Research Article **CODEN: IJRPJK** **ISSN: 2319 – 9563**

International Journal of Research in Pharmaceutical and Nano Sciences

Journal homepage: www.ijrpns.com

https://doi.org/10.36673/IJRPNS.2023.v12.i03.A15

A REVIEW ON PHYTOCHEMISTRY AND PHARMACOLOGIAL PROPERTIES OF *MORINGA OLEIFERA* PLANT

Shiwani Jaiswal*[1], Navneet Kumar Verma[1], Ravindra Singh[1], Pragya Mishra[1], Shweta Yadav[1]

[1*]Buddha Institute of Pharmacy, GIDA, Gorakhpur, Uttar Pradesh, India.

ABSTRACT

For many years, natural materials have been used as a source of treatments and drug leads. Diverse methodologies inspired by natural products are used in the diversity-oriented synthesis of new small molecule libraries. A increasing body of evidence supports the efficacy of these strategies for identifying novel physiologically active chemicals. *Moringa oleifera*, a valuable medical plant, is one of the most commonly farmed species in the Moringaceae family. The plant's many parts have been used to create human medications. The literature review revealed extremely clear insights into this plant's historic use as an antispasmodic, stimulant, expectorant and so on. Bark has emmenogogue and abortifacient properties, as well as antibacterial and antifungal properties. Flowers can be diuretic, stimulant, cholagogue, or tonic. Antiviral, anti-inflammatory, and analgesic activities are found in root bark. Among the pharmacologically documented activity are antimicrobial, anti-inflammatory, oxidative, anticancer, antifertility, hepatoprotective, cardiovascular, antiulcer, analgesic, wound healing, anticonvulsant, antiallergic and anthelmintic effects.

KEYWORDS

Moringa oleifera, Complementary foods, Anti-inflammatory, Antioxidant and Anti-anemia actions.

Author for Correspondence:

Shiwani Jaiswal,

Buddha Institute of Pharmacy,

GIDA, Gorakhpur, Uttar Pradesh, India.

Email: navneet_its04@rediffmail.com

INTRODUCTION

The use of herbal medicine has increased dramatically during the past few decades. Because of its natural origin and minimal negative effects, it is becoming more and more popular in both developing and developed nations[1]. All of India's officially recognised health systems, including Ayurveda, Yoga, Unani, Siddha, Homoeopathy and Naturopathy, rely heavily on herbal medicines. Over 70% of India's 1.1 billion people continue to use these non-allopathic medical systems[2].

Significant sections of the populace in many developing nations rely on traditional healers and their arsenal of medicinal plants to address their healthcare needs. The use of herbal medicines has frequently remained popular due to historical and cultural factors, even if modern medications may coexist alongside such traditional practises. Commercially speaking, these goods are now more readily accessible, particularly in industrialised nations. In the latter half of the 20th century, there was a sharp increase in the use of herbal medicines in developed nations. Herbal medications are an essential component of the traditional and well-established Indian System of Medicine (Ayurveda) in that country[3]. The study of different plant products according to their traditional uses and medicinal value based on their therapeutic efficacy results in the invention of newer and more recent medications for treating different diseases. This information serves as the foundation for the creation of novel medications derived from various plant sources. *Moringa olifera*, a member of the Moringaceae family and often known as "sahajan" in Hindi and "horse radish" in English, is one of these medicinally valuable plants. It is a little, quickly-growing, evergreen or deciduous tree that typically reaches a height of 10 or 12m. It is dispersed throughout Peninsular India, Assam, Bengal, and the Sub-Himalayan Tracts[4]. It is said to have a variety of characteristics, including antispasmodic, diuretic, expectorant and abortifacient[5].

TAXONOMICAL CLASSIFICATION

Kingdom -- Plantae
Sub Kingdom -- Tracheobionta
Super Division -- Spermatophyta
Division -- Magnoliophyta
Class -- Magnoliopsida
Subclass -- Dilleniidae
Order -- Capparales
Family -- Moringaceae
Genus -- Moringa
Species -- Oleifera

BOTANICAL DESCRIPTION

Synonyms

Latin -- *Moringa Oleifera*
Sanskrit -- Subhanjana
Hindi - Saguna; Sainjana
Gujrati -- Suragavo
Tamil -- Morigkai
Telugu -- Mulaga
Malayalam -- Murinna
Punjabi -- Sainjna
Unani -- Sahajan
Ayurvedic -- Raktaka
Arabian -- Rawag
French -- Morungue
Spanish -- Angela
Chinese -- La ken
English -- Ben tree

Geographical Source

In the Sub-Himalayan tracts from Chenab to Oudh, the tree grows untamed. It may grow between sea level and 1400m above sea level. It is frequently grown in close proximity to homes in Assam, Bengal and peninsular India. It is an active coppice[6]. Additionally, it is grown in Sri Lanka, north-eastern Pakistan, north-eastern Bangladesh, West Asia, the Arabian Peninsula, East and West Africa, the entire West Indies, southern Florida, Central and South America from Mexico to Peru, Brazil and Paraguay[7].

Morphology

The *Moringa oleifera* tree is a small, quickly-growing evergreen or deciduous tree that typically reaches a height of 9 metres. Its wood is soft and white, and its bark is corky and sticky. Horseradish is the flavour of roots. The leaves are longitudinally cracked, 30-75cm long, with a jointed main axis and branch, glandular at the joint and whole, glabrous leaflets. The leaves are almost completely green, finely haired, the edges are complete (not serrated), hairless on the upper surface, paler and hairless beneath, with reddish mid-veins, and they are rounded or blunt-pointed at the apex and short-pointed at the base.

The twigs are green and have tiny hairs. Large axillary down panicles of white, fragrant flowers,

pendulous, ribbed pods and triangular-shaped seeds are all present[8].

Traditional uses

The herb has historically been employed as an antispasmodic, stimulant, expectorant, and diuretic. The flavour of the fresh root is bitter and vesicant (horseradish-like). It is used internally as a stimulant, diuretic and antilithic. Gum is mucilaginous and tasteless. Acrid and stimulating, seeds. Bark is emmenogogue, even an abortifacient, as well as antibacterial and antifungal. Flowers are excellent to improve bile flow since they are cholagogues, stimulants, tonics, diuretics and tonics. The herb also functions as an antibacterial and heart circulatory tonic[9,5]. Pods are anthelmintic and antipyretic and fried pods are used to treat diabetes. Root juice is used as an antiepileptic and heart tonic. Used for enlarged liver and spleen, asthma, and neurological debility, deep-In calculus affection, seated inflammation also acts as a diuretic. For sore throats and hoarseness, decoction is gargled. Fruit and root are parasite-repelling. Cooked leaves are used in cases of influenza and catarrhal diseases, while leaf juice is utilised in hiccough (emetic in excessive quantities). Root bark has antiviral, anti-inflammatory and analgesic properties. Flowers and stem bark have low blood sugar. Seed infusions are used to treat venereal illnesses because they are anti-inflammatory, antispasmodic and diuretic. The Ayurvedic Pharmacopoeia of India listed the use of dried root bark in goitre, glycosuria, and lipid diseases (together with dried seeds) and leaf, seed, root bark, and stem bark in internal abscess, piles, among other therapeutic indications[10].

PHYTOCHEMICAL COMPOSITION

Compounds including common sugar, rhamnose, glucosinolate, isocytosinate, and others are abundant in drumstick trees. Moringinine and moringine, two alkaloids, are present in its stem bark[11]. Zinc (Zn), sodium (Na), iron (Fe), calcium (Ca), potassium (K), copper (Cu), manganese (Mn) and magnesium (Mg) are all present in the leaves[12]. According to a phytochemical investigation of the leaves, both ethanolic and aqueous extracts of the plants contain tannins, anthocyanins, cardiac glycosides, carotenes, terpenoids, saponins, steroids, alkaloids, flavonoids and anthraquinones. Quantitative study, however, reveals that the ethanolic extract contains less phytochemicals than the aqueous extract. The results showed that the aqueous extract had higher concentrations of alkaloids (3.07 0.00), anthraquinone (11.68 0.04), carotenoids (1.16 0.05), steroids (3.21 0.00), cardiac glycoside (0.36 0.03), terpenoids (4.84 0.05), and tannins (9.36 0.04) while the ethanolic extracts had higher concentrations of saponin[13]. A total of 32 metabolites were discovered in the stem and leaf tissues of M. oleifera, 22 of which were detected in both stem and leaf tissues. Only stem tissues contained glutamine, tryptophan, and glutamate, while only leaf tissues contained p-cresol, tyrosine, guanosine, adenosine, and 4-aminobutyrate[14]. D-glucose (9.37), D-xylose (2.93), L-rhamnose (6.15), L-arabinose (43.50), D-mannose (3.0) and D-galactose (34.00%) are present in the purified whole-gum exudate of *Moringa oleifera*, whereas L-glucose (23.2), L-mannose (6-O) and L-galactose (70.4%) are present in[15]. An impressive amount of crude proteins (17.01%), ash (7.93%), fatty acids (1.69%), crude fat (2.11%) and crude fibre (7.09%) are found in moringa leaves, which have an energy value of 1440 Kcal/100g. The leaves also contain important minerals like potassium (0.97%), magnesium (0.38%), calcium (1.91%), sodium (192.95ppm), iron (107.48ppm), zinc (60.06ppm), copper (6.10ppm) and manganese (81.65ppm)[12]. We looked at the ethanolic extracts of M. oleifera's leaves, seeds and flowers. Dodecanal, Decanoic acid, Sipo, Ocenol, Satol, Oleol, cis-9-Octadecen-1-ol and 9-Octadecen-1-ol have all been detected in the flowers. Veridiflorol, Roridin E and 9-Octadecenoic Acid are the main components of seeds. The 15 constituents of the leaves included safflower oil, high-oleic safflower oil, 2, 6-dimethyl-1, 7-octadiene-3-ol, 4-hexadecen-6-yne, 2-hexanone, 3-cyclohexyliden-4-ethyl-E2-dodecenylacetate, hexadecanoic acid, palmitic acid ethyl este[16]. Another study found that the flowers

