The Role of Medicinal Plants in Managing Diabetes Mellitus: A Systematic Review

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Abstract – Diabetes mellitus is a global health concern characterized by chronic hyperglycemia due to defects in insulin secretion, action, or both. While conventional antidiabetic therapies are widely available, the increasing prevalence of diabetes and its associated complications have prompted a search for alternative treatment strategies. Medicinal plants, with their rich repository of bioactive compounds, have emerged as potential therapeutic agents in managing diabetes. This review examines the pharmacological effects of medicinal plants toward diabetes mellitus, particularly insulin secretion, inhibition of glucose absorption, and their antioxidant activity. Besides, the current review will summarize the possibility of integrating herbal medication with conventional modern medicine for managing diabetes mellitus holistically.

Keywords- Diabetes mellitus, Medicinal plants, Phytochemicals, Antidiabetic activity, Insulin resistance, Herbal medicine

I. INTRODUCTION

Diabetes mellitus (DM) is one of the major threats to global health, with its occurrence reported in over 500 million cases worldwide (Naga et al., 2025). There are two main types of this metabolic disorder: type 1 diabetes, which is caused by autoimmune destruction of pancreatic β-cells, and type 2 diabetes, associated with insulin resistance and impaired insulin secretion (Eizirik et al., 2020). Due to the chronic nature of DM, complications may be severe and include cardiovascular disease, neuropathy, nephropathy, and retinopathy. Although there have been advancements in pharmacological treatments, the increasing prevalence of DM emphasizes the need for complementary and alternative approaches.

Medicinal plants have been used for quite a long time to treat diabetes in various systems of traditional medicine, including Ayurveda, Traditional Chinese Medicine, and Unani (Basu et al., 2023). These plants are known to possess bioactive compounds, such as alkaloids, flavonoids, terpenoids, saponins, and phenolic acids, which show antidiabetic activity. This review aims to present a systemic overview on the use of medicinal plants in the management of diabetes, specifically discussing their phytochemical profiles, mechanisms of action, and therapeutic potential.

Pathophysiology of Diabetes Mellitus

Diabetes mellitus is caused by the interplay of multiple genetic, environmental, and lifestyle factors. Type 1 diabetes results from an autoimmune response that causes the destruction of pancreatic β-cells, which leads to absolute insulin deficiency. In contrast, type 2 diabetes results from a combination of insulin resistance and β-cell dysfunction, often due to obesity and sedentary lifestyles (Banwart et al., 2024; Janez et al., 2024). Chronic hyperglycemia caused by this condition leads to oxidative stress, inflammation, and the formation of advanced glycation end products, thereby leading to microvascular and macrovascular complications.

Medicinal Plants and Their Antidiabetic Properties

1. Phytochemicals with Antidiabetic Potential

The medicinal plants possessed their therapeutic properties by virtue of the various bioactive compounds, which interact and target multiple aspects of the pathophysiology of diabetes mellitus. It is through this synergistic action that these phytochemicals regulated glucose metabolism, enhanced insulin activity, as well as reduced oxidative stress (Guan et al., 2021). Key compounds include alkaloids, flavonoids, terpenoids, phenolic acids, and saponins. Alkaloids, such as those found in bitter melon and fenugreek, are known to stimulate insulin secretion and enhance glucose uptake, thereby improving blood glucose levels. Flavonoids, on the other hand, exhibit potent antioxidant and anti-inflammatory properties, which help protect pancreatic β-cells from oxidative stress (Theodorakopoulou et al., 2025; Alharbi et al., 2025) . Terpenoids play a crucial role by inhibiting enzymes like α-glucosidase and α-amylase, which reduces the absorption of glucose after meals, leading to better glycemic control. Phenolic acids safeguard β-cells against oxidative stress-induced damage, ensuring the sustained production of insulin. Meanwhile, saponins improve insulin sensitivity and regulate lipid metabolism, making them effective in managing diabetes and its associated complications. Together, these phytochemicals provide a multifaceted approach to tackling diabetes.

