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Review Article

A Review on Nutritional Benefits, Pharmaceutical Properties and Recent Application of Moringa in Pharmacology

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ABSTRACT

Moringa oleifera, also known as the "Miracle Tree," is native to the Indian subcontinent and Southeast Asia. It is believed to have originated in the Himalayan foothills, specifically in the regions of India and Pakistan.Moringa oleifera, a multipurpose plant, has gained significant attention for its exceptional nutritional value and medicinal properties. This review aims to summarize the nutritional benefits, pharmaceutical properties, and recent applications of Moringa in pharmacology. Moringa is rich in essential nutrients, including vitamins, minerals, amino acids, and antioxidants. Its pharmaceutical properties encompass anti-diabetic, anti-obesity, anti-arthritic, anti-ulcer, anti-inflammatory, antioxidant, antimicrobial, and anti-cancer activities. The bioactive compounds present in Moringa, such as isothiocyanates, flavonoids, and phenolic acids, contribute to its medicinal properties. Recent studies have explored the potential applications of Moringa in pharmacology, including the development of novel drugs for managing chronic diseases. This review highlights the potential of Moringa as a valuable resource for both nutritional and pharmaceutical applications, warranting further research and development.

INTRODUCTION

The Moringa genus is part of the Moringaceae family, also known as the 'drumstick' or 'horseradish' family, and contains 13 species [1]. The native range is commonly identified as Sub-Himalayan valleys[2]. Moringa oleifera was originated in Arabia and India. The tree can now be found in landscapes across the Old World's tropics, from South Asia to West Africa, Central America, and the Caribbean. Moringa oleifera is a tropical tree with numerous applications and drought resilience. Agronomic research with Moringa oleifera demonstrate that the plant can grow successfully in mountainous places, in

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weathered soils with low fertility [3]. Moringa seeds are put directly in the pit to encourage quick growth of seedlings. September is the best month to plant seeds in Southern India. To avoid excessive flower shedding during monsoon rains, seed at the appropriate time. Annual moringa types produce fruit seasonally, thus a crop planted in September can be reaped in six months. Fruits of sufficient length and girth are harvested before they generate fibre. The harvest period lasts roughly 2-3 months, and each tree produces 250-400 fruits every year. The Moringa family consists of a single genus, Moringa oleifera Lam. This family is distinguished by parietal placentation, 3-valved fruit, long non-dehiscent berries, and winged seeds. M. oleifera is characterised by leaves that are normally tripinnate, leaflets that are 12-18 mm long, and petioles that are yellow or white without red streaks. The tree is medium-sized [4]. Moringa (Moringa oleifera Lam.) is a widely distributed multipurpose tree that has significant promise as a high-value crop due to its nutritional, medicinal, and preventive characteristics, as well as its industrial applications. Almost every part of the tree has a variety of purposes. It is a fascinating plant due to its bioactive components [5].

Taxonomic Classification

Kingdom - Plantae
Sub kingdom - Tracheobionta
Super Division - Spermatophyta
Division - Magnoliophyta
Class - Magnoliopsida
Subclass - Dilleniidae
Order - Capparales
Family - Moringaceae
Genus – Moringa
Species – Oleifera [6]

Nutritional Benefits

Moringa oleifera fruit pulp contains high levels of calories, carbohydrates, protein, calcium, and potassium. It can be included in a daily diet to boost immunity [7]. Numerous vital nutrients, including vitamins, minerals, amino acids, beta-carotene, antioxidants, anti-inflammatory compounds, and omega 3 and omega 6 fatty acids, have been discovered to be present in moringa. Moringa leaves are thought to be a good source of protein, calcium, B-carotene, vitamin C, and potassium. It functions as an effective natural antioxidant source. Because it contains a variety of antioxidant components, including phenolics, carotenoids, ascorbic acid, and flavonoids [8].