contained the compound kaempferol-3-rutinoside 34, while the leaves contained alanine, aspartic acids, valine, glycine, glutamic acids, threonines, leucines, methionines, cysteines, tryptophans, phenylalanines, lysines, and isoleucines. In the steam, the effects of -sitosterone, -sitosterol, octacosonoic acid, vanillin, and 4-hydroxy mellein were studied[17]. Several amino acids, including 4-(-L-rhamnosyloxy) benzyl isothiocyanate and moringyne, have also been reported to be present in seeds[18]. There have been reports of benzyl isothiocyanate in Moringa roots. Pterygospermin and spirochin, two plant components, are responsible for the plant's antimicrobial effect against bacteria (both gramme positive and gramme negative). The structures of a few phytoconstituents that were extracted from M. oleiferea are shown in Figure No.1[19]. Aldotriouronic acid, also known as O-(-D-glucopyranosyluronic acid), is produced by the acid hydrolysis of Moringa gum (1–6).-β-D-galactopyranosyl, (1→6)-D-galactose[17].

NUTRITIONAL IMPORTANCE

Moringa oleifera is well known as a natural stimulant of energy and a superior food source[20]. It is a great source of natural antioxidants including flavonoids, ascorbic acids, phenolics and carotenoids as well as nutrients like calcium, phosphorus, iron, vitamins (A, B and C), potassium and carotene[21]. When compared to milk, spinach, carrots, bananas, and oranges, moringa leaves contain more calcium, iron, vitamin A, potassium and vitamin C. Comparable to milk and eggs in terms of protein concentration are leaves[22]. Vitamin C boosts immunity against the flu and cold; calcium gives strength to bone and teeth and prevents osteoporosis; vitamin K is required for the proper functioning of proteins and the brain; and vitamin A provides defence against eye and skin diseases, heart ailments, gastro-intestinal ailments and additional health problems[23]. When compared to the other 3 species of Moringa (*stenopetala, peregrine and drouhardii*), *Moringa oleifera* has the highest concentrations of vitamin C, vitamin E, iron and beta-carotene; however, it also has the second-highest protein content (stenopetala's was the highest)[24]. The entire *Moringa oleifera* plant can be consumed[25]. Particularly its tuberous roots, which exhibit greater tolerance to the arid and drought conditions, are used as food. In many cultures around the world, young Moringa tree leaves, petals, or pods can be used in cuisine[26]. The plant can be utilised to end malnutrition and hunger because it is an inexpensive source of essential nutrients and nutraceuticals[27]. Asian people consume *Moringa oleifera's* bloom, pods and young leaves as vegetables. The phenolic compounds, -tocopherols, protein, vitamin C, -carotene, sulfur-containing amino acids, cysteine and methionine are all renewable sources found in every section of this plant[28]. In several nations, including Pakistan, Africa, Hawaii, India, and the Philippines, M. Oleifera's fruit, immature pods, blossoms, and leaves make delicious and nutritious vegetables[29]. Fresh leaves of this plant contain vitamin "A," which is essential for many physiological processes, including cell proliferation, differentiation, apoptosis, vision, reproduction, growth of the embryo, and development[30]. *Moringa oleifera* leaves are edible and a great source of nutrients for people of all ages. In addition to being cooked and eaten like spinach, they are used to produce salads and soups. They are a rich source of vitamins (A, B, and C), minerals (particularly iron), and the amino acids cystine and methionine, which include sulphur. They also contain critical, disease-preventing elements. Unusual for a plant source, the leaves contain an adequate amount of the amino acids (the building blocks of proteins)[31]. For those who cannot get their protein from meat or other sources, the leaves are a great help. *Moringa oleifera* is a terrific source of proteins for infants who are unable to produce enough proteins in accordance with the requirements of their growth due to the presence of histidine and argentine components[32]. Even more micronutrients, such as vitamin A (10 times that of a carrot), calcium (17 times that of milk), potassium (15 times that of a banana), iron (25 times that of spinach), and proteins (9 times that of yoghurt), are present in the

dried leaves of *Moringa Oleifera*[33]. In comparison to direct sunshine, which only maintains 20-40% vitamin A, it is preferable to dry the leaves in the shade, which keeps 50-70% vitamin A. Furthermore, the high temperature may cause the proteins in leaves to break down[34]. Moringa leaf powder that has been thoroughly dried can It should be placed at 50°C for 30 minutes in order to reduce its moisture content because it reabsorbs humidity during or after grinding. When kept in airtight containers below 24°C and away from light and moisture, the powder can be kept for up to 6 months. Malnutrition can be prevented by moringa, especially in nursing mothers and young children. One level tablespoon (8grammes) of powder provides nearly all of the vitamin A, 23% of the iron, 40% of the calcium and 14% of the protein requirements for children ages 1-3. Six rounded spoonfuls of leaf powder can satisfy a woman's daily calcium and iron needs whether she is breastfeeding or pregnant by the Educational Concerns for Hunger Organisation, Church World Service, and Trees for Life, three NGOs (non-governmental organisations). Even at the conclusion of a dry season when there are few other edibles available, this plant is brimming with leaves. You can eat *Moringa oleifera's* leaves raw or cooked. Additionally, they can be kept as dried powder for a number of months without losing any of their nutritional value. They are also used in food fortification[35]. The powder can be added by the teaspoon to vegetables, soups, and baby food to increase nutritional content without altering flavour. A few spoonfuls of the powder can be added to other sauces right before serving, or it can be used in place of fresh leaves to make lead sauces. Adding a tiny bit of this powder doesn't significantly alter the sauce's flavour. Therefore, Moringa leaves are always available for regular, healthy dietary intake[35]. The plant requires relatively little water and nutrient-rich soil for growth, making it simple to grow. The leaves have significant economic potential because they can be used in everyday food diets to address micronutrient deficiencies and guard against chronic degenerative diseases. Thus, the leaves may not only be a great way to create income, jobs, and exports, but they may also be used to treat malnutrition in underdeveloped nations and serve as an excellent substitute for imported foods[31]. The leaves of *Moringa oleifera* (from Lafia, Nigeria) have been studied and found to be effective supplements for improving the health and growth of chickens[12]. Researchers looked into oxalate and oligosaccharides as potential anti-nutrient components in Moringa leaves. The presence of raffinose and stachyose was found in seeds (2298mg/g dry weight) and in early leaves (014mg/g), but not in mature leaves dry mass)[36]. Due to its chemical components, the drumstick plant is utilised as a dietary substitute in underdeveloped countries for imported food supplements to cure malnutrition, particularly in nursing women and newborns[37].

