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REVIEW ARTICLE

Moringa oleifera Lam.: A comprehensive review on its potential for diabetes management and beyond

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Abstract

Diabetes is a metabolic disease characterized by deregulated insulin levels and hyperglycemia. The global healthcare system widely acknowledges the use of medicinal plants as therapeutic agents. One such traditional plant with antidiabetic properties is *Moringa oleifera*, which has been used for centuries. *M. oleifera*, due to its important bioactive compounds such as flavonoid, carotenoid and polyphenols, is used to treat various ailments, including diabetes, cancer, kidney problems and bacterial and viral infections. This review summarizes the applications of *M. oleifera* and its mechanisms for preventing diabetes. Additionally, it explores the influences of *M. oleifera* in treating diabetes, with a specific focus on its mechanism and effectiveness in reducing insulin levels and managing the conditions. The objectives of this review are to presents the most recent information and elucidate the mechanism by which *M. oleifera* prevents diabetes. Additionally, it provides a thorough analysis of *M. oleifera's* applications as a natural treatment and its industrial uses. The review highlights current knowledge gaps and suggests areas for further research. In conclusion, this study enhances our understanding of the comprehensive applications of *M. oleifera*, advancing knowledge and help to prevent diabetes-related complications.

Keywords

Moringa oleifera; diabetes; insulin; cosmetic

Introduction

India is the natural habitat of the perennial tree *Moringa oleifera* Lam. However, it has been extensively distributed across the tropics and subtropics, where it becomes naturalized. *M. oleifera* is an ancient plant known for its unique culinary and therapeutic properties. It has been reported that *M. oleifera* seed extract can reduce blood glucose and cholesterol levels in diabetic rats. In India, *M. oleifera* leaves are frequently consumed as vegetables and its seeds can be used externally to treat gout and rheumatism (1). The tree typically varies in height from 5 to 10 m and has 3-pinnate compound leaves with 12 to 18-mm-long leaflets and a petiole that can be either white or yellow with red streaks. *M. oleifera* has white or milky white, bisexual flower, its seed, found inside pods are almost round (2). *M. oleifera* is the most widely distributed species in the monogeneric group Oleiferaceae, which comprises 13 types of trees and bushes found across the sub-Himalayan regions of Madagascar, Northeastern and Southwestern Africa, India and Sri Lanka (3). Due to its drought resistance, *M. oleifera* has spread to tropical and subtropical

climates. Various parts of the plant, including seeds, leaves, roots and flowers, are consumable by both humans and animals (4). Beyond its notable effectiveness in water purification through flocculation, sedimentation, antibiosis and reduction of Schistosomecercariae titer, *M. oleifera* has been extensively documented in scientific literature for its nutritional value and its antibacterial, hypotensive, antispasmodic, anti-inflammatory, hypocholesterolemic and hypoglycemic properties (5).

Because of its nutritional qualities, amino acid content and flavonoid content-all of which are utilized in food products and the cosmetics industry-*M. oleifera* has earned the moniker "Miracle Tree" and garnered significant industrial attention. Remarkably, 100 g of dried leaves of *M. oleifera* contain nearly 7 times the vitamin C content of oranges, 10 times the vitamin A content of carrots, 17 times the calcium content of milk, 9 times the protein content of yogurt, 15 times the potassium content of bananas and 25 times the iron content of spinach (6). The components of *M. oleifera* significantly contribute to its safety and efficacy. Polyphenols and flavonoids are the primary constituents of *M. oleifera*. These bioactive compounds exhibit promising anti-inflammatory, anti-tumor, gut microbiota-improving, antimicrobial and antioxidant capacities, which protect neurons (7).