Vitamins C, D, and E are also present in M. oleifera, along with beta-carotene of vitamin A, vitamin B, which includes folic acid, pyridoxine, and nicotinic acid. There are phytochemicals such tannins, sterols, terpenoids, flavonoids, saponins, anthraquinones, alkaloids, and reducing sugar in addition to anti-cancerous compounds including glucosinolates, isothiocyanates, glycoside compounds, and glycerol-1-9-octadecanoate. Moringa leaves can also be incorporated into the diet of an obese person because they are low in calories. The fibrous pods can be used to treat digestive problems and prevent colon cancer. Immature pods contain roughly 46.78% fibre and 20.66% protein. Pods contain 30% amino acids, leaves include 44%, and blossoms contain 31%.

Comparable levels of palmitic, linolenic, linoleic, and oleic acids were found in the immature pods and flowers. Numerous elements included in moringa are vital for growth and development, with calcium being one of the most crucial for human development. Moringa leaves can supply 1000 mg, and moringa powder can supply around 4000 mg, whilst 8 ounces of milk can supply 300–400 mg [9]. Complete list of nutritional composition of moringa is tabulated in Table 1.

Table 1Nutritional composition of moringa pods, fresh leaves and dried leaves [10].

S.no	Nutrition analysis	Pods (per 100 g)	Fresh leaves (per 100 g)	Dried leaf (per 100 g)

1.	Moisture %	86.9	75	7.5
2.	Calories	92	205	26
3.	Protein (g)	2.5	6.7	27.1
4.	Fat(g)	0.1	1.7	2.30
5.	Minerals (g)	2	2.3	-
6.	Calcium (mg)	30	440	2003
7.	Magnesium (mg)	24	24	368.0
8.	Phosphorous (mg)	110	70	204.0
9.	Potassium (mg)	24	24	1324
10.	Copper (mg)	3.1	1.1	0.6
11.	Iron (mg)	5.3	0.7	28.2
12.	Oxalic acid (mg)	10	101	0.0
13.	Sulfur (mg)	137	137	870
14.	Carbohydrates (g)	3.7	13.4	38.2
15.	Fiber (g)	4.8	0.9	19.2

Pharmacological Properties Of Moringa

Moringa oleifera has been used medicinally in Ayurvedic and Unani systems for many years [11]. The therapeutic properties and pharmacological actions of Moringa are briefly described below

Anti-Inflammatory

Moringa extracts contained kaempferol, gallic acid, vanillic acid, coumaric acid, and quercetin. The methanolic, aqueous, and ethyl acetate extracts demonstrated the highest in vitro antioxidant potential [12]. Inflammation and oxidative stress are key factors in the pathophysiology of many diseases, including periodontal disease. Moringa extracts' flavonoid content demonstrates how flavonoids contribute to their anti-inflammatory properties [13]. It also contains a minor amount of linoleic and linolenic acids, which are precursors to eicosanoids, a strong category of inflammation modulators. Phytochemicals and unsaturated fatty acids also provide anti-inflammatory properties [14]. MO extracts have anti-inflammatory properties, suggesting they could be a game changer. Most studies show that MO has a significant impact on inflammation and free radical dynamics. Inhibition of inflammatory mediators and oxidants such as ROS, TNFα, and IL-1β was observed. Nitrite generation and PGE2 were reduced, whereas anti-inflammatory IL-10 and IκB-α were raised. Both nitric oxide and IL-6 were suppressed. Downregulating iNOS and COX-2 inhibited IκBα breakdown and reduced NFκB expression. A study discovered lower levels of RelA, a component of the NFκB pathway. Research suggests that the NFκB pathway plays a key role in MO's anti-inflammatory effects [15].

Antimicrobial Activity

Hexane and benzene extracts of moringa shown antifungal efficacy against all tested fungi, water and methanol extracts demonstrated antibacterial activity against all chosen bacteria, and hexane, benzene, and isopropanol extracts demonstrated activity against the Hepatitis B virus. In conclusion, M. oleifera leaves contain compounds that have antibacterial properties [16]. In general, isothiocyanates and their glucosinolate precursors are recognised to have antibacterial characteristics in moringa, which protect the plant from infection. Isothiocyanate action is mostly related to its reactivity with sulfhydryl groups, and the antimicrobial impact is dose-dependent [17]. Furthermore, Moringa's isothiocynate is extremely stable at room temperature. Recently, the antibacterial activity of (gluco)moringin extracted from Moringa oleifera seeds was evaluated against Listeria monocytogenes utilising a broth dilution experiment. The MIC for moringin was 0.124 mg/mL. Transcriptomics revealed that

the seed-derived glucosinolate moringin damaged the bacterial cell wall, as well as the membrane composition and structure of Listeria monocytogenes. Furthermore, moringin activity caused oxidative stress, disrupted energy metabolism and cell motility, and hindered bacterial DNA replication [18].

