PROSPECTS
IN PHARMACEUTICAL SCIENCES

Prospects in Pharmaceutical Sciences, -
https://prospects.wum.edu.pl/

Review Article

ELUCIDATING THE PHYTOCHEMICAL PROFILE AND THERAPEUTIC POTENTIALS OF *MORINGA OLEIFERA*: AN INTEGRATIVE APPROACH

Arvind Kumar Patel*[1], Phool Chandra[2], Neetu Sachan[3], Neha Singh[2], Sandip Chatterjee[1]

[1]*Narayan Institute of Pharmacy, Gopal Narayan Singh University, Jamuhar, Sasaram, Rohtas-821305, Bihar, India*

[2]*Teerthanker Mahaveer College of Pharmacy, Teerthanker Mahaveer University, Moradabad-244001, Uttar Pradesh, India*

[3]*Maharana Pratap College of Pharmacy, Kothi, Mandhana, Kanpur-209217, Uttar Pradesh, India*

* Correspondence, e-mail: akpatel4393@gmail.com
Received: 01.04.2025 / Revised: 17.05.2025 / Accepted: 18.05.2025 / Published online: 08.08.2025

ABSTRACT

Medicines are a substance that serves nutritional, therapeutics, or preventative purposes while the term "herbal medicine" is used to describe plant-based products with therapeutics, preventative, or dietary benefits. This review intends to provide a detailed description related to pharmacological activities and phytoconstituents present in *Moringa oleifera* Lam. The study was performed by literature survey of original research articles published in Pubmed, Science Direct, Web of Science, Scopus and Google, using keywords such as "*Moringa oleifera*", "phytoconstituent" and "pharmacological activities." *Moringa oleifera* is extensively appreciated for its therapeutic qualities, because in the traditional medical system, almost all tree parts, including the roots, bark, gum, leaves, fruits, flowers, seeds, and seed oil are utilized to cure a variety of illnesses like relieves in high cholesterol, colitis, rheumatism, diarrhoea, swollen glands, headaches, hemorrhoids, fever, constipation, bronchitis, and infections of the ears and eyes. Different scientific studies have been conducted on *Moringa oleifera* such as anti-inflammatory, antioxidant, anticancer, antidiabetic, antibacterial, antifungal, hepatoprotective, antifertility, antiasthmatic, anti-colitis, anti-ulcer activity, etc. This pharmacological activity of *Moringa oleifera* is thought to be the presence of the following main phytoconstituents as alkaloids (moringin, niazirin, and niazimicin), flavonoids (procyanidin, isoquercitrin, rutin, astragalin, and apigenin), phenolic acids (gallic acid, syringic acid, and benzoic acid), fatty acids (9-octadecenoic acid and arachidic acid), lipid compounds (fatty acids, fatty alcohols, triacylglycerols, and saturated hydrocarbons), terpenoids and carotenoids (lutein, carotene, and polyprenol), sterols (β-sitosterol), phenols (eugenol), vitamins and antioxidants (ascorbic acid) and pigments (chlorophyll A), etc. In this study, we conclude that many phytoconstituents in *Moringa oleifera* are responsible for producing various types of pharmacological activities.

KEYWORDS: *Moringa oleifera*; Herbal medicines; Cultivation; Phytoconstituents; Pharmacological activities.

1. Introduction

Moringa oleifera Lam. is native to the Indian subcontinent. It is a fast-growing, drought-resistant tree in the Moringaceae family. According to Paliwal *et al.* (2011), it is also known as Moringa, drumstick tree (because of the seeds' thin, triangular sticks), horseradish tree (according to the roots' horseradish flavour), and benzyl oil tree or benzyl tree (due to the oil derived from the seeds) [1]. It is a deciduous tree with a trunk diameter of 45 cm and a height of 10-12 meters. A thick layer of softwood surrounds the white-grey bark. The bark of the shoots is reddish-purple or greenish-white hairy. The tree has an open shade of sagging, fragile limbs and fluffy tripinnate leaves. The fruit is a brown, three-sided hanging capsule that is 20-45 cm tall and contains dark brown, rounded seeds about 1 cm in diameter [2]. Because its immature seed pods and leaves can be used as a vegetable, a traditional herbal remedy, and to filter water, it is frequently cultivated [3]. It is extensively appreciated for its traditional medicinal uses, which include anthelmintic and aphrodisiac effects. It relieves high cholesterol, colitis, rheumatism, diarrhoea, swollen glands, headaches, haemorrhoids, fever,

constipation, bronchitis, and infections of the ears and eyes. This valued tree, with its various components, demonstrates digestive effects. In the traditional medical system, almost all tree parts, including the roots, bark, gum, leaves, fruits, flowers, seeds, and seed oil are utilized to cure a variety of illnesses [4].

Figure 1. Plant and leaves of *Moringa oleifera*.

2. Taxonomical classification [5]

Kingdom	Plantae
Phylum	Streptophyta
Class	Equisetopsida
Subclass	Mangnoliidae
Order	Brassicales
Family	Moringaceae
Genus	*Moringa*
Species	*Moringa oleifera*

3. Common names and synonyms

Moringa oleifera is also known as the drumstick tree because of its fine triangular seed pod, horseradish tree because of the horseradish flavour of its root, and benzyl oil tree or benzyl tree. The homotypic synonyms of *Moringa oleifera* are *Guilandina moringa* L., *Anoma moringa* (L.) Lour., *Hyperanthera moringa* (L.) Vahl, *Moringa moringa* (L.) Millsp. etc., while its heterotypic synonyms are *Hyperanthera decandra* Willd., *Moringa amara* Durin, *Moringa edulis* Medik., *Moringa erecta* Salisb., *Moringa zeylanica* Pers, etc. [5,6].

4. Geographical source

In India, *Moringa oleifera* is primarily found in Tamil Nadu, Karnataka, Kerala, and Andhra Pradesh, although it is also found in Uttar Pradesh and Bihar in the north. It is mostly a perennial plant species that has been cultivated for a very long time.

Moringa is frequently cultivated in home gardens and sold in neighbourhood markets in South and Southeast Asia. The World Vegetable Centre in Taiwan, a centre for vegetable research, also actively cultivates moringa. It can be found in the wild or cultivated in Southeast Asia, South Asia, South America, Africa, Central America, and the Caribbean [7].

5. Cultivation and collection

With an annual production of 1.2 million tonnes of fruit spread across a 380 km area, India is the world's largest producer of moringa. It only blooms once a year, between April and June, in places with colder winters and summers. Flowering can take place twice or even all year long under conditions of more regular seasonal temperatures and consistent rainfall [2].

Tropical, subtropical, and semi-arid climates are where moringa grows best. Although it can survive a variety of soil types, it favours neutral to slightly acidic soils (pH 6.3 to 7.0) and well-drained sandy or loamy soils. A plant that prefers heat and sunlight, moringa cannot tolerate frost. Because it is grown with rainwater and doesn't require expensive irrigation systems, *M. oleifera* is especially well suited to desert regions [8,9].

Moringa oleifera can be grown for its leaves, and factors like season, variety, fertilizer, and irrigation frequency significantly affect its yield. Under warm, dry circumstances with some supplementary fertiliser and irrigation, moringa performs best. Hand tools like knives, scythes, and hooked bayonets are used for harvesting. It is advised to promote branching and boost yield to make harvesting easier by topping, trimming, pruning, or pruning. To keep the pods and leaves within reach, it is typically pruned back to 1-2 m per year and left to grow again [10].

Moringa plants are picked at two years old when they are fully grown and mature. 300 g of freshly collected leaves were removed, ground up, and left to macerate in 70% ethanol for 24 hours at room temperature. The solvent was taken from the leaves after 24 hours. The solvent was dried in an evaporator after 24 hours to find the extract [11].

6. Chemical constituents

6.1. Bark constituents

The bark of *Moringa oleifera* contains procyanidin A2, proanthocyanidin [12], eugenol and ß-sitosterol-3-O-D-galactopyranoside [13].

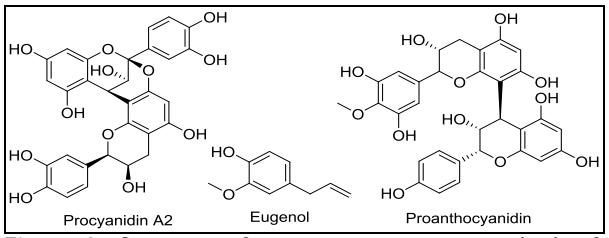

Figure 2. Structure of constituents present in bark of *Moringa oleifera*

6.2. Seeds constituents

The constituents of methanolic seeds extract are ascorbic acid, 2,6 dihexadecanoate, 9-octadecenoic acid, oleic acid, 9-octadecenamide [14]. Hydroalcoholic and aqueous fractions of moringa seeds also contain moringin, niazirin and niazimicin [15].

