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A Review on Pharmacological properties of *Moringa Oligofera*

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Abstract:

Moringa is the most widely cultivated plant in many tropical areas and it is commonly referred to as "drumstick" or "horseradish" tree and in Tamil it is known as "murungai". All parts of the *Moringa* tree–leaves, flowers, fruits, and roots are edible and have been consumed as vegetables for a long time. *Moringa* believed to be a 'super plant' due to its unique properties that combat different ailments. *Moringa oleifera*, has been used in traditional medicinal system for centuries in diverse therapeutic applications. Pharmacological action such as antioxidant, anti-diabetic, cardiovascular, anti-cancer, anti-inflammatory, anti-allergic, anti-convulsant /neuro protective, anti-fertility, hepato and renal protective, antiurolithiatic and diuretic, anti-microbial, antihelimintic, anti-anemic, and wound healing activities are restrained by *Moringa oleifera*. It includes a rich source of vitamin A and C and milk protein. Different types of active phytoconstituents like alkaloids, protein, quinine, saponins, flavonoids, tannin, steroids, fixed oil, and fats are present. Glycosides, (eg. niazirin, niaziridin, niazimicins etc.), glucosinolates (glucomoringin) flavanol glycoside (quercetin) flavonols (kaempferol), Isothiocyanates and sterol glycoside (campesterol, stigmasterol, β-sitosterol, avenasterol) are some important constituents. Though *Moringa oleifera* possess several remedial properties the present review summarized certain important pharmacological activities. Thus our present topic conceivably encourages many prospects for future research to explore the potential compound from a plant source and its pharmacological values on various biological responses.

Keywords: *Moringa oleifera*, Pharmacological Activity, anti-inflammatory, anti-diabetic activity.

Introduction

Moringa is the most widely cultivated species of a monogeneric family, commonly known as "drumstick" (describing the shape of its pods) or "horseradish" tree (referring to the taste of its roots) (Shih et al., 2011). *Moringa* is referred as "murungai" in Tamil and "Sohanjna" in hindi and urudhu.

The Moringa is native of sub-Himalayan tracts of India, Pakistan, Bangladesh, and Afghanistan but can also be found in Tropical Asia, Southwest Asia, Africa, Madagascar, America, and the Caribbean Islands. *Moringa* thrives well in humid tropical areas or hot dry lands but it can also survive destitute soils (Morton, 1991). It endures a wide range of rainfall with a minimum of 250 mm and a maximum at over 3000 mm and a pH of 5.0–9.0 (Palada and Changl, 2003). This perennial plant is fast growing in nature, can reach height ranges from 5 to12 meters. The timber of this tree is considered to be of very inferior quality due to its fragile softwood.

Morphology

Moringa leaves are typically tripinnate or bipinnate, 30-75 cm long on the main axis and branch jointed, with leaflets 1–2 cm long, finely hairy, green and almost hairless on the upper surface, paler beneath, and rounded or blunt-pointed at the apex and short-pointed at the base. The twigs are finely hairy and green. Flowers are white, scented, and grow in large axillary panicles measuring about 10-25 cm long. Individual flowers are approximately 0.7 to 1 cm. Moringa fruits are tri-lobed capsules that are referred to as pods. The pods are pendulous, ribbed, and the seeds are 3-angled (Gupta 2010; Garima Mishra et al 2011). The fruits are around 30-120 cm long. Matured dry seeds are round or triangular in

shape and the kernel (seed) is surrounded by a light woody shell with three papery wings (Abdulkarim et al., 2005).

The leaves, flowers, and fruits of the Moringa trees are edible and have long been consumed as vegetables (Siddhuraju and Becker, 2003). Despite its nutritional value, Moringa is generally believed to be a'super plant' because of its unique properties to combat different ailments in our system.

