

Phytochemistry and Pharmacology of Moringa Tree: An Overview

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Abstract: *Moringa oleifera* (*M. oleifera*) Lam or “kelor”, a common name amongst Indonesian, belongs to the Moringaceae family. It is widely cultivated in India and known as nutritional herbs. Every part of these plants possess a valuable medicinal property. Universally known with the name “horseradish plant” or “drumstick plant” consists of biological exertion such as anticancer, antidiabetic, antihypertensive, treat malnutrition, and beneficial as concentration enhancer and as well as wound healing enterprise. So, the aim of the present review is to present comprehensive information on the traditional uses, phytochemical compound, and pharmacology activities of the medicinal plant, *M. oleifera*, from recognized sources. In the effort in future studies to develop a novel therapeutic medicine, the information provided in this review will be useful.

Keywords: *Moringa oleifera*; anticancer; antidiabetic; pharmacological activities; phytochemical compounds.

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1. Introduction

Medicinal plants are being used by almost 80% of the community in the world as their primary health care [1]. They are also known as a multi-purpose medicinal plant (MMP), and safe for consumption leads to the development of several medicinal products that have been derived from such herbs and plants [2].

M. oleifera Lam encompass a single genus “Moringa” along with thirteen species belongs to the Moringaceae family and among them, the most common is *M. oleifera* Lam tree [3]. Indeed, Moringaceae is known as a monogeneric family including single genus *Moringa* [4]. *M.oleifera* very well known as Sanjana, Horseradish tree, and drumstick, and the name Moringa derivated from a Tamil word, murungai has the meaning of twisted pod [5]. Currently, the plant is cultivated for various purposes in accordance with its high nutritional values and has an excellent range of medicinal uses [6]. *M. oleifera* Lam often resembling a leguminous species at a distance; nevertheless, it is a deciduous tree with sparse foliage and graceful, specifically when in flower but immediately recognized when in fruit. The tree expands averagely 10-12 m high [7]. *M.oleifera* can be categorized into seven categories, namely medicine, food, firewood, fodder, fencing, gum, and coagulant [8].

From the studies of different parts of the *M. oleifera* Lam tree, several bioactive compounds were recognized that provide health benefits beyond the basic nutritional value [9].

In *M. oleifera* leaves, principal polyphenols constituents recognized are flavonoids, mainly consists of kaempferol, myricetin, quercetin, and phenolic acids such as gallic acid [10]. *M. oleifera* possesses hypoglycemic activities, antibacterial, antifungal, antioxidant, and anti-inflammatory activity that has been proven [7].

2. Materials and Methods

The study has collaborated from the relevant other studies in international scientific journals published in PubMed, Google Scholar, Science Direct, Elsevier, Springer, and Scopus and compiled as a review for further details.