PHARMACOLOGICAL ACTIONS

Antimicrobial Activity

In vitro antibacterial properties of *Moringa oleifera* leaves, roots, bark, and seeds against bacteria, yeast, dermatophytes and helminths were reported by A. Caceres *et al*. in 1991 using a disk-diffusion approach. The aqueous extracts from the seeds and the freshly squeezed leaf juice stop the growth of Staphylococcus aureus and Pseudomonas aeruginosa. Other pathogenic Gram-positive and Gram-negative bacteria as well as Candida albicans were not shown to exhibit any action[38]. Using the broth dilution and agar plate procedures, M.O. Nwosu and J.I. Okafor reported the antifungal efficacy of *Moringa oleifera* against seven pathogenic fungi in 1995. The plant's extracts worked well against Trichophyton rubrum and T.mentagraphytes[39]. *Moringa oleifera* seeds of various kinds were found to have antibacterial activity, according to V. Spiliotis *et al*. in 1997. *Bacillus cereus, Candida albicans, Streptococcus faecalis, Staphylococcus aureus, Staphylococcus epidermidis, Bacillus subtilis, Pseudomonas aeruginosa, E. coli, and Aspergillus niger* were among the organisms that all of the variations were tested against[40]. The antibacterial activity of three

fractions of *Moringa oleifera* leaves produced by Sephadex G-25 column chromatography was studied by M. Umar Dahot in 1998. These fractions' single bands may be seen on the Polyacrylamide SDS gel electrophoresis. Small protein/peptides were examined for their ability to inhibit the growth of the bacteria *E. coli Kl. aerogenes, Kl. pneumoniae, S. aureus, and B. subtilis*. Strong inhibitory activity was demonstrated by fractions 1, 2 and 3 against *E. coli, S. aureus and B subtilis*; however, a distinct zone of inhibition was also detected against K. aerogenes with peptide 1.Aspergillusniger was significantly inhibited by fraction 2 in this situation[41]. According to F. Nikkon *et al*. (2003), the chloroform extract of the roots and barks of *Moringa oleifera* exhibits antibacterial action in the form of the aglycone of Deoxy-Niazimicine, which is known as N-benzyl, S-ethyl thioformate. Shigella boydii, Shigella dysenteriae, and Staphylococcus aureus are all susceptible to the substance's antibacterial and antifungal properties[42]. The refined dichloromethane extract of *Moringa oleifera* capsules and the methanolic crude extract both showed antibacterial action, according to Khesorn Nantachit (2006). By agar-well diffusion, the activity of extracted *Moringa oleifera* capsules from column chromatography was also assessed. Against *Staphylococcus aureus, Escherichia coli, Pseudomonas aeruginosa* and *Klebsiella pneumoniae*, the methanolic crude extract exhibited little action. These bacteria were resistant to the pure dichloromethane extract and separated components from column chromatography[43]. The bactericidal activity of the aqueous, acetone and ethanolic extracts of *Moringa oleifera* leaves was reported by J. H. Doughari *et al*, in 2007. The plant's ethanolic extract displayed the highest activity of the three solvents examined, whereas the aqueous extract displayed the least activity at 100mg/ml. The plant extracts' activity were comparable to those of ciprofloxacin, cotrimoxazole, and chloramphenicol, three antibiotics[44]. The ethanolic extracts of the leaves of *Moringa oleifera* have been shown to have *in vitro* antifungal activity against dermatophytes such Trichophyton rubrum, Trichophyton mentagrophytes, Epidermophyton Xoccosum and Microsporumcanis[45]. *Moringa oleifera* seeds were tested for antibacterial activity by Amer Jamil *et al*, in 2008. For the study of antibiotic activity against bacterial (*Pasturellamultocida, Escherichia coli, Bacillus subtilis, and Staphlococcus aureus*) and fungal (*Fusarium solani and Rhizopus solani*) strains, *Moringa oleifera* seed extracts were tested. In comparison to fungal strains, the zones of growth inhibition displayed increased sensitivity to bacterial strains. *Pasturellamultocida and Bacillus subtilis* were the most susceptible strains, according to extracts with minimum inhibitory concentrations (MIC)[46]. Using disc diffusion and the minimum inhibitory concentration (MIC) determination method, M. F. Alam *et al*, (2009) examined the antibacterial activity of *Moringa oleifera* leaf juice and extracts against human pathogenic microorganisms. Four Gramnegative bacteria (*Shigella shinga, Pseudomonas aeruginosa, Shigella sonnei and Pseudomonas spp.)* and six Gram-positive bacteria (*Staphylococcus aureus, Bacillus cereus, Streptococcus-B- haemolytica, Bacillus subtilis, Sarcina lutea and Bacillus megaterium*) were tested. However, all of the studied Gram-positive and Gram-negative bacteria were inhibited by an ethanol extract (1175g) of fresh leaves, with the exception of *S. aureus and Streptococcus-B-haemolytica*[47]. R.E. Renitta *et al*, (2009) reported antimicrobial activity from the ethanolic extract of Moringa oleifera leaves, seeds, and flowers against bacteria like *Escherichia coli, Klebsiella pneumoniae, Enterobacter spp, Proteus mirabilis, Pseudomonas aeroginosa, Salmonella typhi A, Staphylococcus aureus, Streptococcus*[48]. The efficiency of Moringa oleifera steam distillate against bacteria and fungi was examined by T.R. Prashith Kekuda *et al*, in 2010. *E. coli* showed the greatest level of inhibition among the studied microorganisms, followed by *S. aureus, K. pneumoniae, P. aeruginosa and B. subtilis*. Reduced colony diameter on poisoned plates compared to control plates indicated that fungi were being

inhibited. *A. niger* showed the most inhibition, followed by *A. oryzae, A. terreus, and A. nidulans*[49].

Antioxidant Activity

Frozen dried leaf extracts in aqueous ethanolic (70%) and methanolic (80%) solutions exhibit antioxidant and radical-scavenging properties. The leaves of drumsticks are thought to contain natural antioxidants[50]. Antioxidants are more important for preventing stress, which can lead to a variety of degenerative disorders. *Moringa oleifera* possesses a complex profile of flavonoids, including traces of the potent antioxidants *acetylglucosides of isorhamnetin and quercetin as well as malonylglucosides, rutinosides, glucosides and kaempferol*[51]. Extracts of leaves and seeds show biological pesticide action. This plant's leaves are a rich source of antioxidant chemicals[52]. Drumstick is able to prolong the time of protection in foods containing fats because it contains a variety of antioxidants, including carotenoids, flavonoids, phenolics, and ascorbic acid[53]. Aqueous leaf extracts, which are used to treat hyperthyroidism and have antioxidant activities, can regulate thyroid hormone[54,55].

Antispasmodic and antitumor activity

Through calcium channel obstructions, according to pharmacological tests of Moringa leaves, ethanol extract and its component have antispasmodic properties[56]. Blood pressures are stabilised by the juice of moringa leaves. This plant's nitriles, thiocarbamates and glycosides are what cause the blood pressure to decrease. The antispasmodic properties of its roots and the potential anti-tumor properties of its leaves come from the moringa plant[57]. Because it contains a variety of bioactive substances, moringa is a potent anticancer herb. Niazimicin and thiocarbamates, in particular, are bioactive substances that give M. oleifera's leaves significant anticancer activity[58]. The various plant components exhibit spasmolytic effect, supporting the herb's traditional usage in gastrointestinal motility disorders[59].

Anti-Inflammatory Properties

One of the primary traits of disorders that come from a skewed balance of anti-inflammatory cytokines controlled by T helper cells is inflammation[60]. The metabolic inefficiency that leads to type 2 diabetes is associated with increased levels of systemic pro-inflammation markers[61]. It is a hallmark of diabetes individuals that they have higher levels of both TNF- and IL6, which promotes the progression of microvascular and macrovascular abnormalities. Numerous research have emphasised the favourable anti-inflammatory characteristics of *Moringa oleifera* seeds and pods[62,63]. A carrageen in-induced rat paw oedema test revealed that *Moringa* oleifera root extracts had immediate anti-inflammatory effects[64,65].

Anti-Diabetic Properties

The metabolic syndrome (MetS) is a collection of risk factors that are connected to abnormalities in blood pressure, glucose and lipid metabolism and obesity[66,67]. Recently, the incidence of MetS health consequences, such as Type 2 diabetes, has increased, placing a burden on public health, especially in developing countries[68]. This has made it necessary to investigate the therapeutic effectiveness of complementary and alternative therapies. Orally ingested *Moringa oleifera* leaf extract lowers blood pressure, according to experimental animal models. The development of diabetes brought on by fructose[69]. Recent research demonstrates that *Moringa oleifera* leaf powder reduces alloxan-induced hyperglycemia[70]. Demonstrating that it has the ability to control diabetes. A study on animals further supported these anti-diabetic qualities of *Moringa oleifera*, showing that aqueous leaf extracts normalised diet- and streptozotocin-induced hyperglycemia and hyperinsulinaemia[71,72]. On rats with weakly and severely induced diabetes, the anti-diabetic potential of various dosages of aqueous *Moringa oleifera* leaf extract was examined. Normal rats given 200mg/kg of *Moringa oleifera* showed decreased glucose levels (29.9%). Rats with severe diabetes had their glucose levels reduced by 69.2 and 51.2%, respectively, to levels that were close to normal. After 21 days of *Moringa oleifera* treatment, an improvement in total protein and haemoglobin levels was also noted, favourably lowering

diabetes[73,74]. In this investigation, it was discovered that the hypoglycemic effects of *Moringa oleifera* extract and Glipizide, an anti-diabetic medication, were very similar. This experimental data supports the claimed ability of *Moringa oleifera* extracts to treat diabetic situations. The fruit powder extract of *Moringa oleifera* was found to include N-benzyl nitriles, benzyl thiocarbamates, a benzyl ester, and N-benzyl carbamates, all of which were found to expressly promote the production of insulin in mouse pancreatic beta cells. The released insulin has anti-cyclooxygenase and anti-lipid peroxidation effects[75]. Renal, cardiovascular and ocular problems are caused by hyperglycemia resulting from either insulin action orbits aberrant production[76]. Reports on Type 1 and Type 2 diabetic rats, *Moringa oleifera* aqueous leaf extracts demonstrated strong anti-hyperlipedemic and antihyperglycemic effects. When Yassa *et al*, examined the anti-diabetic properties of an aqueous extract of *Moringa oleifera* leaves in histomorphometrical, ultrastructural, and biochemical studies[77]. The main causes of the progression of diabetes's development and consequences were impaired antioxidant defence mechanisms that prolonged oxidative stress and lipid peroxidation[78].