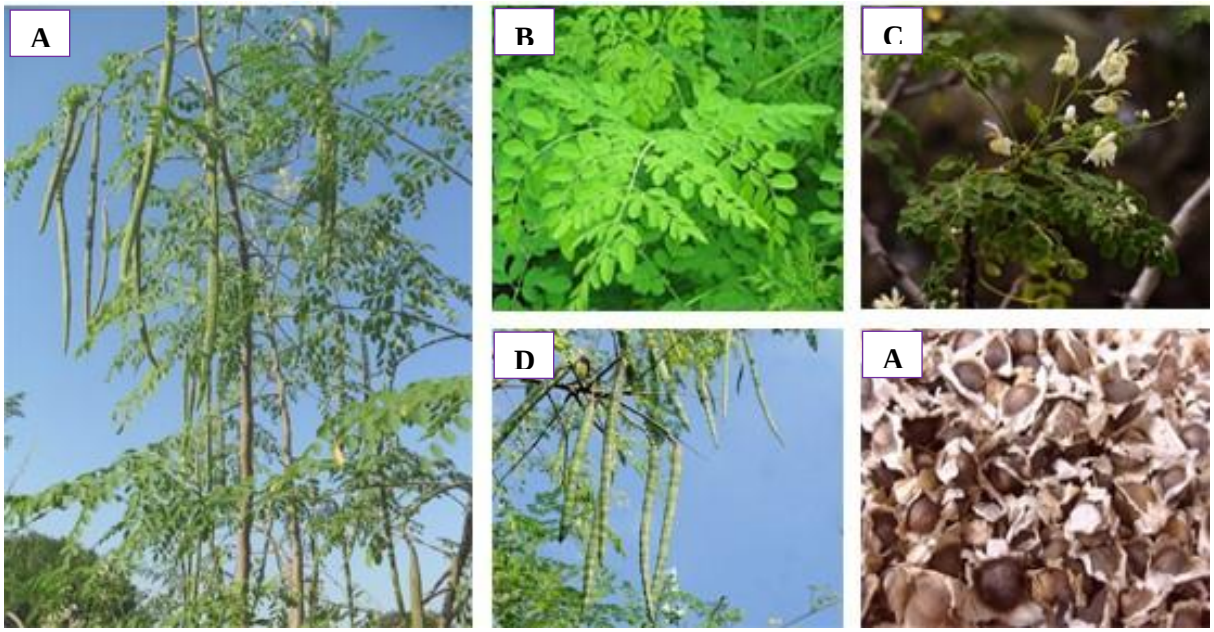

Figure: A- Arial part; B- Leaves, C- Flowers; D-Fruits; F-Seeds.

Traditional usage

In ancient medicine, *Moringa oleifera* was used as a medicinal agent by the Romans, Greeks, and Egyptians (Fahey 2005). It has been traditionally used in the Siddha, Ayurvedic and Unani medicinal systems. The different parts of the *Moringa oleifera* are widely used in diverse therapeutic applications. In India, the leaves are used as an antihypertensive, antidiabetic, antianxiety agent, diuretic, antidiarrheal, colitis and gonorrhoea (Fuglie 2002). Poultices are made from leaves used to cure skin diseases in Nicaragua, India, Guatemala, and Senegal. The leaves of *Moringa oleifera* have lactation enhancing effects (Peter Francis et al., 2014). In the Philippines, lactating mothers consume Moringa leaves cooked with shellfish and chicken as a soup to improve lactation (Siddhuraju et al., 2003). The roots of *Moringa oleifera* are used in India to treat edema, wounds and ulcers; hiccups; asthma, rheumatism, gout, kidney stones, and diseases of the liver and spleen (Fuglie 2002). The bark of roots and stems has been used for the treatment of wounds and skin infections, scurvy, sore eyes, delirium, digestive complaints, and also against snake venom (Akindele et al., 2021). In particular, the bark is used as an aphrodisiac, an abortifacient, and to treat upper respiratory tract infections (Bobbie Posmontier 2011). The pods are known to be anthelmintic, antipyretic, and antidiabetic (Swati et al., 2018). The resin of this plant is used for headaches, fevers, gastroenteritis, asthma, dental caries, rheumatism, and syphilis, as well as to terminate pregnancy (Fuglie, 2002). The seeds are utilised for the treatment of fever, tumors, warts, hysteria, scurvy, prostate, bladder ailments and used as a purgative (Bobbie Posmontier, 2011). In addition, the seeds are traditionally used as a natural coagulant to purify water contamination (Katayon, et al., 2006).