Anti-Cancer

Isothiocyanates (ITCS) from M. oleifera are one type of active substance that can inhibit cancer proliferation and promote cancer cell apoptosis via multiple signalling pathways, thereby reducing cancer migration and metastasis while having little effect on normal cells. M. oleifera contains a variety of ITCs, but the most common is 4-(a-L-rhamnosyloxy)benzyl isothiocyanate, also called moringa isothiocyanate (MIC-1) [19]. The extracts of M. oleifera leaves contain a number of bioactive anti-cancer components that may be responsible for their potent anti-cancer action against the A549 cell line.M. oleifera extracts have anti-cancer properties by inhibiting cell motility and colony formation in colorectal and breast cancer cell lines. Furthermore, it was previously proven that the water-soluble fraction of M. oleifera leaves triggered apoptosis in lung cancer cells, and is therefore a novel type of possible anticancer candidate chemical [20].

Anti-Allergic

Moringa oleifera leaf extract was subjected to phytochemical screening, which identified the presence of polyterpenes/sterols, polyphenols, tannins, alkaloids, and flavonoids while excluding saponosides and quinones.. Moringa oleifera leaf E.T. A. shown antihistaminic effects when given to allergic mice. As a result, its capacity to suppress the allergic response would indicate the presence of chemicals with antihistaminic properties. The extract's ability to stimulate the body's immune system may also be the cause of its anti-allergic characteristic [21]. Extracts from M. oleifera leaves, seeds, and pods showed anti-allergic properties by preventing both the early and late stages of allergic reactions. Specifically, the leaf extract inhibited the release of TNF-α, IL-4, and beta-hexosaminidase more than the positive control, ketotifen fumarate. M. oleifera's high concentration of flavonoids and flavanol glucosides, including rutin, kaempferol, astragalin, and quercetin, may be linked to the plant's anti-allergic properties [22].

Anti-Asthma

In asthmatic mice, extract from the leaves of Moringa oleifera Lam. Has been demonstrated to lower the eosinophil level and stabilise the mast cell count. The extract of M. oleifera leaves did not differ statistically significantly.There was no statistically significant difference between the extract of M. oleifera leaves and the positive controls that received dexamethasone in lowering the eosinophil count (p-value = 0.503). The p-value was 0.176 when compared to positive controls (dexamethasone) for mast cell stabilisation [23].

Anti-Obesity

It is considered that MO is made up of a diverse range of metabolites with antioxidant properties that have the ability to reduce blood sugar and cause hypolipidemia. The MO extract recovers the levels of different adipokines and directly affects visceral fat mass [24]. Visceral adiposity is thought to be a direct link between obesity and a number of metabolic illnesses, including an increased chance of developing type 2 diabetes, atherosclerosis, and hypertension, all of which are clinically classified as metabolic syndrome. The study found that administering an ethanolic extract of M. oleifera to obese females reduced body weight increase as well as AI and CRI. Thus, it reduced obesity and atherogenic dyslipidaemia. M. oleifera is as effective as simvastatin, a well-known cholesterol-lowering medication. Simvastatin inhibits 3-hydroxy-3-methylglutaryl coenzyme A reductase, which is the main enzyme

in the cholesterol production pathway. As a result, it decreases atherogenicity and cardiovascular mortality by improving the lipid profile, specifically TC and LDL-C, and increasing HDL-C production. The ethanolic extract of M. oleifera and simvastatin decreased insulin resistance and type 2 diabetes mellitus [25].