Anti-Cancer Properties

Although chemotherapy has advanced in its ability to treat cancer, side effects include skin irritation, nausea, nephrotoxicity, infertility, anaemia, and hair loss still exist[79]. For this reason, the hunt for alternative cancer treatments must prioritise natural plant-derived anti-cancer sources of treatment with minimal side effects. Previous studies have shown that *Moringa* oleifera extracts have the ability to treat cancer[80,81]. The aqueous portion of *Moringa oleifera* leaf extract reportedly caused HepG2 cells to undergo apoptosis in lung cancer cells[82]. HepG2 cell and lung cancer cell growth was significantly reduced (by 52%) when leaf extracts were taken orally[83]. One benefit of oral cancer therapy is that it causes the cancer cells and surrounding tissues to be exposed to cytotoxic chemicals over an extended period of time. Niaziminin, a thiocarbamate produced from *Moringa oleifera* leaf, is strictly structurally controlled to prevent tumor-promoter-induced Epstein-Barr virus (EBV) activation[84]. Showed that the 300g/mL aqueous *Moringa oleifera* leaf extract significantly reduced the development of tumour cells, internal ROS levels, and induced apoptosis in lung and other cancer cell types. In addition, compared to untreated cells, *Moringa oleifera* extracts caused the down-regulation of 90% of the examined genes by margins more than 2-fold. The authors came to the conclusion that the treatment with *Moringa oleifera* leaf extract caused aberrant RNA, which in turn caused the down-regulation of these genes. Vasanth and other people[85].

Antifertility Activity

In 1987, A.O. Prakash and colleagues looked into the antifertility potential of an aqueous extract of Moringa oleifera roots. Rats' uterine histoarchitecture throughout the pre- and post-implantation stages has been examined in relation to the influence of an aqueous extract[86]. In female reproductive organs of cyclic rats, S. Shukla *et al*, (1988) observed anti-implantation activity from the aqueous extract of *Moringa oleifera* as well as antifertility activity from the plant's roots. The uterine wet weight of rats with bilateral ovariectomies increased over time after extract administration via oral administration. The activation of uterine histo-architecture facilitated this estrogenic activity. When the extract was administered along with estradiol dipropionate (EDP), the uterine wet weight gradually decreased as opposed to the increase seen with EDP alone, and uterine histological structures were likewise suppressed[87,88]. Using ovariectomized rats, S. Shukla *et al*, (1989) examined the antifertility effects of an aqueous extract of *Moringa oleifera* roots on the genital tract in both the presence and absence of progesterone and estradiol dipropionate. The extract itself, when administered, encouraged the uterine histoarchitecture, as shown by an increase in the luminal epithelium's height, the development of the glands, the stroma's looseness, and the presence of a rich vascularity. The cervix's epithelium displayed metaplastic alterations with

noticeable keratinization. In the vagina, stroma was loose, rugae had grown and cornification was quite noticeable. A synergistic effect was seen when the extract and estradiol were supplied together and an inhibition was seen when progesterone was added to the mix[89].

Hepatoprotective Activity

The haematological and hepatorenal effects of a methanolic extract of *Moringa oleifera* roots were examined by U.K. Mazumder *et al*, in 1999. On the functions of the liver, kidneys and haematological markers in mice, doses of the crude extract (CE) were examined. At low and moderate dose levels of daily and low dose levels of weekly therapy with the extract, no change in haematological and biochemical parameters was seen. However, the serum aminotransferase and plasma cholesterol levels were considerably altered by the extract at a modest dose level throughout a weekly treatment. High dose also altered total bilirubin, non protein nitrogen, blood urea and plasma protein in addition to the aforementioned measures. A considerable rise in WBC count and a significant reduction in clotting time were seen with high dose daily treatment of CE as well as moderate and high dose weekly treatment[90]. In a 2002 study, L. Pari and N.A. Kumar examined the hepatoprotective effects of *Moringa oleifera* leaf ethanolic extract on liver damage brought on by antitubercular medications including isoniazid (INH), rifampicin (RMP), and pyrazinamide (PZA) in rats. administration of the extract orally revealed a Significant preventive function is demonstrated by its impact on blood levels of lipids and lipid peroxidation as well as glutamic oxaloacetic transaminase (aspartate aminotransferase), glutamic pyruvic transaminase (alanine aminotransferase), alkaline phosphatase, and bilirubin. Histopathological analysis of liver sections was added to this observation[91].

Cardiovascular Activity

Niazirin, Niazirinin, and three mustard oil glycosides were isolated from the ethanolic extract of *Moringa oleifera* leaves by S. Faizi *et al*, in 1994. Niaziminin A and B, as well as 4-[(4'-O-acetyl-alpha-L-rhamnosyloxy) benzyl] isothiocyanate, demonstrated hypotensive action[92]. The ethanolic extract of *Moringa oleifera* leaves yielded six novel and three synthetically recognised glycosides, according to S. Faizi *et al*, (1995). Thiocarbamates shown hypotensive action, and the majority of these compounds having thiocarbamate, carbamate, or nitrile groups are fully acetylated glycosides[93]. S. Ghasi *et al*, (2000) examined the hypocholesterolemic effects of a crude *Moringa oleifera* leaf extract. Statistics showed that the effect on serum cholesterol was significant. There was no discernible impact on serum total protein. The crude extract, however, caused a 15.22% rise in serum albumin[94]. In a 2008 study, N. Ara *et al*, compared the effects of ethanolic extracts of *Moringa oleifera* leaves with atenolol on the levels of serum cholesterol, triglycerides, blood sugar, heart weight, and body weight in rats given adrenaline. The relationships between the aforementioned biochemical markers were established. After careful examination, the *Moringa oleifera* leaf extract significantly altered each cardiovascular parameter[95]. Using simvastatin as a reference medication, P. Chumark *et al*, (2008) reported that *Moringa oleifera* leaves had antiatherosclerotic and hypolipidemic action. In both *in vitro* and *ex vivo* investigations, the extract dramatically increased the lagtime of conjugated diene (CD) synthesis and prevented the formation of thiobarbituric acid reactive substances (TBARS) in a dose-dependent way. It effectively reduced cholesterol levels and atherosclerotic plaque formation in hypercholesterol-fed rabbits to roughly 50 and 86%, respectively[96]. The cardioprotective effects of lyophilized hydroalcoholic extract of Moringa oleifera were examined by M. Nandave *et al*, (2009) in the isoproterenol (ISP)-induced model of myocardial infarction in male wistar albino rats. Compared to the ISP control group, chronic treatment with moringa significantly improved the modulation of the biochemical enzymes superoxide dismutase, catalase, glutathione peroxidase, lactate dehydrogenase and creatine kinase-MB. However, it had no discernible effect on reduced glutathione

levels. Treatment with moringa greatly slowed the growth of lipid peroxidation in cardiac tissue[97].

Anti-ulcer Activity

Using ondansetron as the standard medication, S. Debnath and D. Guha (2007) observed that the aqueous extract of *Moringa oleifera* leaves had an anti-ulcer effect on adult holtzman albino rats of either sex[98].

Analgesic, Antipyretic and wound healing activity

B. Medhi *et al*, (1996) used the acetic acid-induced writhing method to test the analgesic effectiveness of a methanolic extract of *Moringa oleifera* root bark in mice[99]. In male Swiss albino mice, B.S. Rathi *et al*, (2006) examined the ability of an aqueous extract of Moringa oleifera leaves to promote wound healing. Increases in hydroxyproline content, granuloma dry weight, skinbreaking strength, granuloma breaking strength, and scar area reduction were all significantly seen[100]. The antipyretic and wound healing properties of the ethanolic and ethyl acetate extracts of Moringa oleifera leaves were described by V.I. Hukkeri *et al*, in 2006. While ethyl acetate extract of dried leaves demonstrated significant wound healing activity (10% extracts in the form of ointment) on excision, incision and dead space (granuloma) wound models in rats, ethanolic and ethyl acetate extracts of seeds demonstrated significant antipyretic activity in rats[101].