Pharmacological Activity

Antioxidant activity:

Leaves and the whole pod of *Moringa oligofera* exhibit antioxidant properties (Luqman et al., 2012). Aqueous extract of tender and matured leaves showed a strong free scavenging effect on 2, 2-diphenyl-2-picryl hydrazyl (DPPH) radicals, superoxide, nitric oxide radicals, and inhibition of lipid peroxidation due to high levels of polyphenols (Sreelatha and Padma 2009). Fruit extract showed advantageous results in eliminating free radicals and reducing iron and FeSO4-induced microsomal lipid peroxidation in a dose-dependent manner. (Pasha et al., 2010; Sathish et al., 2014; Wangcharoen andGomolmanee, 2011). Verma et al. (2012) experimented with *Moringo oligofera* in rat gastric ulcers and reported that 50% of ethanolic extracts were found to change in SOD (superoxide dismutase), CAT (catalase) and LPO (lipid peroxidation) levels, which indicate an antioxidant defence activity. The scavenging activity was proposed to be attributed to triterpenoids, moringyne, monopalmitic and di-oleic triglycerides, campesterol, stigmasterol, -sitosterol, avenasterol, vitamin A, and its precursor -carotene have been shown to contribute to antioxidant properties (Stavros et al., 2011).

Anti-diabetic activity:

Aqueous extracts of *Moringa oligofera* leaves showed anti-diabetic activity on glucose tolerance in Goto-Kakizaki and Wistar rats (Suzuki et al., 2007; Misahra et al., 2011). A study reported that an aqueous leaf increased insulin levels and decreased insulin resistance, helping to combat hyperglycemia in diabetic rats (Tuorkey, 2016). Paula et al., reported a protein in the leaf and the seed coat of *Moringa oleifera* had an antigenic epitope similar to insulin and displayed hypoglycemic activity on oral administration. (Paula et al., 2016; Paula et al., 2017). Moringa oleifera leaf extract was found to reduce FPG levels, post-prandial levels, blood glycated hemoglobin, total cholesterol, non-HDL-C, HDL-C, VLDL-C, and LDL-C in Type 2 diabetic patients (Kumari, 2010; Nambiar et al., 2010; Ghiridhari et al., 2011).*Moringa oleifera* leaf powder (4 g) significantly increased the insulin level in healthy subjects (Anthanont et al., 2016).

Tende et al. (2011) stated that the hypoglycemic and anti-hyperglycemic activities of the leaves of *Moringa oleifera* may be probably due to the presence of terpenoids that promote stimulation of the beta cells and subsequent secretion of insulin. Another study reported that the seed extract reduces lipid peroxidation and increases antioxidant enzyme activity in streptozotocin-induced mice. Al-Malki and El Rabey (2015) define formalised formalised formalised formalised formalised formalised formalised formalised formalised formalised formalised formalised formalThis study also reported that bioactive compounds such as quercetin, kaempferol, glucomoringin, and chlorogenic acid have shown various biological activities, including hypoglycemic effects. Besides these compounds, isothiocyanates, for example, 4-(3'-O-acetyl--L-rhamnosyloxy)benzyl4-[(4'-O-Acetyl--L-rhamnosyloxy)benzyl] glucosinolate4-[(-L-rhamnosyloxy) benzyl] glucosinolate4-[(2'-O-acetyl--L-rhamnosyloxy) benzyl] isothiocyanate4-[(3'-O-acetyl--L-rhamnosyloxy) benzyl] isothiocyanate4-[(4'-O-acetyl--L-rhamnosyloxy) benzyl] isothiocyanate and 4-[(4'-O-acetyl--L-rhamnosyloxy) benzyl]Isothiocyanate (Waterman et al., 2015) and benzylamine (Iffiu-Soltesz et al., 2010) from *Moringa oleifera* were reported to show antidiabetic activity.

Cardiovascular activity:

The ethanolic leaf extract of *Moringa oleifera* leaves was reported to reduce pulmonary arterial blood pressure immediately after administration of monocrotaline to rats and increase SOD levels, which might be the primary reason for the antihypertension activity in pulmonary hypertension (Chen et

al., 2012). The active constituents niaziridin, niazinin A, niazinin B, and niazimicin have been reported for hypotensive action (Chen et al., 2012, Gilani et al., 1994).

Seeds of *Moringa oleifera* also displayed cardioprotective activity in spontaneous hypertensive rats (Dangi et al., 2002; Randriamboavonjy et al., 2016). The seed extract increased cardiac diastolic function and reduced nocturnal heart rate without altering the blood pressure of the rats. Similarly, it decreased fibrosis and left ventricular relative, anterior, and interseptal wall thickness. Furthermore, it decreased cardiac triglyceride levels while increasing plasmatic prostacyclin and PPAR- and activity (Randriamboavonjy et al., 2016).Other studies reported that the antioxidant activity of *Moringa oleifera* leaf butanolic extract helped to reduce cardiac necrosis and oxidative stress in isoproterenol-induced rats (Panda, 2015). The leaf extracts reduced lipid peroxidation, increased antioxidants, and reduced inflammation and necrosis in the myofibrillar structure. Moringa oleifera's cardioprotective activity may be due to the compound N, -L-rhamnopyranosyl vincosamide (Panda et al., 2013).

