# Herbal Treatment of Diabetes

Nimra Arshad<sup>1</sup>, Iqra Zahoor<sup>1</sup>, Khoula Saleem<sup>2</sup>, Urwa Kanwal<sup>1</sup>, Sibgha Kanwal<sup>1</sup>, Aleena Manzoor<sup>1</sup>, Humera Ramzan<sup>2</sup>, Mashael Waqar<sup>2</sup> and Mariam Afzal<sup>1</sup>

<sup>1</sup>Department of Zoology, Government College University Faisalabad <sup>2</sup>Department of Pharmacy, Government College University Faisalabad \*Corresponding author: <u>nimraarshad1144@gmail.com</u>

## Abstract

This chapter intends to explore the use of herbal medicines in managing diabetes by covering both historical usage and recent advancements. Diabetes mellitus is a chronic carbohydrate metabolism disorder that results from a defect in insulin secretion, insulin action, or both. Conventional treatment is effective but often has side effects and limitations. However, herbal medicines for managing diabetes offer a complementary approach with potential benefits such as improved insulin sensitivity and glucose metabolism. This chapter talks about different herbs used for diabetes management, including Bitter Melon, Fenugreek, Cinnamon, and others, as well as their mechanisms of action and the scientific evidence about their effectiveness. Although these herbs show some promising effects, challenges such as standardization, safety, and efficacy remain. The future direction of this work is to combine traditional and modern medicine to standardize and validate herbal treatment in diabetes management. Potential for improvement of therapeutic outcomes and patient quality of life could be obtained using integrative approaches, namely integrating herbal medicine with conventional treatments.

Keywords: Diabetes, Herbs, Treatment, Aloevera, Glucose, Insulin

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## Introduction

Diabetes was first documented by the Egyptians and is characterized by weight loss and polyuria. The term diabetes mellitus was introduced by the Greek physician Aertaeus. The Greek term diabetes means "to pass through," and the Latin word mellitus translates to honey, indicating sweetness. Diabetes markedly increases prolonged morbidity and premature mortality, causing a greater yearly death rate than HIV-AIDS, with around one fatality every 10 seconds. The global diabetes epidemic has arisen along with extensive industrialization and a marked rise in obesity rates. Measuring prevalence accurately is difficult due to two main factors: the inconsistency in standards and methods of data collecting across various countries, and recent surveys forecasting an increase in adult diabetes prevalence from 4% in 1995 to 6.4% by 2025. Moreover, forecasts suggest a rapid change, with a 42% growth from 51 to 72 million in rich nations and a 170% escalation from 84 to 228 million in poor countries. The worldwide incidence of diabetes in adults is anticipated to rise from 194 million in 2003 to roughly 380 million by 2025. In 2025, the nations most affected by this disease will be India, China, and the United States. A further alarming factor is that a substantial segment of the patient population, over 50%, remains undetected (Kaul et al., 2012).

The understanding of diabetes has changed significantly over time, early mentions are found in ancient civilizations like Egypt and India, where symptoms such as frequent urination and the loss of weight for no apparent reasons were used to be recorded (Royal College of Physicians, 2023). A condition defined as excessive urination is documented in ancient Egyptian writings from 1500 B.C. Indian physicians called it madhumeha ('honey urine') because of its attraction to ants. The ancient Indian physician Sushruta and the surgeon Charaka (400–500 A.D.) identified two forms of diabetes, subsequently designated as Type I and Type II (Lakhtakia, 2013). According to modern understanding, Type 1, Type 2 and gestational diabetes differ the most regarding the pathophysiological mechanisms and risk factors (WHO, 2023). New information about the way genetics, lifestyle, and environmental factors work together to promote and slow the development and progression of diabetes has shaped prevention and therapeutic efforts in both tragedy and triumph (CDC, 2023).

## **Diabetes Mellitus**

Diabetes mellitus is not a singular condition; its definition varies based on individual perspective. Medically, it denotes a collection of metabolic disorders linked to hyperglycemia, resulting from partial or complete insulin deficiency. Chronic hyperglycemia can lead to microvascular problems in the retina, kidneys, or peripheral nerves. While these traits are indicative of diabetes, they cannot serve as definitive criteria for the illness due to their prolonged onset. Macrovascular consequences of diabetes, such as myocardial infarction, stroke, and peripheral artery disease, are more prevalent as they often manifest in the pre-diabetic state. Diabetes has been proposed to be characterized as 'premature atherosclerosis accompanied by hyperglycemia', thereby highlighting the clinical issues that predominantly afflict patients (Egan & Dinneen, 2018).