3. Results and Discussion

3.1. Traditional uses.

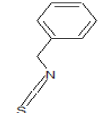
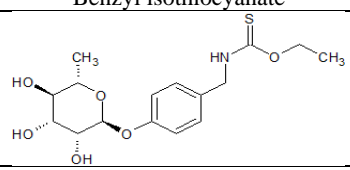
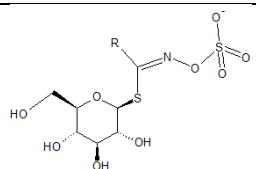
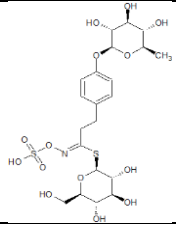
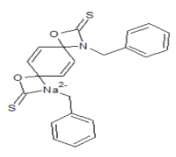
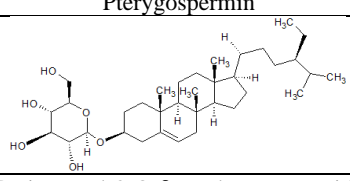
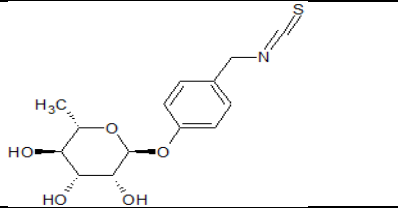
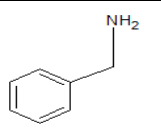
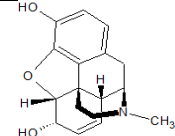
M. oleifera leaves have been exploited for both curative and preventive and are able to avoid 300 diseases, according to Ayurvedic traditional medicine [11]. Initially, herbal medicine by Africans and Indians used *M. oleifera* to cure more than 300 diseases [12]. *M. oleifera* leaves were used to treat fever, sore throat, hemorrhoids, inflammation, and to combat vitamin C deficiency traditionally [13]. Increasing demands of energy lead to biodiesel production using Moringa seed due to its excellent source of fatty acids [14]. Another study [15] reported that *M. oleifera* has low polyunsaturated fatty acids, which has the same content as oleic fatty acid, but slightly less linolenic and linoleic fatty acid compared to olive oil. This property provides Moringa oil with good stability, therefore highly treasured by the cosmetic field. *M. oleifera* has been utilized against AIDS and related secondary infections associated with HIV by Africans as their traditional medicine [16]. From the reported study [17], *M. oleifera* oil has been used traditionally in the treatment of hypertension, rheumatism, and arthritis; besides, it has been used as a high-quality vegetable oil due to the presence of more than 70% unsaturated fatty acids. In Nigeria, *M. oleifera* is used by medical practitioners in the treatment of conceptive disease in women and to boost male fertility [18]. Meanwhile, seeds of *M. oleifera* were useful in drinking water purification traditionally in many parts of Africa. Besides that, the plant was called a “clarifying tree” due to its strong coagulation attributes of suspended mud [19]. Some parts of the world, like Romans, Egyptians, and Greeks, reported in history that extracted edible oil from *M. oleifera* was used as a skin lotion and as perfume. Ancient Egyptians used Moringa oil for skin protection in the desert weather [20].

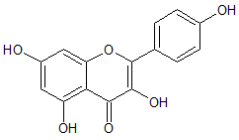
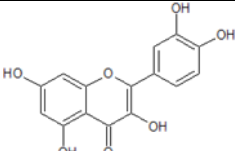
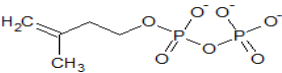
3.2. Phytochemical compounds.

Chemicals derived from plants are known as phytochemicals from the secondary metabolic compounds. Secondary metabolites are the source of bioactive compounds in plants [21]. High-performance thin-layer chromatography (HPTLC) fingerprinting and phytochemical evaluation plays a crucial role in authentication and identification of plants as well as assessing the quality of the herbal medication [13]. Chemical constituents that are most ordinary in *M. oleifera* were tannin, and polyphenols content have functions in protecting the plants from herbivores and regulation of seed germination, also in the plant growth [22]. The main flavonoids consist of *M. oleifera* tree was quercetin, and kaempferol, eventually obtained through methanol or ethanol extraction. Kaempferol is dominant in cancer cell apoptosis as well as good in preventing DNA damage [23]. Moringa trees also consist of a discernible

amount of tannins. The lowest concentration of tannins can be found in seeds; in contrast, the highest amount can be found in dried leaves of Moringa tree [24]. Alternatively, the author of another study [25] reported that *M. oleifera* seeds are rich in polyunsaturated fatty acids. Besides that, the presence of phytochemical constituents is responsible for the therapeutic potency of medicinal plants [26]. Various parts of the *M. oleifera* consists of phytochemical constituents and are listed in Table 1 below [27].

Table 1. Phytochemical compounds in various parts and their structures and properties.