Diabetes is a metabolic disorder characterized by high blood sugar levels and abnormalities in insulin production, often occurring alongside obesity and overweight. According to the World Health Organization (WHO), diabetes mellitus ranks among the top 10 causes of death and morbidity globally (8). The condition can arise from various factors, including the destruction of pancreatic beta cells, dysfunction insulin production, genetic abnormalities, endocrinopathies, exocrine pancreatic disease (such as pancreatitis), drug or chemical -related infections and other hereditary conditions. Clinically, diabetes mellitus is categorized into 2 main types, as defined by the American Diabetes Association (ADA) in 2012. Type 1 diabetes, or insulin-dependent diabetes mellitus (IDDM), is categorized by autoimmune processes that cause irreversible damage to the pancreas. Type 2 diabetes, or non-insulin-dependent diabetes mellitus (NIDDM), is marked by insulin and pancreatic beta -cell failure (9). The World Health Organization (WHO), emphasizes the evaluation of traditional plants for diabetes treatment because they are often less harmful, more effective and present fewer side effects than conventional medications (10, 11). High blood sugar levels can increase the number of macrophages, lymphocytes and inflammatory cytokines, such as TNF-α, IL-1β and IL-6, which negatively impact the body's metabolic state (12). Using medicinal plants as therapeutic agents is widely accepted as a viable method to enhance wellness, particularly in low-income nations. The widespread adoption of these therapies is driven by factors such as accessibility, perceived efficacy, low side effects and cultural acceptance (13). Managing blood sugar through food is crucial for preventing the adverse effects of diabetes mellitus. This management can be achieved through conventional or herbal medicine. Many plants contain nutritious and bioactive components and are used for their medicinal properties. *M. oleifera*, known for its high protein, vitamin and mineral content in its leaves, is one such plant used for glycemic management (14).

M. oleifera has shown significant effects in reducing insulin dysregulation and preventing diabetes. Its beneficial impact on diabetes treatment is well-documented. The article presents latest findings on *M. oleifera* role in diabetes prevention and the mechanism by which it regulates insulin level. Additionally, it includes a brief discussion on the value realization of *M. oleifera*. By analyzing scientific research and conducting trials, this work aims to provide valuable insights into the use of *M. oleifera* for managing diabetic disorders.

Usage of *M. oleifera*

Treatment of type 2 diabetes mellitus (T2DM)

Due to the strong bioactive isothiocyanates found in *M. oleifera* seeds, they have historically been utilized in the treatment of T2DM (15). The leaves of *M. oleifera* contain several beneficial compounds. For example, isothiocyanates in the leaves reduce hepatic gluconeogenesis and improve insulin resistance (16). The plant has been shown to lower blood sugar levels and treat diabetic lesions in rats (17). Additionally, leaf extract has been used to enhance testicular histology and improve sperm characteristics in diabetic mice (18). According to research, *M. oleifera* flowers exhibit strong antioxidant qualities and significantly inhibit key enzymes responsible for glucose hydrolysis *in vitro*, making them a promising phytotherapy for diabetes management (19). Aqueous extracts of *M. oleifera* leaves have ameliorative effects on diabetes-induced hunger and testicular weight reduction in Wistar rats, highlighting its potential to improve testicular health due to its antidiabetic properties (20). For individuals without diabetes, consuming *M. oleifera* powder did not affect blood glucose levels. However, in diabetic patients, blood glucose levels significantly reduced after 90 min. Diabetic patients who took 2 g of *M. oleifera* showed a trend toward a smaller progressive area under the glucose curve (21). Another study found that leaf extract from *M. oleifera* significantly normalized fasting blood glucose levels in mice (22). A medication based on *M. oleifera* would be highly effective in protecting against various risk factors associated with renal diseases (23) (Table 1).

Treatment of cancer

Additionally, *M. oleifera* has shown benefits for cancer treatment. According to research, *M. oleifera* is frequently employed as a cancer treatment agent due to its significant ability to inhibit tumor growth without interfering with the body's normal metabolism or functionality (24). It has also been found to be effective in preventing breast cancer (25). Beyond its potential as a novel dietary item, *M. oleifera* foliage may prevent the formation of cancer cells and improve overall human health (26). Furthermore, some of the most reliable and effective antagonists for the treatment of estrogen

Table 1. Therapeutic properties of *Moringa oleifera* plant

Sl. No.	Therapeutic characteristics	References
1	Anti-diabetic (reducing blood glucose)	(54)
2	Control of cancer diseases (breast cancer)	(25)
3	Inhibit the tumor progression	(7)
4	Anti-bacterial and anti-viral properties	(58)
5	Has the potential to control (COVID 19)	(29)
6	Kidney diseases control properties	(23)
7	Anti-oxidant properties which protects the body against all the diseases	(7)
8	Increase skin hydration level	(30)

receptor-positive cancers, which target CDK-2, include ellagic acid, chlorogenic acid and quercetin. *M. oleifera* is a potential candidate for CDK-2 inhibition, making it a promising option for breast cancer treatment (27).