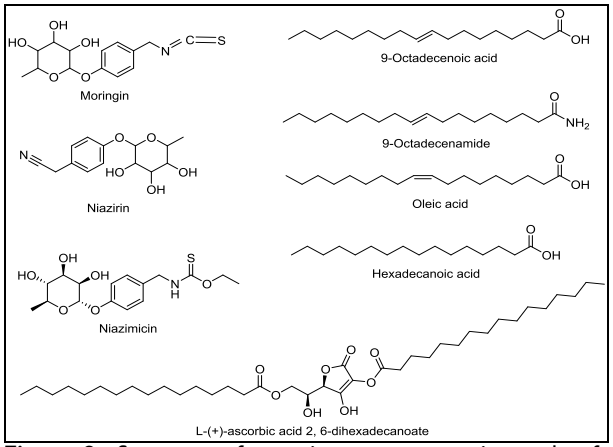

Figure 3. Structure of constituents present in seeds of *Moringa oleifera*

6.3. Leaves constituents

Chemical investigation of alcoholic fraction of moringa leaves contains lutein, fatty acid like palmitic acid, myritic acid, linolenic acid, stearic acid, oleic acid, and phenolic acid like gallic acid, and syringic acid. It also contains carotene, polyprenol, ß-sitosterol and chlorophyll A, [16]. It additionally contains niazirin, niazirinin and niazimicin a nitrile glycoside, isoquercitrin, rutin, astragalin, apigenin, 5 caffeoylquinic acid, benzoic acid and ethyl palmitate [17].

The constituents of methanolic leave extract of moringa are 9- octadecenoic acid, ascorbic acid, 2,6 dihexadecanoate,3-ethyl 2,4-dimethyl pentane, phytol and 4-hydroxyl 4-methyl 2-pentanone [14], glucosinolate and isothiocyanate [18].

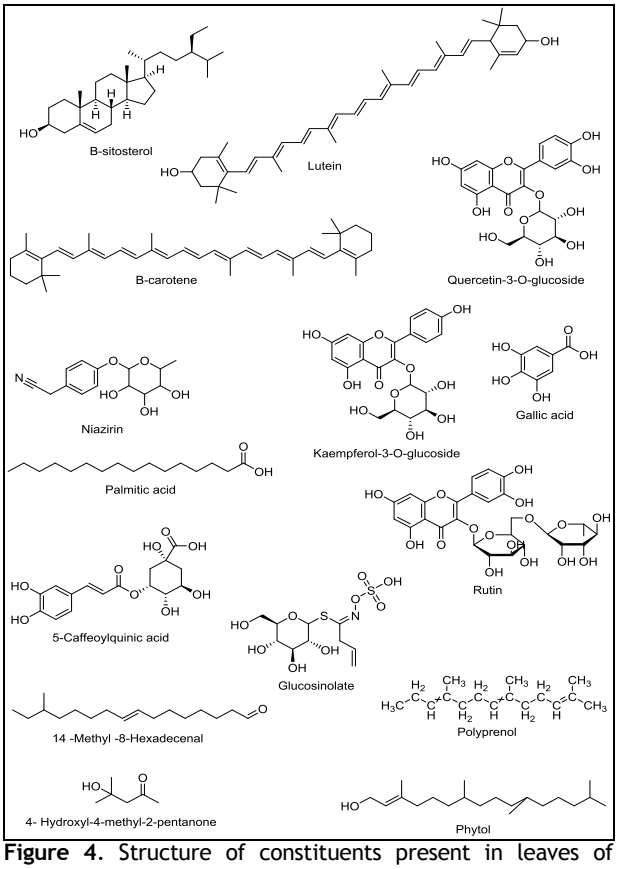

Figure 4. Structure of constituents present in leaves of *Moringa oleifera*

6.4. Roots constituents

Roots of *Moringa oleifera* contain procyanidin [12], aurantiamide acetate, 1,3 dibenzyl urea, capsaicin, capsazepine [19], N-benzyl, S-ethylthioformate, palmitic acid, arachidic acid [20].

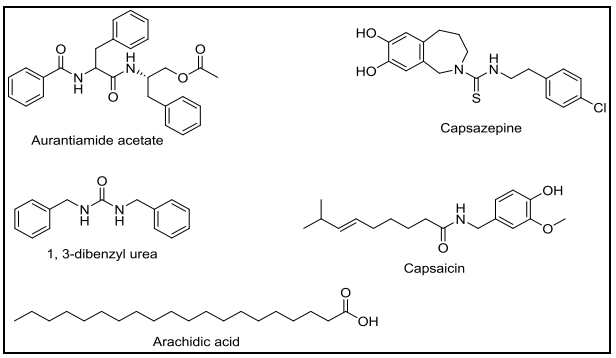

Figure 5. Structure of constituents present in roots of *Moringa oleifera*

Table 1. Phytoconstituents present in different parts of *Moringa oleifera*

Plant part	Chemical constituents	Ref
Bark	Procyanidin A2, proanthocyanidin, N-benzyl S-ethylthioformate, eugenol and ß-sitosterol-3-O-D-galactopyranoside	[12, 13, 21]
Seeds	Ascorbic acid, 2,6-dihexadecanoate, 9-octadecenoic acid, oleic acid, 9-octadecenamide, moringin, niazirin and niazimicin	[14, 15]
Leaves	Lutein, gallic acid, palmitic acid, myristic acid, linolenic acid, stearic acid, oleic acid, syringic acid, carotene, polyprenol, ß-sitosterol, chlorophyll A, niazirin, niazirinin, niazimicin, isoquercitrin, rutin, astragalin, apigenin, 5-caffeoylquinic acid, benzoic acid, ethyl palmitate, 9-octadecenoic acid, ascorbic acid, 2,6-dihexadecanoate, 3-ethyl 2,4-dimethyl pentane, phytol, 4-hydroxyl 4-methyl 2-pentanone, glucosinolate and isothiocyanate	[14, 16-18]
Roots	Procyanidin, aurantiamide acetate, 1,3-dibenzyl urea, capsaicin, capsazepine, N-benzyl S-ethylthioformate, palmitic acid, and arachidic acid	[12, 19, 21]

7. Traditional uses

Almost every part of *Moringa oleifera*, was used in the traditional medicine system. Colitis, rheumatism, diarrhoea, enlarged glands, headaches, haemorrhoids, fever, constipation, bronchitis, and infections of the ears and eyes are just a few of the many conditions it has historically been used to treat. Additionally, it is used to improve general health, aid with digestion, reduce cholesterol, and strengthen immunity [4]. Preparations made from moringa are used in many cultures to treat respiratory conditions including bronchitis and asthma, as well as to treat skin infections, joint discomfort, and inflammation. The seeds and seed oil have also been utilized for their antibacterial and cleansing qualities. These traditions demonstrate the plant's essential function in natural treatment systems around the globe [22].

8. Pharmacological activities

Scientific studies on the different parts of *Moringa oleifera* have revealed various pharmacological activities.

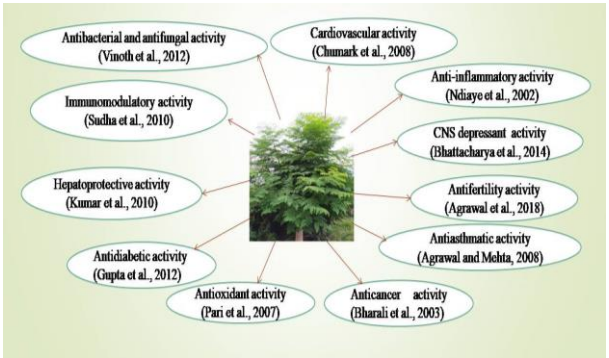

Figure 6. Scientific study of *Moringa oleifera*

8.1. Anti-inflammatory activity

One of the most typical symptoms of many chronic disorders is inflammation. It is the body's typical defensive reaction to tissue damage brought on by physical trauma, chemical irritants, or microorganisms [23]. For inhibiting carrageenan-induced edema in rats, an aqueous extract of *Moringa oleifera* roots (750 and 1000 mg/kg) showed dose-dependent anti-inflammatory effect and the effect of 1000 mg/kg was comparable to that of indomethacin, a strong anti-inflammatory medication [24]. In another investigation, ripe seeds reduced edema by 77% at the dose of 3 mg/kg, whereas crude ethanolic extract of seeds reduced edema by 85% at a dose of 3 mg/kg body weight caused by carrageenan-induced cure paw edema in mice [25]. Similar activity was seen when leaves, seeds, flowers, roots, and bark were submerged in hot water [26].