2. Common Medicinal Plants Used in Diabetes Management

Several medicinal plants have been extensively studied and utilized for their antidiabetic properties. Bioactive compounds of *Momordica charantia*, known as charantin, vicine, and polypeptide-p, stimulate the release of insulin while promoting glucose uptake in peripheral tissues and interfering with intestinal glucose absorption (Richter et al., 2023). *Trigonella foenum-*

graecum, commonly known as the fenugreek plant, with its seeds rich in soluble fiber and saponins, retards carbohydrate digestion, thereby reducing postprandial blood sugar spikes while promoting improved insulin sensitivity (Tewari et al., 2024). *Gymnema sylvestre*, often termed the "sugar destroyer," contains gymnemic acids that prevent the absorption of sugar in the intestine and stimulate the pancreatic β-cells to produce insulin (Selvaraj et al., 2022). *Cinnamomum verum*, popularly known as cinnamon, consists of polyphenol molecules that serve as insulin agonists, activate glucose uptake in the cells, and dramatically reduce blood glucose levels in fasted individuals. Finally, *Ocimum sanctum* (holy basil) leaves are rich in antioxidants and eugenol, which improve glucose metabolism and mitigate oxidative stress, offering an additional layer of protection against diabetes-related complications (Arya et al., 2024). These plants, with their unique bioactive compounds, form the backbone of traditional antidiabetic therapies.

Table1: Summary of Medicinal Plants with Antidiabetic Properties

Plant Name	**Bioactive Compounds**	**Mechanisms of Action**	**Therapeutic Effects**
Momordica charantia	Charantin, Vicine, Polypeptide-p	Stimulates insulin secretion, inhibits glucose absorption	Reduces fasting blood glucose
Trigonella foenum-graecum	Saponins, Fiber	Delays carbohydrate digestion, improves insulin sensitivity	Lowers postprandial glucose
Gymnema sylvestre	Gymnemic acids	Inhibits sugar absorption, regenerates β-cells	Lowers blood sugar levels
Cinnamomum verum	Polyphenols	Mimics insulin, improves glucose uptake	Reduces HbA1c levels
Ocimum sanctum	Eugenol, Antioxidants	Reduces oxidative stress, enhances glucose metabolism	Improves glucose tolerance

Mechanisms of Action of Medicinal Plants

1. Stimulating Insulin Secretion

Some medicinal plants have been demonstrated to activate the pancreatic β-cell function and increase its capability for insulin production. Alkaloids extracted from bitter melon and fenugreek have the capability of evoking the secretory response and increase glucose uptake in tissues by promoting an insulin release from β-cells (Haeri et al., 2023; Matalqah et al., 2025). This action has the potential for re-establishment of glucose balance in Type 2 diabetic individuals who suffer

a decrease in β-cell function.

2. Enhancement of Insulin Sensitivity

Another major way through which medicinal plants aid in the management of diabetes is through increasing insulin sensitivity. Phytochemicals like phenolic acids and flavonoids increase the sensitivity of the insulin receptors, allowing for efficient uptake of glucose into muscle and adipose tissues (Hajiaghaalipour et al., 2015). This increased glucose uptake lowers blood sugar levels and eliminates the insulin resistance that is typically found in Type 2 diabetes.

3. Antagonism of Carbohydrate Absorption

Another mechanism is the inhibition of carbohydrate-digesting enzymes such as α-glucosidase and α-amylase. Compounds like gymnemic acids and terpenoids inhibit the activity of these enzymes, thereby slowing down the breakdown and absorption of carbohydrates in the intestines (Elbakry et al.,2023). This reduces the postprandial rise in blood glucose levels, thus contributing to better glycemic control.

4. Antioxidant and Anti-inflammatory Activities

Oxidative stress and inflammation are major contributors to the progression of diabetes and its complications. Flavonoids and polyphenols present in medicinal plants effectively neutralize ROS and downregulate pro-inflammatory pathways (Agarwal et al., 2023; Yudatama et al.,2025). By reducing oxidative damage and inflammation, these compounds not only protect pancreatic β-cells but also mitigate the risk of diabetes-related complications such as cardiovascular diseases and neuropathy.