Treatment of bacterial and viral disease

According to recent researches, *M. oleifera* extract exhibits strong inhibitory effects on various bacterial strains, including both Gram-positive and Gram-negative bacteria (28, 29). Additionally, *M. oleifera* seeds contain soluble lectin with antibacterial properties effective against *Bacillus cereus*, *Bacillus pumillus*, *Bacillus megaterium*, *Escherichia coli*, *Pseudomonas stutzeri* and *Micrococcus luteus*. This soluble lectin also possesses immunomodulatory characteristics, providing protection against nematicidal and insecticidal diseases.

Furthermore, the tree *M. oleifera* contains components such as kaempferol, pterygospermin, morphine, quercetin and apigenin, which can significantly boost the immune system. These compounds may enhance immunity against COVID-19, enabling individuals with strong immune systems to combat and fend off SARS-CoV-2, the virus responsible for COVID-19 (30).

Cosmetic usage

Despite its medicinal significance, *M. oleifera* is also valuable for commercial use. For example, cream made from *Moringa* seed oils is suitable for cosmetic applications. These lotions, derived from *Moringa* seed oil, possess antioxidant properties, enhance skin hydration and reduce skin erythema (31). Due to their extensive therapeutic applications, natural extracts have been of interest since ancient times. Recently, researchers have focused on understanding the phytochemical compositions, properties and potential uses of these extracts in various fields, including food and cosmetics (32). According to the research, *M. oleifera* leaves, in particular may serve as a highly promising organic source of anti-aging skincare agents, helping to counteract aging and wrinkles on the skin (33). This potential is of great interest to the cosmetics and cosmeceutical industries, warranting further investigation.

Food for animals

Due to reports of *M. oleifera* containing numerous bioactive compounds, a variety of dietary supplements based on this plant are commercially available (34). Numerous publications have illustrated various aspects of the application of *M. oleifera*. However, very few review studies address its application in food preparation by defining its function as a food ingredient and its usage as a natural additive, focusing on food biochemistry, safety and sensory acceptability (35). When added in moderation to the diets of non-ruminant livestock, the metabolites and beneficial compounds in *M. oleifera* forage meal (comprising leaves and stems) did not result in any harm (36). To boost daily intake of protein, fiber and minerals, incorporating powdered *M. oleifera* leaves into breads is recommended, utilizing this robust crop (37). Encouraging the cultivation and use of *M. oleifera* food products will be beneficial for the welfare of those living in marginalized communities (38) (Table 2).

Table 2. Industrial usage of *Moringa oleifera*

SN	Industrial purposes	References
1	*Moringa* seed oil cream	(30)
2	Cosmetics, foods	(31)
3	Enhance sensory acceptance and safety of foods	(33)
4	Provide daily protein consumption	(35)
5	Protect the skincare	(37)
6	Pesticides, pharmaceuticals	(38)
7	Provide the green fiber	(40)

Treatment of water

M. oleifera is utilized as an absorber and in the treatment of water, with the capacity to remove various impurities such as dyes, pesticides and medications (39). Similar results were obtained by other studies (40), indicating that *Moringa* is an inexpensive, environmentally friendly sorbent that can effectively remove organophosphorus insecticides from polluted water. Additionally, research has shown that seeds and leaf extracts of *M. oleifera* have beneficial impacts on the purification of ground water (41). Using the leaves and seeds significantly improves chemical and physical characteristics, such as pH, hardness, metallic impurities and turbidity, providing a natural coagulant that combat the effects of chemical coagulants. Furthermore, studies demonstrated that the seeds of *M. oleifera* can be used for water treatment and biofuel production as well (29) (Fig. 1).

