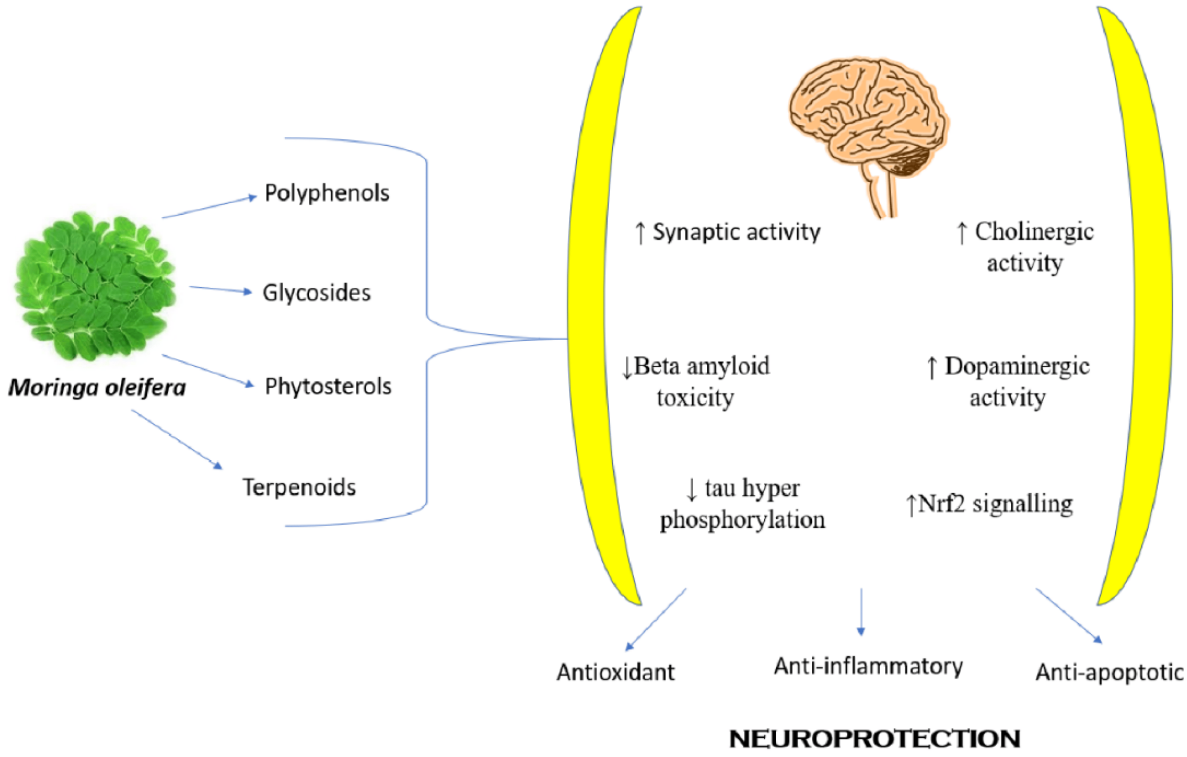


Figure 2. The various phytoconstituents present in *M oleifera* are responsible for numerous neuroprotective effects. *M. oleifera* is responsible for upregulating synaptic activity, cholinergic activity, dopaminergic activity, signaling of NrF2 (Nuclear factor erythroid 2-related factor 2), and simultaneously decreasing beta-amyloid toxicity and phosphorylation of tau proteins.

2.12. Neuropathic Pain

The broad spectrum of phytoconstituents of the leaves extract of Moringa has led researchers to develop a herbal alternative for treating chronic neuropathic pain caused by constriction. The need to limit conventional analgesics for this disease. Diabetic rats inflicted with neuropathic pain caused by chronic constriction were used for the study. Tests conducted before and after treatment with moringa leaves showed that they significantly altered the neuropathic pain condition in diabetic rats. It suggests that the drop in oxidative stress might be the underlying mechanism in treating neuropathic pain and thus could be used as an effective novel source for the same [85].

A research team explored the bio-guided fractions of Moringa seed extract on a diabetes-induced neuropathic pain model. After conducting various oxidative and other experimental studies on induced and treated rats, the team concluded that the extract-treated rats exhibited reasonable glycemic control and antinociceptive properties and proved to be a powerful neuroprotective agent with a high margin of safety (**Figure 5**) [86].