Anti-cancer activity:

An aqueous extract of *Moringa oleifera* pods showed inhibitory effects of cell proliferation against dextran sodium sulfate-and azoxymethane-induced mouse colon carcinogenesis. The study reported that the high content of omega-9 oleic fatty acid and glucomoringin in the extract possess anti-inflammatory activity and could modulate cancer cell proliferation (Budda et al., 2011). Tiloke et al. (2013) studied the antiproliferative effect of *Moringa oleifera* crude aqueous leaf extract on cancerous human alveolar epithelial cells. The extract was thought to contain active compounds 4-(4′-Oacetyl--L-rhamnopyranosyloxy) benzyl isothiocyanate and niazimicin, which were responsible for caspase 9 activity regulation.Leaf extract of *Moringa oleifera* decreased the proliferation of B16F10 melanoma cells, causing cancerous cell apoptosis in the sub G1-area and induced cell arrest in the G2/M phase. The extract was also shown to increase the p27Kip1, p53, and p21WAF1/Cip1 levels in melanoma cells. (2013) (Gismondi et al.).The presence of eugenol in *Moringa oleifera* bark inhibited the activity of E2F1/survivin and D-allose in leaves inhibited cancer cells in the G1 phase of MDA-MB-231 and HCT-8 cells (Al-Asmari et al., 2015). According to Rajan et al. (2016), 4-(-L-rhamnopyranosyloxybenzyl) isothiocyanate (glucomoringin isothiocyanate) inhibited malignant astrocytoma cells via oxidative stress-mediated apoptosis via Bax and p53 activation.

Anti-inflammatory activity:

Moringa oligofera exerts its anti-inflammatory activity through various events. Moringa oleifera leaf extracts (hexane, chloroform, ethyl acetate, and butanol) inhibited IL-1, IL-6, PGE2, TNF-, and NO (nitric oxide) production in the NF-B pathway of LPS macrophages (Arulselvan et al., 2016).The ethyl acetate extract showed the strongest inhibitory activity that blocked the nuclear translocation of NF-κB and increased inhibitor κB expression. The same mechanism was also observed in *Moringa oleifera* fruit extract. Both 4-[(2′-O-acetyl--L-rhamnosyloxy)benzyl] isothiocyanate and 4-[(3′-O-acetyl--L-rhamnosyloxy)benzyl] isothiocyanate were found in the leaf ethyl acetate extract and have anti-inflammatory activity (Gothai et al., 2016).A hydroethanolic flower extract suppresses the activity of inflammatory mediators and proinflammatory cytokines such as PGE2, IL-6, IL-1, TNF-, NF-B, iNOS, NO, and COX2 in LPS-induced RAW264.7 macrophages (Tan et al., 2015). The extract increased the activity of the anti-inflammatory cytokines IL-10 and 1κB-α. Among the different parts of *Moringa oleifera*, the

fruit also showed the highest anti-inflammatory activity by reducing proinflammatory cytokines like NO (nitrous oxide) in LPS-induced RAW264.7 cells (Lee et al., 2013).

The compounds aurantiamide acetate and 1,3-dibenzyl urea, isolated from Moringa oleifera roots, inhibited IL-2 and TNF- activity (Sashidara et al., 2009).The compounds found in the leaves, specifically 4-[(-Lrhamnosyloxy) benzyl] isothiocyanate and 4-[(4'-Oacetyl--L-rhamnosyloxy) benzyl] isothiocyanate, regulate IL-1 and iNOS expression as well as reduce inflammatory marker expression in RAW macrophages (Waterman et al., 2014).According to Galuppo et al. (2014), the compound 4-[(-L-rhamnosyloxy) benzyl] isothiocyanate reduced Bax/BCl-2 imbalance and inhibited TNF- activity on myelin.Oligodendrocytes glycoprotein 35–55-induced C57B1/G male mice and also showed antioxidant activity against cerebral tissue damage induced by cerebral ischemia reperfusion in rats (Galuppo et al., 2015).

