The Antidiabetic Effect of Moringa oleifera Gum Powder on Streptozotocin Induced Diabetic Rats

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Abstract: Many plant species are utilized for their nutritional and medicinal benefits, with Moringa oleifera, known as the "Miracle Tree," standing out due to its exceptionally high antioxidant content and broad therapeutic potential. Various parts of this plant, including its gum, have demonstrated notable antidiabetic properties. Diabetes mellitus, a complex metabolic disorder characterized by persistent hyperglycemia, currently affects around 537 million adults aged 20 to 79 globally—accounting for 10.5% of adults in this age group—and is projected to rise to 643 million by 2030 and 783 million by 2045. Experimental studies on 24 adult albino Wistar rats treated with streptozotocin were divided into 4 groups and were fed with a standard diet and MOGP at two concentrations for 30 days, showed a reduction in body weight and blood glucose levels, suggesting that MOGP could be developed into diabetes-friendly food products with promising therapeutic value.

Key words: Moringa oleifera gum powder, diabetes mellitus, fiber, body weight, blood glucose, antidiabetic, albino wistar rats, metabolic, insulin, streptozotocin.

Introduction

Ever since ancient times, in search for rescue for their disease, the people looked for drugs in nature. The beginnings of the medicinal plants use were instinctive, as is the case with animals [1]. Several plant species are used by humans for their nutritional and /or medicinal qualities.[2] According to World Health Organization,80% of the world' s population use traditional medicine and medicinal plants for health care in various forms. India has a significant diversity of medicinal plants. Some of these plants are used in the treatment of diabetes. Moringa oleifera, commonly known as the horseradish tree or drumstick tree, belongs to the genus Moringa within the family Moringaceae. Although native to India, it is widely cultivated across tropical and subtropical regions of Africa, Asia, and Central and South America. Its versatile applications—as a food and animal feed, a dietary supplement, and a functional ingredient in cosmetic products—have contributed to its growing global cultivation and trade.[3].

The Miracle tree or Moringa oleifera lam . (MO) is postulated to have the highest

antioxidant content in food and also remarkable range of medicinal uses and high nutritional value. The leaves of this plant provide a rich source of carotenoids, vitamins, minerals, amino acids, alkaloids and flavonoids and a rare combination of phenolic compounds, including zeatin, quercetin, kaempferol, apigenin and many other phytoconstituents that offer essential and disease preventing nutrients to humans [4]

Diabetes mellitus (DM), commonly referred to as diabetes, is a complex metabolic disorder. It is primarily characterized by persistent hyperglycemia, which can lead to a range of systemic complications., a physiologically abnormal condition represented by continued elevated blood glucose levels. Hyperglycemia results from anomalies in either insulin secretion or insulin action or both and manifests in a chronic and heterogeneous manner as carbohydrate, fat and protein metabolic dysfunctions[5,6]. Diabetes mellitus, disorder of macromolecule metabolism characterized by impaired ability of the body supply or answer endocrine and there by maintain correct levels of sugar (glucose) within the blood[7].

Diabetes mellitus is a serious chronic metabolic disorder characterized by either inadequate insulin production or impaired utilization of insulin by the body, leading to persistent hyperglycemia. Globally, an estimated 537 million adults aged 20 to 79 years—representing approximately 10.5% of the population within this age group—are currently affected by diabetes. Projections indicate that the global prevalence will rise to 643 million by 2030 and further escalate to 783 million by 2045.[8] . The Number of people living with diabetes rose from 200 million in 1990 to 830 million in 2022. Prevalence has been rising more rapidly in low and middle income countries than high income countriesIn 2021, diabetes and diabetes-related kidney disease were responsible for over two million deaths globally. Furthermore, elevated blood glucose levels contributed to approximately 11% of all cardiovascular-related mortalities, underscoring the significant burden of hyperglycemia on global health outcomes.[9] . The global diabetes prevalence in 2019 is estimated to be 9.3 % (463 million people), rising to 10.2% (578 million) by 2030 and 10.9% (700million) by 2045. The prevalence is higher in urban (10.8%) than rural (7.2%) areas and in high income (10.4%) than low income countries (4.0%). One in two (50.1%) people living with diabetes do not know that they have diabetes. The global prevalence of impaired glucose tolerance is estimated to be 7.5% (374 million) in 2019 and projected to reach 8.0% (454 million) by 2030 and 8.6 % (548 million) by 2045. As of current estimates, diabetes affects nearly 500 million individuals worldwide. Epidemiological projections indicate a substantial increase in global prevalence, with anticipated growth of approximately 25% by 2030 and 51% by 2045.