Anti-diabetic Activity

In Goto-Kakizaki and Wistar rats, K. Suzuki *et al*, (2007) showed that the leaves of *Moringa oleifera* had an anti-diabetic impact on glucose tolerance. In Wistar rats, moringa dramatically lowered blood sugar levels. There was a noticeably higher area under the blood glucose change curve inthe rats of Goto-Kakizaki. Compared to Wistar rats, Goto-Kakizaki rats responded more strongly to MO[102]. Aqueous extract from *Moringa oleifera* leaves has been shown to have anti-diabetic effects on glycemic control, haemoglobin, total protein, urine sugar, urine protein, and body weight by D. Jaiswal *et al*, (2009)[103].

Diuretic and antiurolithiatic activity

The diuretic properties of hot water infusions of *Moringa oleifera* flowers, leaves, roots, seeds, stalks, or bark were described by Caceres *et al*, in 1992. Rats were given oral doses of Moringa extract, and the diuretic efficacy was assessed by measuring urine production in metabolic cages[104]. *Moringa oleifera* root-wood extracts tested for antiurolithiatic efficacy on calcium oxalate urolithiasis in male Wistar albino rats by R.V. Karadi *et al*, in 2006. An oral dose of the *Moringa oleifera* aqueous and alcoholic extract dramatically decreased the increased urine oxalate, demonstrating a regulatory effect on endogenous oxalate production. Curative and preventive treatment using aqueous and alcoholic extracts greatly reduced the elevated deposition of components that form stones in the kidneys of calculogenic rats[105].

The root bark of *Moringa oleifera's* plant has antiurolithiatic properties, according to R.V. Karadi *et al*, (2008). Oxalate, calcium and phosphate levels in the urine and renal retention were dramatically reduced by both extracts. The extracts also dramatically decreased high serum levels of urea nitrogen, creatinine, and uric acid[106].

CNS Activity

The anticonvulsant properties of the aqueous extract of *Moringa oleifera* roots were studied by K. Ray *et al*, in 2003. The impact on adult albino Holtzman strain rats' locomotor activity, brain serotonin (5-HTT), dopamine (DA) and norepinephrine (NE) levels after penicillin (PCN)-induced convulsions was investigated[107]. The effects of an ethanolic extract of *Moringa oleifera* leaves on brain monoamines (norepinephrine, dopamine and serotonin) and EEG wave patterns in rats with Alzheimer's disease were examined by R. Ganguly and D. Guha in 2008. The monoamine levels in several brain regions are returned to nearly normal levels after treatment with *Moringa oleifera* leaf extract[108].

Local Anaesthetic Activity

Moringa oleifera root bark methanolic extract was tested for local anaesthetic action in frog and guinea

pig models by B. Medhi *et al*, in 1996. Both animal models showed evidence of local anaesthetic action[99].

Anti-allergic Activity

(2007) S.G. Mahajan and A.A. Mehta showed that the ethanolic extract of *Moringa oleifera* seeds inhibited both systemic and local anaphylaxis. The potential of extract to prevent anaphylaxis was investigated in a mouse model of systemic anaphylactic shock brought on by Compound 48/80. Anti-IgE-antibody-activated passive cutaneous anaphylaxis was another method utilised to evaluate the effectiveness of the extract[109].

Anthelmintic Activity

Moringa oleifera was found to have anthelmintic properties, according to T. Rastogi *et al*. The Indian earthworm Pheritima posthuma was tested for anthelmintic action using ethanol extracts of the *Moringa oleifera* plant. Different extract concentrations were examined, and the results were expressed in terms of the length of time it took the worms to become paralysed and die. Distilled water was utilised as a control group and piperazine citrate (10mg/ml) as a reference standard[110].

Figure No.1: Flower panicle

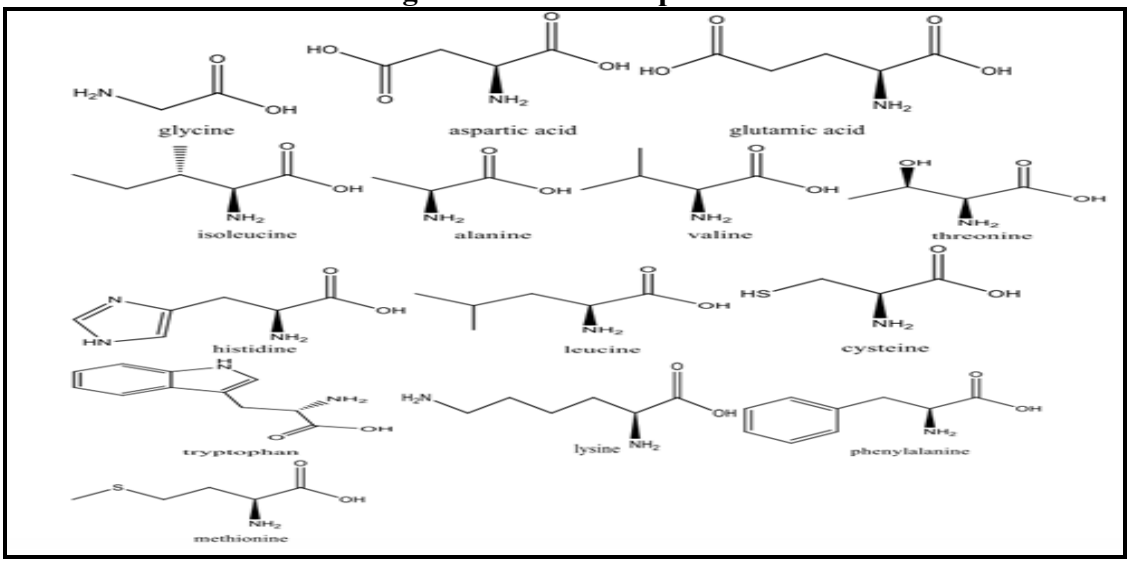

Figure No.2: Structures of some phytoconstituents isolated from *Moringa oleiferea*

CONCLUSION

Glycosides, phenols, sterols and flavanol glycosides are abundant in *Moringa oleifera* and may have therapeutic and/or nutritional value. These include the three mustard oil glycosides, 4-[(4'-O-acetyl-alpha-L-rhamnosyloxy)benzyl] isothiocyanate, niaziminin A and niazimin B, as well as the ethanolic extracts of niazirin and niazirin from Moringa oleifera leaves. Only very high amounts of 4-(alpha-l-rhamnopyranosyloxy)-
benzylglucosinolate were found in the seeds. The amounts of 4-(alpha-l-rhamnopyranosyloxy)-benzylglucosinolate and benzyl glucosinolate in *Moringa oleifera* roots are high. The plant produces four distinct monoacetyl isomers of this glucosinolate in addition to aspartic acid, glutamic acid, glycine, threonine, alanine, valine, leucine, isoleucine, histidine, lysine, phenylalanine, tryptophan, cysteine and methionine in its leaves. This review discusses a number of significant phytochemical and pharmacological studies on *Moringa oleifera* and draws critical conclusions from them that could be followed up on to provide lead compounds for new herbal remedies.

ACKNOWLEDGEMENT

The authors wish to express their sincere gratitude to Buddha Institute of Pharmacy, GIDA, Gorakhpur, Uttar Pradesh, India for providing necessary facilities to carry out this review work.

CONFLICT OF INTEREST

We declare that we have no conflict of interest.

REFERENCES

1. Brahmachari U N. Herbal remedy, *Current Science,* 81(1), 2001, 15-16.
2. Vaidya A D B, Devasagayam T P A. Current status of herbal drugs in India: An overview, *Journal of Clinical Biochemistry and Nutrition,* 41(1), 2007, 1-11.
3. Rai J. Popularity of herbal drugs -A challenge to rational practice (Time to Amend Undergraduate Curriculum), *JK Science,* 7(3), 2005, 180.
4. Gupta R K. Medicinal and aromatic plants, *CBS Publishers and Distributors,* 2010, 151-152.
5. Nadkarni K M. Indian materia medica, *Bombay Popular Prakashan,* 1, 2009, 811-816.
6. Roloff A, Lang U, Stimm B. Enzyklopadie der holzgewachse, *Handbuch und Atlas Der Dendrologie,* 2009, 1-8.
7. Khare C P. Indian medicinal plants, *Springer,* 2007, 422-423.
8. The Ayurvedic pharmacopoeia of India, *Department of Indian Systems of Medicine and Homeopathy New Delhi, Part –I,* 2, 155-157.
9. Eilert U, Wolters B, Nahrstedt A. The antibiotic principle of seeds of *Moringa oleifera* and *Moringa stenopetala*, *Planta Medica,* 42(1), 1981, 55-61.
10. Villasenor I M, Lim-Sylianco C Y, Dayrit F. Mutagens from roasted seeds of *Moringa oleifera*, *Mutat Res,* 224(2), 1989, 209-212.
11. Anwar, Farooq, Ashraf, Muhammad. Gilani, Anwarul Hassan. *Moringa oleifera*: A food plant with multiple medicinal uses, *Phytotherapy Research: An International Journal Devoted to Pharmacological and Toxicological Evaluation of Natural Product Derivatives,* 21(1), 2007, 17-25.
12. Ogbe A O. Affiku. Proximate study, mineral and anti-nutrient composition of *Moringa oleifera* leaves harvested from Lafia, Nigeria: Potential benefits in poultry nutrition and health, *The Journal of Microbiology, Biotechnology and Food Sciences,* 1(3), 2011, 296.
13. Nweze, Nkechinyere O. Nwafor, Felix I. Phytochemical, proximate and mineral composition of leaf extracts of Moringa oleifera Lam, from Nsukka, *IOSR Journal of Pharmacy and Biological Sciences (IOSR-JPBS),* 9(1), 2014, 99-103.
14. Mahmud, Iqbal, Chowdhury, Kamal. Boroujerdi, Arezue. Tissue-specific metabolic profile study of *Moringa oleifera* L. using

nuclear magnetic resonance spectroscopy, *Plant tissue culture and biotechnology/Bangladesh Association for Plant Tissue Culture and Biotechnology, BAPTC and B,* 24(1), 2014, 77-86.