8.2. Antioxidant activity

Antioxidants are chemicals that give the body free atoms while preventing the formation of free radicals, which harm cells and result in oxidative stress. Additionally, they have been demonstrated to have an impact on the prevention and treatment of some acute and chronic illnesses, including cancer, heart disease, and stroke, as well as the aging process. Natural antioxidants are primarily found in medicinal plants [27]. In comparison to ascorbic acid, a well-known antioxidant, the methanolic extract of *Moringa oleifera* leaves showed good antioxidant activity (IC_{50} value of 49.86 g/mL) [28]. According to Pari *et al*. (2007), the main components of *Moringa oleifera* leaf extract are bioactive phenolic compounds that support antioxidant activity with total antioxidant activity as 0.636 µmol Trolox/mg [29]. Similar to ascorbic acid in terms of its antioxidant activity against the radicals 2,2-dipheny l-1-picrylhydrazyl (DPPH) and NO, the methanolic extract of *Moringa oleifera* seeds was found to be equally active [30]. According to Lalas and Tsaknis (2002), moringa seed oil exhibits more antioxidant activity than both butylated hydroxytoluene (BHT) and tocopherol [31].

8.3. Anti-tumor and anticancer activity

A significant source of conventional medications for the treatment of many types of cancer has been identified as medicinal plants. According to Kamuhabwa *et al*. (2000), plants are frequently employed to make antitumor chemicals that are clinically effective anticancer medicines [32]. By triggering the apoptotic pathway in HeLa cells, aqueous extract of *Moringa oleifera* leaves has demonstrated strong anticancer activity with IC_{50} value of 70 µg/mL [33]. According to Parvathy and Umamaheshwari (2007), methanolic leaf extract exhibited cytotoxic activity against human multiple myeloma cells (U266B1) with an ID_{50} of 0.32 µg/mL [34]. The hydroalcoholic extract of drumsticks of *Moringa oleifera* at the dose of 250 mg/kg for 14 days, produced a significant decrease in skin papilloma in a mouse model [35].

8.4. Antidiabetic activity

The most prevalent metabolic disease in the world is diabetes, which is a serious public health issue. It leads to hyperglycaemia, which develops into microvascular and macrovascular problems and frequently results in mortality. Scientific investigations have validated the antidiabetic characteristics of numerous medicinal plants, which have been utilised for centuries in various communities to treat diabetes [36]. Numerous studies using lab animals have assessed the anti-diabetic effectiveness of *Moringa oleifera*. Its seeds, roots, and stem bark, aqueous, ethanolic, and methanolic extracts have been demonstrated to give effective glycemic control in diabetic animals and human models [37]. *Moringa oleifera* pod and leaves methanolic extracts had anti-diabetic properties and were effective against streptozotocin zithromax (STZ)-induced diabetic albino rats. After 21 days of treatment with 150 and 300 mg/kg, rats showed reduced serum levels of glucose and nitric oxide, while insulin and protein levels increased, indicating a significant slowdown in the progression of diabetes [38]. Huang *et al*. (2020) also revealed the mechanism of the anti-insulin resistance effect of moringa seed extract at 10 µg/mL that stabilised the SRC, PTPN1 and caspase-3 [39]. While Jiang *et al*. (2024) found the protective effect of moringa stem extract on islet ß-cell at 500 mg/kg [40].

8.5. Immunomodulatory activity

The scientific community is very interested in the use of plants for immunomodulation since it provides an alternative to traditional chemotherapy for some disorders. It is predicated on plants' capacity to modify immunological function efficiently, so supporting good health and maintaining the body's resistance to infections [41]. An experimental mouse model of cellular and humoral immunity was used to assess the immunomodulatory properties of a methanolic extract of *Moringa oleifera* leaves. Two dosages of the extract (250 and 750 mg/kg, *p.o.*) markedly raised blood immunoglobulin levels and shielded mice from *Pasteurella bovis*-induced death. An indirect hemagglutination test revealed a considerable rise in circulating antibody levels. Furthermore, extracts from the *Moringa oleifera* leaves boost neutrophil adhesion, reduce the effects of cyclophosphamide on neutropenia, and raise the phagocytic index in tests for the removal of charcoal [42].

8.6. Antibacterial and antifungal activity

Due to the rise in antimicrobial resistance, interest in therapeutic plants and microorganisms with antimicrobial characteristics has been on trend. This resistance could be the result of improper usage of prescription medications or unfavourable antibiotic side effects. Plants are also being used more frequently as an alternative to conventional medications to treat infectious diseases because of the high expense of those medications [43]. *Salmonella* sp., *Staphylococcus aureus*, *Pseudomonas aeruginosa*, and *Escherichia coli* were sensitive to the antibacterial effects of both aqueous and ethanolic extracts of *Moringa oleifera* leaves [44]. But *Escherichia coli*, *Enterobacter*, *Proteus vulgaris*, and *Staphylococcus aureus* were treatable with the acetone leaf extract of moringa at a concentration of 5 mg/mL, while *Micrococcus kristinae* were inhibited at 0.5 mg/mL. Saponins, tannins, phenolic phytoconstituents, and alkaloids were found to have antibacterial properties [43]. *Salmonella typhi*, *Escherichia coli*, *Enterobacter* spp., *Staphylococcus aureus*, *Pseudomonas aeruginosa*, can be treated with ethanolic, and chloroform extracts of *Moringa oleifera* leaves at 200 mg/mL [45]. *Pseudomonas aeruginosa*, *Staphylococcus aureus*, and *Escherichia coli* were all suppressed by petroleum ether extracts of *Moringa oleifera* roots. In contrast to chloroform and water extracts, which inhibited *Pseudomonas aeruginosa* and

Escherichia coli, ethanolic extract inhibited *Staphylococcus aureus*, *Proteus mirabilis*. Its bio-selenium nanoparticle preparation also showed antibacterial activity against *Listeria monocytogenes* and *Corynebacterium diphtheriae* at a concentration of 7 mg/mL [46].

8.7. Hepatoprotective activity

The liver is a crucial organ that performs several essential tasks, such as detoxification and protein synthesis. If these tasks are interfered with by the numerous substances we are exposed to, the results could be fatal [47]. Wistar rats treated with 500 mg/kg of its ethanolic leaves extract showed less necrotic cell damage and wider hepatic sinusoidal space compared to the negative control group, which showed obvious hepatic cord torsion, disappearance of necrotic cells, and sinusoids [48]. This study examined the hepatoprotective effect of *Moringa oleifera* ethanol leaf extract on the histology of paracetamol-induced liver damage. Using histopathological endpoints, methanol extracts of *Moringa oleifera* leaves and flowers enhanced hepatoprotective efficacy against carbon tetrachloride-induced hepatotoxicity in rats. At a dose of 250 mg/kg orally, the extract significantly protected against bilirubin, serum glutamate pyruvate transferase (SGPT), serum glutamate oxaloacetate transferase (SGOT), alkaline transferase, and lysosomal enzyme levels in serum. The liver cell degeneration brought on by CTLs was likewise normalised in the extract-treated group's liver sections, which were also comparable to silymarin, a well-known hepatoprotective compound. Additionally, they hypothesised that coumarin's capacity to regulate inflammatory mediators and avert cell damage may contribute to the hepatoprotective impact [49].

8.8. Cardiovascular activity

Cardiovascular disease (CVD) is a group of illnesses that affect the heart and blood vessels, including hypertension, hyperlipidemia, thromboembolism, coronary heart disease, congestive heart failure, angina chest pain, atherosclerosis, cerebral insufficiency, venous insufficiency, cardiac arrhythmia, etc [50]. CVD is the leading cause of death worldwide, and medicinal plants have been used to treat it. Their capacity to function as antioxidants, vasodilators, adrenergic receptor antagonists, and platelet-activating factor (PAF) may be the cause of this [51]. In rabbits given a 12-week high cholesterol diet (HCD) (5%), *Moringa oleifera* caused dyslipidemia. Following the treatment diet, plasma levels of triglycerides (TG), high-density lipoprotein (HDL), low-density lipoprotein (LDL), and total cholesterol (TC) were elevated in rabbits fed the HCD. The carotid arteries had extensive plaque formation as a result of the diet. The aforesaid elevations were decreased in HCD rabbits given a daily dose of 100 mg/kg body weight of *Moringa oleifera* aqueous leaves extract, and TC, lipoprotein cholesterol, TGs, and plaque formation rate were all lowered by 50%, 75%, and 97%, respectively. Simvastatin, which lowers cholesterol, has a protective effect that is comparable to that at a daily dose of 5 mg/kg body weight [52,53]. Similar results were found when HCD albino rats got a methanolic extract of *Moringa oleifera* leaves and when HCD rabbits received an aqueous extract of *Moringa oleifera* fruit [54]. The recent study on moringa by Kumulosasi *et al*. (2021) revealed the antihypertensive effect of it ethanolic and aqueous stem extract at the dose of 1000 mg/kg [55] whereas in another study Odii *et al*. (2023) found the antihypertensive effect of its methanolic leaves extract by producing negative ionotropic and chronotropic effect at 10 mg/mL [56].