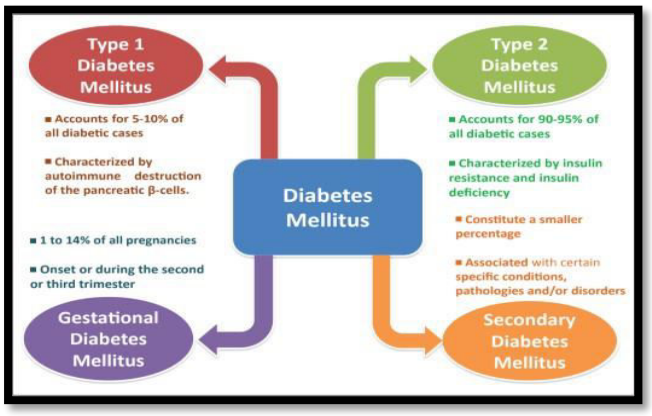
[10] The first principally accepted classification of diabetes was revealed by UN agency within the year 1970 [11] and changed within the year 1985 [12] . The classification encompasses each clinical stages and aetiological sorts of diabetes and different classes of hyperglycemia[13]

Type I diabetes mellitus

Type 1 Diabetes (T1D) is an autoimmune disease that results in the killing of pancreatic islet β cells, leading to metabolic failure requiring lifelong insulin treatment. T1D occurs in individuals with a genetic predisposition, in whom disease onset and progression is triggered by environmental and immunological events. Although the need for multiple factors- genetic environmental and immunological to induce the disease would suggest that TID is a rare event [14]. There is decline in β cell sensitivity to glucose. As the first insulin response decreases, the last insulin response rises, potentially indicating a compensation mechanism. Higher glucose levels are a sign of T1D even when they are within the normal range. When T1D develops there are significant glucose variations It may be possible to anticipate the development of diabetes more accurately in at risk persons by using metabolic markers such as dysglycemia[15]. T1DM is most commonly seen in children and adolescents though it can develop at any age. This type of diabetes is additionally known as reaction diabetes and antecedently referred to as juvenile – onset or ketosisprone polygenic disease the individual may be with different autoimmune disorders like Graves malady, Hashioto thyroiditis and Addison Malady[16].

Type II diabetes mellitus

It is a metabolic disorder primarily caused by a combination of two factors such as impaired insulin secretion by pancreatic β cells and progressive failure of insulin sensitive tissues to respond to insulin. T2DM is also popularly known as Maturity onset DM or Non Insulin Dependent Diabetes Mellitus [17] . Insulin Secretion varies widely in response to insulin sensitivity to maintain adequate glucose levels. Type 2 diabetic patients have a low disposition index; therefore, they are unable to appropriately enhance their insulin production to combat insulin resistance. Insulin production is significantly reduced or eliminated due to glucose stimulation. T2D patients have high ratio of proinsulin to insulin (C Peptide)[18].



Mujjeeb Z banday, Aga S.Sameer and SaniyaNissar, Pathophysiology of Diabetes: An Overview [30]

Role fiber in diabetes mellitus

Dietary fiber comprises plant-based components that resist digestion and absorption in the human gastrointestinal tract. It contributes significantly to digestive function, supports blood sugar regulation, and helps lower the risk of chronic conditions such as type 2 diabetes and cardiovascular disease. Fiber is typically classified into soluble and insoluble forms, each exerting unique physiological effects based on their chemical structure and fermentability[19].