15. Bhattacharya, Subhas B, Das, Asit K. Banerji, Nilima. Chemical investigations on the gum exudate from sajna (*Moringa oleifera*), *Carbohydrate Research,* 102(1), 1982, 253-262.
16. Nepolean P, Anitha J. Emilin R R. Isolation, analysis and identification of phytochemicals of antimicrobial activity of *Moringa oleifera* Lam, *Current Biotica,* 3(1), 2009, 33-37.
17. Rastogi, Ram P, Mehrotra B N. Compendium of Indian medicinal plants, *Central Drug Research Institute, Lucknow and National Institute of Science Communication and Information Resources, New Delhi,* 1990, 388-389.
18. Gupta, Anil Kumar. Quality standards of Indian medicinal plants, *Indian Council of Medical Research,* 2003, 1.
19. Mishra, Garima, Singh, Pradeep, Verma, Ramesh, Kumar, Sunil, Srivastav, Saurabh, Jha K K. Khosa R L. Traditional uses, phytochemistry and pharmacological properties of *Moringa oleifera* plant: An overview, *Der Pharmacia Lettre,* 3(2), 2011, 141-164.
20. Aney S, Tambe, Rashmi, Kulkarni, Maushumi. Bhise, Kiran. Pharmacological and pharmaceutical potential of *Moringa oleifera*: A review, *Journal of Pharmacy Research,* 2(9), 2009, 1424-1426.
21. Patel S, Thakur A S, Chandy A, Manigauha A. *Moringa oleifera*: A review of there medicinal and economical importance to the health and nation, *Drug Invention Today,* 2(7), 2010, 339-342.
22. Fahey, Jed W. *Moringa oleifera*: A review of the medical evidence for its nutritional, therapeutic, and prophylactic properties, *Part 1, Trees for Life Journal,* 1(5), 2005, 21205-22185.
23. Mahmood, Khawaja Tahir, Mugal, Tahira. Haq, Ikram U L. *Moringa oleifera*: A natural gift-A review, *Journal of Pharmaceutical Sciences and Research,* 2(11), 2010, 775-781. Mukunzi, Daniel, Nsor-Atindana, John, Xiaoming, Zhang, Gahungu, Arthur, Karangwa, Eric, Mukamurezi, Godelieve, Al-Domi, Hayder, Princewill-Ogbonna, Ijeoma L, Ogbonna, Princewill C. Arief, Novirman Jamarun. Comparison of volatile profile of *Moringa oleifera* leaves from Rwanda and China using HS-SPME, *Pakistan Journal of Nutrition,* 10(7), 2011, 602-608.
24. Freiberger, C E, Vanderjagt, D J, Pastuszyn, A, Glew, R S, Mounkaila, G, Millson M, Glew R H. Nutrient content of the edible leaves of seven wild plants from Niger, *Plant Foods for Human Nutrition,* 53(1), 1998, 57-69.
25. Koul, Bhupendra. Chase, Neikouzo. *Moringa oleifera* Lam: Panacea to several maladies, *J. Chem. Pharmaceut. Res,* 2015(76), 2015, 687-707.
26. Maizuwo, Adamu Idris, Hassan, Aminu Sharif, Momoh, Hassanah. Muhammad, Jabir Abdullahi. Phytochemical constituents, biological activities, therapeutic potentials and nutritional values of *Moringa oleifera* (Zogale): A review, *Journal of Drug Design and Medicinal Chemistry,* 3(4), 2017, 60.
27. Saini, Ramesh Kumar, Sivanesan, Iyyakkannu. Keum, Young-Soo. Phytochemicals of *Moringa oleifera*: A review of their nutritional, therapeutic and industrial significance, *3 Biotech,* 6(2), 2016, 203.
28. Ferreira, Paulo Michel Pinheiro, Farias, Davi Felipe, Oliveira, Jose Tadeu De Abreu. Carvalho, Ana De Fatima Urano. *Moringa oleifera*: Bioactive compounds and nutritional potential, *Revista De Nutricao,* 21(4), 2008, 431-437.
29. Mughal, Haseeb M, Ali, Gayoor, Srivastava, Iqbal P S, Muhammad. Improvement of drumstick (Moringa pterygosperma Gaertn.)-a

unique source of food and medicine through tissue culture, *Hamdard Medicus,* 42(1), 1999, 37-42.

30. Leone, Alessandro, Spada, Alberto, Battezzati, Alberto, Schiraldi, Alberto, Aristil, Junior. Bertoli, Simona. Cultivation, genetic, ethnopharmacology, phytochemistry and pharmacology of *Moringa oleifera* leaves: An overview, *International Journal of Molecular Sciences,* 16(6), 2015, 12791-12835.
31. Mishra, Satya Prakash, Singh, Pankaj Singh, Sanjay. Processing of *Moringa oleifera* leaves for human consumption, *Bulletin of Environment, Pharmacology and Life Sciences,* 2(1), 2012, 28-31.
32. Manzoor, Maleeha, Anwar, Farooq, Iqbal, Tahira. Bhanger, M I. Physico-chemical characterization of Moringa concanensis seeds and seed oil, *Journal of the American Oil Chemists' Society,* 84(5), 2007, 413-419.
33. Mahatab S N, Ali A. Asaduzzaman A H M. Nutritional potential of sajna leaves in goats, *Livestock Advisor,* 12(12), 1987, 9-12. Manzoor, Maleeha, Anwar, Farooq, Iqbal, Tahira. Bhanger M I. Physico-chemical characterization of Moringa concanensis seeds and seed oil, *Journal of the American Oil Chemists' Society,* 84(5), 2007, 413-419.
34. Martin L. Price. The moringa tree, *ECHO Technical Note,* 2007, 1-19.
35. Fuglie, Lowell J. The miracle tree: *Moringa oleifera*, natural nutrition for the tropics, *Church World Service,* 1999, 63. Mishra, Satya Prakash, Singh, Pankaj. Singh, Sanjay. Processing of *Moringa oleifera* leaves for human consumption, *Bulletin of Environment, Pharmacology and Life Sciences,* 2(1), 2012, 28-31.
36. Yang, Ray-Yu, Chang, Lien-Chung, Hsu, Jenn-Chung, Weng, Brian Bc, Palada, Manuel C, Chadha M L. Levasseur, Virginie. Nutritional and functional properties of Moringa leaves-From germplasm, to plant, to food, to health, Moringa leaves: Strategies, standards and markets for a better impact on nutrition in Africa, *Moringa News, CDE, CTA, GFU, Paris,* 2006.
37. Amabye, Teklit Gebregiorgis, Gebrehiwot, Kindeya. Chemical compositions and nutritional value of Moringa oleifera available in the market of Mekelle, *Journal of Food and Nutrition Sciences,* 3(5), 2016, 187-190.
38. Caceres A, Cabrera O, Morales O, Mollinedo P, Mendia P. Pharmacological properties of Moringa oleifera. 1: Preliminary screening for antimicrobial activity, *Journal of Ethnopharmacology,* 33(3), 1991, 213-216.
39. Nwosu M O, Okafor J I. Preliminary studies of the antifungal activities of some medical plants against basidiobolus and some other pathogenic Fungi, *Mycoses,* 38(5-6), 1995, 191-195.
40. Spiliotis V, Lalas S, Gergis V, Dourtoglou V. *Pharm Pharmacol Lett,* 7(4), 1997, 39-40.
41. Umar Dahot M. Antimicrobial activity of small protein of *moringa oleifera* leaves, *Journal of Islamic Academy of Sciences,* 11(1), 1998, 27-32.
42. Nikkon F, Saud Z A, Rahman M H, Haque M E. *In vitro* antimicrobial activity of the compound isolated from chloroform extract of *Moringa oleifera* Lam, *Pakistan Journal of Biological Sciences,* 6(22), 2003, 1888-1890.
43. Nantachit K. *CMU Journal,* 5(3), 2006, 365-368.
44. Doughari J H, Pukuma M S, De N. Antibacterial effects of Balanites aegyptiaca L. Drel. and *Moringa oleifera* Lam. on Salmonella typhi, *African Journal of Biotechnology,* 6(19), 2007, 2212-2215.
45. Chuang P H, Lee C W, Chou J Y, Murugan M, Shieh B J, Chen H M. Antifungal activity of crude extracts and essential oil of *Moringa oleifera* Lam, *Bioresource Technology,* 98(1), 2007, 232-236.
46. Raheela Jabeen, Muhammad Shahid, Amer Jamil, Muhammad Ashraf. Microscopic evaluation of the antimicrobial activity of seed extracts of *moringa oleifera*, *Pak. J. Bot,* 40(4), 2008, 1349-1358.

