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MORINGA LEAF EXTRACTS: A NUTRITIONAL POWERHOUSE FOR COMBATING MALNUTRITION

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Abstract: The tropical and subtropical parts of the world are home to the Indian native Moringa oleifera plant. It is often referred to as the "horseradish tree" or the "drumstick tree." Because moringa can tolerate both moderate cold and severe drought, it is commonly grown all over the world. Every portion of the tree is ideal for commercial or nutritional applications because to its high nutrient levels. Minerals, vitamins, and other vital phytochemicals are abundant in the leaves. Leaf extracts are used to treat malnutrition and increase breast milk production in nursing mothers. It has prospective use as an antibacterial, antidiabetic, anticancer, and anti-inflammatory drug. Water treatment uses a lot of M. oleifera seed, a natural coagulant. The scientific endeavor of this study sheds light on the potential use of moringa in commercial goods, including its fortification against cancer and diabetes. This paper examines how moringa is used medicinally in a variety of fields and covers its commercialization, pharmacological qualities, and cultivation. Moringa is known as the "Miracle Tree."

Key words: Moringa oleifera; Miracle Tree; Antidiabetic; Anticancer; Coagulant.

Abbreviations:

AGE: advanced glycated end products; **ATP:** adenosine triphosphate; **BITC:** benzyl isothiocyanate; **RAGE:** receptor for advanced glycated end products; **ROS:** reactive oxygen species; **STZ:** streptozotocin.

1. Introduction

Malnutrition can be effectively treated using Moringa oleifera, a member of the Moringaceae family. Because its leaves, pods, and seeds contain a range of vital compounds, moringa is high in nutrients. It's

really said that moringa has seven times the amount of vitamin C, ten times the amount of vitamin A, seventeen times the amount of calcium, nine times the amount of protein, fifteen times the amount of potassium, twenty-five times the amount of iron, and seven times the amount of calcium found in milk [1].

Moringa is a sustainable treatment for malnutrition since it is simple to grow. Children in nations like Senegal and Benin are given moringa treatments [2Youngsters who aren't given enough breast milk frequently exhibit signs of malnutrition. In order to increase milk production, breastfeeding moms are typically administered lactogogues. The phytosterol-based lactogogue functions as a precursor to the hormones needed for the development of reproductive organs. Hormone precursors, such as stigmasterol, sitosterol, and kampesterol, are abundant in moringa phytosterols. These substances raise the synthesis of estrogen, which in turn promotes the growth of the mammary gland ducts, resulting in the secretion of milk. It is used to treat under-3-year-old children who are malnourished [3]. During pregnancy, a woman can consume around six spoonfuls of leaf powder to satisfy her daily needs for calcium and iron. An overview of the pharmacological characteristics, nutritional benefits, commercially useful medical uses, and cultivation of moringa are given in this article. There are no in-depth studies on the use of moringa to treat cancer and diabetes. This research attempts to close the gap.

2. Plantation and soil conditions

Any tropical or subtropical area of the planet with temperatures between 25 and 35 °C is suitable for M. oleifera cultivation. It needs loamy or sandy soil with a pH range of mildly acidic to slightly alkaline and 250–3000 mm of net rainfall [4]. Because direct seeding has a high percentage of germination, it is used. Moringa seeds may be inserted into the ground at a depth of 2 cm, and they are predicted to sprout 5 to 12 days after being planted. Containers may also be used to spread moringa. Sand or loamy soil is put into plastic bags with the seedlings. It can be moved after it reaches a height of around 30 cm. The tap roots are delicate and prone to damage, thus great caution must be used while transplanting. Cuttings of the tree that are one meter long and 4-5 centimeters in diameter can also be grown, although the deep roots of these plants might not be very strong. These plants are typically wind- and drought-sensitive. Large-scale, intense, and semi-intensive moringa plantations may be used for commercial reasons. Spacing is crucial in commercial agriculture because it facilitates plant care and harvesting. The nutritional makeup of M. oleifera varies depending on the area [5]. The nutritional components of a tree cultivated in Nigeria differ somewhat from those of an Indian tree. Semi-deciduous and Savannah areas are the two natural settings where Asante et al. investigated the nutritional variations in leaves [6]. It demonstrated how less nutrient-dense the latter was in comparison to the former and linked this to the warm temperatures in the Savannah areas. The denature of proteins and enzymes at elevated temperatures may account for the variation in nutritional composition.