The potential of *M. oleifera* in diabetes therapy

Chemical components of *M. oleifera*

The leaves, pods and seeds of *Moringa* plants are rich in vital phytochemicals, making them highly nutritious. *M. oleifera* is well- documented to contain high levels of vitamin C, vitamin A, calcium, protein, potassium and iron (42). Based on their chemical structure, the

Fig. 1. The special medicinal properties of *Moringa oleifera.*

phytochemicals derived from the *Moringa* plant can be classified into 5 groups: polyphenols, sulfur-containing compounds, alkaloids, terpenoids and carotenoids. It is widely believed that the abundance of these phytonutrients accounts for the diverse biological activities and disease-prevention potential of *Moringa* (43). Additionally, *M. oleifera* contains a significant amount of unsaturated fats. The seed oil of *M. Oleifera* contains 233.29 mg/kg of α-tocopherol, 9.04 mg/kg of β-tocopherol and 10.13 mg/kg of δ-tocopherol. Using ICP-MS, 10 elements were identified in *M. oleifera* seed oil, with calcium being the most abundant (44). According to research, different cultivars of *M. oleifera* vary in their

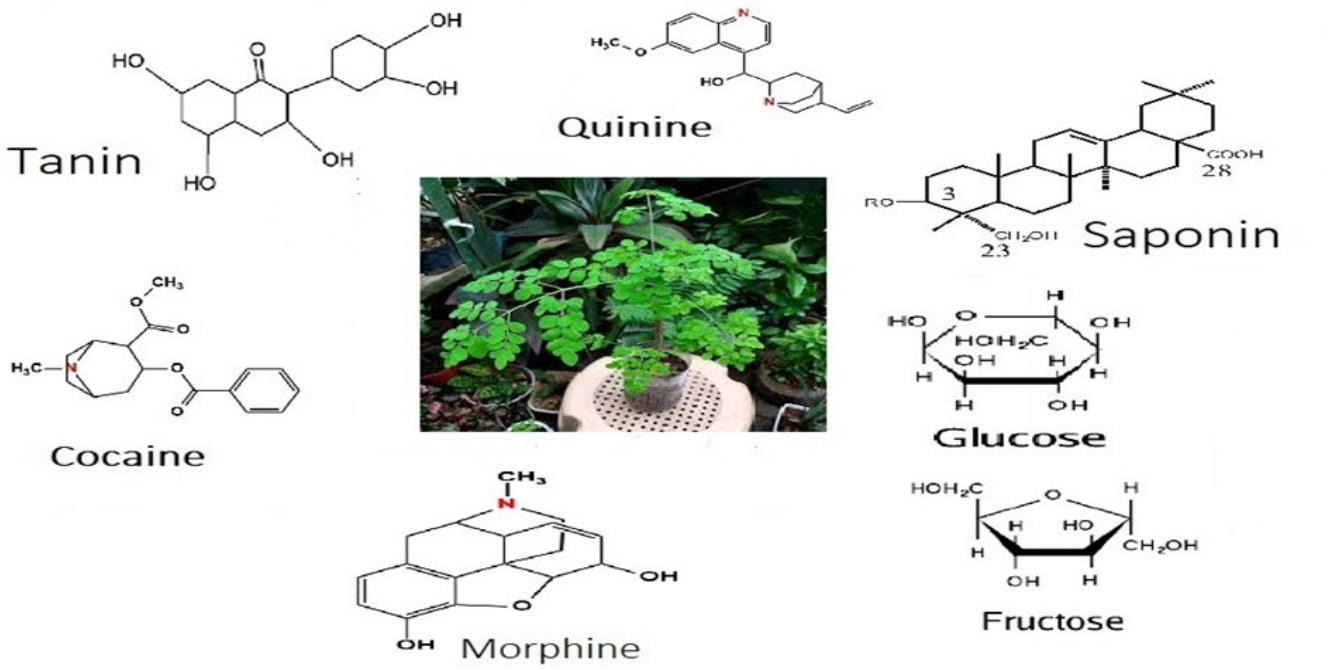

Fig. 2. The *Moringa oleifera* with some of the great phytochemicals alkaloids, saccharides, tannins and saponins.

antioxidants, phytochemical and antibacterial characteristics (45) (Fig. 2).