2.13. Wound Healing Effect

A significant effect in studies on wound healing after incision or excision was demonstrated for ethyl acetate, and water extract of *M. oleifera* leaves at a 300 mg/kg dose [27]. Studies reported that in preclinical studies, leaves, seeds, and dried pulp extracts have shown effective enhancement of wound closure, granuloma rupture strength, and reduction of skin rupture strength in the scar area [87]. Leaf extracts have shown promising results in diabetic animals by improving the downregulation of inflammatory markers and increasing the vascular endothelial growth factor level in the injured tissue [16]. Compounds present in aqueous extract have shown a considerable effect on diabetic foot ulcers by downregulating the levels of various inflammatory markers [87]. The researcher conducted an in vitro assay to select the standardized extract with the highest potency, which was then converted into a film for wound healing. The result showed that the aqueous extract had the maximum cell proliferation and migration properties among the different extracts [88].

2.14. Immunomodulatory Activity

Methanolic extract of the plant contains active constituents such as isothiocyanate and glycoside cyanide, which exhibit immunostimulatory activity and effectively enhance immunity. The recent research suggests that various bioactive compounds have been used to treat various immune-related disorders such as cancer, hypertension, and diabetes, thereby enhancing host immunity [89].

2.15. Hematological Activity

M. oleifera has demonstrated its significant benefits in hematological activities. A randomized, double-blind study suggests that aqueous leaf extract effectively improves women's low hemoglobin levels (8–12 g/dL) [90]. Another study showed that *M. oleifera* leaves, when taken for 14 days by healthy volunteers, significantly improved platelet counts [16].

2.16. Anti-Obesity Activity

In a study, oral treatment with leaf powder of *M. oleifera* for a duration of nearly 49 days was found to significantly reduce body mass index (BMI) in rats suffering from hypercholesterolemia [91]. The mechanistic approach behind this was the downregulation of mRNA expression of the hormones resistin and leptin and the concomitant increase in regulation of the gene adiponectin in rats [16]. A recent study revealed the mechanistic approach for the anti-obesity effect of *M. oleifera*. The plant significantly improved lipid profile by reducing body weight. It also regulated adipogenesis-related genes, increased glucose tolerance, and decreased levels of hormones such as vaspin, leptin, and resistin (**Figure 3**) [92].

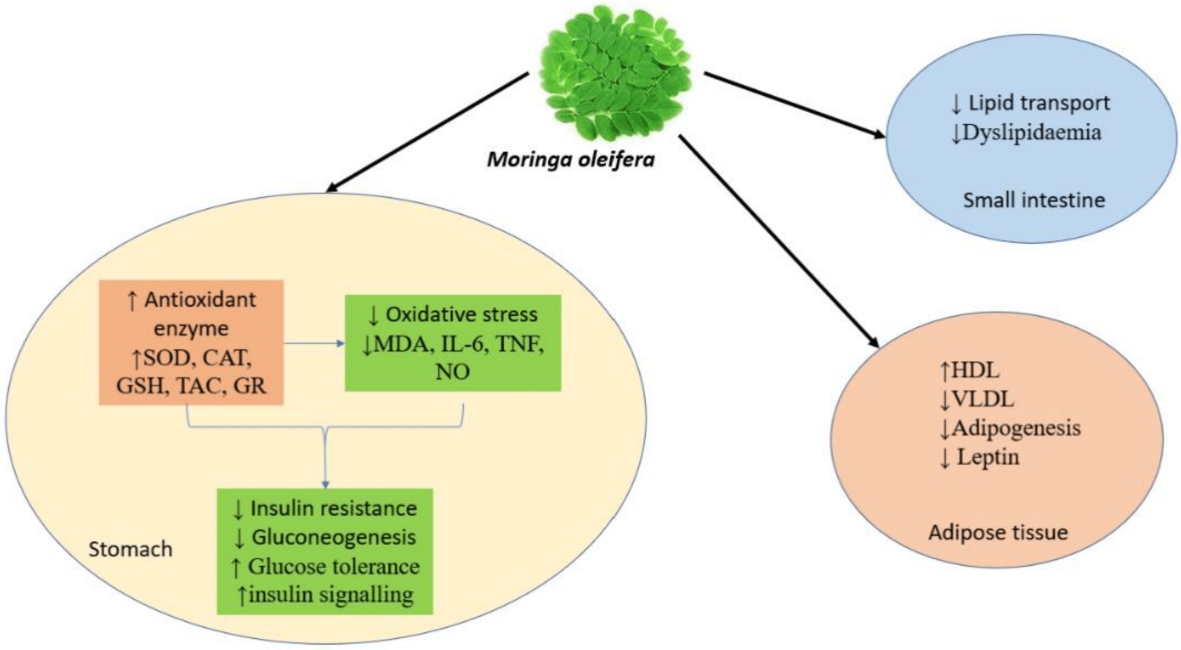


Figure 3. *M. oleifera* as a promising anti-obesity agent. Various in-vitro findings suggest that supplements of *M. oleifera* cause direct inhibition of pancreatic lipase, thus reducing the conversion of triglycerides into simple. Moringa has fat storage regulation by upregulation of lipolysis-associated protein and down-regulating the expression of protein related to fat storage. It is also effective in the improvement of antioxidant levels. Besides these, Moringa is also responsible for increasing ghrelin levels and decreasing leptin, producing a feeling of satiety.