A key component that determines a plant's vigor and nutritional content is its soil. Different nutritional contents were seen on plant sections when fertilizers were administered either alone or in combination with other substances, as demonstrated by Dania et al. [7]. In order to investigate the impact on the nutritional content, three types of fertilizers were provided: NPK, organic base, and chicken dung. It was discovered that poultry manure produced the greatest results when compared to phosphorous, potassium, sodium, and manganese. Similarly, after applying chicken manure, the girth of the stem and the development of the leaves of the moringa plant rose. Despite nutritional variations, the plant's general nutrient characteristics stay the same. Because of this, moringa has global potential as a nutraceutical.

3. Nutritive properties

M. oleifera is a veritable treasure trove of vital minerals and antioxidants. Minerals including calcium, potassium, zinc, magnesium, iron, and copper are abundant in M. oleifera leaves [2]. M. oleifera also contains vitamins such as beta-carotene, vitamin A, and vitamins B, C, D, and E, such as pyridoxine,

nicotinic acid, and folic acid [8]. Anti-cancerous agents such glucosinolates, isothiocyanates, glycoside compounds, and glycerol-1-9-octadecanoate are found along with phytochemicals like tannins, sterols, terpenoids, flavonoids, saponins, anthraquinones, alkaloids, and reducing sugar [9]. Moringa leaves can be included in an obese person's diet due to their low calorific content. The fibrous pods have been found to be beneficial in treating digestive issues and preventing colon cancer [10,62]. According to study, immature pods have a protein level of about 20.66% and a fiber content of about 46.78%. Amino acid content is found in 30% of pods, 44% in leaves, and 31% in flowers. Similar concentrations of palmitic, linolenic, linoleic, and oleic acids were found in the immature pods and flowers [11].

There are several elements found in moringa that are vital for human growth and development, with calcium being one of the most vital. Eight ounces of milk can have 300–400 mg, however moringa powder and leaves can contain more than 4000 mg and 1000 mg, respectively. Anemia can be treated using moringa powder as an alternative to iron pills. The iron content in beef is only 2 mg, but the powdered moringa leaf has 28 mg. Moringa is said to have a higher iron content than spinach [12]. Zinc must be obtained through a healthy diet in order for sperm cells to develop properly and for DNA and RNA synthesis to occur. The amount of zinc found in M. oleifera leaves ranges from 25.5 to 31.03 mg/kg, which matches the daily need for zinc in the diet [13].

PUFAs, which include oleic acid, linoleic acid, and linolenic acid, can regulate cholesterol. Studies reveal that moringa seed oil has around 76% PUFA, which makes it perfect to use in place of olive oil [14]. It is important to remember that the location affects the composition of nutrients. According to Fuglie [12], the nutritional content varies with the seasons. Research revealed that iron and vitamin C were more prevalent in the cold, dry season, whereas vitamin A was more prevalent in the hot, wet season [15]. The location, climate, and other environmental variables have a major impact on the nutritional content of the tree, which explains the discrepancy in findings [16]. An exhaustive inventory of the nutrients found in leaves, pods, and seeds are shown in Table 1.

4. Processing of moringa

When plants are treated, much of their nutritional value is lost. When the nutritional contents of raw, germinated, and fermented moringa seed flour were examined, it was discovered that the raw seed flour had more phytochemicals, while the fermented and germinated seed flour had the highest amount of amino acids [17,59]. The microbial activity during fermentation and the biochemical activity during germination may be the cause of this. Nonetheless, a research examined the effects of blanching, simmering, and boiling to see how much of the nutrients in moringa leaves were retained. It's interesting to note that boiling was the most successful strategy overall because it greatly decreased the amounts of cyanide, oxalate, and phytate compared to the other two procedures.