Diabetes mellitus is a chronic carbohydrate metabolism disorder that results from a defect in insulin secretion, insulin action, or both (ADA, 2023). If left untreated, high blood sugar can cause serious long-term complications such as cardiovascular disease, neuropathy, nephropathy, and retinopathy (WHO, 2023). There are three primary types of diabetes: Gestational diabetes, Type 1, and Type 2 diabetes.

#### **Type 1 Diabetes**

Type 1 diabetes accounts for approximately 5–10% of all diabetes cases; however, its prevalence is increasing worldwide, leading to considerable short-term and long-term effects. The condition has a notable hereditary component, mainly transmitted through the HLA complex; however, the factors that trigger the onset of clinical disease are largely unknown (Daneman, 2006).

Type 1 diabetes is an autoimmune disorder characterized by the immune system's attack on and destruction of insulin-producing beta cells in the pancreas, resulting in total insulin deficiency (Mayo Clinic, 2023). This condition typically manifests during childhood or adolescence, although it may onset at any age. Individuals with Type 1 diabetes require lifelong insulin administration to prevent complications and regulate blood glucose levels (NIDDK, 2023).

#### **Type 2 Diabetes**

Type 2 diabetes mellitus (T2DM) is characterized by the dysregulation of glucose, lipid, and protein metabolism, which arises from reduced insulin production, insulin resistance, or a combination of these factors. Type 2 diabetes mellitus (T2DM) is the most common form of diabetes, accounting for over 90% of all cases, in contrast to type 1 diabetes mellitus (T1DM) and gestational diabetes. In recent decades, understanding the onset and progression of T2DM has improved considerably. The main cause is the progressive decline in insulin secretion by pancreatic  $\beta$ -cells, usually occurring in the context of existing insulin resistance in skeletal muscle, liver, and adipose tissue (DeFronzo et al., 2015).

## **Gestational Diabetes**

Gestational diabetes mellitus (GDM) is defined as a condition of glucose intolerance of varying severity, first recognized during pregnancy. Gestational diabetes mellitus (GDM) is diagnosed through the screening of pregnant women for clinical risk factors, followed by glucose tolerance tests for those identified as at risk. This condition is generally mild and asymptomatic, although exceptions may occur. Gestational diabetes mellitus (GDM) appears to result from a similar array of physiological and genetic abnormalities that characterize diabetes in non-pregnant individuals. Women diagnosed with gestational diabetes mellitus (GDM) exhibit an increased risk of developing diabetes in non-pregnant states (Buchanan & Xiang, 2005). Also, women who develop gestational diabetes are at a higher risk of developing Type 2 diabetes after pregnancy. Management of diabetes includes dietary changes, regular physical activity, and, occasionally, insulin or other medications to keep blood glucose at a healthy level (ADA, 2023).

## **Diabetes Management using Herbal Medicine**

Management of diabetes consists of long-term medication, diet, and exercise; patients and their healthcare providers are seeking alternatives, including herbal medicine to complement conventional treatment regimens. These herbs are natural materials derived from plants that have been used for centuries across all cultures for supposed medicinal properties. Certain herbs have been researched and have shown in clinical trials that they can help improve blood glucose increase insulin sensitivity, and that these herbs provide antioxidant and anti-inflammatory benefits to manage diabetes. Ginseng, Fenugreek, Berberine, and Cinnamon are herbs under the spotlight for their potential to support glucose metabolism and promote general metabolic health.