Studies on *M. oleifera* have highlighted the nutritional richness of its leaves, which are abundant in calcium, iron, potassium, phosphorus, vitamin C and vitamin D (53). The seeds of *M. oleifera* have been analyzed to contain 42.71 % lipids, 31.43 % protein, 10.44 % sugars (including 2.05 % reducing sugars) and 1.43 % fiber (49). The essential phytochemical composition of this plant includes well-known polyphenols, flavonoids, alkaloids, saccharides, tannins, saponins, glucosinolates and nitrile glycosides, contributing to its therapeutic properties (54). Moreover, *M. oleifera* serves as a rich source of taurine, alkaloids, proteins, tannins, carotenes, iron, potassium, calcium, terpenes and quinines. Its natural antioxidants include astragalin, flavonoids, phenolics, anthocyanins, cinnamates and carotenoids, such as quercetin and chlorogenic acids (55). Polysaccharides are identified as one of the main bioactive compounds in *M. oleifera* Lam, possessing immune-modulatory, anticancer, antioxidant, intestinal health protective and antidiabetic properties (56) (Table 3).

Furthermore, the levels of protein, fat, ash, crude fiber and nitrogen-free extraction found in *M. oleifera* leaves are consistent with previously reported values. *M. oleifera* leaf flour is an excellent source of nutrients due to its high fiber content and balanced levels of fat, protein and carbohydrates. The ash content of *M. oleifera* leaf flour serves as an indicator of its mineral balance (57) (Table 4).

Mechanism to reduce the insulin resistance

Diabetes mellitus (DM) is a complex disease characterized by a partial deficiency in insulin secretion and function. It affects all major organs of the body (58). According to (59), the antidiabetic substances found in *M. oleifera* leaves aid in the regeneration of pancreatic beta cells and protect against free radicals. Numerous studies have demonstrated that *Moringa* leaf powder possess antidiabetic properties capable of reducing blood glucose

Table 3. Phytochemicals of *Moringa oleifera* and their effects

Phytochemicals	Effects	References
Phenolic acids	It has anti-inflammatory properties, protect of cell components from oxidation, ant-oxidant activity, anti-arthritic and inhibition of protein denaturation.	(44)
Alkaloids	It has anti-inflammatory effects, control of microorganisms properties, safety of the foods, anticancer, antidiabetic properties.	(46)
Terpenoids	It has antimicrobial, anticancer, antidiabetic, hypolipidemic effects, antioxidant effects, improvement of aorta damages, reducing accumulation of fat.	(47)
Tanin	It is used for enhancement of nutritional qualities, medicinal values and having anti-inflammatory properties as well.	(47)
Saponin	It has antifungal activity, water treatment, antibacterial properties, enhancing the nutritional qualities, anti-aging and hepatoprotective activity and immunological enhancement activity as well.	(48) (49)
Saccharides	It is used for treatment of diabetes, tumor, bacterial disease, regulation of immune systems and prevention of oxidant activities.	(51)
Glycosides	Free radical scavenger, anti-inflammation, antiapototic, antioxidant properties, hypoglycemic, hypolipidemic impacts, anti-cancer properties.	(50)
Flavonoids	It is used for treatment of cancer, diabetes, inflammatory, ulcer,septic and malaria, hypoglycemic, hypolipidemic, anti-aging as well.	(26)
Anthocyanins	Anti-oxidant activities, antimicrobial properties, lowering of cholesterol.	(51)
Carotenoids	It is utilized for treatment of oxidant, microbial, diabetes, cancer, proliferative, application in the food industry, improvement in shelf life of fats	(26) (52)