8.9. Antifertility activity

Contraceptive side effects and their long-term safety remain a serious concern despite the wide range of medications and devices that are already on the market for contraception. Women have historically employed herbal remedies to facilitate labour, increase menstrual flow, or decrease fertility [57]. The following approach was used to demonstrate the anti-fertility effects of *Moringa oleifera* stem bark extract. Pregnant rats weighing 130 to 200 g were randomized into four groups. Laparotomy was performed on the 10th day of pregnancy, and live fetuses were observed in both horns of the uterus. Rats in the experimental groups were given 25, 50, and 100 mg/kg of flower stem bark, while rats in the control group were given 0.5 mL of distilled water once daily. Alcoholic extracts of *Moringa oleifera* have been shown to affect estrogenic activity and the estrous cycle, supporting its antifertility properties. The number of live births was shown to be noticeably decreased by the alcoholic extract, whereas post-implantation loss and the absorption rate both increased clearly. There were more spontaneous abortions at the 100 mg/kg dose than at any other level. The extract demonstrated substantial estrogenic effects (vaginal opening, vaginal keratinization, and increased uterine weight) in ovariectomized juvenile rats and lengthened the estrous cycle, particularly the intermotion phase, in laboratory animals. They claimed that ovarian and extra-ovarian hormones were responsible for the breakdown of ovarian extracts [58]. A recent study examined the antifertility effects of ethanol extracts of *Moringa oleifera* leaves and roots in female Wistar rats in a dose-dependent manner at 250 mg/kg and 500 mg/kg [59].

8.10. Central nervous system (CNS) activity

An essential organ system of the human body is the CNS. Alzheimer's disease and other degenerative neurological conditions have an impact on a variety of body functions, including balance, mobility, memory, mental function, and cardiac function. These illnesses are fatal and generally incurable [60]. Numerous herbal remedies have demonstrated activity against illnesses of the CNS and are effective painkillers. Using the actophotometer test and the rotarod test, Bhattacharya *et al*. assessed the locomotor activity and muscle relaxant activity of the ethanolic leaves extract of *Moringa oleifera* in an albino rat model. There were six groups of six albino rats were taken. Normal saline (2 mL/kg) was given orally to the control group, while diazepam (10 mg/kg) was given to the standard group while 50, 100, 200, and 400 mg/kg of the extract was given to the experimental group, respectively. The outcomes demonstrated strong CNS depressive and muscle-relaxing properties in a dose-dependent manner in the ethanolic extract of *Moringa oleifera*. According to their theories, substances found in plants, such as flavonoids and saponins, easily cross the blood-brain barrier and have a variety of effects on the central nervous system, including memory, cognition, and neurodegeneration. They also theorize that these effects are mediated through GABA, which may be the cause of the compound's CNS inhibitory and muscle-relaxing properties [61]. Using mice as their test subjects, Bakre *et*

al. investigated the neurobehavioral and anticonvulsant effects of ethanol extracts of *Moringa oleifera* leaves. Open field, well plate, Y-maze, elevated plus maze (EPM), and pentobarbital-induced hypnosis were used to evaluate neurobehavioral characteristics, whereas pentyletetrazole, picrotoxin, and hypnotic-induced seizures were used in this study of *Moringa oleifera*. According to the findings, herding, grooming, falling, and locomotion were all significantly and dose-dependently reduced by the extract (250-2000 mg/kg). Additionally, it enhances memory and learning while simultaneously boosting anxiety's effects. Additionally, the extract (2000 mg/kg) treated mice from seizures brought on by pentylenetetrazole but did not affect seizures brought on by picrotoxin and strychnine [62]. It also modulates cholinergic and purinergic enzyme activity in microglial cells and is effective in hippocampal sclerosis with temporal lobe epilepsy [63,64]

8.11. Antiasthmatic activity

A significant fraction of the world's population suffers from asthma, which accounts for most of the cases in international studies [65]. Asthma can be treated with Moringa, n-butanol extract from their seeds. In guinea pigs, ovalbumin causes airway irritation that can be effectively treated with *Moringa oleifera*. By increasing total volume, breathing rate, and total differential cell counts in blood and lavage fluid, they found that the herb protected against acetylcholine-induced bronchoconstriction and airway inflammation. They concluded that the extract's anti-asthmatic effect resulted from a modification of the Th1/Th2 cytokine imbalance at 400 mg/kg [66]. To determine the efficacy of *Moringa oleifera* seed extract in the treatment of bronchial asthma, Agrawal and Mehta carried out a clinical trial. Twenty people with mild to moderate asthma received dried seed kernels extract at a dose of 3 g/daily for three weeks. The outcomes demonstrated that the use of *Moringa oleifera* extract considerably reduced the severity of asthma symptoms while simultaneously enhancing lung function. Most patients had significantly lower erythrocyte sedimentation rates (ESR) and noticeably higher haemoglobin (Hb) values. The values of forced vital capacity, forced expiratory volume, and peak expiratory flow in asthma patients all showed considerable improvements. *Moringa oleifera* had no negative effects on any patient. As a result, *Moringa oleifera* seeds are thought to be effective in the treatment of bronchial asthma patients [67]. Suresh *et al*. (2020) also found the anti-asthmatic effect of methanolic leaf extract of moringa against ovalbumin-induced allergic asthma in a dose-dependent manner at 250 and 500 mg/kg [68].

8.12. Antiurolithiatic activities

To evaluate its antiurolithiatic activities, the CuO and CuO nanoparticles doped with 20% Ag obtained from the aqueous leaf extract of *Moringa oleifera* were prepared. By using X-ray powder diffraction, the nanoparticles' average crystallite size and monoclinic crystal structure were determined. Field emission scanning electron microscopy (FE-SEM) and transmission electron microscopy (TEM) investigation of the synthesised nanoparticles reveals nanostructures. The synthesised doped CuO nanoparticles exhibited growth inhibition against bacteria but had remarkable antimicrobial action when silver (Ag) was added at a higher dopant concentration of 20%. When the concentration of nanoparticles was increased, the weight of the crystals generated steadily reduced, going from 2.67 g to 0.51 g for pure and from 2.67 g to 0.36 g at 5% concentration for 20% CuO doped with Ag. This decreases the rate of struvite stone nucleation that results in urinary tract infections and encourages the development of magnesium ammonium phosphate hexahydrate crystals. Therefore, an ideal challenge for environmental, biological, and pharmaceutical applications would be the favourable effect of Ag-doped green synthetic and pure CuO nanoparticles [69].

8.13. Anti-colitis activity

Rats exposed to colitis produced by acetic acid are protected by the aqueous extract of *Moringa oleifera* leaves. In the treated animals, the extract enhanced antioxidants (CAT and GSH) and lowered pro-oxidant indicators (MDA and NO) in a dose-dependent manner at 25, 50, and 100 mg/kg orally. Additionally, moringa extract decreased colon weight-to-length ratio and histological scores, which may indicate its ameliorating effect on experimentally induced colitis in rats. This could enhance its anti-anxiety properties. These findings may support the use of this plant for the treatment of digestive diseases in conventional medicine [70].

8.14. Galactagogue activity

A natural galactagogue called moringa is used to boost breast milk production in the first few weeks after giving birth. To these 88 postpartum women were randomly assigned to one research group that received oral capsules containing leaves extract of *Moringa oleifera* at 450 mg and one control group that received oral capsules containing a placebo and the capsule was given 2 times before meal for 3 days. The findings demonstrated that on day three postpartum, there was no difference in the median milk volume between the Moringa leaf group (73.5 mL) and the control group (50 mL). However, compared to the control group, the moringa group produced 47% more breast milk at the dose of 900 mg/day. The Moringa group's exclusive breastfeeding rate at six months surpassed the WHO target. To enhance the production of breast milk, moringa leaves can be utilised as a prolactin herb [71].

8.15. Anti-ulcer activity

Additionally, moringa exhibits antiulcer and gastroprotective effects. Dalhoumi *et al*. (2022) have looked at the role of *Moringa oleifera* extract and its phytochemicals in antiulcer activity. In this investigation, rats with stomach ulcers were treated with a single oral dose of 100 mg/kg body weight of *Moringa oleifera* leaf extract for this study, ulcer were generated with a 150 mmol/L HCl solution. The findings demonstrated that the gastric mucosa of rats treated with the plant produced a large amount of mucus and therefore had a high pH in rats pre-treated with *Moringa oleifera* compared to animals suffering from ulcers. While in the plant-protected stomach, the injury rate was significantly lower (79%). Interestingly, oral administration of *Moringa oleifera* protects the gastric mucosa by reducing muscular dystrophy (MDA) levels and increasing antioxidant enzyme activity in adults [72].