Soluble dietary fiber is characterized by its ability to dissolve in water, forming viscous gel-like structures within the gastrointestinal tract. This physicochemical property contributes to delayed gastric emptying, which in turn enhances satiety and may facilitate weight management through reduced caloric intake. [20].Soluable fiber is believed to beneficial in lowering glucose levels and controlling obesity in adults with obesity[21] and patients with T2DM[22]. High dietary fiber intake has a prebiotic effect on SCFA-producing microbial species. SCFAs have shown pleiotropic effects in different targets that improve glucose metabolism [23] . A high-fiber diet slows carbohydrate digestion and absorption, thereby reducing postprandial blood glucose levels. It also enhances satiety, which may contribute to weight reduction. In individuals with insulin resistance, one proposed mechanism involves the production of short-chain fatty acids (SCFAs), generated through the fermentation of dietary fiber by gut microbes in the colon. These SCFAs exert anti-inflammatory effects on intestinal epithelial and immune cells, supporting improved metabolic function[24&25].

The present study is designed to investigate the potential antidiabetic effects of Moringa oleifera Gum Powder (MOGP) in a experimental model of diabetes. Diabetes mellitus will be induced in albino Wistar rats using streptozotocin (STZ). Through this investigation, the study seeks to explore the therapeutic potential of MOGP as a natural,

plant-derived intervention for diabetes management. This research was conducted in accordance with the ethical guidelines approved by the Institutional Animal Ethics Committee (IQAEC).

Materials and methods

Collection and preparation of MOGP

The production of Moringa oleifera gum (MOG) began with making incisions in the tree bark to collect the naturally exuded gum. The harvested gum was authenticated as Moringa oleifera by the Botanical Survey of India (BSI), Coimbatore. It was then examined for purity, and any adhering bark or debris was carefully removed. The cleaned gum was shadow-dried for approximately 2 to 4 weeks. Once fully dried, it was broken into smaller fragments and finely ground using a mechanical mixer. The resulting powder was sieved through a 60-mesh screen multiple times (4–6 passes) to obtain a uniform Moringa oleiferagum polysaccharide (MOGP) powder.

Selection of animals

Male adult albino rats weighing about 200g -300 g were used in the present investigation. All the rats were given a period of acclimatization for 15 days before starting the experiment. They were fed ad libitum everyday with standard diet and were given free access to water and food. Ethical clearance was sought to carry out the animal study.

Induction of diabetes mellitus

Overnight-fasted male Wistar albino rats received a single intraperitoneal dose of Streptozotocin (50 mg/kg body weight), dissolved in 0.01 M citrate buffer (pH 4.5), to induce experimental diabetes. To prevent acute hypoglycemia, a 5% glucose solution was provided orally during the first 24 hours. The development of diabetes was validated within three days by marked glycosuria and elevated fasting blood glucose levels.

Diabetes was confirmed on the third day following Streptozotocin administration by measuring fasting blood glucose levels using glucose oxidase–peroxidase reactive strips and a portable glucometer. Animals presenting blood glucose concentrations exceeding 250 mg/dL were classified as diabetic and subsequently included in the experimental group for further investigation. This selection criterion ensured consistency in the diabetic phenotype across the study population, facilitating reliable analysis of treatment effects and metabolic outcomes.

Experimental design

A total of 24 albino Wistar rats were utilized for the evaluation of anti diabetic activity, comprising 18 diabetic (surviving) rats and 6 normoglycemic controls. The animals were randomly assigned into four groups, each containing six rats, as follows:

- Group I served as the normoglycemic control and received a standard diet.
- Group II consisted of streptozotocin (STZ)-induced diabetic rats maintained on a standard diet.
- Group III included STZ-induced diabetic rats treated with 2.5% Moringa oleifera gum powder (MOGP) incorporated into the feed.
- Group IV comprised STZ-induced diabetic rats administered with 5% MOGP-enriched feed.

Groups III and IV were administered MOGP through specially prepared feed pellets, formulated by incorporating the respective concentrations of MOGP into the standard diet. This pelletized feed was provided for duration of 30 days. The initiation of MOGP administration was designated as Day 1, corresponding to the third day post-induction of diabetes. Blood samples were collected weekly via tail snipping to assess fasting blood glucose levels and body weight. These parameters were monitored on Days 1, 8, 15, 22, and 30 of the treatment period using a glucometer.

Results and discussion

Body weight:

Table 1. The impact of Moringa oleifera gum powder on body weight alterations in streptozotocin-induced diabetic rats.