Table 4. Minerals and vitamins components of *Moringa oleifera* plant parts

	g/100 g plant materials					
Vitamins and minerals	**Fresh leaves**	**Dry leaves**	**Powder**	**Seeds**	**Pods**	**References**
Vitamin B1	0.01	2.02	2.64	0.05	0.05	(42)
Vitamin B2	0.05	21.3	20.5	0.06	0.07	
Vitamin B3	0.8	7.6	8.2	0.2	0.2	
Vitamin C	220	15.8	17.3	4.5	120	
Vitamin E	448	10.8	113	751	-	
Potassium	259	1236	1324	-	259	
Copper	0.07	0.49	0.57	5.20	3.1	
Iron	0.85	25.6	28.2	-	5.3	
Sulphur	-	-	870	0.05	137	
Phosphorus	70	252	204	75	110	
Magnesium	42	448	368	635	24	
Calcium	440	2185	2003	45	30	
Protein	6.7	29.4	27.1	-	-	
Fats	1.7	5.2	2.3	-	-	
Carbohydrate	12.5	41.2	38.2	-	-	
Fiber	0.9	12.5	19.2			

levels in humans.

Minimizing postprandial hyperglycemia is crucial for managing diabetes mellitus. Alpha amylase, a digestive enzyme in the intestines, hydrolyzes carbohydrates. Alpha amylase inhibitor prevents breakdown of polysaccharides into mono and disaccharides. By delaying carbohydrate metabolism and inhibiting glucose release from starch, these inhibitors help prevent postprandial hyperglycemia (60). Bioactive components in various parts of *M. oleifera* have shown potent anti-diabetic effects in streptozotocin-induced diabetic rats. These effects likely result from the combined suppression of α-amylase, activation of AMP-kinase and lipoprotein lipase, liver homogenization and enhanced regulation of serum transport proteins (GLUT-1 and GLUT-4), as well as increased regulation of glucose-6-phosphate dehydrogenase (61).

Moringa is rich in various phytochemicals that may contribute to its α-amylase inhibitory effects. The leaves contain phenolic compounds, ascorbic acid, tannins, alkaloids, saponins, terpenoids and sterols such as β-sitosterol, stigmasterol and campesterol as well as flavonoids like quercetin, kaempferol and myricetin. These compounds are present in significant amounts across multiple parts of the plant (62). Ethanolic extracts of *M. oleifera* leaves have been suggested as effective in attenuating hyperglycemia, primarily due to their high flavonoid content and inhibition of intestinal α-glucosidase activity. Some screened phytochemicals, currently undergoing pharmacophoric and molecular docking studies, have shown stable binding to the active site of the mutant insulin receptor, indicating their potential as therapeutic candidates for diabetes mellitus treatment (63) (Fig. 3). For individuals with pre diabetes who have not yet developed insulin resistance, increased insulin production can be beneficial. Additionally, proteins extracted from *M. oleifera* leaves have been found to resemble insulin, further supporting their potential use in managing diabetes.

In summary, *M. oleifera* can treat the diabetes through several mechanisms: (1) *M. oleifera* impedes the activities α-amylase and α-glucosidase. (2) The plant decreases cholesterol components, lowers the levels of low-density lipoprotein cholesterol and reduces total triglyceride. (3) *M. oleifera* boost high-density lipoprotein components and improves bile acid binding. (4) The plant enhances the capacities of antioxidant enzymes such as superoxide dismutase (SOD) and glutathione peroxidase (GSH-Px). (5) *M. oleifera* reduces oxidative factors like malondialdehyde (MDA) and catalase (CAT). (6) The plant lowers the levels of inflammatory elements such as tumor necrosis factor-alpha (TNF-α), interleukin-6 (IL-6) and inducible nitric oxide synthase (iNOS) (Fig. 3).

Discussion

Medicinal plants are rich in phytochemical compounds with antidiabetic properties, which have the potential to stimulate insulin production and inhibit intestinal glucose absorption. Among these, *Moringa* leaves (*Moringa oleifera* Lam.), have been utilized for decades in complementary medicine to lower blood glucose levels. The anti-