Anti-Diabetes

Moringa oleifera has been shown to have anti-diabetic properties in a number of research conducted in Sub-Saharan Africa and elsewhere. M.oleifera leaves are a good supply of green leafy vegetables that can help diabetic patients avoid difficulties. The aqueous extract suppresses the activities of α amylase and α glucosidase, improving antioxidant capacity, glucose tolerance, and glucose absorption rate in yeast cells. The aqueous extract can be employed as phytopharmaceuticals for the control of diabetes, whether as an adjuvant or alone. Quercetin dramatically boosts the hepatic activities of glucokinase and insulin. Terpenoids found in leaves may stimulate β cells and promote insulin production [26]. MO's fruit, flower, and leaf have the ability to reduce glucose levels in STZ-OVX rats. The MO plant has been shown to have osteoprotective properties; therefore, blood glucose, serum AlP, and TRAcP levels were examined in order to demonstrate the plant's osteoprotective and hypoglycemic efficacy. Compared to the control and OVX groups, the diabetic (STZ-induced) group showed a significant increase attributable to insulin resistance or Glut receptor malfunction. OVX hyperglycaemic rats had the same physiological glucose load. Treatment with MO extracts resulted in a reduction in the glucose load; however, because to the synergistic effects of osteoporosis and hyperglycemia, it did not decrease to the usual level. This is most likely owing to a negative calcium balance caused by increased urine calcium loss and decreased intestinal absorption, which may be a result of diminished renal production of 1,25-dihydroxy vitamin D3. Another cause for a drop in glucose titer is the role of flavanoids and polypenols [27]. The inhibitory action of methanolic extracts of stem bark and flowering buds on α-glucosidase. The results revealed that both the buds and bark extract were highly effective against this enzyme. Moringa oleifera L. methanolic extract of flowering bud (500 mg/kg body weight) significantly decreased blood glucose (322.5±48.35 to 173.8±29.53mg/dl) and increased body weight in diabetic mice (27.17±2.041 to 31.83±2.639) compared to untreated diabetic mice (32±1.8 to 25±3.8) [28]. The antidiabetic activity of the leaf extracts and the control (acarbose) was substantially higher ($p \leq .05$) than that of the main and lateral roots.When compared to the reference/positive Control, the leaves' antidiabetic activity was noticeably very similar. However, the acarbose, which was used as the control, outperformed the extracts from the leaves and root plants [29].

Anti-Oxidant Activity

The extracts' in vitro antioxidant activity was assessed using the 2,2-diphenyl-1-picrylhydrazyl (DPPH), 2,2-azino-bis-3-ethylenebenzothiozoline-6-sulfonic acid (ABTS), and ferric reducing antioxidant power (FRAP) techniques. The polyphenolic chemicals were identified primarily in the leaflets. The HPLC/MS analysis identified 15 chemicals from the hydroxycinnamic acid, anthocyanin, flavonols, methoxyflavone, tyrosol, dihydrochalcones, flavones, and methoxyflavone families. The ethanolic extracts shown strong antioxidant activity against DPPH, ABTS, and FRAP [30]. Moringa oleifera has remarkable antioxidant activity and is a rich source of antioxidants since it contains a variety of chemicals such as ascorbic acid, flavonoids, phenolics, and carotenoids. Antioxidant activity is vital for protecting cells from oxidation. In this regard, the antioxidant

chemicals contained in Moringa leaves are particularly effective for photoprotection against oxidative stress generated by UV radiation, which, if prolonged, can lead to skin cancer. The scavenging activity against the ABTS+ free radical is low when compared to other Indian plant extracts recognised for their unique antioxidant profiles [31]. M. oleifera leaves contain a wide range of active components, particularly reducing agents such as phenolics, flavonoids, and carbohydrates, which can act as antioxidants, antiradicals, and reducing or capping agents in the production of different NPs (La2O3, CuO, FeO3, Ag, and ZnO). The antioxidant activity of several biosynthesised metal NPs varied according to extract concentration and incubation period. Nanoparticles tested for cytotoxicity showed good potency against T47D and A549 cell lines, with IC50 ranges of 38 to 210 µg/mL and 26 to 115 µg/mL, respectively. However, HepG2 and Wi38 cell lines demonstrated considerably better resistance against all tested NPs as compared to Doxorubicin [32].