Research showed that Ginseng, particularly Panax ginseng, helps in the improvement of insulin sensitivity and also helpful in reducing the blood sugar levels (Parmar et al., 2024). Just like fenugreek seeds, rich in soluble fiber and having compounds that are capable of affecting insulin activity have been found to lower blood sugar levels and improve control of blood sugar in diabetic patients (Ulbricht et al., 2006). Active ingredients in plants like Goldenseal, and berberine, have been shown to have very positive anti-diabetic effects by regulating blood sugar and increasing insulin sensitivity (Yin et al., 2008). As evidenced by science, cinnamon is used in the traditional way (in both cooking and traditional medicine) to improve insulin sensitivity and bring down fasting blood glucose levels (Blevins et al., 2007).

These promising findings need to be taken with a grain of salt, however, as the use in treating diabetes is not without risk: efficacy can vary, and many herbal medicines are not standardized in formulas. Clinical trials of these herbs can be encouraging, but often involve small sample sizes or no follow-up beyond a given length of time, which inhibits their ability to prove or disprove the claims these herbs can support.

## Limitations of Conventional Treatments

Most of the time conventional treatments for diabetes are medications like metformin, sulfonylureas, insulin, and lifestyle modification which include diet and exercise. Although these treatments do roll back blood glucose levels, there are some limitations in these treatments that include side effects, long-term risks, and the fear of developing drug resistance.

For example, metformin is the first-line option for diabetes Type 2 and works by improving insulin sensitivity and reducing glucose production in the liver. But it can have side effects on the digestive system including nausea, diarrhea, and in some cases a vitamin  $B_{12}$  deficiency (Bailey & Turner, 1996). It also has the risk with insulin therapy, which is often used for Type 1 diabetes or advanced Type 2 diabetes, such as weight gain, hypoglycemia, and insulin resistance over time. Long-term use of sulfonylureas may also increase the risk of hypoglycemia and beta cell dysfunction (Del Prato & Pulizzi, 2006).

#### Key Herbs used in Diabetes Management

Although conventional approach to diabetes management is still hold the main stage, however, evidence is building that certain herbs can support blood sugar regulation as well as insulin sensitivity. The following is a review of key herbs used in diabetes management along with their mechanisms of action.

### Bitter Melon (Momordica charantia)

Bitter melon known for its ability to mimic insulin activity in order to help glucose be taken up by cells. They have shown that compounds from bitter melon such as charantin and momordicin improve glucose utilization and can have an insulin-like effect (Basch et al., 2003). Bitter melon also has been shown to lower blood glucose levels in type 1 and type 2 diabetes by promoting glucose metabolism in peripheral tissues (Joseph & Jini, 2013).

#### Fenugreek (Trigonella foenum-graecum)

Soluble fiber in fenugreek seeds can slow down the absorption of glucose and lower a postprandial blood sugar spike. Furthermore, researches indicated that fenugreek can stimulate insulin secretion, it also aid in glucose homeostasis in the body (Haxhiraj et al., 2024). Good glycemic control also comes from the high fiber content, especially in type 2 diabetes.

#### Cinnamon (Cinnamomum spp.)

Cinnamon use is commonly for its potential for enhancing blood glucose and lipid profiles. Cinnamon has been shown to reduce fasting blood glucose levels and to increase insulin sensitivity (Blevins et al., 2007).

## Gymnema Sylvestre

The bitter-tasting gymnema sylvester is the "sugar destroyer" because it suppresses sugar cravings and reduces glucose absorption from the intestines. Show to increase glucose utilization through improvement of insulin function and increase of insulin secretion (Singh et al., 2008).

## Aloe Vera

Aloe vera has also provided a proving ground for its potential to be used in the control of glycemic control. Bioactive compounds present in the plant have antioxidant properties and can decrease oxidative stress, a major causative factor for the development of insulin resistance (Suksomboon et al., 2016). Aloe vera supplementation is shown to improve blood glucose, especially in persons with type 2 diabetes (Malini, 2022).

#### Turmeric (Curcumin)

Its active compound curcumin has had the spotlight shining on it for its anti-inflammatory properties. Curcumin has been used to combat inflammation, a major trigger of diabetes. In addition, curcumin may also protect pancreatic beta cells from oxidative stress which is key to maintaining the insulin-producing capacity (Fuloria et al., 2022). It has been determined through researches that curcumin is effective in the improvement of glucose metabolism and helpful in decreasing HbA1c levels in diabetic patients (Pathomwichaiwat et al., 2023).