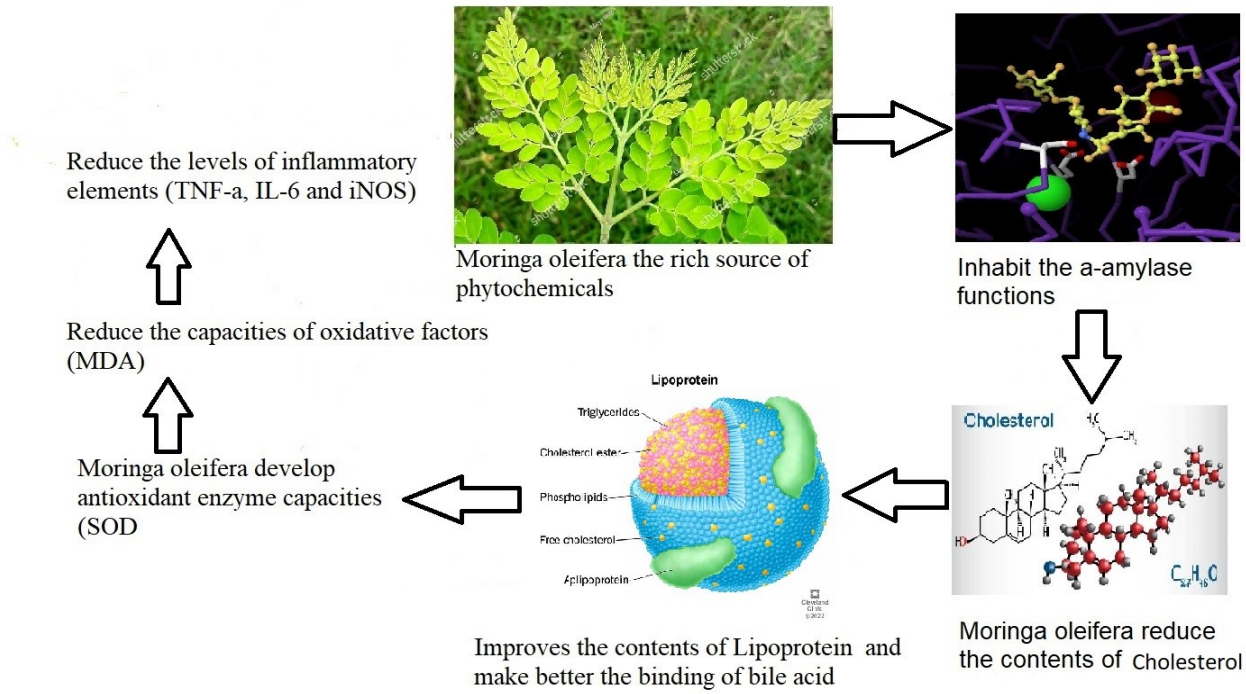

Fig. 3. The mechanism by which the diabetes is controlled.

hyperglycemic properties of *Moringa* leaves are attributed to their content of flavonoids, phenolic acid, alkaloid, terpenoids, tannin, saponins, carotenoid, anthocyanin and saccharides. These compounds stimulate pancreatic β cells to increase insulin secretion (64). *M. oleifera* is effective in treating both Type 1 and Type 2 diabetes. Type 1 diabetes results from the non-production of insulin, a hormone that regulates blood glucose level. Type 2 diabetes occurs due to insulin resistance, often caused by Beta cell dysfunctions, leading to impaired insulin signaling and elevated glucose levels (65).

Historically, *Moringa* has been used to treat rheumatism and is known for its anti-inflammatory, anti-tumor, anti-bacterial, anti-cholesterol, laxatives and anti-fungal properties. Other benefits of *Moringa* leaves include treating allergies, aches and pains, open wounds, preventing hypertension and lowering blood glucose, uric acid and cholesterol levels (66). These findings are supported by research (67), which indicates that the entire *M. oleifera* plant, including its leaves, roots, seeds, bark, fruits, flowers and immature pods, has cardiovascular benefits due to its high ascorbic acid content, aiding in insulin production. Additionally, *M. oleifera* has anticancer, antiulcer, antispasmodic, anti-inflammatory and antidiabetic properties, helping to maintain normal blood glucose levels.