Plant parts	Chemical structure	Properties	References
Leaves	 Benzyl isothiocyanate	Anticancer activity, anti-inflammatory activity	[28]
	 Niazimicin	Anticancer activity	[29]
	 Glucosinolates	Chemopreventive activity by activating apoptosis	[28]
	 Glucomoringin	Anti-colon carcinogenic activity	[30]
	Seeds	 Pterygospermin	Chron's disease, gout, rheumatism, cramp, epilepsy, hyperthyroidism, anti-herpes simplex virus arthritis
 B-sitosterol-3-O-β-D-glucopyranoside		Anti-tumor enhancer	[31]
 4-(α-L-rhamnosyloxy) benzyl isothiocyanate		Anti-tumor enhancer, antimicrobial	[2]
Root bark		 Moriginine	Anti-inflammatory activity, antiulcer
	 Morphine		

Flowers			Prevent carcinogenesis and inhibit mutations, inhibit production	[34]
	Kaempferol	Quercetin		
Whole plant			Anti-hyperglycemic activity, hypoglycemic	[35]
	Terpenoids			

3.3. Pharmacological activities.

3.3.1. Anticancer.

According to The World Health Organization (WHO), cancer is responsible for an estimated 9.6 million deaths and is the second leading cause of death globally in 2018. Globally, cancer contributes to approximately 1 in 6 deaths [36]. Commonly anticancer agents used to target the ROS induction, but, in a study, Moringa leaf extracts are found to have the ability to attack them [37]. Several studies reported that *M. oleifera* leaves have anticancer activities [38]. Recent studies of *M. oleifera* and *Indigofera arrecta* leaf extracts validated synergistic activities and anti-proliferative of both plants towards cancer cells. The two extracts, in combination with 5-Fluorouracil, showed improvement in anti-proliferative activities compared to single extracts [39]. In a study, *M. oleifera* ethanolic seed and leaves extract exhibited potent anti-tumor activity. Related bioactive compounds such as isothiocyanate and thiocarbamate are the compounds isolated and possess the inhibitory action on the tumor promoter [27]. Interestingly, another study [40] presented that *M.oleifera* aqueous leaf extract reduced the pancreatic cancer cell existence, tumor growth, and metastatic activity. The data from another research [41] revealed that *M. oleifera* worked through the induction of apoptosis and necrosis mechanism to exhibit cell death. *M. oleifera* contained kaempferol and quercetin from the flavonoid group functions as a “scavenger” of free radicals that prevent excessive formation of reactive oxygen species (ROS), which contribute to a reduction in NF-kb activity in MCF-7 cancer cells located in the pancreas and ovary cells. Besides that, *M. oleifera* also had the potential to enhance the killing of cervical cancer cells [42]. Another study [43] signified that phenolics elements and total dietary fiber consist of Moringa might have the chemopreventive ability as it revealed the suppressive effects of Moringa leaves *in vivo* model of AOM/DSS-induced colorectal carcinogenesis. Supplementation of *M. oleifera* leaf extract has resulted in the reduction of lipid peroxidation products in cells exposed to excess oxidative stress and normal cells for 24h at concentrations of 200 to 1000 µg/ml [44].

3.3.2. Antidiabetic agent.

Ethyl acetate fraction and leaf extracts of *M. oleifera* could decrease glucose levels to the normal range (P<0.05). The extracts showed anti-hyperglycemic activity in diabetic rats by stimulating insulin production from the beta cells of the pancreas. Ethyl acetate fraction of *M. oleifera* significantly lowered the glycosylated hemoglobin level in the elevated Streptozotocin-induced diabetes (STZ) (P<0.05) [45]. In previous research [46] suggested *M. oleifera* is a plant that credits of antidiabetic activity due to its ability to inhibit ATP-sensitive potassium channels in pancreatic beta cells, which leads to cell membrane depolarization that accounts for voltage-dependent calcium channels to open and cause a rise in intracellular