Table 2. Pharmacological activities of *Moringa oleifera*

Activities	Parts of plant	Fraction	Doses	Mechanism of action	Ref.
Antioxidant activity	Leaves, seeds	Ethanolic, aqueous	100-500 mg/kg, oral in rat	Reduces oxidative stress markers such as malondialdehyde and hydrogen peroxide	[73-75]
Antimicrobial activity	Leaves, seeds, bark	Methanolic, ethanolic, aqueous	50-200 mg/mL *in-vitro*	Exhibits activity against bacterial and fungal pathogens	[76-78]
Anti-inflammatory activity	Leaves, seed	Methanolic, aqueous	200-400 mg/kg, oral in rat	Inhibits pro-inflammatory cytokines and COX-2 expression	[79-81]
Antidiabetic activity	Leaves	Aqueous, ethanolic	100-300 mg/kg, oral in rat	Reduces fasting blood glucose, improves insulin sensitivity, and upregulates GLUT4	[82,83]
Neuroprotective activity	Leaves, seeds	Aqueous, ethanolic	250-500 mg/kg, oral in rat	Protects neurons, improves cognitive function, and reduces neuroinflammation	[84]
Spasmolytic activity	Seeds	Methanolic	100-300 mg/kg, oral in rat	Relaxes intestinal and uterine muscles	[85]
Purgative effect	Leaves, seeds	Aqueous, methanolic	200-500 mg/kg, oral in rat	Increases fecal pellets and improves intestinal motility	[86,87]
Hepatoprotective activity	Leaves, bark	Aqueous, ethanolic	200-400 mg/kg, oral in rat	Reduces liver enzymes and protects against hepatotoxicity	[88,89]
Anticancer activity	Leaves, seeds	Ethanolic, methanolic	50-200 µg/mL (*in-vitro*) and 100-300 mg/kg oral in rat	Inhibits cancer cell proliferation and induces apoptosis	[79,90]
Cardioprotective activity	Leaves, seeds	Aqueous, methanolic	100-400 mg/kg, oral in rat	Reduces blood pressure, cholesterol levels, and oxidative stress in the heart	[91,92]
Anti-ulcer effects	Leaves, seeds, bark	Aqueous, ethanolic	200-400 mg/kg, oral in rat	Reduces gastric acidity, protects gastric mucosa	[93-95]
Wound healing activity	Leaves, bark	Ethanolic, aqueous	5-10% (w/w) topical formulation	Enhances collagen synthesis, promotes tissue regeneration	[96,97]
Diuretic activity	Leaves, seeds	Aqueous, methanolic	100-300 mg/kg oral in rat	Increases urine output and promotes renal function	[87,98]
Analgesic activity	Leaves, bark	Ethanolic, methanolic	200-400 mg/kg oral in rat	Reduces pain perception and inflammatory pain	[99,100]
Antipyretic effect	Leaves	Ethanolic, aqueous	100-400 mg/kg oral in rat	Reduces fever and body temperature	[100]
Anti-obesity activity	Leaves, seeds	Methanolic, aqueous	200-400 mg/kg oral in rat	Lowers triglycerides, LDL cholesterol, and increases HDL	[101,102]
Immunomodulatory activity	Leaves, seeds	Aqueous, methanolic	5-10% suspension in fish	Enhances immune response, increases cytokine production	[103]

9. Conclusion and prospects

Moringa oleifera has attracted a lot of scientific interest because of its varied pharmacological characteristics and rich phytochemical makeup. Its diverse medicinal potential is attributed to the presence of bioactive substances such as flavonoids, alkaloids, tannins, saponins, etc., as highlighted in this review. Its anti-inflammatory, anti-microbial, antidiabetic, hepatoprotective, cardioprotective, and neuroprotective properties have been shown in studies, which makes it a viable option for the creation of functional foods and natural medications.

Therefore, we conclude that there are many chemical constituents present in different parts of *Moringa oleifera* that are responsible for producing various types of pharmacological activities. This plant is also used in food preparation and is thought to be entirely safe. However, continuous studies have been carried out related to the clinical and toxicological profile of *Moringa oleifera*. Thus, further studies should concentrate on issues of *Moringa oleifera* medicinal value and effectiveness, safety, and quality control.

Author Contributions: Conceptualization, A.K.P., P.C. and N.S.; data curation, A.K.P., N. Singh and S.C.; writing-original draft preparation, A.K.P. and N. Singh; writing-review and editing, P.C. and N.S.; supervision, N.S. and P.C. All authors have read and agreed to the published version of the manuscript.

Source of funding: None

Conflicts of Interest: Declared none.

References

1. Ritu Paliwal, R.P.; Veena Sharma, V.S.; Pracheta, P. A review on horse radish tree (*Moringa oleifera*): a multipurpose tree with high economic and commercial importance. *Asian Journal of Biotechnology* **2011,** 3(4), 317-328.

2. Pérez-Rivera, E.P.; Montes-Ávila, J.; Castro-Tamayo, C.B.; Portillo-Loera, J.J.; Castillo-López, R.I. Agronomical aspects of *Moringa oleifera* (Moringa) in *Biological and pharmacological properties of the genus Moringa* 39-63 (CRC Press, 2021)
3. Kalibbala, H.M.; Wahlberg, O.; Hawumba, T.J. The impact of *Moringa oleifera* as a coagulant aid on the removal of trihalomethane (THM) precursors and iron from drinking water. *Water Science and Technology: Water Supply* **2009,** 9(6), 707-714.
4. Anwar, F.; Latif, S.; Ashraf, M.; Gilani, A.H. *Moringa oleifera*: a food plant with multiple medicinal uses. *Phytotherapy Research: An International Journal Devoted to Pharmacological and Toxicological Evaluation of Natural Product Derivatives* **2007,** 21(1), 17-25.
5. POWO. Plants of the World Online. Facilitated by the Royal Botanic Gardens, Kew. *Published on the Internet* **2025.**
6. Bhadra, C.; Pal, S.; Adhikari, K. Efficacy evaluation of chromium (VI) adsorption on clay soil blended with Azadiracta indica (Neem) and *Moringa oleifera* (Drum stick) seed shell. *J. Indian Chem. Soc* **2019,** 96, 1-5.
7. Radovich, T. Farm and forestry production and marketing profile for Moringa (*Moringa oleifera*). (Permanent Agriculture Resources (PAR): Holualoa, HI, USA, 2011.
8. Gadzirayi, C.T.; Mudyiwa, S.M.; Mupangwa, J.F.; Gotosa, J. Cultivation practices and utilisation of *Moringa oleifera* provenances by small holder farmers: caseof Zimbabwe. *Asian Journal of Agricultural Extension Economics & Sociology* **2013,** 2(2), 152-162.
9. Gandji, K.; Salako, V.K.; Fandohan, A.B.; Assogbadjo, A.E.; Glèlè Kakaï, R.L. Factors determining the use and cultivation of *Moringa oleifera* Lam. in the Republic of Benin. *Econ. Bot.* **2018,** 72, 332-345.
10. Walshaw, S. Plant resources of tropical Africa 2. Vegetables. *Econ. Bot.* **2005,** 59(4), 401-402.
11. Soares, T.F.S.N.; da Silva, A.V.C.; Muniz, E.N. Moringa leaf extract: A cost-effective and sustainable product to improve plant growth. *S. Afr. J. Bot.* **2021,** 141, 171-176.
12. Atawodi, S.E.; Atawodi, J.C.; Idakwo, G.A.; Pfundstein, B.; Haubner, R.; Wurtele, G.; Bartsch, H.; Owen, R.W. Evaluation of the polyphenol content and antioxidant properties of methanol extracts of the leaves, stem, and root barks of *Moringa oleifera* Lam. *J. Med. Food* **2010,** 13(3), 710-716.
13. Al-Asmari, A.K.; Albalawi, S.M.; Athar, M.T.; Khan, A.Q.; Al-Shahrani, H.; Islam, M. *Moringa oleifera* as an anti-cancer agent against breast and colorectal cancer cell lines. *PLoS One* **2015,** 10(8), e0135814.
14. Aja, P.M.; Nwachukwu, N.; Ibiam, U.A.; Igwenyi, I.O.; Offor, C.E.; Orji, U.O. Chemical constituents of *Moringa oleifera* leaves and seeds from Abakaliki, Nigeria. *American Journal of Phytomedicine and Clinical Therapeutics* **2014,** 2(3), 310-321.
15. Guevara, A.P.; Vargas, C.; Sakurai, H.; Fujiwara, Y.; Hashimoto, K.; Maoka, T.; Kozuka, M.; Ito, Y.; Tokuda, H.; Nishino, H. An antitumor promoter from *Moringa oleifera* Lam. *Mutation Research/Genetic Toxicology and Environmental Mutagenesis* **1999,** 440(2), 181-188.
16. Ragasa, C.Y.; Medecilo, M.P.; Shen, C.C. Chemical constituents of *Moringa oleifera* Lam. leaves. *delta* **2015,** 1, 1a.
17. Manguro, L.O.A.; Lemmen, P. Phenolics of *Moringa oleifera* leaves. *Nat. Prod. Res.* **2007,** 21(1), 56-68.
18. Lopez-Rodriguez, N.A.; Gaytán-Martínez, M.; de la Luz Reyes-Vega, M.; Loarca-Piña, G. Glucosinolates and isothiocyanates from *Moringa oleifera*: Chemical and biological approaches. *Plant Foods Hum. Nutr.* **2020,** 75, 447-457.
19. Sashidhara, K.V.; Rosaiah, J.N.; Tyagi, E.; Shukla, R.; Raghubir, R.; Rajendran, S.M. Rare dipeptide and urea derivatives from roots of *Moringa oleifera* as potential anti-inflammatory and antinociceptive agents. *Eur. J. Med. Chem.* **2009,** 44(1), 432-436.
20. Kumar, N.; Pratibha; Pareek, S. Bioactive Compounds of Moringa (Moringa Species). 1-22 (2021).doi: 10.1007/978-3-030-44578-2_28-1
21. Abd El Baky, H.H.; El-Baroty, G.S. Characterization of Egyptian Moringa peregrine seed oil and its bioactivities. *Int. J. Manage. Sci. Bus. Res* **2013,** 2(7), 98-108.
22. Fahey, J. *Moringa oleifera*: A Review of the Medical Evidence for Its Nutritional, Therapeutic, and Prophylactic Properties. Part 1. *Trees Life J* **2005,** 1doi: 10.1201/9781420039078.ch12
23. Chen, L.; Deng, H.; Cui, H.; Fang, J.; Zuo, Z.; Deng, J.; Li, Y.; Wang, X.; Zhao, L. Inflammatory responses and inflammation-associated diseases in organs. *Oncotarget* **2018,** 9(6), 7204-7218. doi: 10.18632/oncotarget.23208
24. Ndiaye, M.; Dieye, A.M.; Mariko, F.; Tall, A.; Faye, B. Contribution to the study of the anti-inflammatory activity of *Moringa oleifera* (Moringaceae). *Dakar Med.* **2002,** 47(2), 210-212.
25. Guevara, A.P.; Vargas, C.; Uy, M. Anti-inflammatory and antitumor activities of seed extracts of malunggay, *Moringa oleifera* L.(Moringaceae). *Philipp. J. Sci.* **1996,** 125(3), 175-184.
26. Alhakmani, F.; Kumar, S.; Khan, S.A. Estimation of total phenolic content, in-vitro antioxidant and anti-inflammatory activity of flowers of *Moringa oleifera*. *Asian Pacific journal of tropical biomedicine* **2013,** 3(8), 623-627.
27. Sreelatha, S.; Jeyachitra, A.; Padma, P.R. Antiproliferation and induction of apoptosis by *Moringa oleifera* leaf extract on human cancer cells. *Food Chem. Toxicol.* **2011,** 49(6), 1270-1275.
28. Sharma, N.; Gupta, P.C.; Rao, C.V. Nutrient content, mineral content and antioxidant activity of Amaranthus viridis and *Moringa oleifera* leaves. *Research Journal of medicinal plant* **2012.**
29. Pari, L.; Karamac, M.; Kosinska, A.; Rybarczyk, A.; Amarowicz, R. Antioxidant activity of the crude extracts of drumstick tree [*Moringa oleifera* Lam.] and sweet broomweed [Scoparia dulcis L.] leaves. *Polish journal of food and nutrition sciences* **2007,** 57(2), 203-208.
30. Mukeshbhai, P.D.K. Evaluation of anti-stress and anti-oxidant activity of Morninga oleifera pods. **2011.**
31. Lalas, S.; Tsaknis, J. Characterization of *Moringa oleifera* seed oil variety "Periyakulam 1". *J. Food Compost. Anal.* **2002,** 15(1), 65-77.