Anti-Ulcer Property

Spicy foods, stress, alcohol, stomach surgery, and Helicobacter pylori are all known causes of peptic ulcer disease. Natural ingredients are being investigated as a means of generating ulcer treatments with low side effects. The powders' antioxidant, total phenolic content (TPC), and anti-ulcer properties were studied, as well as their suitability for soup fortification. The TPC of Moringa oleifera (MO) leaves and fermented soybean (Natto) extracts was high in both soybean and MO leaf aqueous extracts. Gallic acid was found to be the primary phenolic component in soybean Natto at 1464.304 µg/gm, while chlorogenic acid was the primary component in MO leaves at 2218.493 µg/gm. According to the antioxidant activity results, MO leaves had 2.6 times the antioxidant activity of fermented soybean Natto (1, 1-diphenyl-2-picrylhydrazyl). Furthermore, ferric reducing power activities results showed that MO leaves produced 64.4 times more reducing power activities than fermented soybean Natto. After 7 days of pre-treatment with Natto (25, 50%) and aqueous extract of MO leaves (5, 10%), all animals were administered by asprineat a dose of 500 mg/kg bw suspended in water for the induction of acute gastric ulcer, ulcer index, protective index, volume of gastric juice, and pH of gastric juice were evaluated. Biochemical markers such as lipid peroxidation, superoxide dismutase (SOD), gluthathione peroxidase (GPx), malondialdehyde (MDA), and Catalase (CAT) were assessed. Ranitidine served as a positive control. All morphological and biochemical criteria revealed considerable anti-ulcer activity in soybean natto and an aqueous extract of MO leaves. The anti-ulcer activity was nearly identical to the positive control. Ready-to-cook soup was a good product to be supplemented with soybean natto or MO leaves, and the inclusion of soybean natto was judged to be extremely acceptable when compared to the control sample in some circumstances due to its meat-like flavour and taste, which was more acceptable to some panellists. Other samples demonstrated a gradient of admission [33]. The methanolic extract is a powerful radical scavenger, with an estimated value of 87.54% at a higher concentration (500 µg/ml), and an antibacterial agent. Furthermore, the M. oleifera infusion inhibited DPPH by 80.58%. In vivo research revealed that mucus was extensively formed in the gastrointestinal mucosa of plant-treated rats, resulting in higher pH in rats pretreated with M. oleifera compared to ulcerated animals. The lesion index was significantly reduced (79%) in stomachs treated by plant. Interestingly, oral dosing of M. oleifera protected the gastric mucosa by lowering MDA levels while enhancing antioxidant enzyme activity (CAT, SOD, GPx) [34].

Anti-Arthritic Activity

Moringa leaf extracts may have anti-arthritic properties due to its flavonoids, saponins, and alkaloids, which are present in both ethanolic and aqueous extracts. The extract contains chemicals that could explain the plant's anti-arthritic capabilities and support its usage in traditional medicine. MO has experienced great international excitement and commercial success because to its positive effects [35]. A combination of Cardiospermum halicacabum and Moringa oleifera leaf extract was tested for its anti-inflammatory and anti-arthritic properties in vitro. Human red blood cell (HRBC) membrane stabilisation was used to test the ethanolic extract of leaves mixture's in vitro anti-inflammatory properties, while bovine serum protein denaturation and egg albumin denaturation were used to test its in vitro antiarthritic properties. The ethanolic extract's activity was contrasted with that of diclofenec sodium, a common anti-inflammatory medication. Diclofenac sodium was shown to be less effective than an ethanolic extract of a combination of Cardiospermum halicacabum and Moringa oleifera in inhibiting the denaturation of egg albumin. We may conclude that the combination of Moringa oleifera and Cardiospermum halicacabum has good anti-inflammatory and anti-arthritic properties in vitro [36]. Using primary human fibroblast-like synoviocytes (HFLS) isolated from healthy individuals and an arthritis patient (HFLS-RA), proteomics analysis was used to investigate the anti-arthritic properties of Moringa oleifera (MO), a tropical medicinal plant, and its underlying mechanism. Early studies used the MTT test to assess MO's impact on cell viability in order to determine the ideal dosage. The cells were separated into two groups: (1) MO treatment group (HFLS and HFLS-RA), dose-dependent treatment (500, 750, 1000, 50, 75, 100, 150, and 200 mg/mL); and (2) Negative control groups ((a) HFLS and (b) HFLS-RA, 0.1 M phosphate-buffered saline (PBS) only). Cells were split into two groups for proteomics investigations: (1) MO Treatment group (HFLS-RA), 75 mg/mL (optimal concentration); and (2) Negative control group (HFLS-RA), vehicle only (as previously mentioned). Cells were collected and examined for proteome-wide expression (Proteomics) or cell viability (MTT test) following a 24-hour treatment period. Proteomic data were validated using confocal immunofluorescence. The results of the MTT assay demonstrate that MO is not cytotoxic and, as a result, has no effect on cell viability below 75 mg/mL. According to proteomics data, MO either enhances (five proteins) or mitigates (35 proteins) the expression of all 40 proteins that are aberrantly expressed in HFLS-RA. In particular, the five proteins—Heat shock 70 kDa protein 1A/1B, Kallistatin, programmed cell death 6-interacting protein, haemoglobin subunit alpha, and Aldo-keto reductase family 1 member C1—were downregulated in HFLS-RA and were generally linked to normal protective processes like anti-inflammatory and apoptotic activities, while the 35 proteins were primarily linked to pathological processes like inflammation, aberrant proliferation, and cell adhesion [37].