Processing can thus be done to maximize the usage of necessary nutrients from the seeds and leaves because the presence of phytate and other anti-nutrients might lower the bioavailability of certain nutrients [18,63]. Boiling enhanced the availability of iron and antioxidant content, according to Yang et al. [15]. For this reason, nutritional issues can be addressed using processed moringa seed flour. However, some research indicates that the mildly bitter taste of moringa makes kids reject to eat it [70]. Moringa noodles were created by Kiranawati et al. [19] using three different cooking techniques: sautéing, steaming, and boiling. Rats were used in the testing of these noodles, and the effects on the mammary glands were examined. It's interesting to note that the rats' mammary glands responded better to the sautéed noodles, increasing milk output. Because the oil used to sauté the noodles was high in sterols, the effect on the lactogogum levels enhanced. Additionally, M. oleifera has been added to chocolate. According to a recent study that examined various moringa percentages in chocolate fortification, 20% moringa inclusion in cocoa powder was optimal. In a similar vein, adding moringa to halawa tahinia enhanced the treat's nutritional content. Such research has demonstrated the possibility of creating chocolate and halawa tahinia that are high in protein

and minerals [20]. There are a number of these moringa fortifications that may be used to guarantee that kids are getting enough nutrients.

4.1. Preservation methods

Moringa's nutrients do not degrade even when stored over extended periods of time. The leaves can be frozen or dried for storage. According to a study by Yang et al.[15], leaves dehydrated in a low temperature oven preserved more nutrients than freeze-dried leaves, with the exception of vitamin C. Therefore, to maintain a steady supply of nutrients in the leaves, drying may be accomplished with a low-cost domestic equipment like a stove. Dehydration preservation extends Moringa's shelf life without compromising its nutritional content. An excessive amount of moringa leaves a significant iron buildup. Hemochromatosis and gastrointestinal problems can be brought on by high iron. Therefore, it is recommended that a daily dose of 70 g of moringa be taken to prevent overaccumulation of nutrients [21].

Table 1
The nutrient compositions[a] of leaves, leaf powder, seeds and pods.

Nutrients	Fresh leaves	Dry leaves	Leaf powder	Seed	Pods
Calories (cal)	92	329	205	–	26
Protein (g)	6.7	29.4	27.1	35.97 ± 0.19	2.5
Fat (g)	1.7	5.2	2.3	38.67 ± 0.03	0.1
Carbohydrate (g)	12.5	41.2	38.2	8.67 ± 0.12	3.7
Fibre (g)	0.9	12.5	19.2	2.87 ± 0.03	4.8
Vitamin B1 (mg)	0.06	2.02	2.64	0.05	0.05
Vitamin B2 (mg)	0.05	21.3	20.5	0.06	0.07
Vitamin B3 (mg)	0.8	7.6	8.2	0.2	0.2
Vitamin C (mg)	220	15.8	17.3	4.5 ± 0.17	120
Vitamin E (mg)	448	10.8	113	751.67 ± 4.41	–
Calcium (mg)	440	2185	2003	45	30
Magnesium (mg)	42	448	368	635 ± 8.66	24
Phosphorus (mg)	70	252	204	75	110
Potassium (mg)	259	1236	1324	–	259
Copper (mg)	0.07	0.49	0.57	5.20 ± 0.15	3.1
Iron (mg)	0.85	25.6	28.2	–	5.3
Sulphur (mg)	–	–	870	0.05	137

[a] All values are in 100 g per plant material [12,52,60].

5. Medicinal properties

More than 300 ailments can be cured with M. oleifera, which is sometimes regarded to as a panacea. Africans and Indians have traditionally employed moringa in herbal therapy. It is an effective medicinal agent because of the phytochemicals it contains. This section reviews the impact of moringa on several ailments, including cancer and diabetes.