32. Kamuhabwa, A.; Nshimo, C.; de Witte, P. Cytotoxicity of some medicinal plant extracts used in Tanzanian traditional medicine. *J. Ethnopharmacol*. **2000,** 70(2), 143-149.
33. Nair, S.; Varalakshmi, K.N. Anticancer, cytotoxic potential of *Moringa oleifera* extracts on HeLa cell line. *J Nat Pharm* **2011,** 2(3), 138-142.
34. Parvathy, M.V.S.; Umamaheshwari, A. Cytotoxic effect of *Moringa oleifera* leaf extracts on human multiple myeloma cell lines. *Trend in Medical Research* **2007,** 2(1), 44-50.
35. Bharali, R.; Tabassum, J.; Azad, M.R.H. Chemomodulatory effect of *Moringa oleifera*, Lam, on hepatic carcinogen metabolising enzymes, antioxidant parameters and skin papillomagenesis in mice. *Asian Pac. J. Cancer Prev.* **2003,** 4(2), 131-140.
36. Edoga, C.O.; Njoku, O.O.; Amadi, E.N.; Okeke, J.J. Blood sugar lowering effect of *Moringa oleifera* Lam in albino rats. *Int J Sci Technol* **2013,** 3(1), 88-90.
37. Muhammad, H.I.; Asmawi, M.Z.; Khan, N.A.K. A review on promising phytochemical, nutritional and glycemic control studies on *Moringa oleifera* Lam. in tropical and sub-tropical regions. *Asian Pacific Journal of Tropical Biomedicine* **2016,** 6(10), 896-902.
38. Gupta, R.; Mathur, M.; Bajaj, V.K.; Katariya, P.; Yadav, S.; Kamal, R.; Gupta, R.S. Evaluation of antidiabetic and antioxidant activity of *Moringa oleifera* in experimental diabetes. *J. Diabetes* **2012,** 4(2), 164-171.
39. Huang, Q.; Liu, R.; Liu, J.; Huang, Q.; Liu, S.; Jiang, Y. Integrated network pharmacology analysis and experimental validation to reveal the mechanism of anti-insulin resistance effects of *Moringa oleifera* seeds. *Drug Des. Devel. Ther.* **2020**, 4069-4084.
40. Jiang, X.; Tang, J.; Gao, Z.; Chen, C.; Li, W.; Peng, L.; Li, H.; Zhao, H.; Zhao, Y. Exploring the protection on islet ß-cells and hypoglycemic effect of *Moringa oleifera* stem based on network pharmacology and experimental validation. *J. Funct. Foods* **2024,** 122, 106499.
41. Padayachee, B.; Baijnath, H. An overview of the medicinal importance of Moringaceae. *Journal of Medicinal Plants Research* **2012,** 6(48), 5831-5839.
42. Sudha, P.; Asdaq, S.M.; Dhamingi, S.S.; Chandrakala, G.K. Immunomodulatory activity of methanolic leaf extract of *Moringa oleifera* in animals. *Indian J Physiol Pharmacol* **2010,** 54(2), 133-140.
43. Moyo, B.; Masika, P.J.; Julius; Muchenje, V. Antimicrobial activities of *Moringa oleifera* Lam leaf extracts. *African Journal of Biotechnology* **2011,** 11doi: 10.5897/AJB10.686
44. Enerijiofi, K.E.; Akapo, F.H.; Erhabor, J.O. GC-MS analysis and antibacterial activities of *Moringa oleifera* leaf extracts on selected clinical bacterial isolates. *Bulletin of the National Research Centre* **2021,** 45(1), 179. doi: 10.1186/s42269-021-00640-9
45. Nepolean, P.; Anitha, J.; Renitta, R.E. Isolation, analysis and identification of phytochemicals of antimicrobial activity of *Moringa oleifera* Lam. *Current Biotica* **2009,** 3(1), 33-39.
46. Ao, B.; Lv, J.; Yang, H.; He, F.; Hu, Y.; Hu, B.; Jiang, H.; Huo, X.; Tu, J.; Xia, X. *Moringa oleifera* extract mediated the synthesis of Bio-SeNPs with antibacterial activity against Listeria monocytogenes and *Corynebacterium diphtheriae*. *LWT* **2022,** 165, 113751.
47. Kalra, A.; Yetiskul, E.; Wehrle, C.J.; Tuma, F. Physiology, Liver. in *StatPearls* (StatPearls Publishing, 2025.
48. Buraimoh, A.A.; Bako, I.G.; Ibrahim, F.B. Hepatoprotective effect of ethanolic leave extract of *Moringa oleifera* on the histology of paracetamol induced liver damage in wistar rats. *Int. J. Anim. Vet. Adv.* **2011,** 3(1), 10-13.
49. Kumar, P.; Singh, K.; Kumar, A. Hepatoprotective Studies on Aerial Parts of *Moringa oleifera* Lam. on Carbon tetrachloride induced liver cell damage in albino rats. *Ann. Biol. Res.* **2010.**
50. Thiriet, M. *Cardiovascular Disease: An Introduction*, *Vasculopathies*. 2019 Feb 19;8:1-90. doi: 10.1007/978-3-319-89315-0_1.
51. Shaito, A.; Thuan, D.T.B.; Phu, H.T.; Nguyen, T.H.D.; Hasan, H.; Halabi, S.; Abdelhady, S.; Nasrallah, G.K.; Eid, A.H.; Pintus, G. Herbal Medicine for Cardiovascular Diseases: Efficacy, Mechanisms, and Safety. *Front. Pharmacol.* **2020,** 11, 422. doi: 10.3389/fphar.2020.00422
52. Chumark, P.; Khunawat, P.; Sanvarinda, Y.; Phornchirasilp, S.; Morales, N.P.; Phivthong-Ngam, L.; Ratanachamnong, P.; Srisawat, S.; Klai-upsorn, S.P. The in vitro and ex vivo antioxidant properties, hypolipidaemic and antiatherosclerotic activities of water extract of *Moringa oleifera* Lam. leaves. *J. Ethnopharmacol.* **2008,** 116(3), 439-446.
53. Alia, F.; Putri, M.; Anggraeni, N.; Syamsunarno, M.R.A.A. The potency of *Moringa oleifera* Lam. as protective agent in cardiac damage and vascular dysfunction. *Front. Pharmacol.* **2022,** 12, 724439.
54. Mehta, K.; Balaraman, R.; Amin, A.H.; Bafna, P.A.; Gulati, O.D. Effect of fruits of *Moringa oleifera* on the lipid profile of normal and hypercholesterolaemic rabbits. *J. Ethnopharmacol.* **2003,** 86(2-3), 191-195.
55. Kumolosasi, E.; Wei, C.C.; Abdullah, A.Z.; Abd Manap, N.S.; Lee, W.L.; Yousuf, M.H.; Ying, L.S.; Buang, F.; Said, M.M.; Mohamad, H.F. Antihypertensive activities of standardised *Moringa oleifera* Lam.(merunggai) extracts in spontaneously hypertensive rats. *Sains Malays* **2021,** 50(3), 769-778.
56. Odii, E.C.; Okoro, J.O.; Okorie, A.N.; Asogwa, C.N.; Chukwuka, C.O.; Okoye, C.O.; Okeke, E.S.; Ejere, V.C.; Eyo, J.E. Antihypertensive Effect of *Moringa oleifera* (Moringaceae) Methanolic Leaf Extract (MoMLE) on Cricetomys gambianus (Muridae). *Tropical Journal of Natural Product Research* **2022,** 6(10).
57. Bodhankar, S.L.; Garg, S.K.; Mathur, V.S. Antifertility screening of plants. Part IX. Effect of five indigenous plants on early pregnancy in female albino rats. *The Indian journal of medical research* **1974,** 62(6), 831-837.
58. Zade, V.; Dabhadkar, D. Antifertility effect of alcoholic extract of *Moringa oleifera* stem bark on estrous cycle and estrogenic activity of female albino rat. *American Journal of Advanced Drug Delivery* **2015,** 3(3), 223-235.
59. Agrawal, S.S.; Vishal, D.; Sumeet, G.; Shekhar, C.; Ashish, N.; Parul, D.; Ankita, S.; Prakash, A.;