Recent Application of Moringa in Pharmacology.

Since ethnomedical plants don't have any negative side effects, they can be used to cure wounds, while chemical medications are becoming more and more problematic. The effectiveness of Moringa oleifera seeds, a crucial ethnomedicinal plant, in healing wounds was investigated in this study. The wound healing efficacy of n-hexane extract and hydrogels of Moringa oleifera seeds both in vitro (antioxidant and antibacterial activities) and in vivo (excision and incision wound healing models) was evaluated. The Agar well diffusion method and the DPPH free radical scavenging experiment were used to evaluate the antibacterial and antioxidant properties,

respectively. Swiss albino mice were utilised to test the wound-healing properties of hydrogels, namely 5% and 10% hexane extracts of Moringa oleifera seeds, in excision and incision wound models. Both antibacterial and antioxidant properties were demonstrated by the n-hexane extract. Furthermore, until the completion of the procedure in both models, the hydrogels made with n-hexane extract of Moringa oleifera seeds shown a notable amount of wound healing activity in comparison to the control and standard. Additionally, the results of the histological analysis supported the findings of improved vascularity of the immediate skin, decreased inflammatory cells, and quicker tissue regeneration. n-hexane hydrogel formulation of Moringa oleifera seeds may be used as an alternate therapy for skin restoration during wound healing, according to the results (both in vitro and in vivo) [38]. Acacia gum and 2% hydroxyl propylmethylcellulose (HPMC) were used as binders in the wet granulation process to create the tablets. Both official and informal Pharmacopoeia procedures were used to examine them. For five days, 400 mg/kg of Moringa oleifera extract and tablets were given to diabetic rats. In diabetic rats, the extract and pills significantly lowered blood glucose levels. These findings demonstrated that in diabetic rats, the extract and prepared tablets have anti-diabetic effects [39].

For 30 days, adults with baseline serum LDL >2.6 mmol/L (>100 mg/dL) and minimal cardiovascular risk received Moringa oleifera leaf capsules at a dose of 350 mg each capsule, taken twice a day, three times a day. The results were comparable to the placebo group. Malunggay and placebo had similar effects on secondary efficacy outcomes (weight, body mass index, fasting blood sugar, serum glucose 2 hours after 75 gramme oral glucose load, total cholesterol, HDL, and triglycerides) and secondary safety outcomes (serum creatinine, ALT, and complete blood count). The malunggay and placebo groups experienced similar adverse effects. Taking malunggay pil's did not result in any serious adverse outcomes [40]. Rat hair development was examined in relation to single-use Hair Tonic formulations that contained ethanol extracts of fragrant pandan leaves (Pandanus amaryllifolius Roxb) and kelor leaves (Moringa oleifera Lam.). The process started with the ethanol extract of kelor leaves and ethanol extract of fragrant pandan leaves being maserated. Then, the extracts were characterised using both specific and non-specific parameters. Then, the extracts' chemical content was tested, and Hair Tonic preparations were made, including F1 (positive control), F2 (6% kelor leaf extract), F3 (6% ethanol pandan extract), F4 (2% kelor leaf extract combined with 4% ethanol pandan extract), F5 (3% kelor leaf ethanol extract and 3% ethanol pandan leaf extract), and F6 (4% kelor leaf ethanol extract and 2% ethanol pandan leaf extract) [41]. Evaluation of the Effects of Leaf Extracts from Azadirachta indica A. Juss., Citrus hystrix DC., and Moringa oleifera Lam. On Dental Plaque and Gingivitis Rungnapa and Watunyoo Buakaew Plants 10 (6), 1153, 2021; Pankla Sranujit, Chanai Noysang, Supaporn Sangouam, Nungruthai Suphrom, Yordhathai Thongsri, Pachuen Potup, and Kanchana Usuwanthim Gingivitis can be effectively avoided by practicing good oral hygiene and managing the development of microbial plaque biofilms. Mouthwashes that contained leaf extracts of the medicinal plants Azadirachta indica A. Juss. (NE), Moringa oleifera Lam. (MO), and Citrus hystrix DC. (KL) were evaluated for their potential as an adjuvant treatment for gingivitis and oral healthcare. KL, a KL + MO combo, and a KL + NE combination were the three mouthwash varieties that were created [42].