Group	Dose	Body weight (g)					
		0 th day	(a) 1 st day	(b) 8 th day	(c) 15 th day	(d) 22 th day	(e) 30 th day
Normal Control	-	285.00 ± 20.62	285.83 ± 22.45	289.17 ± 21.16	291.67 ± 25.08	295.00 ± 20.85	295.00 ± 23.
Diabetic Control (STZ induced)	50 mg/ Kg BW (once)	268.33 ± 41.86	273.33 ± 30.82	285.00 ± 47.43	280.00 ± 51.64	262.50 ± 58.03	283.33 ± 24.01
Diabetic + lower dose MOGP Feed	2.5%	305.00 ± 42.79	304.17 ± 38.43	300.83 ± 40.01	295.50 ± 38.93	290.83 ± 41.29	287.50 ± 39.49
Diabetic + higher dose MOGP Feed	5%	313.33 ± 26.92	312.50 ± 25.62	307.50 ± 29.66	297.50 ± 30.25	289.17 ± 28.27	284.17 ± 27.46

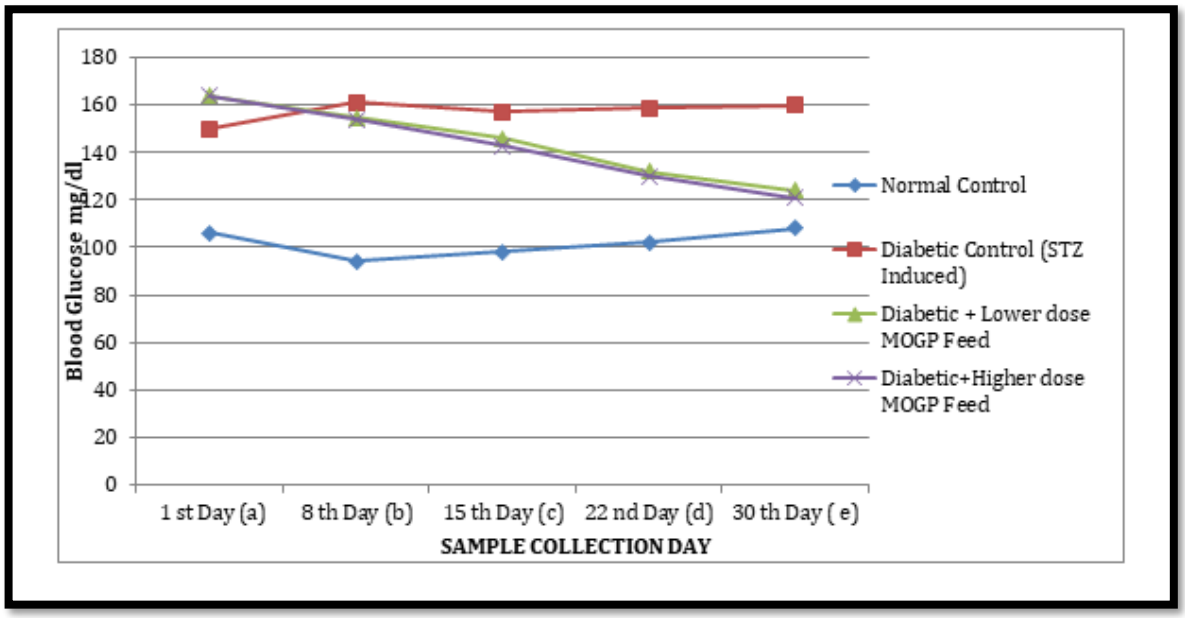
Values are expressed as mean ± SD (n=6)

The body weight trends observed across all experimental groups from day 1 to day 30 reveal distinct physiological responses (table-1) to diabetes induction and Moringa oleifera gum powder (MOGP) supplementation. In the normal control group, body weight increased progressively over the study period, indicating healthy growth and metabolic balance. In contrast, the diabetic control group displayed erratic weight changes, with a transient increase followed by a decline by day 22, suggesting the catabolic impact of streptozotocin (STZ)- induced diabetes and disrupted energy homeostasis.

Animals supplemented with a low dose (2.5%) of MOGP exhibited a gradual decline in weight over time, with significant reductions emerging by day 15, indicating a potential metabolic modulation effect. Notably, the high-dose (5%) MOGP group demonstrated a marked and statistically significant reduction in body weight from day 15 onwards, suggesting a dose-dependent response. These results imply that MOGP, particularly at higher concentrations, may influence weight regulation in diabetic models, potentially through mechanisms related to glycemic control or nutrient utilization.