M. oleifera leaf extracts possess pharmacological properties beneficial for managing diabetes. The potent biological characteristics of polysaccharides derived from *M. oleifera* leaves have garnered significant interest in recent years. These polysaccharides, with an average molecular weight of 76500 kDa, include galactose, arabinose and rhamnose (68). According to research, *M. oleifera* can directly lower blood glucose levels by interacting with anti-insulin antibodies, in addition to stimulating insulin production from pancreatic β-cells (69). This exceptional hypoglycemic action has been demonstrated in various animal models of diabetes as well as inhuman volunteers. *M. oleifera's* fully acetylated glycosides not only enhance its hypotensive action to protect the cardiovascular system but also provide diuretic, lipid-removal and calcium antagonist properties. Studies have shown that total phenol and flavonoid concentrations are higher in *M. oleifera* leaves harvested from different agro-climatic zones and extracted with ethanol and methanol compared to water extracts (70). The hydroxyl molecules of flavonoids play a significant role in directly eliminating free radicals, while phenolic substances reduce free radicals by transferring electrons or hydrogen atoms from their hydroxyl groups.

Additionally, *M. oleifera* has been reported to lower glucose levels in Wistar rats with Type 2 diabetes. This reduction in glucose levels may be attributed to phytochemicals such as polyphenols, including glycoside, quercetin, rutin and kaempferol. It has also been shown that both single and combined extracts of *M. oleifera* with vitamin A (VA) have hepatoprotective effects and may be safer for preventing diabetes-related liver damage (71). Furthermore, another study identified approximately 43 bioactive compounds and 40 lipophilic bioactive components in *M. oleifera* extracts, which are highly effective in managing diabetes. The mechanisms reported for diabetes management include inhibition of α-amylase and α-glucosidase activities, prevention of glucose uptake from the intestine, reduced gluconeogenesis in the liver and increased insulin secretion and sensitivity (72).

Overall, this review highlights the significant impacts of the phytochemical characteristics and mechanisms of *M. oleifera* in managing diabetes and beyond. Numerous studies have demonstrated that the "miracle tree" possesses a wealth of phytochemicals crucial for diabetes management. Additionally, this plant shows promising effects in controlling other conditions such as cancer, inflammation, bacterial and viral diseases, oxidative stress, aging prevention, immune system regulation, aorta damage improvement, tumor treatment and protein denaturation inhibition. Beyond its medicinal properties, *M. oleifera* can play a major role in the cosmetic industry, particularly in oil creams and skin care as well as in providing nutritious fiber-rich foods for animals. However, the limitations include the scarcity of studies on the impact of this plant in managing diabetes in humans, indicating the need for further research. Additionally, future research should address the cost forecast for preparing products derived from this miracle tree.

Conclusion

Moringa oleifera is a significant plant with diverse applications in medicine, nutrition and industry. This review highlights its phytochemicals and mechanisms contributing to its antidiabetic properties. Findings indicate that *M. oleifera* contains unique phytochemicals such as carotenoids, polyphenols, alkaloids, terpenoids and sulfur-containing compounds. These components exhibit strong antidiabetic, laxative, anti-inflammatory, anti-tumor, antibacterial and anti-cholesterol properties. The mechanisms by which *M. oleifera* controls insulin resistance and exhibits strong antidiabetic action in streptozotocin-induced diabetic rats include coordinated α-amylase suppression, AMP-kinase and lipoprotein lipase stimulation, regulation of serum glucose transportation proteins (GLUT-1 and GLUT-4) and increased regulation of liver glucose-6-phosphate dehydrogenase. Therefore, this study offers valuable insights into the use of *Moringa* in diabetes treatment. Various parts of *M. oleifera*, including the seeds, leaves and stems, can serve as supplements with potential benefits for preventing diabetic conditions. It is recommended that individuals incorporate these parts of the miracle tree into their daily diet to support overall health and help prevent this illness. *Moringa* holds promise as a natural supplement for the prevention and management of diabetes. Future research should prioritize clinical trials and explore its potential in other therapeutic applications.

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Authors' contributions

Each author has contributed to and helped with the production of this work, helping to design the data, obtain the data, review the data and provide their approval before the paper is submitted.

Compliance with ethical standards

Conflict of interest: The authors state that they have no conflicts of interest.

Ethical issues: None.

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