5.1. Anti-diabetic properties

It has been demonstrated that moringa can treat Type 1 and Type 2 diabetes. Patients with type 1 diabetes are those who do not produce enough insulin, a hormone that keeps blood glucose levels within the normal range. Insulin resistance is linked to type 2 diabetes. Another possible cause of type 2 diabetes is dysfunctional beta cells, which are unable to detect glucose levels and as a result decrease insulin signaling, raising blood glucose levels [22]. Moringa has been demonstrated in several research to have anti-diabetic properties. A research has demonstrated that M. oleifera aqueous extracts can treat insulin-resistant Type 2 diabetes in mice as well as Type 1 diabetes produced by streptozotocin [23].

In another study, the researchers fed the STZinduced diabetes rats with Moringa seed powder and noticed that the blood glucose level fell when fasting [50]. Moreover, the blood antioxidant enzyme levels rose in the rats given 500 mg/kg body weight of moringa seed powder. This demonstrates that the antioxidants in moringa can reduce ROS brought on by STZ induction in beta cells [8]. Beta cells produce superoxides and

reactive oxygen species (ROS) when xanthine oxidase is assisted by STZ in ATP dephosphorylation processes [24]. Beta cells are destroyed in individuals with hyperglycemia (Fig. 1). Reactive oxygen species are therefore released when there is an increase in glucose entering the mitochondria. Because beta cells don't produce many antioxidants, they eventually undergo apoptosis[25, 26]. This lowers insulin secretion, which causes hyperglycemia and eventually Type 2 diabetes. Quercitin and phenolics, two types of flavonoids, have been identified as antioxidants that scavenge reactive oxygen species (ROS). It is possible to speculate that the flavonoids in moringa scavenge the ROS generated from mitochondria, preserving the beta cells and so preventing hyperglycemia [27,50].

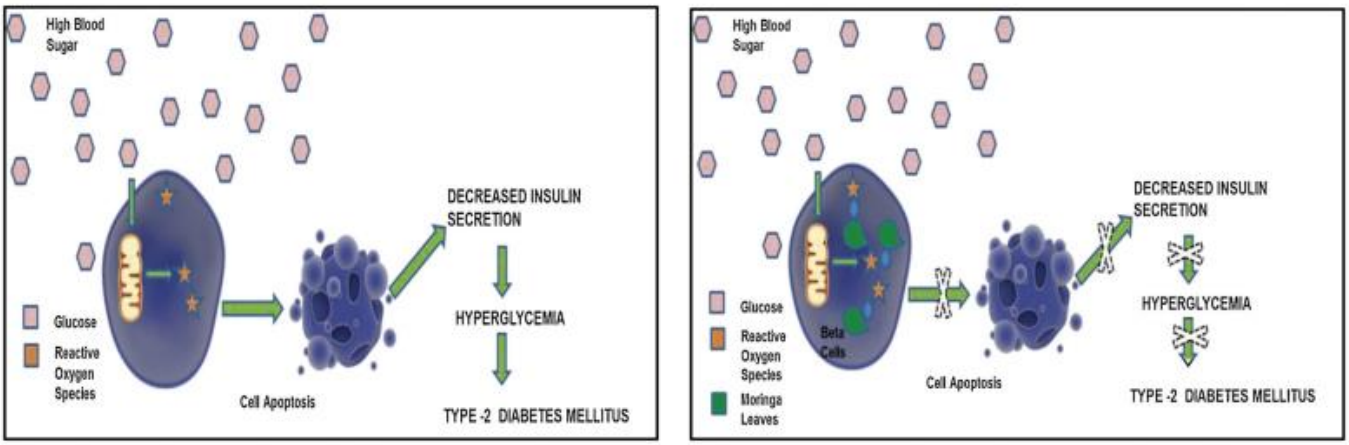


Fig. 1. The way that elevated blood sugar causes diabetes and how moringa slows down the disease's progression. High blood glucose levels cause beta cells' mitochondria to undergo glycolysis, which produces reactive oxygen species. This ultimately results in beta cell death, which lowers insulin output, raises blood sugar levels, and ultimately causes Type 2 diabetes. Moringa, on the other hand, can prevent beta cells from going through apoptosis. Antioxidants found in moringa work with reactive oxygen species to stop cell damage and other negative effects. [8,22,25,50].