#### **Berberine-containing Plants**

Extensive research on the effect it has on metabolic health has been conducted on Berberine, an active compound of plants like *Berberis vulgaris*. Dong et al. (2012) demonstrated that berberine improved insulin sensitivity; increased glucose uptake; and regulated lipid metabolism. The mechanism of action seems to be its ability to activate AMP-activated protein kinase (AMPK) to lower blood sugar and improve overall metabolic function (Guo et al., 2021).

#### **Other Emerging Herbs**

Traditional uses of neem (*Azadirachta indica*) have included its anti-hyperglycemic activities. Studies done recently indicate that neem can increase insulin secretion and sensitivity and decrease blood sugar levels (Islas et al., 2020). Adaptogenic properties of holy basil (*Ocimum sanctum*) have been disclosed and demonstrated for the capacity to decrease blood glucose levels and enhance insulin functionality (Ezeani et al., 2017). Shishtar et al. (2014) studied if ginseng (*Panax ginseng*) could lower blood glucose levels and increase insulin sensitivity, due to its actions on insulin hypersecretion and glucose metabolism.

#### Mechanisms of Action

Of all the herbs used in diabetes management, they have multiple effects that aid in regulating blood sugar, increase insulin sensitivity, protect pancreatic beta cells, and prevent complications from diabetes. Glucose regulation is one of the key actions. Bitter melon and fenugreek are also known to lower blood glucose. Compounds that mimic insulin in bitter melon help to enhance glucose uptake by cells (Joseph & Jini, 2013). With its higher soluble fiber content, fenugreek slows digestion of glucose and helps prevent blood spike from the meal (Haxhiraj et al., 2024). Despite its effectiveness in enhancing insulin sensitivity Cinnamon also very helpful for improving glucose regulation, halting an elevation in blood sugar in human body (Blevins et al., 2007).

Enhancing Insulin sensitivity is another effective mechanism to counter the diabetes. Herbs, such as cinnamon and berberine can reduce insulin resistance that is a key problem in type 2 diabetes. Insulin receptors activated by cinnamon promote improved insulin signaling and glucose utilization by the body (Blevins et al., 2007). Similarly, berberine from Berberis vulgaris activates AMP-activated protein kinase (AMPK) which is a central regulator of glucose metabolism and insulin sensitivity (Guo et al., 2021).

There are many herbs as well that help form and regenerate beta cells as the original, insulin-producing cells in the pancreas. For instance, Gymnema sylvestre has been shown to regenerate damaged beta cells and enhance their insulin secretion as well as glucose metabolism (Singh et al., 2008). For those with diabetes, it also has protective effects on beta cells, lowering oxidative and inflammatory stress which can harm pancreatic cells (Fuloria et al., 2022).

Finally, controlling the complications of diabetes including cardiovascular disease and neuropathy requires anti-inflammatory and antioxidant effects. Antioxidants found in curcumin turmeric and aloe vera, and curcumin turmeric itself, help to reduce chronic inflammation and oxidative stress—both of which are associated with the progression of diabetic complications (Suksomboon et al., 2016; Fuloria et al., 2022). These anti-inflammatory and antioxidant properties are the keys to protecting our tissues and organs from the damage that improper, prolonged high blood sugar levels can do to them.

## Scientific Research and Evidence

Research consisting of preclinical and clinical studies supports the use of herbs in management of diabetes. Herbs such as bitter melon, fenugreek, and berberine, are also found to preclinically reduce blood glucose levels and improve insulin sensitivity (Joseph & Jini, 2013). Cinnamon and gymnema sylvestre are also shown to do well in clinical studies concerning their effect on blood sugar control and insulin sensitivity in humans (Blevins et al. 2007; Singh et al., 2008).

Some herbs, however, are similarly effective as conventional antidiabetic drugs. For example, berberine has also shown an equivalent effect to metformin in improving glucose control (Guo et al., 2021). Similarly, research has shown cinnamon also to reduce blood glucose levels as much as some diabetes medications (Blevins et al., 2007). These herbs are helpful herbs, but they are used as adjuncts to traditional treatment, rather than substituting for them.