calcium in the beta cell and enhances insulin release. Another study explains that the kaempferol-3-O-glucoside, quercetin-3- β -D-glucoside, and cryptochlorogenic acid, compounds of the butanol fraction, and *M. oleifera* 95 % (v/v) ethanol extract are responsible for the anti-hyperglycemic effect in diabetic rats [47]. Diabetic animals that received *M. oleifera* showed recovery of weight in comparison with diabetic animals that had a significant decrease in body weight [48]. From seven human studies, one study exposed that *M. oleifera* gave incredible results where it significantly increases insulin production in a healthy human, the other five studies demonstrated a significant reduction in human blood glucose level, and the other study found that a decrease in post-prandial blood glucose and Moringa also possess the ability to reduce the measure of blood glucose levels, Hemoglobin A1C [49]. The new approach, such as in silico study, could be conspicuous to perceive the best bioactive compound of *M. oleifera* [50]. The study finally elected five phytochemicals, a-phenolic steroid, sitoglucoside (glycoside), hemlock tannin, 2-phenylchromenylium, and anthraquinone, which exhibited valuable binding within the active pocket of the targeted protein and there are the components that contribute to a significant reduction in blood glucose level. In addition, from the same source, higher anthraquinone concentration was reported from the aqueous extracts of *M. oleifera*. *M. oleifera* seems to contribute higher antidiabetic activity than the standard drug, acarbose that has been long in the market. The highest α -amylase inhibitory activity obtained from the hexane and methanol leaves extracts (IC_{50} value = 9.397 mg/ml and 8.217mg/ml), respectively [51]. A study [52] suggested that in the rat soleus, kaempferol plays the role by stimulating glucose uptake via the PKC and P13K pathways. Moringa seed powder significantly reduced fasting blood sugar when administered in STZ-induced diabetic rats [49].

3.3.3. Antihypertensive agent.

Four pure compounds, niazimicin A+B, niazinin A, and niazinin B, found from the *M. oleifera* leaves effectively lowered blood pressure in rats arbitrated possibly using a calcium antagonist effect [53]. A study investigated the activity-directed fractionation using pods of *M. oleifera* in ethanol extracts has led to the bioactive compounds that are responsible for the hypotensive activity. The compounds were thiocarbamate and isothiocyanate glycosides. In another study, aqueous and ethanol extracts of *M. oleifera* revealed pronounced comparable results in lowering blood pressure in both extracts [54]. Saponin has been identified in the *M. oleifera* for the antihypertension properties [38]. In order to further support the antihypertensive activity in the *M. oleifera*, a study was conducted and successfully isolated the compound responsible for these properties, such as isothiocyanate glycosides and thiocarbamate isolated from the acetate phase of the ethanol extract of *M. oleifera* pods [54].

3.3.4. Anti-gastric ulcer activity.

M. oleifera leaf extract, in combination with *Curcuma longa* was suggested, can be used in prevention of peptic ulcer disease in a study. The result obtained showed that *M. oleifera* leaf + *Curcuma longa* extracts used in the treated animals significantly increased ulcer inhibition (71.64%, 75.57%) compared to *Curcuma longa* (44.10%, 46.53%) and *M. oleifera* leaf (53.43%, 57.58), respectively [55]. It was proven that the chemical constituents responsible for the gastroprotective activity are alkaloids, sterols, flavonoids, glycoside, and terpenoids; hence *M. oleifera* is rich in source of them. Therefore, *M. oleifera* leaf aqueous extracts offer gastroprotection against acid alcohol-induced ulcers as a result of its antioxidant and anti-

inflammatory activity [56]. In order to reduce the development of a gastric ulcer, the steroid constituents in the *M. oleifera* seeds play a major role. Besides that, an antiulcer agent in the *M. oleifera* is offered by the flavonoids that act by protecting the gastrointestinal mucosa from the lesions formed by the different destructive agents and experimental ulcer models [57].

3.3.5. Antibacterial activity.

M.oleifera is a good antibacterial agent and proved in the study where there is a great reduction in the growth of test bacteria observed. The most inhibition using distillate *M. oleifera*, on *Klebsiella pneumoniae*, *Escherichia coli*, *Pseudomonas aeruginosa*, and *Bacillus subtilis*, and *Staphylococcus aureus* was observed [58]. In addition, a study found that using Erythromycin as a positive control, *M. oleifera* showed potential antibacterial activity against four major bacterial strains tested, *Bacillus megaterium*, *Citrobacter freundii*, *Staphylococcus aureus*, and *Pseudomonas fluorescens* [14]. The previous study expressed that the root bark of the *M. oleifera* was responsible for antibacterial and antifungal activities due to the aglycone of deoxy-niazimicin isolated from the chloroform fraction of ethanol extract [31]. Recently, there was a study [59] on *Catharanthus roseus* and *M. oleifera* leaf extracts, using the method of gas chromatography-mass spectrometry (GC-MS). However, the reported results on chemical profiling shielding to methanolic leaf extracts of *Catharanthus roseus* compared to aqueous leaf extracts of *M. oleifera* in their antioxidant and antimicrobial activity. A larger inhibition zone against *Pseudomonas aeruginosa* than *Erwinia carotovora* revealed the antibacterial effect of methanol, ethanol, and ethyl acetate *M. oleifera* leaves extracts [60]. Interestingly, viruses and bacteria in the turbid and contaminated water are capable of appealing and sticking fast to *M. oleifera* seeds. Thus *M. oleifera* possesses this unique characteristic [61].