Diabetes can cause retinopathy, nephropathy, atherosclerosis, and other problems. Such illnesses can be avoided by using moringa. Advanced glycated end products (AGEs) are produced when blood glucose levels are too high and interacts with proteins. The RAGE that is expressed on the surface of immune cells is bound by these AGEs. Interleukin-6 and interferons are two cytokines whose transcription is boosted as a result of this relationship. On the surface endothelium of arteries, cell adhesion molecules are expressed concurrently[28]. This promotes transendothelial migration, which results in artery inflammation and atherosclerosis (Fig. 2). Moringa has anti-atherosclerotic properties [29].Moringa's antioxidant qualities help to explain its anti-atherogenic characteristics.

5.2. Anticancer properties

Misuse of drugs is a contributing factor in one out of every seven deaths from the prevalent illness cancer. There are 2.4 million incidences of cancer annually in India, yet there are no known causes of the disease. The illness can be brought on by a number of things, including radiation exposure, smoking, and inactivity [69]. Chemotherapy, radiation, and surgery are among the costliest and side-effect-prone cancer therapies. Because M. oleifera is safe, dependable, and natural at recommended dosages, it can be employed as an anticancer drug. According to studies, moringa can be utilized as an anti-neoproliferative drug, which stops cancer cells from growing. Leaf extracts, both soluble and solvent-based, have been shown to be effective anticancer agents. Moreover, studies indicate that the capacity of cancer to produce reactive oxygen species in cancer cells may be the cause of its anti-proliferative action. Studies reveal that apoptosis is caused by reactive oxygen species that are created within the cells. The overexpression of caspase 3 and caspase 9,

which are involved in the apoptotic process, further supports this [30,31,64]. Moringa is a perfect anticancer drug since its generation of ROS is selective and exclusively targets cancer cells. Furthermore, it was demonstrated by Tiloke et al. [30] that the extracts enhanced the production of glutathione-S-transferase, an enzyme that prevents the development of antioxidants. Although it is usual practice for anticancer drugs to target cancer by inducing ROS, these compounds should also possess the ability to assault antioxidant enzymes [32]. Nonetheless, it has been demonstrated that moringa leaf extracts function as antioxidants and anticancer agents via inducing ROS. We still need to investigate the precise behavior of the two opposing characteristics of the leaves. The anticancer properties of the leaves are attributed to glucosinolates, niazimicin, and benzyl isothiocyanate [33]. It has been demonstrated that benzoyl isothiocyanate and cancer are related. Studies reveal that BTC produces intracellular ROS, which results in cell death. This may be among the factors contributing to moringa's effectiveness as an anticancer agent [34, 35, 65].