In addition to that, meta-analysis and systematic review support the efficacy of herbal remedy. A review of cinnamon's impact on type 2 diabetes concluded 'significant reductions in fasting blood glucose and HbA1c' (Allen et al., 2013). Like berberine, a meta-analysis of the effect of berberine on improving insulin sensitivity and blood glucose control was reported (Wang et al., 2019).

## **Cultural and Traditional Applications**

Some form of herbal remedies is traditional used in treating diabetes. Herbs like bitter melon, fenugreek, turmeric, are a staple in Ayurveda for regulated blood sugar and insulin sensitivity. Glyconorm and Ayurvedic formulation, incorporates these herbs so as to balance blood glucose and also provide for good health (Chattopadhyay et al., 2022).

Traditional Chinese Medicine (TCM) uses ginseng and even astragalus to manage diabetes. Astragalus supports pancreatic function and glucose metabolism (Li et al., 2019); while it also improves insulin sensitivity and reduces blood glucose levels (Kim et al., 2011).

Indigenous culture in Ethnomedicine uses plants such as bitter melon and neem to manage diabetes. Bitter melon and neem have a long history of lowering blood sugar and as an antioxidant and anti-inflammatory that prevents complications (Mahwish et al., 2021; Asghar et al., 2022).

## **Challenges in Herbal Treatment**

Herbal remedies may promise to help manage diabetes, but it has several utility and diffusion challenges. But the biggest problem is a lack of standardization when it comes to herbal products. Unlike pharmaceutical drugs, herbal products frequently are of varying composition, potency, and quality. Their effectiveness and safety are complicated by this variability (Zhang et al., 2011).

Yet a further difficulty consists in the lack of determination of bioactive components in herbal remedies. Many herbs contain many compounds with a complex identification of the specific bioactive molecules responsible for the herb's therapeutic effects. Without a precise identification, it is hard to standardize dosage and ensure the same results (Chawla et al., 2013).

There are regulatory issues and certification that block the use of any herbal treatment. Herbal products are not regulated as strictly in many countries as pharmaceutical products, and so you may not be certain about their quality or their certification. The risks include contamination and adulteration, absolute and inaccurate labeling (Hossain et al., 2022).

## Integration with Conventional Diabetes Management

A complementary approach to managing diabetes is by integrating herbal treatment with conventional diabetes therapies. For instance, cinnamon or berberine, when taken along with insulin or oral antidiabetic drugs like metformin may improve blood sugar control and insulin sensitivity (Blevins et al., 2007; Guo et al., 2021). Such a combination is expected to allow for a lower dose of pharmaceutical medications with a lower potential for side effects leading to effective glycemic control.

Lifestyle modifications, such as an improved diet and regular physical activity, contribute to diabetes management as much as herbal remedies. Herbal therapies can be added to these lifestyle changes and greatly augment their effects. Fenugreek combination with proper diet modifications seems to improve insulin sensitivity and reduce blood glucose levels (Kim et al., 2023). Such integrative approaches deal with more than just insulin resistance and inflammation: they approach the disease in an integrated way addressing many aspects of diabetes.

The effectiveness and safety of the therapeutic regimen can be monitored by monitoring blood sugar levels during combined treatment. Since herbal and conventional treatments can not only interact but also work synergistically for blood glucose control, it is important to keep a close track of blood glucose, as regular blood glucose testing helps prevent hypoglycemia and other herb-drug interactions (Allen et al., 2013). Patients should pay attention to any newfound or worsening symptoms as they may be signs of an adverse reaction to the herb when used with conventional treatments while on more than one medication.

## **Preventing Diabetes with Herbs**

Prevention of diabetes is one role that herbal remedies have to play and in people with prediabetes or those at risk of metabolic syndrome. Cinnamon, bitter melon, and fenugreek have also been found to reduce progression from prediabetes to type 2 diabetes by improving insulin sensitivity and lowering blood glucose levels (Blevins et al., 2007; Kooti et al., 2016). They can also help to moderate glucose metabolism to avoid prediabetic conditions and insulin resistance.

Herbs can also help your body in weight management, which is a big part of combating type 2 diabetes, specifically. Herbal remedies like

*Garcinia cambogia* and green tea extract are often used to promote weight loss or to decrease fat (Payab et al., 2018). The direct effect of weight loss lowers insulin resistance increases insulin sensitivity and reduces diabetes risk (Franz, 2017).