3.3.6. Antifungal activity.

M. oleifera seed oil is directly applied to the distressed area, mostly to treat the ringworms [62]. Previous research [63] reported that antifungal activity was exerted maximally using methanol extracts of *M. oleifera* (25 mm) against *Trichoderma harzianum* whereas ethanol extracts inhibited *Penicillium spp.* (9.1 ± 0.1 mm), *Candida albicans* (10.0 ± 0.1 mm) and *Mucor spp.* (9.1 ± 0.3 mm). In addition, *M. oleifera* leaves extract could be potentially employed in the treatment of Aspergillosis in humans due to the result of the study indicated that the extract had strong antifungal activity against *A. flavus*, a fungus causing Aspergillosis in humans [64].

3.3.7. Anti-inflammatory activity.

Hot water infusions of *M. oleifera* leaves, flowers, seeds, roots, and stalks using carrageenan-induced in-vitro anti-inflammatory, and the extract was pharmacologically evaluated. Aqueous and methanolic extract of *M. oleifera* bark and root, methanolic extract of flowers and leaves, and ethanolic seed extracts possessed anti-inflammatory effects [27]. Investigation of using *M. oleifera* hydroethanolic bioactive leaf extracts to assess the anti-inflammatory activity by the inhibition of nitric oxide (NO) gave significant result when the extract successfully inhibit the secretion of NO release and other inflammatory markers such as interleukin (IL)-6, and IL-1 β and prostaglandin E2, tumor necrosis factor- α (TNF- α) [65]. In another study, *M. oleifera* seed oil with oleic acid indicated that they possess a crucial anti-

inflammatory effect like intruded with the steps in the PKC pathways that were related to those of the glucocorticoid response [66]. Moreover, a study reported, after performing suitable physicochemical evaluation studies, the Moringa oil-based cream formulation MF₄ prepared using 500 mg of potassium hydroxide as alkali was found to be a stable formulation function to antagonize the initial and late phase of inflammation induced by carrageenan [67]. Besides that, a study inferred that the anti-inflammatory effects of silver nanoparticles (AgNps) synthesized from *M. oleifera* flowers exhibited a great and higher inhibition percentage by albumin denaturation activity [68].

3.3.8. Anti-asthmatic activity.

M. oleifera seed kernels used in bronchial asthma have shown concurrent improvement in the respiratory functions and a remarkable decrease in the severity of symptoms of asthma, therefore in the study reported the efficacy and safety of the seeds [58]. Methanolic extract *M. oleifera* leaves exerted bronchodilator effect such as block the release of inflammatory mediators into the local lung tissues and inhibit inflammatory mediators such as histamine at a dose at dose 250 mg/kg and 500 mg/kg. The study confirmed that *M. oleifera* leaves had anti-asthmatic activity [69]. The most phytochemical constituents consisted of the leaves compared to seeds of *M. oleifera*; therefore, higher phytochemical compounds have encouraged the study to evaluate the anti-asthmatic effects using dexamethasone as the standard drug. The result obtained suggested that *M. oleifera* leaf possessed a great effect against mast cell degranulation, anti-inflammation, and bronchospasm [69].