A study reported that ethanolic seed extract of *Moringa oleifera* inhibited the reaction of delayed hypersensitivity by reducing mean foot pad thickness in mice in paw edoema and inflammation (Mahajan and Mehta, 2010). Likewise, methanolic leaf extract of *Moringa oleifera* reduced the edematogenic effect of carrageenan-induced and histamine-induced paw edoema (Adedapo et al., 2015).

Hydroethanolic and methanolic leaf extracts of *Moringa oleifera* stimulated both cellular and humoral immunity of normal and immuno-suppressed mice in a dose-dependent manner (Gupta et al., 2010; Nfambi et al., 2015). The ethanolic seed extract decreased macrophage phagocytosis and white blood cell concentration, exhibiting immunosuppressive activity (Mahajan and Mehta, 2010). The compounds detected from ethanolic leaf extract, namely quercetin-3-O-glucoside, kaempferol-3-O-glucoside, and crypto chlorogenic acid, showed anti-inflammatory activity, inhibiting the migration and chemotactic oxidation of polymorphonuclear leukocytes (Vongsak et al., 2013).

Anti-allergic activity

Mahajan and Mehta (2007) reported the inhibitory action of ethanolic extract of Moringa oleifera seeds on systemic and local anaphylaxis. The potential anti-anaphylactic effect of ethanolic root extract was studied on compound 48/80-induced systemic anaphylactic shock and passive cutaneous (local) anaphylaxis activated by anti IgE-antibody in a mouse model. The seed extract inhibited passive cutaneous anaphylaxis induced by anti-IgG (IgG) antibodies and histamine release from mast cells. The underlying mechanism of this inhibitory action could be attributed to membrane stabilising action (Mahajan and Mehta 2007). An aqueous extract of *Moringa oleifera* leaves also reduced scratching frequency in an Ovalbumin sensitization model (Hagiwara 2016).

Anti-convulsant/neuroprotective activity:

Studies were conducted to discern the anti-convulsant activity effects of methanolic leaf extract of *Moringa oleifera* against PTZ (pentylenetetrazole) and MEZ (maximal electroshock) induced convulsions at 200 mg/kg and 400 mg/kg dosage levels. As reference standards, diazepam and phenytoin were used

as reference standards. In both of the tests, methanolic extract significantly delayed the onset of seizures in Ptz-induced convulsions and significantly reduced the duration of hind limb extension in the MES test at both the dose levels. The presence of alkaloids, flavonoids, and tannins present in the methanolic leaf extract of *Moringa oleifera* may promote an anti-convulsant effect (Amrutia et al., 2011). Two independent experiments investigated anti-convulsant activity of the aqueous root extract of *Moringa oleifera* against penicillin (PCN) induced convulsion. Root extract significantly increased locomotor behavior, serotonin (5-HTT), dopamine (DA), and norepinephrine (NE) levels in the brain, and suppressed penicillin-induced epileptic seizures (Talhaliani and Kar 2000; Ray et al., 2003).A study assessed the effects of ethanolic leaf extract of *Moringa oleifera* on alzheimer's disease in a rat model and indicated that it increased EEG wave pattern and restored the monoamine level of the brain. (Ganguly and Guha, 2008

Anti-fertility activity:

The effects of aqueous root extract of *Moringa oleifera were* studied during pre and post-implantation stages in rats. The root extract promotes an undesirable condition of the uterus for implantation of the fertilised eggs (Prakash et al. (1987). The aqueous and 90% ethanol leaf extracts were tested on 10 days of insemination in rats, with special reference to their effects on foetal development. It was reported that the leaf extracts of *Moringa oleifera* aborted 100% of implantation (Shukla et al., 1988; Nath et al., 1992). In the presence and absence of estradiol dipropionate and progesterone, the root aqueous extract was found to be effective as an anti-fertility agent.A high dose of the root extract, 600 mg/kg, was found to be anti-progestational activity, preventing the formation of the deciduoma in rats (Shukla et al., 1988). It also reduced the protein concentration for the formation of the uterus (Prakash et al., 1988).