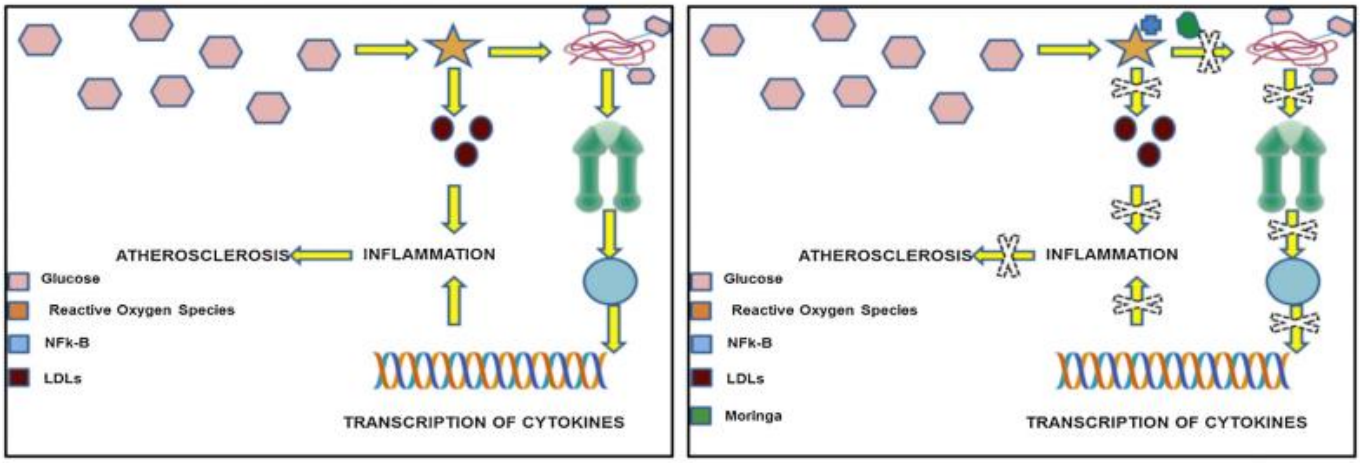


Fig. 2. Mechanism of diabetes that causes atherosclerosis and how moringa slows down the disease's advancement. Glycolysis produces high blood glucose, which generates ROS, which subsequently makes LDLs and AGEs. While AGE can induce NFk-B expression when coupled with RAGE produced on the cell surface, LDLs can directly cause inflammation. Inflammation may result from this, as well as the production of other cytokines. Atherosclerosis results from the transendothelial migration of immune cells and LDLs brought on by inflammation. As an anti-atherosclerotic agent, moringa can stop atherosclerosis by scavenging ROS and inhibiting the production of AGE and LDL [8,24,28,29].

Table 2
Nutritional compositions and medicinal uses of different parts of Moringa.

Part of tree	Medicinal uses	Nutritive properties	Suggestion	References
Leaves	Moringa leaves treat asthma, hyperglycemia, Dyslipidemia, flu, heart burn, syphilis, malaria, pneumonia, diarrhea, headaches, scurvy, skin diseases, bronchitis, eye and ear infections. Also reduces, blood pressure and cholesterol and acts as an anticancer, antimicrobial, Antioxidant, antidiabetic and anti-atherosclerotic agents, neuroprotectant	Moringa leaves contain fiber, fat proteins and minerals like Ca, Mg, P, K, Cu, Fe, and S. Vitamins like Vitamin-A (Beta-carotene), vitamin B-choline, vitamin B1-thiamine, riboflavin, nicotinic acid and ascorbic acid are present. Various amino acids like Arg, His, Lys, Trp, Phe, Thr, Leu, Met, Ile, Val are present. Phytochemicals like tannins, sterols, saponins, trepenoids, phenolics, alkaloids and flavanoids like quercitin, isoquercitin, kaemfericitin, isothiocyanates and glycoside compounds are present	The presence of flavanoids gives leaves the antidiabetic and antioxidant properties. The isothiocyanates are anticancer agents. Flavanoids like quercitin and others are known for anti-proliferative, anticancer agent. The presence of minerals and vitamins help in boosting the immune system and cure a myriad of diseases	[1,8,12,17,31,40]
Seeds	Seeds of moringa help in treating hyperthyroidism, Chrohn's disease, antiherpes-simplex virus arthritis, rheumatism, gout, cramp, epilepsy and sexually transmitted diseases, can act as antimicrobial and anti-inflammatory agents	Contains oleic acid (Ben oil), antibiotic called pterygospermin, and fatty acids like Linoleic acid, linolenic acid, behenic acid, Phytochemicals like tannins, saponin, phenolics, phytate, flavanoids, terpenoids and lectins. Apart from these, fats, fiber, proteins, minerals, vitamins like A, B, C and amino acids	The presence of flavanoids gives its anti-inflammatory property. The antibiotic pterygospermin is responsible for antimicrobial properties. The other phyto-chemicals help in treating various diseases	[1,2,4,38,61]
Root Bark	Root bark acts as a cardiac stimulant, anti-ulcer and anti-inflammatory agent	Alkaloids like morphine, moriginine, minerals like calcium, magnesium and sodium	The alkaloid helps the bark to be antiulcer, a cardiac stimulant and helps to relax the muscles	[39,41]
Flower	Moringa flowers act as hypocholesterolemic, anti-arthritic agents can cure urinary problems and cold	It contains calcium and potassium and amino acids. They also contain nectar	The presence of nectar makes them viable for use by beekeepers.	[12,38]
Pods	Moringa pods treat diarrhea, liver and spleen problems, and joint pain	Rich in fiber, lipids, non-structural carbohydrates, protein and ash. Fatty acids like oleic acid, linoleic acid, palmitic acid and linolenic acid are also present	The presence of PUFA in the pods can be used in the diet of obese	[12]