## **Complications of Diabetes and Herbal Solutions**

Herbal remedies have been looked at for the potential treatment of diabetes complications of neuropathy, retinopathy, and nephropathy. Studies have also shown that herbs such as turmeric (containing curcumin) and ginseng are helpful in the reduction of inflammation and oxidative stress in diabetic patients to manage the diabetic neuropathy (Yuan et al., 2012). The evidence suggests that antioxidants, such as vitamin E and grape seed, promote an improvement in blood flow, and decrease retinal cell damage from oxidative damage in retinopathy (Alfonso-Muñoz et al., 2021).

#### **Emerging Research and Innovations**

Research in herbal medicine for diabetes is still in the stage of research that is, obtaining the novel analysis of herbs with anti-diabetic potential while ensuring the extraction and formulation of herbal products. New studies are now evaluating how pomegranate, moringa, and ashwagandha reduce blood glucose and improve insulin function (Sriraman et al., 2023). As their novel mechanisms of action and ability to target multiple branches of the diabetes road map are attracting attention to these herbs.

Increasing development of extraction and formulation technologies has made herbal treatment more bioavailable and efficacious. For example, techniques like nanotechnology and liposomal encapsulation enhance herb's active compounds absorption, for example berberine and cinnamon (Wang et al., 2023).

## Advocacy and Awareness

Saving communities from unsafe use of herbal remedies for diabetes is extremely important to provide effective and safe treatment. Herbs can be used by the public and especially individuals to reduce risk of disease, promote good health, treat symptoms of disease, and increase longevity, but this can be done through public health campaigns and community outreach programs that help to increase awareness of the benefits and risks of using herbs as well as accurate information about proper dosages, potential interactions with pharmaceuticals and side effects (Kumar et al., 2020).

Herbal treatments are regarded as safe and effective means of treatment by patients, however healthcare professionals act as important supporting role to guide patients in the best direction. They should present evidence based recommendations, and follow up with monitoring of outcomes of combined herbal and conventional treatments to prevent unfavorable results and side effects (Gong et al., 2024).

### **Future Directions**

Presenting herbal treatment for diabetes at a bridging moment between traditional medicine and modern science could define the future of herbal treatments for diabetes. In the last few hundred years, traditional medicine also used herbs to treat diabetes, but modern science can give the evidence that proves and optimizes these herbal treatments. To establish scientifically backed frames, the collaborations between scientists and traditional healers are important to be built. Such partnerships can result in a more integrative approach to managing diabetes, and help result in better, safer, and more effective therapies (Coopoosamy et al., 2023).

Going forward, herbal treatments for diabetes will only be useful to the extent that those two worlds can be bridged. SciHerbal Collaboration will establish partnerships between herbalists and scientists to develop clinically proven, standardized herbal drugs to be integrated into mainstream health care (DiSanto et al., 2015). Promotion and research on herbal treatments rely on public and private sector investment. Further research will be carried out into herb based therapeutic potential, better extraction techniques, standardized products, and will advance to better treatments for diabetes and its complications (Gupta et al., 2023).

Further work is in developing clinically validated, standardized herbal drugs. Although many herbal remedies are promising, the quality and efficacy of many herbal remedies vary across plant composition and preparation methods. By standardizing these herbs through rigorous clinical trials, in controlled environments, and by use of modern phytochemical analysis, we will get more reliable outcomes (Baker et al., 2020). Lack of pharmacologically tested herbal formulations also makes it difficult to overcome current limitation in dosage accuracy, bioavailability and safety, thereby making them unsuitable for widespread clinical use.

## Conclusion

The historical implications and new scientific backing of herbal medicines for diabetes are explored. The use of Bitter Melon, Fenugreek, Cinnamon, and other herbs appears promising because they may promote insulin sensitivity and glucose metabolism, but their integration into 'standard' diabetes care should be approached cautiously. Nevertheless, challenges of standardization, safety, efficacy, and regulatory approval continue to be strong. The future direction for research is to bridge the gap between what is done traditionally with plants and what is acceptable in modern medicine for safer, effective, and reliable herbal treatments in diabetes therapy.

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