Hepato and renal protective activity

The methanolic leaf extract of *Moringa oleifera* showed renal and hepatoprotective effects in rats (Oyagbemi et al. 2013). Studies investigated that the leaf extract reduced aspartate aminotransferase (AST), alkaline phosphatase (ALP), alanine aminotransferase (ALT) (Pari and Kumar 2002; Sharifudin et al., 2013), and blood urea nitrose (BUN) and creatinine (Ouedraogo et al., 2013) and were further confirmed by histopathological examinations. Similar results were observed in nickel-induced nephrotoxicity and supplemented with *Moringa oleifera* diets in Wistar rats (Adeyemi et Elebiyo. (2014). Many experiments evaluated the effects of leaf, oil, and seed ethanolic extracts against arsenic, acetaminophen HgCl2 toxicities, and gamma radiation, and those were reported to display antioxidant activity, which is responsiblefor renal and hepatoprotective effects. (Gupta et al., 2007; Fakurazi et al., 2008; Sinha et al., 2011; Abarikwu et al., 2017). Leaf extract has shown hepatoprotective effects against antitubercular drugs and alloxan-induced liver damage in diabetic rats (Omodanisi et al., 2017). Dieting supplementation of *Moringa oleifera* for 21 days showed a significant reduction in hepatic injury (Pari and Kumar, 2002; Toppo et al., 2015). Alkaloids, quercetin, kaempferol, flavonoids, ascorbic acid, and benzylglucosinolate were found to be responsible for hepatoprotective activity (Gilani et al., 1997; Ruckmani et al., 1998).

Antiurolithiatic and Diuretic activity

The aqueous and alcoholic root extract of *Moringa oleifera* on calcium oxalate urolithiasis rats promoted antiurolithiatic activity. These root extracts significantly decreased the elevated urinary oxalate, showing a regulatory action on endogenous oxalate synthesis (Karadi et al. 2006). The aqueous and alcoholic extract of the root bark of *Moringa oleifera* also significantly lowered the urinary excretion and kidney retention levels of oxalate, calcium and phosphate. Furthermore, this study reported that elevated serum urea nitrogen, creatinine and uric acid levels were significantly reduced by the extracts (Karadi et al. (2008). The aqueous extract of bark also showed a reduction in the weight of stone produced by the ethylene glycol (1%) induced urolithiasis model. Diuretic activity-Hot water infusion of flowers, leaves, seeds, and bark of *Moringa oleifera* showed increasing urine output in rats (Fahaad et al., 2010). Campesterol, stigmasterol, β-sitosterol, and avenasterol were responsible for this activity (Caceres et al., 1992).

Anti-microbial activity:

Various research has been conducted on the antimicrobial activity of *Moringa oligofera*. Hexane and methanol seed extracts showed inhibition against waterborne pathogens, primarily against *Salmonella typhii*, *Vibrio cholera*, and *Escherichia coli* (Walter et al., 2011). The ethanol extracts of the seeds and leaves also exhibited inhibition against the dermatophytes *Trichophyton mentagrophytes*, *Microsporum canis*, *Trichophyton rubrum*, and *Epidermophyton floccosum*(Chuang et al., 2007). Methanolic extract of leaves inhibited urinary tract pathogens, such as *Staphylococcus aureus*, *Klebsiella pneumoniae*, *Staphylococcus saprophyticus*, and *Escherichia coli* (Rockwood et al., 2013; Singh 2014; Abdalla et al., 2016). Ethanolic extracts of root and bark possessed antifungal activity against *Aspergillus niger*, *Neurospora crassa*, *Rhizopus stolonifer*, and *Microsporum gypseum* (Jha et al., 2009; Zaffer et al., 2015) and also showed inhibitory activity against the protozoan *Leishmania donovani* (Kaur et al., 2014). Ethyl acetate, acetone, and ethanol extracts of *Moringa oleifera* seeds, roots, leaves, and a mixture, were assessed for their dental antibacterial and antifungal activity. These extracts showed inhibition of *Streptococcus aureus* and *Streptococcus mutans*, strikingly ethanolic leaf extract showing the maximum inhibition (Elgamily et al., 2016). However, the high concentrations of *Moringa oleifera* seeds were reported to inhibit Candida albicans' growth (Saadabi and Abu Zaid, 2011). Flavonoids, tannins, steroids, alkaloids, saponins, benzyl isothiocyanate, and benzylglucosinolate were found to be responsible for antimicrobial activity (Vinoth et al., 2012; Pinal et al., 2014), whereas pterygospermin was found to be responsible for antifungal activity (Rao et al., 1946; Fahey 2005).