5.3. Other diseases

One can utilize moringa as an effective neuroprotectant. Brain blood flow restriction is the cause of cerebral ischemia. Lipid peroxidation and reperfusion follow, resulting in reactive oxygen species. Because of its antioxidants, moringa helps protect the brain by lowering reactive oxygen species [36, 37]. Because M. oleifera has been demonstrated to support spatial memory, it is used to treat dementia. It has been demonstrated that leaf extracts reduce acetylcholine esterase activity, which enhances cholinergic function and memory [38]. Adeyemi et al.'s research [39] demonstrated that include moringa in a rat's diet can prevent renal failure by raising the protein content and lowering blood levels of creatinine and urea. Moringa can be utilized as an antiulcer drug since it reduced the acidity of stomach ulcers by 86.15% and 85.13% at dosages of 500 mg and 350 mg, respectively [40]. Herbalists who treat AIDS patients often prescribe moringa. It is advised that people with HIV incorporate moringa in their diet in an effort to strengthen their immune systems. To confirm moringa's impact on anti-retroviral medications, additional study is necessary [41]. In arthritic rats, the hydro-alcoholic extract of moringa flowers decreased the levels of TNF-alpha, IL-1, and rheumatoid factor. This demonstrates that moringa can effectively treat arthritis [42]. antibacterial drugs are required due to the prevalence of microbial illnesses; M. oleifera has been shown to be an effective antibacterial agent [66]. The ability of M. oleifera extracts to combat microorganisms such as Bacillus subtilis, Staphylococcus aureus, and Vibrio cholera has been demonstrated by a study conducted by Viera et al. [43]. The seeds' antibacterial properties were explained by the presence

of benzyl isothiocyanate, moringine, and pterygospermin [67]. Table 2 lists the nutritional value and therapeutic use of the various Moringa components.

6. Commercial applications

Ben oil is an oil that is extracted from moringa seeds. Sterols, tocopherols, and oleic acid are abundant in this oil. Furthermore, it is resistant to oxidative rancidity. The oil can be used as lubricant, perfume, and cooking oil in place of olive oil [14, 44]. Pesticides and organic contaminants can be absorbed by the pods. Moringa seeds may precipitate organics and mineral particles out of a solution and have excellent coagulant qualities [1,53]. By neutralizing the electrical charges of the particles in the water to generate flocs that make the particles filterable, chemical coagulants such polymers and aluminum sulfate (Alum) and ferric sulfate remove suspended particles from waste water. The cationic protein included in M. oleifera seeds makes them a natural coagulant that may be used to clear murky water. Given the high cost and scarcity of other coagulants such alum, activated carbon, and ferric chloride, this feature of M. oleifera seeds is drawing a lot of attention [58]. In order to handle tapioca starch waste water, Suhartini et al. [45] created a two-stage clarifier. First, they added coconut fiber, then they added a layer of sand medium mixed with powdered M. oleifera. This improved the physical and chemical features of the clarifier and stabilized the pH level. Water contaminated with heavy metals (including lead, copper, cadmium, chromium, and arsenic) can be cleaned up using moringa seed extract [46]. By reducing settling time, M. oleifera functionalized with magnetic nanoparticles, such as iron oxide, were found to be advantageous in the treatment of surface water [55]. By inhibiting bacterial development, seed extracts' antibacterial qualities help to avoid waterborne illnesses. Because M. oleifera seeds are so abundant, their qualities may be widely applied to prevent disease and improve the quality of life in rural areas.