3.3.9. Antioxidant activity.

In a study using 2,2'-diphenyl-1-picrylhydrazyl (DPPH) radical method, *M. oleifera* exhibited promising antioxidant activity from the most isolated compounds in different *in vitro* bioassay when contradicted with standard antioxidant compounds [70]. Besides that, ethanol and methanol extract of Indian *M. oleifera* possessed the highest antioxidant activity, with 66.8% and 65.1%, respectively [38]. Various types of good natural compounds presented in *M. oleifera* leaves such as flavonoids, ascorbic acid, carotenoids, and phenolic glorified the *M. oleifera* as an excellent source of antioxidants [54]. In addition, antioxidant elements that present in *M.oleifera* have commanded the ability to extend the duration of food containing fats, and among them were phenolics, flavonoids, carotenoids, and ascorbic acid [71]. Fruits such as strawberries, well-known in the antioxidant properties, the author mentioned that *M. oleifera* showed slightly higher antioxidants, especially in the leaves [72]. An *in vivo* study [73], in which Moringa seed extract assessed on normal and obese C57BL/6J male mice, revealed that Moringa seed extract had the ability to improve metabolic health by its intracellular antioxidant and anti-inflammatory activities. Correspondingly, the author from another study declared that aqueous extract of *M. oleifera* possessed antioxidant activity against free radical, superoxide radical, nitric oxide, and 2,2-diphenyl-1-picrylhydrazyl (DPPH) [74]. The main and lateral roots possessed better antioxidant activity than the leaves of *M. oleifera* found in the variation of antioxidant activity [75]. The identified phytochemical constituents gave significant antioxidant activity from *M. oleifera* plant were isothiocyanates, glucosinolates, and thiocarbamates were reported by the author from another study [76]. In a conducted study in Nigeria recently found descending order of antioxidant activity in *M. oleifera* was root barks > leaves > stem; however, they did not test the seeds [77]. Another

study supported the fact that roasting of *M.oleifera* leaves extract improved phenolics composition and exerted a good antioxidant (radical scavenging and ferric reducing) potential [78].

3.4. Malnutrition.

Mostly, the leaves of *M. oleifera* possess an abundant number of small molecules of human importance to encounter malnutrition. The root and leaves were observed to contain the Fe, Zn, Mg transporters, and Ca storage proteins [79]. In the *M. oleifera* tissue, prevailing minerals are Magnesium (Mg), Potassium (K), and calcium (Ca) [80]. The main components that contributed to combating the infant malnutrition [81] were histidine-2 amino acids and arginine from the *M. oleifera*; however, the same study recommended that *M. oleifera* leaves which are high in protein and iron content are not suitable in the initial treatment of the severely malnourished child. Moreover, from the other study [82], common galactagogue names search terms also included *M. oleifera* names and been claimed to have galactagogue properties. Antinutrients such as saponins, tannins, phytates, and oxalates existed in low amounts in *M. oleifera* [83], tripertenoid and phlobatannin were not obtained. These antinutrients may intrude on the absorption of some nutrients when consuming in immense quantities, although it is not necessarily toxic [72].

3.4.1. Wound-healing activity.

M. oleifera leaves showed a promising wound healing activity when there is a significant enhancement of cell proliferation and migration of Diabetic Human Dermal Fibroblast cells [84]. A bioactive compound such as hydroxyproline has shown a decreasing effect in scar area breaking strength in dead models of rats eventually from the extraction of the seeds, dried pulps, and leaves of *M. oleifera* [85]. In addition, an aqueous extract of *M. oleifera* leaves showed a significant increase in wound closure rate, granuloma breaking strength, dry granuloma weight, skin breaking strength, hydroxyproline content, and decrease in scar area was observed [86]. Moreover, topical treatment using *M. oleifera* stem cream (6%) intruded UV-B-induced oxidative stress injury, and *M. oleifera* stem (100-400 µg/ml) protected the epidermic cell against oxidative stress injury in the epidermis of the mouse skin [87]. Apart from that, recent studies revealed that higher tissue regeneration and ascended the tube-shaped structure epithelium protein in wound tissue of diabetic animals because given by leaf extraction that exerts wound healing [85].