Prakash, T.; Kumar, P. Antifertility Activity of Ethanol Leaf Extract of *Moringa oleifera* Lam. in Female Wistar Rats. *Indian J. Pharm. Sci.* **2018,** 80(3).

60. Fajri, M. The potential of *Moringa oleifera* as immune booster against COVID 19. Vol. 807 022008 (IOP Publishing, 2021).
61. Bhattacharya, A.; Naik, M.R.; Agrawal, D.; Sahu, P.K.; Kumar, S.; Mishra, S.S. CNS depressant and muscle relaxant effect of ethanolic leaf extract of *Moringa oleifera* on albino rats. *Int J PharmTech Res* **2014,** 6, 1441-1449.
62. Bakre, A.G.; Aderibigbe, A.O.; Ademowo, O.G. Studies on neuropharmacological profile of ethanol extract of *Moringa oleifera* leaves in mice. *J. Ethnopharmacol.* **2013,** 149(3), 783-789.
63. Adefegha, S.A.; Assmann, C.E.; Schetinger, M.R.C.; de Andrade, C.M.; Emanuelli, T. *Moringa oleifera* modulates cholinergic and purinergic enzymes activity in BV-2 microglial cells. *Metab. Brain Dis.* **2021,** 36, 627-638.
64. Fayez, S.; Shady, N.H.; Fawzy, I.M.; Maher, S.A.; Elrehany, M.; Alqahtani, A.M.; Allehyani, E.S.; Shawky, A.M.; Abdelmohsen, U.R.; Mostafa, N.M. Moringa extract reverses pilocarpine-induced hippocampal sclerosis in rats with temporal lobe epilepsy. *J. Funct. Foods* **2023,** 111, 105905.
65. Wang, Z.; Li, Y.; Gao, Y.; Fu, Y.; Lin, J.; Lei, X.; Zheng, J.; Jiang, M. Global, regional, and national burden of asthma and its attributable risk factors from 1990 to 2019: a systematic analysis for the Global Burden of Disease Study 2019. *Respir. Res.* **2023,** 24(1), 169. doi: 10.1186/s12931-023-02475-6
66. Mahajan, S.G.; Banerjee, A.; Chauhan, B.F.; Padh, H.; Nivsarkar, M.; Mehta, A.A. Inhibitory effect of n-butanol fraction of *Moringa oleifera* Lam. seeds on ovalbumin-induced airway inflammation in a guinea pig model of asthma. *Int. J. Toxicol.* **2009,** 28(6), 519-527.
67. Agrawal, B.; Mehta, A. Antiasthmatic activity of *Moringa oleifera* Lam: A clinical study. *Indian J. Pharmacol.* **2008,** 40(1), 28-31.
68. Suresh, S.; Chhipa, A.S.; Gupta, M.; Lalotra, S.; Sisodia, S.S.; Baksi, R.; Nivsarkar, M. Phytochemical analysis and pharmacological evaluation of methanolic leaf extract of *Moringa oleifera* Lam. in ovalbumin induced allergic asthma. *S. Afr. J. Bot.* **2020,** 130, 484-493.
69. Preethi, D.R.A.; Philominal, A. Antimicrobial and antiurolithiatic activities of pure and silver doped copper oxide nanoparticles using *Moringa oleifera* leaf extract on struvite urinary stones. *Applied Surface Science Advances* **2022,** 12, 100351.
70. Noubissi, P.A.; Njilifac, Q.; Tagne, M.A.F.; Nguepi, M.S.D.; Fondjo, A.F.; Emégam, N.K.; Mukam, J.N.; Zintchem, R.; Wambe, H.; Fankem, G.O. Anxiolytic and anti-colitis effects of *Moringa oleifera* leaf-aqueous extract on acetic acid-induced colon inflammation in rat. *Biomed. Pharmacother.* **2022,** 154, 113652.
71. Fungtammasan, S.; Phupong, V. The effect of *Moringa oleifera* capsule in increasing breast milk volume in early postpartum patients: A double-blind, randomized controlled trial. *European Journal of Obstetrics & Gynecology and Reproductive Biology: X* **2022,** 16, 100171.
72. Dalhoumi, W.; Guesmi, F.; Bouzidi, A.; Akermi, S.; Hfaiedh, N.; Saidi, I. Therapeutic strategies of *Moringa oleifera* Lam.(Moringaceae) for stomach and forestomach ulceration induced by HCl/EtOH in rat model. *Saudi J. Biol. Sci.* **2022,** 29(6), 103284.
73. Adedapo, A.A.; Ogunmiluyi, I.O.; Falayi, O.O.; Ogunpolu, B.S.; Oyagbemi, A.A.; Orishadipe, A.; Omobowale, T.O.; Yakubu, M.A.; Oguntibeju, O.O. The lyophilized aqueous leaf extract of *Moringa oleifera* blunts streptozocin-induced diabetes in rats through upregulation of GLUT 4 signaling pathway and anti-oxidant effect. *Scientific African* **2020,** 10, e00619.
74. Al-Bedak, O.A.-H.M.; Rashed, A.; Oshkondali, S.; Kushlaf, N.; Elshebani, A.; Alacrouk, S.A.; Oshkondale, F.; Elsheli, M.; Almesai, Z.R.; Shaeroun, A. GC-MS analysis and evaluation of antioxidant, anticancer, cytotoxicity, and hypoglycemic properties of the libyan *Moringa oleifera* leaf extract on alloxan-induced diabetes in mice. *Bulletin of Pharmaceutical Sciences Assiut University* **2024,** 47(2), 837-852.
75. Famurewa, O. Antioxidant Activities of Different Solvent Extracts of *Moringa oleifera* Seeds Using DPPH Assay. *Asian Journal of Chemical Sciences* **2023,** 13, 78-85. doi: 10.9734/ajocs/2023/v13i5255
76. Asghar, N.; Aziz, A.; Azhar, M.F.; El-Sharnouby, M.; Irfan, U.; Rafiq, I.; Farooq, H.; Rehmani, M.I.A.; Sakran, M.I.; Altalhi, A. Assessment of Phytochemical Analysis, Nutritional Composition and Antimicrobial Activity of *Moringa oleifera*. *Phyton (0031-9457)* **2022,** 91(8).
77. Anzano, A.; de Falco, B.; Ammar, M.; Ricciardelli, A.; Grauso, L.; Sabbah, M.; Capparelli, R.; Lanzotti, V. Chemical analysis and antimicrobial activity of *Moringa oleifera* Lam. leaves and seeds. *Molecules* **2022,** 27(24), 8920.
78. Juvatkar, P.; Waghulde, S.; Naik, P.; Gorde, N. *Antimicrobial activity of bark of Moringa oleifera L*, (2015).doi: 10.3390/ecsoc-19-b001
79. Tedjo, A.; Aprilliyani, I.; Kusmardi, K.; Megawati, A.; Noor, D.R. *Moringa oleifera* Leaves Ethanol Extract Inhibits HT-29 Cells and COX-2 Expression Predictably Through PPARγ Activation. *Majalah Obat Tradisional* **2024,** 29(2), 184-191.
80. Luetragoon, T.; Sranujit, R.P.; Noysang, C.; Thongsri, Y.; Potup, P.; Somboonjun, J.; Maichandi, N.; Suphrom, N.; Sangouam, S.; Usuwanthim, K. Evaluation of anti-inflammatory effect of *Moringa oleifera* lam. And Cyanthillium cinereum (less) H. Rob. Lozenges in volunteer smokers. *Plants* **2021,** 10(7), 1336.
81. Araújo, L.C.; Aguiar, J.S.; Napoleão, T.H.; Mota, F.V.; Barros, A.L.; Moura, M.C.; Coriolano, M.C.; Coelho, L.C.; Silva, T.G.; Paiva, P.M. Evaluation of cytotoxic and anti-inflammatory activities of extracts and lectins from *Moringa oleifera* seeds. *PLoS One* **2013,** 8(12), e81973. doi: 10.1371/journal.pone.0081973
82. Hidayati, S.; Sulistyawati, R.; Nurani, L.H. Regulation of ethyl acetate fraction from *Moringa oleifera* leaves to improve lipid metabolism and