Antihelimintic activity:

Different concentrations of ethanolic extracts of *Moringa oleifera* and *Vitex negundo* were tested against the Indian earthworm *Pheritima posthuma*. Ethanolic leaf extract showed more anthelminthique activity against the Indian earthworm, *Pherritima posthuma*, compared to *Vitex negundo* in a dose-dependent manner (Rastogi et al., 2009). The aqueous and ethanolic leaf extract of *Moringa oleifera* was evaluated against fresh eggs, embryonated eggs, L1 and L2 larvae of *Haemonchus contortus*. The results revealed that ethanolic leaf extract was most efficient on eggs, inhibiting 60.3% and 92.8% of egg embryonation (Tayo et al., 2014). Similarly, aqueous and ethanolic seed extracts of *Moringa oleifera* against *Haemonchus contortus* eggs showed potent ovicidal and larvicidal activity (Ferreira et al., 2009; Cabardo and Portugaliza 2017). The flowers of *Moringa oleifera* are also considered to be of high anthelmintic activity, comparable with piperazine citrate, a standard drug (Trapti et al., 2009). In

veterinary practice, *Moringa oleifera* leaves could find their application in the treatment of avian coccidiosis (Shola et al., 2013).

Anti-anemic activity

A randomized, double-blind, placebo-controlled study was conducted on women who were anaemic with haemoglobin levels between 8 and 12 g/dL and were treated with aqueous extract of *Moringa oligofera* leaf, resulting in an increase in mean haemoglobin and mean corpuscular haemoglobin concentration (Suzana et al., 2017). Other studies have found that giving Moringa oligofera leaves to healthy human volunteers for 14 days results in a significant increase in platelet count (Adegbite et al., 2016; Archibong et al., 2017).

Anti-asthmatic activity

In various models, seed extract of *Moringa oligofera* against asthma was investigated in various models. The proposed mechanism for this activity was a direct bronchodilator effect combined with anti-inflammatory and antimicrobial actions (Anita and Babita, 2008) and inhibition of immediate hypersensitive reactions (Goyal et al., 2009). Ethanolic seed extract tested against ovalbumin-induced airway inflammation in guinea pigs indicated a significant increase in respiratory parameters and reduction in interleukins in broncho-alveolar lavage (Mahajan SG, Mehta 2008). The fine power of *Moringa oleifera* seed was evaluated in patients with mild-to-moderate bronchial asthma, and many patients showed an increase in haemoglobin (Hb) level and a reduction in erythrocyte sedimentation rate (ESR). The seed powder produced significant improvements in forced vital capacity, forced expiratory volume in one second, and peak expiratory flow rate values (Agrawal and Mehta 2008). Likewise, alcoholic extracts of *Moringa oleifera* seed were found to be spasmolytic in acetylcholine, histamine, Bacl2 and 5HT induced bronchospasm (Mehta and Agrawal 2008).

Wound healing activity

Extracts of leaf, dried pulp, and seeds of *Moringa oleifera* showed a significant increase in hydroxyproline content, wound-closure rate, granuloma-breaking strength, and granuloma dry weight, and a decrease in scar area and skin-breaking strength in incision, excision, and dead space wound models in rats (Rathi et al., 2006; Misahra et al., 2011; Momoh et al.,2013). This was supported by Hukkeri et al., (2006) investigation that showed the antipyretic and wound healing properties of ethanolic and ethyl acetate leaf extracts of *Moringa oleiferam*. Another study conducted on diabetic animals treated with leaf extract showed improved tissue regeneration, down-regulated inflammatory mediators, and unregulated vascular endothelial growth factor and decreased wound size (Muhammad et al., 2016) and remarkable anti-proliferative and anti-migratory effects on normal human dermal fibroblasts (Gothai et al., 2016).

Conclusion

The current review describes the pharmacological activity of *Moringa oleifera* and its phytochemical constituents. Our study highlighted antioxidant, anti-diabetic, cardiovascular, anti-cancer, anti-inflammatory, anti-allergic, anti-epileptic, neuroprotective, anti-fertility, hepato and renal protective,

anti-microbial, anthelmintic, anti-anemic, anti-asthmatic, and wound healing activities beside many pharmacological activities of this miracle plant. *Moringa oleifera* possesses several remedial properties that undoubtedly influence various biological manifestations, thus it could be proposed as an alternative medicine for the treatment of different diseases. Thus, our present topic conceivably opens multiple venues for future research to explore the potential compounds derived from plant sources and their pharmacological values in various biological responses.

Conflicts of interest

The authors declare that there are no conflicts of interest.

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