Blood glucose

Graph 1. The effectiveness of Moringa oleifera gum powder on blood glucose of STZ induced albino wister rats.



From the graph -1 the evaluation of blood glucose levels over the experimental timeline revealed clear distinctions in glycemic control among the treatment groups. The normalcontrol group maintained stable glucose concentrations throughout the study, exhibiting only minor physiological fluctuations, which underscores the metabolic homeostasis in healthy animals. In contrast, the diabetic control group, induced with streptozotocin (STZ), showed a significant elevation in blood glucose from

day 0 to day 1, which persisted with minimal variation through day 30. This sustained hyperglycemia reflects the hallmark diabetic phenotype associated with STZ-induced β-cell dysfunction.

Notably, the groups receiving Moringa oleifera gum powder (MOGP) supplementation demonstrated a time-dependent reduction in blood glucose levels. In both the low-dose (2.5%) and high-dose (5%) MOGP-fed diabetic groups, glucose levels peaked on day 1 and gradually declined over the subsequent days. The high-dose group exhibited a more pronounced and consistent hypoglycemic effect, with levels approaching normoglycemia by day 30. These findings suggest that MOGP may exert a dose-responsive antidiabetic effect, potentially mediated by enhanced insulin sensitivity, delayed carbohydrate absorption, or improved pancreatic function. Collectively, the data support the therapeutic potential of MOGP as a functional dietary component for glycemic regulation in diabetic conditions.

Moringa oleifera gum Powder is high in fiber which plays a significant role in regulating blood glucose levels. It slows gastric emptying, reduces the rate of glucose absorption, and improves insulin sensitivity. Reynolds et al., 2020 justifies that, this helps in managing postprandial blood sugar spikes and long-term glycemic control, particularly in individuals with diabetes or prediabetes[26]

Zhu, Bo, and Liu (2020) [27] highlighted a multifaceted interplay between dietary fiber and diabetes management through several key physiological mechanisms. When regularly consumed, soluble fiber is fermented by gut microbiota, producing short-chain fatty acids (SCFAs) like acetate, propionate, and butyrate. These SCFAs stimulate hormones such as GLP-1 and PYY that enhance insulin secretion, increase satiety, and help regulate blood glucose. Fiber intake also promotes beneficial changes in gut microbiota composition, supporting metabolic health and suppressing inflammation-causing metabolites. Additionally, SCFAs activate receptors like GPR41 and GPR43, which help regulate glucose metabolism, insulin sensitivity, and energy balance. Together, these processes improve beta-cell function, reduce postprandial glucose spikes, and enhance long-term glycemic control in individuals with type 2 diabetes[27].

Soluble fiber slows the digestion and absorption of carbohydrates, which helps stabilize postprandial (after-meal) blood glucose levels**.** This can reduce the frequency and severity of blood sugar spikes, making insulin dosing more predictable. Additionally, fiber- rich diets have been linked to lower levels of systemic inflammation, which is important because chronic inflammation can worsen diabetes-related complications in type I [28].

The other parts of Moringa leaves are rich in polyphenols like quercetin and chlorogenic acid, which enhance insulin sensitivity and slow glucose absorption**.** Seeds contain antioxidants and proteins that protect pancreatic β-cells and reduce oxidative

stress. The pods (or drumsticks), commonly consumed in diets, provide dietary fiber and essential micronutrients that aid in moderating postprandial glucose spikes. Even the roots, though used cautiously due to potential toxicity at high doses, harbor alkaloids and compounds that may influence carbohydrate metabolism. Collectively, these components support glycemic control by improving insulin action, mitigating inflammation, and regulating glucose uptake[29]

Conclusion:

Moringa oleifera gum exhibits strong antidiabetic potential by helping regulate blood glucose levels, improving insulin responsiveness, and reducing oxidative stress. These therapeutic effects are largely due to its abundance of health-enhancing compounds like polysaccharides, flavonoids, and phenolic acids. Owing to its natural origin, compatibility with biological systems, and functional properties, Moringa gum offers promising opportunities for future use in the functional food and nutraceutical sectors. It could be integrated into diabetic-friendly products—such as high-fiber snacks, functional beverages, and meal replacements—not only to enhance shelf life and product quality but also to deliver medicinal benefits.

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