insulin sensitivity in type 2 diabetes. *Int. J. Pharm. Pharm. Sci* **2018,** 10, 78-82.
83. Morolahun, E.A.; Pemba, S.K.; Celestine, C. Antihyperglycaemic effect of aqueous extract of *Moringa oleifera* leaf on alloxan-induced diabetic male Wistar rats. *Journal of Diabetes and Endocrinology* **2019,** 10(1), 8-12.
84. Azlan, U.K.; Khairul Annuar, N.A.; Mediani, A.; Aizat, W.M.; Damanhuri, H.A.; Tong, X.; Yanagisawa, D.; Tooyama, I.; Wan Ngah, W.Z.; Jantan, I. An insight into the neuroprotective and anti-neuroinflammatory effects and mechanisms of *Moringa oleifera*. *Front. Pharmacol*. **2023,** 13, 1035220.
85. El-Sayed, M.G.A.; El-Komy, A.A.A.; Salah, E. The Pharmacodynamic Profile of Hydroethanolic Seed Extract of *Moringa oleifera* on Intestinal and Uterine Contractility. *Benha Veterinary Medical Journal* **2018,** 35(1), 203-215.
86. Yue, X.-N.; Wang, S.; Yang, B.; Feng, S.-Y.; Fu, R.; Qu, C.-H.; Li, Z.Y. Comparative study of purgative pharmacological effects and mechanisms of *Moringa oleifera* leaves and Rhei Radix et Rhizoma. *China Journal of Chinese Materia Medica* **2023,** 48(19), 5259-5270.
87. Islam, M.; Bokshi, B.; Das, A.; Sadhu, S.; Nath, N.; Joardar, J.C.; Hossen, K. Diuretic and laxative activities of *Moringa oleifera* seeds and pods in mice. *Khulna University Studies* **2021,** 17, 31-39. doi: 10.53808/KUS.2020.17.1and2.2006-L
88. Aristianti, A.; Nurkhaeri, N.; Y Tandiarrang, V.; Awaluddin, A.; Muslimin, L. Formulation and pharmacological studies of leaves of Moringa (*Moringa oleifera*), a novel hepatoprotection in oral drug formulations. *Open Access Macedonian Journal of Medical Sciences*. **2021.**
89. Abushal, S.A. Hepatoprotective Effect of *Moringa oleifera* Leaves and Seeds Powder on Carbon Tetrachloride Induced Hepatotoxicity in Rats. *Alexandria Science Exchange Journal* **2020,** 41(July-September), 371-379. doi: 10.21608/asejaiqjsae.2020.115132
90. Laude, J.; Picart, M.; Lim, A.; Tun, J.; Ramones, C.M.; Relin, K.; Chicote, M.; Belen, E.; Ratnayake, R.; Matthews, J.; Luesch, H.; Salvador-Reyes, L.; Concepcion, G. *Moringa oleifera* compounds from seeds and extracts from leaves: anticancer and cancer chemopreventive properties; preparation of leaf extract-based herbal syrup. *SciEnggJ* **2023,** 15, 192-227. doi: 10.54645/FKTG97181
91. Randriamboavonjy, J.I.; Loirand, G.; Vaillant, N.; Lauzier, B.; Derbré, S.; Michalet, S.; Pacaud, P.; Tesse, A. Cardiac Protective Effects of *Moringa oleifera* Seeds in Spontaneous Hypertensive Rats. *Am. J. Hypertens*. **2016,** 29(7), 873-881. doi: 10.1093/ajh/hpw001
92. Mousa, H.R.; Eldeeb, A.A.; Ali, A.M. Cardioprotective effects of *Moringa oleifera* extract on biochemical, inflammatory, histological and ultrastructural changes in nandrolone decanoate induced cardiotoxicity in male adult albino rats. *The Egyptian Journal of Forensic Sciences and Applied Toxicology* **2023,** 23(2), 101-120.
93. Choudhary, M.K.; Bodakhe, S.H.; Gupta, S.K. Assessment of the antiulcer potential of *Moringa oleifera* root-bark extract in rats. *Journal of acupuncture and meridian studies* **2013,** 6(4), 214-220. doi: 10.1016/j.jams.2013.07.003
94. Lawal, F.; Garba, K.; Shuai'bu, A.B.; Chedi, B.A.Z. Evaluation of the antiulcer activity of aqueous seed extract of *Moringa oleifera* lamarck (Moringaceae). *Trop J Nat Prod Res* **2018,** 2(3), 140-144.
95. Devaraj, V.C.; Mohammed, A.; Venugopal, S. Effect of Leaves and Fruits of *Moringa oleifera*. on Gastric and Duodenal Ulcers. *Pharm. Biol*. **2008,** 45, 332-338. doi: 10.1080/13880200701212924
96. Mohammad Shafie, N.; Raja Shahriman Shah, R.N.I.; Krishnan, P.; Abdul Haleem, N.; Tan, T.Y.C. Scoping review: evaluation of *Moringa oleifera* (Lam.) for potential wound healing in In Vivo studies. *Molecules* **2022,** 27(17), 5541.
97. Ali, A.; Garg, P.; Goyal, R.; Khan, A.; Negi, P.; Li, X.; Kulshrestha, S. An efficient wound healing hydrogel based on a hydroalcoholic extract of *Moringa oleifera* seeds. *S. Afr. J. Bot*. **2022,** 145, 192-198.
98. Tahkur, R.; Soren, G.; Pathapati, R.; Buchineni, M. Diuretic activity of *Moringa oleifera* leaves extract in swiss albino rats. *The Pharma Innovation* **2016,** 5, 8-10.
99. Tamanna, S.; Tonny, T.; Sarker, A.; Sathy, S.; Hussain, M.I. *Evaluation of Analgesic Activity of Moringa Oleifera Lam. Stem Bark Extract by Acid Induced Writhing Response Method*, (2017).
100. Marref, S.E.; Melakhessou, M.A.; Becheker, I.; Mekersi, N.; Marref, C. Acute Oral Toxicity, Anti-Inflammatory and Anti-pyretic Activities of Methanol Extract of *Moringa oleifera* LAM in Albino Rats. *African Journal of Biological Sciences* **2024,** 6, 2432-2441.
101. Hajinezhad, M.R.; Mokhtarpour, A.; Mirheidari, A. Hypolipidemic and antioxidant effects of aqueous ethanolic extract from Moringa peregrina leaves on high-fat diet-induced fatty liver disease in rabbits. *Comp. Clin. Path*. **2023,** 32(4), 617-628.
102. Kilany, O.E.; Abdelrazek, H.M.A.; Aldayel, T.S.; Abdo, S.; Mahmoud, M.M.A. Anti-obesity potential of Moringa olifera seed extract and lycopene on high fat diet induced obesity in male Sprauge Dawely rats. *Saudi J. Biol. Sci*. **2020,** 27(10), 2733-2746. doi: 10.1016/j.sjbs.2020.06.026
103. Nassar, A.; Gharib, A.A.E.; Abdelgalil, S.Y.; AbdAllah, H.M.; Elmowalid, G.A. Immunomodulatory, antioxidant, and growth-promoting activities of dietary fermented *Moringa oleifera* in Nile tilapia (Oreochromus niloticus) with in-vivo protection against Aeromonas hydrophila. *BMC Vet. Res*. **2024,** 20(1), 231. doi: 10.1186/s12917-024-04070-3