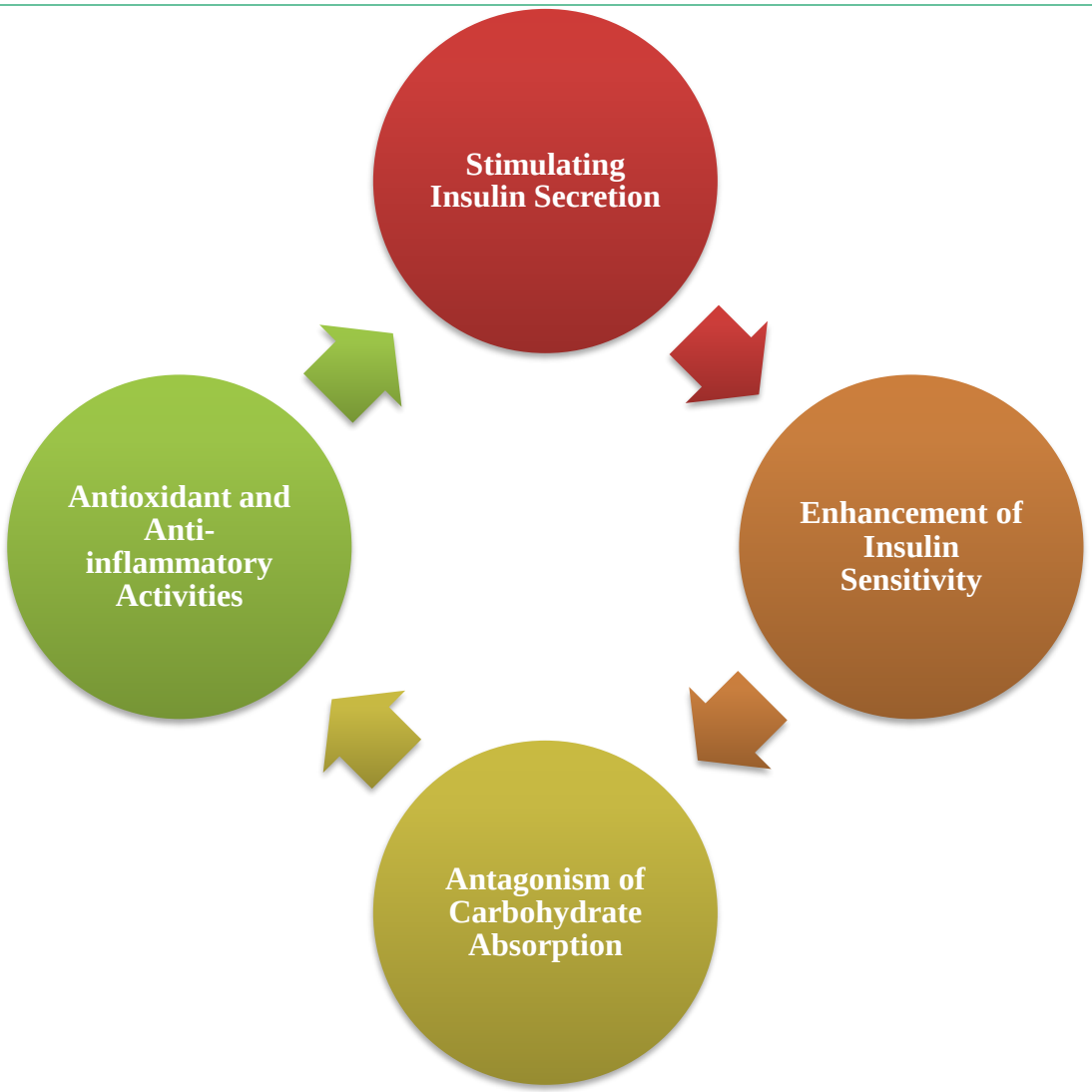

Figure 1: Mechanisms of Action of Medicinal Plants

Challenges and Future Directions

Medicinal plants demonstrate lots of promising antidiabetic potential, but these compounds will face some big hurdles in their application. The immediate challenge is standardization and quality control. There may be variability in phytochemical content because of the environment, plant maturity, and even genetic diversity, among others, which makes these remedies fail. Standardized protocols therefore are necessary for cultivation, harvesting, and processing (Lupo et al., 2025; Dalal et al.,2025). The second challenge would be to find an optimal dosage and their long-term safety. There are a lot of medicinal plants whose clinical trials on their safety and efficacy are minimal or nonexistent. Integration into conventional medical practice will not be achieved by

these types of drugs without proper studies that ensure no side effects with modern antidiabetic therapy but instead combine in a synergistic manner. Over-harvesting of medicinal plants threatens biodiversity; therefore, adoption of sustainable cultivation practices, conservation of the species, and encouragement of community-based conservation programs will be vital. Future research directions should be targeted at the elucidation of molecular mechanisms by which medicinal plants exert their antidiabetic effects. Clinical trials on large scales are also required to be conducted to authenticate their efficacy and standardize their formulations. Also, biotechnological advancements can be exploited to upscale the production of bioactive compounds, thereby making available a steady supply of high-quality plant-based remedies.

Conclusion

Medicinal plants have enormous potential in managing diabetes mellitus through the regulation of multiple pathways involved in glucose metabolism, oxidative stress, and inflammation. They are integrated into diabetes management strategies as a holistic, cost-effective, and accessible approach to combat this global health challenge. Challenges in standardization, safety, and sustainability, however, must be addressed to unlock their full potential. With continued research and innovation, medicinal plants could play an important role in how the future of diabetes management would turn out to provide therapeutic as well as preventive advantages to the humanity.

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