47. Rahman M M, Islam Sheikh M M, Sharmin S A, Islam M S, Rahman A, Mizanur Rahman M, Alam M F. Traditional uses, phytochemistry and pharmacological properties of *Moringa oleifera* plant: An overview, *CMU Journal,* 8(2), 2009, 219-228.
48. Nepolean P, Anitha J, Renitta R E. Isolation, analysis and identification of phytochemicals of antimicrobial activity of *Moringa oleifera* Lam, *Current Biotica,* 3(1), 2009, 33-39.
49. Prashith Kekuda T R, Mallikarjun N, Swathi D, Nayana K V, Meera B. Aiyar, Rohini T R. Traditional uses, phytochemistry and pharmacological properties of Moringa oleifera plant: An overview, *J. Pharm. Sci and Res,* 2(1), 2010, 34-37.
50. Aney J S, Tambe, Rashmi, Kulkarni, Maushumi. Bhise, Kiran. Pharmacological and pharmaceutical potential of *Moringa oleifera*: A review, *Journal of Pharmacy Research,* 2(9), 2009, 1424-1426.
51. Santos, Andrea F S, Argolo, Adriana C C, Paiva, Patricia M G, Coelho, Luana C B B. Antioxidant activity of *Moringa oleifera* tissue extracts, *Phytotherapy Research,* 26(9), 2012, 1366-1370.
52. Leone, Alessandro, Spada, Alberto, Battezzati, Alberto, Schiraldi, Alberto, Aristil, Junior, Bertoli, Simona. Cultivation, genetic, ethnopharmacology, phytochemistry and pharmacology of *Moringa oleifera* leaves: An overview, *International Journal of Molecular Sciences,* 16(6), 2015, 12791-12835.
53. Mouminah, Haneen Hamed Saleh. Effect of dried *Moringa oleifera* leaves on the nutritional and organoleptic characteristics of cookies, *Alexandria Science Exchange Journal,* 36(4), 2015, 297-302.
54. Pal, Saroj K, Mukherjee, Pulok K, Saha B P. Studies on the antiulcer activity of *Moringa oleifera* leaf extract on gastric ulcer models in rats, Phytotherapy Research, 9(6), 1995, 463-465.
55. Pal, Saroj K, Mukherjee, Pulok K, Kakali Saha, Pal M, Saha B P. Antimicrobial action of the leaf extract of *Moringa oleifera* Lam, *Ancient Science of Life,* 14(3), 1995, 197.
56. Dubey, Durgesh Kumar, Dora, Jyotsna, Kumar, Anil. Gulsan, Ratan Kumar. A multipurpose tree-*Moringa oleifera*, *International Journal of Pharmaceutical and Chemical Sciences,* 2(1), 2013, 415-423.
57. Kumar, Sudhir P, Mishra, Debasis, Ghosh, Goutam. Panda, Chandra S. Medicinal uses and pharmacological properties of *Moringa oleifera*, *International Journal of Phytomedicine,* 2(3), 2010, 210-216.
58. Guevara, Amelia P, Vargas, Carolyn, Sakurai, Hiromu, Fujiwara, Yasuhiro, Hashimoto, Keiji, Maoka, Takashi, Kozuka, Mutzuo, Ito, Yoshohiro, Tokuda, Harukuni. Nishino, Hoyoku. An antitumor promoter from *Moringa oleifera* Lam, *Mutation Research/Genetic Toxicology and Environmental Mutagenesis,* 440(2), 1999, 181-188.
59. Gilani, Anwar H, Aftab, Khalid, Suria, Amin, Siddiqui, Salimuzzaman, Salem, Rubeena, Siddiqui, Bina S. Faizi, Shaheen. Pharmacological studies on hypotensive and spasmolytic activities of pure compounds from *Moringa oleifera*, *Phytotherapy Research,* 8(2), 1994, 87-91.
60. Feldmann M, Brennan F M, Maini R N. Role of cytokines in rheumatoid arthritis, *Annu. Rev. Immunol,* 14, 1996, 397-440.
61. Graves D T, Liu R, Oates T W. Diabetes enhanced inflammation and apoptosis-impact on periodontal pathosis , *Periodontology 2000,* 45(1), 2007, 128-137.
62. Marajo L C C, Augier J S, Napoleon T H, Moat F V B, Barros A L S, Maura M C, Coriolanus, M C, Coelho L C B B, Silva T G, Paiva P M G. Evaluation of cytotoxic and anti-inflammatory activities of extracts and lectins from *Moringa oleifera* seeds, *Plops One,* 8(12), 2013, e81973.
63. Muangnoi C, Chingsuwanrote P, Praengamthanachoti P, Svasti S, Tuntipopipat S. *Moringa oleifera* pod inhibits

inflammatory mediator production by lipopolysaccharide-stimulated raw 264.7 murine macrophage cell lines, *Inflammation,* 35(2), 2012, 445-455.

64. Sulaiman M R, Zakaria Z, Bujarimin A, Somchit M, Israf D, Moin S. Evaluation of *Moringa oleifera* aqueous extract for antinociceptive and anti-inflammatory activities in animal models, *Pharm. Biol,* 46(12), 2008, 838-845.
65. Udupa S, Udupa A, Kulkarni D. Studies on the anti-inflammatory and wound healing properties of *Moringa oleifera* and Aegle marmelos, *Fitoterapia,* 65(2), 1994, 119-123.
66. Cavallari I, Cannon C P, Braunwald E, Goodrich E L, Im K, Lukas M A, O'donoghue M L. Metabolic syndrome and the risk of adverse cardiovascular events after an acute coronary syndrome, *Eur. J. Prev. Cardiol,* 25(8), 2018, 830-838.
67. Grundy S M. Metabolic syndrome update, *Trends Cardiovasc. Med,* 26(4), 2016, 364-373.
68. Oneill S, Odriscoll L. Metabolic syndrome: A closer look at the growing epidemic and its associated pathologies, *Obes Res,* 16(1), 2015, 1-12.
69. Lopez M, Rios-Silva M, Huerta M, Cardenas Y, Bricio-Barrios J A, Diaz-Reval M I, Urzua Z, Huerta-Trujillo M, Lopez-Quezada K, Trujillo X. Effects of *Moringa oleifera* leaf powder on metabolic syndrome induced in male Wistar rats: A preliminary study, *J. Int. Med. Res,* 46(8), 2018, 3327-3336.
70. Villarruel-Lopez A, Lopez-de La Mora D, Vazquez-Paulino O, Puebla-Mora A, Torres-Vitela M R, Guerrero-Quiroz L, Nuno K. Effect of Moringa oleifera consumption on diabetic rats, *BMC Complement. Altern. Med,* 18(1), 2018, 127.
71. Divi S, Bellamkonda R, Dasireddy S K. Evaluation of antidiabetic and antihyperlipedemic potential of aqueous extract of Moringa oleifera in fructose fed insulin resistant and STZ induced diabetic wistar rats: A comparative study, *Asian J. Pharm. Clin. Res,* 5(1), 2012, 67-72.
72. Sugunabai J, Jayaraj M, Karpagam T, Varalakshmi B. Antidiabetic efficiency of *Moringa oleifera* and Solanum nigrum, *Int. J. Pharm. Pharm. Sci,* 6(1), 2014, 40-42.
73. Jaiswal D, Rai P K, Kumar A, Mehta S, Watal G. Effect of *Moringa oleifera* Lam. leaves aqueous extract therapy on hyperglycemic rats, *J. Ethnopharmacol,* 123(3), 2009, 392-396.
74. WHO. World Health Organisation, Study group on diabetes mellitus, *WHO: Geneva, Switzerland,* 1994, 78-79.
75. Francis J A, Jayaprakasam B, Olson L K, Nair M. Insulin secretagogues from *Moringa oleifera* with cyclooxygenase enzyme and lipid peroxidation inhibiting activities, *Helv. Chim. Acta,* 87(2), 2004, 317-326.
76. Park, A. Park's Textbook of social and preventive medicine, *Banarasidas Bhanot Publishers, Jabalpur, India,* 2007.
77. Yassa H D, Tohamy A F. Extract of *Moringa oleifera* leaves ameliorates streptozotocin-induced diabetes mellitus in adult rats, *Acta Histochem,* 116(5), 2014, 844-854.
78. Rudge M V, Damasceno D C, Volpato G T, Almeida F C, Calderon I M, Lemonica I P. Effect of Ginkgo biloba on the reproductive outcome and oxidative stress biomarkers of streptozotocin-induced diabetic rats, *Braz. J. Med. Biol. Res,* 40(8), 2007, 1095-1099.
79. Khan H A, Alhomida A S. A review of the logistic role of l-carnitine in the management of radiation toxicity and radiotherapy side effects, *J. Appl. Toxicol,* 31(8), 2011, 707-713.
80. Guevara A, 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, *Mutat Res. Genet. Toxicol Environ. Mutagen,* 440(2), 1999, 181-188.
81. Parvathy M, Umamaheshwari A. Cytotoxic effect of *Moringa oleifera* leaf extracts on