CONCLUSION

Moringa is a nutrient-dense plant, rich in essential vitamins, minerals, proteins, and antioxidants. Its

leaves, seeds, and pods contain high levels of vitamin C, vitamin A, calcium, potassium, and iron, making it an excellent dietary supplement. The amino acid profile of moringa is comparable to that of eggs, making it a valuable protein source, particularly in regions suffering from malnutrition. Furthermore, the plant is rich in polyphenols, flavonoids, and glucosinolates, which contribute to its antioxidant and anti-inflammatory properties. Moringa exhibits significant hypoglycemic activity. Its compounds, such as isothiocyanates and chlorogenic acid, regulate blood glucose levels by enhancing insulin secretion and improving glucose uptake. Studies have demonstrated its efficacy in reducing fasting blood sugar levels, making it a natural remedy for managing diabetes. Rich in fiber and bioactive compounds, moringa aids in weight management by reducing fat accumulation and improving lipid metabolism. It regulates appetite and decreases oxidative stress, contributing to better overall metabolic health. The anti-inflammatory and antioxidant compounds in moringa, such as quercetin and kaempferol, help alleviate symptoms of arthritis. They inhibit pro-inflammatory cytokines, reducing joint pain and swelling. Moringa's gastroprotective properties are attributed to its ability to enhance mucosal defense mechanisms and neutralize free radicals. Its leaf extract has been shown to significantly reduce ulcer formation by inhibiting gastric acid secretion and promoting healing. Moringa combats inflammation through its rich content of flavonoids, tannins, and saponins, which inhibit inflammatory pathways. These properties are beneficial for conditions such as asthma, cardiovascular diseases, and inflammatory bowel disorders. The plant's high levels of antioxidants, including vitamin C, beta-carotene, and polyphenols, help neutralize free radicals, preventing oxidative stress-related damage. This activity supports the prevention of chronic diseases such as cancer, diabetes, and neurodegenerative disorders. Moringa exhibits broad-spectrum antimicrobial activity against bacteria, fungi, and viruses. Its bioactive compounds disrupt microbial membranes, making it effective in treating infections and enhancing food preservation. Bioactive compounds such as niazimicin and benzyl isothiocyanate exhibit chemopreventive effects by inducing apoptosis and inhibiting tumor growth. Moringa has shown promise in preclinical studies against cancers of the breast, colon, and pancreas. Moringa's rich phytochemical profile positions it as a promising agent in drug formulation. It is used in developing herbal supplements, anti-diabetic medications, and anti-inflammatory drugs. Additionally, its antimicrobial properties make it a candidate for wound healing and infection control. Ongoing research is exploring its potential in nanomedicine and as an adjuvant in cancer therapies.

In conclusion, moringa offers an exceptional combination of nutritional and pharmaceutical benefits. Its incorporation into pharmacological research and therapeutic formulations holds immense potential for addressing global health challenges. Continued exploration and innovation in this field will further unlock the therapeutic potential of this remarkable plant.

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