2.17. Anti-Allergic Activity

The ethanolic seeds extract reduced histamine release and also suppressed the anaphylaxis induced by anti-immunoglobulin G. The mechanism underlying this effect may be the membrane-stabilizing potential of mast cells in an oval albumin sensitization model [16].

2.18. Anti-Diabetic Activity

Moringa leaves showed excellent results in the glucose tolerance of Wistar and Goto-Kakizaki rats and also lowered blood glucose levels. The aqueous extract showed an antidiabetic effect in rats by controlling blood glucose levels, protein, sugar, and hemoglobin [29]. The leaves of the plant were found to lower glucose levels

within three hours of intake, but not more than the standard drug glibenclamide. Moringa seeds, when administered orally, contain insulin-like proteins that have antigenic epitopes such as insulin and exhibit antihyperglycemic activity [93]. Leaf extracts of the plant also have antidiabetic activity as they increased CAT and MDA levels, reduced FPG levels, hemoglobin levels, LDL-C, and VLDL-C in type 2 diabetic patients and, most importantly, increased insulin levels in healthy subjects [94]. The seed extract of the plant reduced LPO levels and amplified the antioxidant effect in mice induced with streptozotocin, the seed extract was also able to reduce IgG, IgA, and IL -6 parameters and pancreatic β-cell activity, and it was suggested that the bioactive compound responsible for this effect were quercetin, kaempferol, glucomoringin, chlorogenic acid, and isothiocyanates [95].

2.19. Diuretic Activity

The alcoholic and aqueous root extract of *M. oleifera* significantly affects calcium oxalate urolithiasis in male rats. This reduction was observed due to the decrease in the retention level of oxalates, calcium and phosphates as well as serum urea nitrogen, creatinine, and uric acid [5].

2.20. Angiotensin Converting Enzyme (ACE) Activity

Compounds such as niazimin-A, niazicin-A, and niaziminin-B are stated to be present in the *M. oleifera* plant extract. These compounds were found to have potent antihypertensive activity when targeted to (ACE), an important enzyme of the renin-angiotensin system. The researchers observed this activity by protein–ligand docking and found that the compounds have a high affinity for the angiotensin-converting enzyme compared with captopril and enalapril (standard drug) [96]. The angiotensin enzyme rennin plays a prominent role in regulating blood pressure and leading to diseases such as hypertension, kidney disease, and other cardiovascular diseases. The study found that the role of *M. oleifera* with two other plants (*Azadirachta indica* and *Hibiscus sabdariffa*) inhibited the enzyme with percentage inhibition (71.8%, 74%, and 73.4%) compared to standard drugs (captopril and enalapril). The compound responsible for this activity of Moringa was termed β-sitosterol [97].

2.21. Anti-Venom Effect

The leaves of the plant extract have been shown to be effective against the venom of *Naja Nigricollis* (a snake species) in rats. This snake's venom contains potent neurotoxins that cause the degradation of phospholipids at the plasma membrane, affecting the normal neurotransmission process and causing hemolysis and hemorrhage. The results showed that Moringa extract effectively cured acute anemia, and a remarkable increase in micronucleated polychromatic erythrocytes was observed in rats treated with *M. oleifera* [98].

2.22. Cytotoxicity Effect

The cytotoxic potential of *M. oleifera* on human mesenchymal myeloma cell lines is observed in methanolic extract. The results of the extracts showed a higher ID50 value than other extracts. The researchers also found that the alkaloids and flavonoids contained in the plant showed some similarity to vincristine and vinblastine by random experiments. Therefore, the plant can be recommended for the herbal treatment of myeloma patients [31].

It was found that the ethanolic leaves extract of *M. oleifera* contains active constituents that can alleviate cyclophosphamide-induced testicular toxicity by promoting genes associated with the functional integrity of spermatozoa and enlargement of DNA in spermatogonia. Therefore, the administration of the extract not only improved blood and intestinal hormone levels but also modulated the expression of genes responsible for Sertoli and spermatogonial cells [99].

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