human multiple myeloma cell lines, *Trends Med. Res,* 2(1), 2007, 44-50.
82. Jung I L. Soluble extract from *Moringa oleifera* leaves with a new anticancer activity, *PLoS One,* 9(4), 2014, e95492.
83. Jung I L, Lee J H, Kang S C. A potential oral anticancer drug candidate, *Moringa oleifera* leaf extract, induces the apoptosis of human hepatocellular carcinoma cells, *Oncol. Lett,* 10(3), 2015, 1597-1604.
84. Guevara A, 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, *Mutat Res. Genet. Toxicol Environ. Mutagen,* 440(2), 1999, 181-188.
85. Vasanth K, Ilango K, Mohan Kumar R, Agrawal A, Dubey G P. Anticancer activity of *Moringa oleifera* mediated silver nanoparticles on human cervical carcinoma cells by apoptosis induction, *Colloids Surf. B,* 117, 2014, 354-359.
86. Prakash A O, Pathak S, Shukla S, Mathur R. Uterine histoarchitecture during pre and post-implantation periods of rats treated with aqueous extract of *Moringa oleifera* Lam, *Acta Eur Fertil,* 18(2), 1987, 129-135.
87. Shukla S, Mathur R, Prakash A O. Biochemical and physiological alterations in female reproductive organs of cyclic rats treated with aqueous extract of *Moringa oleifera* Lam, *Acta Eur Fertil,* 19(4), 1988, 225-232.
88. Shukla S, Mathur R, Prakash A O. Antifertility profile of the aqueous extract of *Moringa oleifera* roots, *Journal of Ethnopharmacology,* 22(1), 1988, 51-62.
89. Shukla S, Mathur R, Prakash A O. Histoarchitecture of the genital tract of ovariectomized rats treated with an aqueous extract of *Moringa Oleifera* roots, *Journal of Ethnopharmacology,* 25(3), 1989, 249-261.
90. Mazumder U K, Gupta M, Chakrabarti S, Pal D. Evaluation of hematological and hepatorenal functions of methanolic extract of Moringa oleifera Lam. root treated mice, *Indian Journal of Experimental Biology,* 37(6), 1999, 612-614.
91. Pari L, Kumar N A. Hepatoprotective activity of *Moringa oleifera* on antitubercular drug-induced liver damage in rats, *J Med Food,* 5(3), 2002, 171-177.
92. Faizi S, Siddiqui B S, Saleem R, Siddiqui S, Aftab K, Gilani A H. solation and structure elucidation of new nitrile and mustard oil glycosides from Moringa oleifera and their effect on blood pressure, *J Nat Prod,* 57(9), 1994, 1256-1261.
93. Faizi S, Siddiqui B S, Saleem R, Siddiqui S, Aftab K, Gilani A H. Fully acetylated carbamate and hypotensive thiocarbamate glycosides from *Moringa oleifera*, *Phytochemistry,* 38(4), 1995, 957-963.
94. Ghasi S, Nwobodo E, Ofili J O. Hypocholesterolemic effects of crude extract of leaf of *Moringa oleifera* Lam in high-fat diet fed wistar rats, *Journal of Ethnopharmacology,* 69(1), 2000, 21-25.
95. Ara N, Rashid M, Amran M S. Comparison of *Moringa oleifera* leaves extract with atenolol on serum triglyceride, serum cholesterol, blood glucose, heart weight, body weight in adrenaline induced rats, *Saudi Journal of Biological Sciences,* 15(2), 2008, 253-258.
96. Chumark P, Khunawat P, Sanvarinda Y, Phornchirasilp S, Morales N P, Phivthong Ngam L, Ratanachamnong P, Srisawat S, Pongrapeeporn K U. The *in vitro* and *ex vivo* antioxidant properties, hypolipidaemic and antiatherosclerotic activities of water extract of *Moringa Oleifera* Lam. leaves, *Journal of Ethnopharmacology,* 116(3), 2008, 439-446.
97. Nandave M, Ojha S K, Joshi S, Kumari S, Arya D S. *Moringa oleifera* leaf extract prevents isoproterenol-induced myocardial damage in rats: evidence for an antioxidant, antiperoxidative, and cardioprotective intervention, *J Med Food,* 12(1), 2009, 47-55.
98. Debnath S, Guha D. *Indian Journal of Experimental Biology,* 45, 2007, 726-731.

99. Medhi B, Khanikor H N, Lahon L C, Mohan P, Barua C C. Antiinflammatory Effects of Moringa oleifera Root Extract, *International Journal of Pharmacognosy,* 34(3), 1996, 207-212.
100. Rathi B S, Bodhankar S L, Baheti A M. Evaluation of aqueous leaves extract of Moringa oleifera Linn for wound healing in albino rats, *Indian Journal of Experimental Biology,* 44(11), 2006, 898-901.
101. Hukkeri V I, Nagathan C V, Karadi R V, Patil B S. Antipyretic and wound healing activities of *Moringa oleifera* Lam. in rats, *Indian J Pharm Sci,* 68(1), 2006, 124-126.
102. Ndong M, Uehara M, Katsumata S, Suzuki K. Effects of oral administration of *moringa oleifera* lam on glucose tolerance in goto-kakizaki and wistar rats, *J. Clin. Biochem. Nutr,* 40(3), 2007, 229-233.
103. Jaiswal D, Kumar Rai P, Kumar A, Mehta S, Watal G. Effect of *Moringa oleifera* Lam. leaves aqueous extract therapy on hyperglycemic rats, *Journal of Ethnopharmacology,* 123(3), 2009, 392-396.
104. Caceres A, Saravia A, Rizzo S, Zabala L, De Leon E, Nave F. Pharmacologic properties of Moringa oleifera. 2: Screening for antispasmodic, antiinflammatory and diuretic activity, *Journal of Ethnopharmacology,* 36(3), 1992, 233-237.
105. Karadi R V, Gadge N B, Alagawadi K R, Savadi R V. Effect of *Moringa oleifera* lam, root-wood on ethylene glycol induced urolithiasis in rats, *Journal of Ethnopharmacology,* 105(1-2), 2006, 306-311.
106. Karadi R V, Palkar M B, Gaviraj E N, Gadge N B, Mannur V S, Alagawadi K R. Antiurolithiatic property of *Moringa oleifera* root bark, *Pharmaceutical Biology,* 46(12), 2008, 861-865.
107. Ray K, Hazra R, Guha D. Central inhibitory effect of Moringa oleifera root extract: Possible role of neurotransmitters, *Indian Journal of Experimental Biology,* 41(11), 2003, 1279-1284.
108. Ganguly R, Guha D. Alteration of brain monoamines and EEG wave pattern in rat model of Alzheimer's disease and protection by *Moringa oleifera*, *Indian J Med Res,* 128(6), 2008, 744-751.
109. Mahajan S G, Mehta A A. Inhibitory action of ethanolic extract of seeds of *Moringa oleifera* Lam. on systemic and local anaphylaxis, *J Immunotoxicol,* 4(4), 2007, 287-294.
110. Rastogi T, Bhutda V, Moon K, Aswar P B, Khadabadi S S. Comparative studies on anthelmintic activity of *Moringa oleifera* and Vitex Negundo, *Asian J. Research Chem,* 2(2), 2009, 181-182.
111. www.echocommunity.org/By: Kathryn A. Witt PhD, RD, LDN Published: 2020-01-01
112. www.public.asu.edu.

Please cite this article in press as: Shiwani Jaiswal *et al*. A review on phytochemistry and pharmacologial properties of *Moringa oleifera* plant, *International Journal of Research in Pharmaceutical and Nano Sciences,* 12(3), 2023, 112-129.