3.4.2. Prevention of liver injury.

In previous research [88], it is demonstrated that *M. oleifera* had the ability to inhibit the acetaminophen-induced liver injury mice hence the significant rise of liver enzymes activity as well as nitrite, malondialdehyde, TNF, and IL-1β prior to the administration of the *M. oleifera* extract. The effects given were such as nitric oxide synthesis, lipid peroxidation, and GSH depletion in the liver was relevantly inhibited by *M. oleifera* extract. The other study investigated the inhibitory effects of the *M. oleifera* isolated secondary elements and extracts against two principle CYP450 isozymes (CYP2D6 and CYP3A4), that we're obliged to 50% drug metabolism clinically. The other study expressed that *M. oleifera* extract was safe for normal cells such as the liver and kidney [89].

3.4.3. Cardioprotective activity.

M. oleifera has the vincosamide chemical constituents in their respective leaves [90]. *M. oleifera* leaves extract also has anti-adipogenic effects and the chemical constituents identified were iso-quercetin derivatives that contribute to the effects [91]. Obesity has a correlation in initiating heart problems; therefore, the study suggested that *M. oleifera* treatment promoted apoptosis in mature adipocytes and prevent obesity. In addition, a study reported that oxidative stress-induced different chronic diseases such as cardiovascular complications could be prevented by the intake of *M. oleifera* due to the presence of flavonoids [92]. Furthermore, an effective dose of 500 mg/kg was identified for the prevention and treatment of acute ischemic stroke, besides Moringa seed extract treatment also improved animal survival and reversed spatial cognitive impairment as well as promoted cholinergic neurotransmission during the delayed stages of ischemic stroke, neurogenesis, and neuroplasticity [93].

3.4.4. Concentration enhancer.

Consuming 5-10 g of *M. oleifera* cookies for two weeks promoted the concentration ability in male teenagers aged 13-15 years [38]. There is another study that suggested an outcome of Moringa seed extract on the grounds of a mechanism like modulation of cholinergic activity via the Akt, CREB, and ERK1/2 signaling pathways. Moringa seed extract could be a potent neuropharmacological drug against amnesia. Furthermore, the same study reported that Moringa seed extract could protect the mice from memory dysfunction and scopolamine-induced learning [95]. Furthermore, a study demonstrated that *M. oleifera* leaves extract gave a memory-enhancing effect partly via the enhanced cholinergic function and via the decreased oxidative stress. However, suppression of monoamine oxidase (MAO) and increased regional blood flow also showed a rise to the enhanced dopaminergic function by the *M. oleifera* leaves extract [96].

3.4.5. Immunomodulatory activity.

The previous research [97] has shown that good immuno-boosting effects can be obtained from the leaves of *M. oleifera* as the study extracted and isolated a novel polysaccharide, MOP-3 composed of galactose, glucose, and arabinose. There was a study conducted using the carbon clearance method in male white mice, the immunomodulatory effect that is immunostimulant was gain from *M. oleifera* leaf extract that could increase the total number of leukocyte cells in the blood test animals [98]. *M. oleifera* supplementation of broiler's diet would alleviate the degenerative changes that occurred in live tissue; besides, we are able to modulate the immune response by regulating mRNA expression levels of the innate immune response mediators such as IL6 and IL2 [99]. Alkaloids are abundant phytochemicals found in *M. oleifera* and can exert immunomodulatory activities; some bitter alkaloids (tropane alkaloids) are metabolized into dimethylxanthine in the liver and finally to methyl uric by CYP450 Oxygenase systems [100].

4. Conclusions

The significant contribution in phytochemical compounds may explain the pharmacological activities ascribed to *M. oleifera*. *M. oleifera* has a vast number of economic

applications and multidimensional properties. It is good nutrition as well as inexpensive and can be used to prevent a lot of diseases. Additionally, most of the plant parts like leaves, seeds, roots, and flowers are useful for various treatments. Therefore, *M. oleifera* contributed to the potential value in prevention or treatment of a series of chronic diseases. The literature review supported the uses of various parts of the *M. oleifera* pharmacologically. Further, more researches are needed for the development of a suitable dosage form using the isolated active constituents of the *M. oleifera*.

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Conflicts of Interest

The authors declare no conflict of interest.

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