The seedcakes of the moringa plant may be used as fertilizer or green manure, while the seeds itself can be used to make biodiesel and be used in cosmetics. The tea derived from moringa flowers has a reduced cholesterol content. Fried moringa blossoms are reported to taste like mushrooms [68]. Beekeepers use the moringa blooms because they are excellent nectar sources. The root bark has therapeutic properties and is used to treat heart problems, eye conditions, and dyspepsia [51]. Moringa taproot is used as a spice. You may use the tree's gum to make calico prints. Additionally, the gum and roots have anti-inflammatory, antifungal, and antibacterial qualities [54]. Zeatin, a foliar growth hormone derived from leaves, is a great crop production enhancer that may boost yields by 25% to 30% [12]. Moringa may be incorporated and fortified in a major way to address malnutrition and vitamin deficiencies. Research has attempted to fortify moringa in snacks. A sensory analysis of cookies produced with a combination of maize flour and moringa seed flour was conducted by Aluko et al. [47]. The combination of 92.5% maize and 7.5% moringa seed flour received the highest approval when the flour was combined with varying amounts of the two flours. Because of its color, flavor, scent, and sharpness, this was favorably received. Moringa leaves have also been added to cereal gruels to boost their protein and calorie levels. The cereal gruel was fermented and blanched, including 35% moringa leaves and 65% popcorn. While the blanched grain had a greater mineral content, the fermented ones had higher levels of protein and energy [48]. In an effort to increase the amount of nutrients in snacks, Owusu et al. [49] also employed moringa as a fortificant and made cream and butter crackers with moringa and Ipomoea batatas as fortificants. The cream crackers were found to be widely approved based on the sensory evaluation. Hens and layers can benefit from eating M. oleifera leaves as a great source of protein, since they can replace more costly components like soybean meal and crushed nut cake [56,57].

Taking into account the opinions of several fortifications, it is proposed that other foods might also benefit from this kind of addition. Moringa may be added to snacks to increase their nutritional content. The majority of snacks are composed of corn meal, however research has shown that adding a small amount of moringa to maize flour can increase the snack's nutritional value by adding minerals, energy, and protein.

Before commercial moringa is introduced to the market, more research on moringa as a fortified Indian snack is necessary.

7. Conclusion and future prospects

In India, research on M. oleifera is still in its infancy. Utilizing the nutrients from this amazing tree for a range of uses is crucial. M. oleifera possesses strong anti-cancer and anti-diabetic qualities. Nevertheless, it is uncommon to find double-blind studies that support these moringa benefits. To confirm the main mechanisms of moringa as an antidiabetic and an anticancer drug, more research is required. There are many intriguing questions left unresolved. Additional research is required to determine the antioxidant properties of aqueous extracts on cancer cells. Research has demonstrated that the presence of ROS in cancer cells caused by moringa results in necrosis or apoptosis. Antioxidants are also included in the aqueous extracts, though. We still need to investigate the precise mechanism behind this irony. Subsequent investigation is necessary to determine how environmental conditions impact the nutrient levels in leaves and other sections of M. oleifera growing worldwide.

New medicinal compounds may be developed as a result of ongoing research to isolate endophytic fungus and pinpoint the M. oleifera enzymes or proteins responsible for the anticancer and antidiabetic action. Evaluating M. oleifera's economic usage as a bio-coagulant is yet another area of focus. It might be a good substitute for purifying water. Snacks are in high demand in the market. Therefore, adding moringa to snacks offers two benefits in the fight against malnutrition. The tree, which is indigenous to India, has the potential to generate significant economic benefits for the country if companies and academics take use of its high nutritional value and conduct more study to support previous findings.

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