



# Herbal Plants for Diabetes Treatment: A Comprehensive Review of Pharmacological and Phytochemical Properties

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## Abstract

Herbal plants have been used for centuries in the treatment of diabetes, and modern scientific studies have confirmed their potential antidiabetic properties. These plants contain various bioactive compounds that exhibit antidiabetic activity through different mechanisms of action. Preclinical and clinical studies have shown promising results in the antidiabetic effects of these plants, with some showing comparable or even superior efficacy compared to standard diabetes medications. However, herbal plants can also pose potential adverse effects and drug interactions, especially when used in combination with other medications. Therefore, it is important to minimize risks by consulting with a healthcare professional before starting any herbal treatment and monitoring blood glucose levels regularly. Future research should focus on investigating the synergistic effects of multiple compounds in herbal plants, exploring novel compounds for diabetes treatment, and conducting larger, well-designed clinical trials to establish their safety and efficacy. Collaborative efforts between traditional medicine practitioners, pharmacologists, and clinicians can help bridge the gap between traditional and modern medicine and improve patient outcomes. Integrating herbal medicine into conventional diabetes management plans can offer a holistic and personalized approach to diabetes care. In summary, herbal plants provide a promising alternative or complementary approach to standard diabetes treatment, but further research is needed to fully understand their mechanisms of action and ensure their safety and efficacy.

**Keywords:** antidiabetic, herbal, Pharmacological, Phytochemical.

## I. Introduction

### Brief overview of diabetes and its prevalence

Diabetes is a chronic metabolic disorder characterized by high blood sugar levels resulting from inadequate insulin production or impaired insulin action. Insulin is a hormone produced by the pancreas that regulates blood sugar levels by facilitating the uptake and utilization of glucose by the body's cells. In people with diabetes, the body either cannot produce enough insulin or cannot effectively use the insulin produced, resulting in hyperglycemia (high blood sugar levels). Diabetes is a major public health concern, affecting over 400 million people worldwide, with a projected increase to 700 million by 2045. According to the International Diabetes Federation, diabetes caused 4.2 million deaths in 2019 alone. In the United States, 34.2 million people (10.5% of the population) have diabetes, with an estimated 7.3 million undiagnosed cases.[1]

There are two main types of diabetes: type 1 diabetes and type 2 diabetes. Type 1 diabetes is an autoimmune disease



in which the body's immune system attacks and destroys the insulin-producing beta cells in the pancreas. Type 1 diabetes typically develops in childhood or adolescence, and people with type 1 diabetes require lifelong insulin therapy. Type 2 diabetes is the most common form of diabetes, accounting for 90-95% of all cases. Type 2 diabetes typically develops in adulthood and is often associated with obesity, physical inactivity, and poor dietary habits.[2]

Other less common types of diabetes include gestational diabetes, which develops during pregnancy, and monogenic diabetes, which is caused by mutations in a single gene. The complications of diabetes can be severe and include cardiovascular disease, kidney disease, nerve damage, blindness, and lower limb amputations. The risk of developing these complications can be reduced by maintaining good bloodsugar control and managing other risk factors such as high blood pressure and high cholesterol. The management of diabetes involves a combination of lifestyle changes, medication, and monitoring. Lifestyle changes include maintaining a healthy diet, engaging in regular physical activity, and maintaining a healthy weight. Medications for diabetes include insulin, oral hypoglycemic agents, and other injectable medications such as GLP-1 agonists and SGLT2 inhibitors. Monitoring involves regular blood sugar testing and monitoring of other health parameters such as blood pressure and cholesterol levels.[3,4]

Despite the availability of effective treatments for diabetes, many people still struggle to achieve good blood sugar control. This has led to an increased interest in complementary and alternative therapies, including herbal plants, for the management of diabetes. While some herbal plants have been found to have antidiabetic activity, their safety and effectiveness need to be evaluated through rigorous scientific studies before they can be recommended for routine use in the management of diabetes.[5]

### **Importance of exploring herbal plants for diabetes treatment**

Exploring herbal plants for diabetes treatment is important for several reasons.

Firstly, diabetes is a chronic condition that requires lifelong management. While conventional medications such as insulin and oral hypoglycemic agents are effective in controlling blood sugar levels, they can also have side effects and may not be suitable for all individuals. Therefore, exploring alternative treatments such as herbal plants can provide more options for individuals with diabetes to manage their condition.[6]

Secondly, herbal plants have been used for centuries in traditional medicine for the treatment of various ailments, including diabetes. These plants contain bioactive compounds that have been shown to have antidiabetic properties. By studying these compounds and their mechanisms of action, researchers can develop new therapies for diabetes that are safer, more effective, and more affordable than existing treatments.[7]

Thirdly, herbal plants may offer a more holistic approach to diabetes management by addressing not only blood sugar levels but also other health parameters such as inflammation, oxidative stress, and lipid metabolism. For example, some herbal plants have been shown to have anti-inflammatory and antioxidant properties, which may help reduce the risk of diabetes-related complications such as cardiovascular disease.[8]

Finally, exploring herbal plants for diabetes treatment can contribute to the growing field of personalized medicine.



Different individuals may respond differently to conventional medications, and some may experience adverse effects. By identifying which herbal plants are most effective for different subgroups of individuals with diabetes, healthcare providers can tailor treatment plans to each individual's specific needs and preferences.[9,10]

Overall, exploring herbal plants for diabetes treatment is important for expanding treatment options, developing new therapies, addressing multiple health parameters, and personalizing treatment plans for individuals with diabetes. However, it is important to conduct rigorous scientific studies to evaluate the safety and effectiveness of herbal plants before recommending them for routine use in the management of diabetes.[11]

## **II. Pharmacological Properties of Herbal Plants for Diabetes Treatment Antidiabetic activity of herbal plants**

Many plants are rich sources of bioactive compounds with specific pharmacological properties, and they do not cause undesirable side effects [12,13]. For many years, the communities of developing countries have placed high hopes on these plant treatments, and the use of cheap medicinal plants instead of drugs to treat diabetes is common there. At present, developed countries are also more inclined to adopt such solutions.

Medicinal plants contain various phytoconstituents (e.g., terpenoids, saponins, flavonoids, carotenoids, alkaloids, glycosides) with antidiabetic activity [14,15,16]. The complex plant matrix is a carrier of many phytoconstituents, which determines the specific interaction of these compounds; this is, however, difficult to reproduce and brings health benefits [17]. Chan et al. [18] noted in their work that antidiabetic ingredients are definitely most frequently found in leaves (more than 35% of the analyzed plants), while in other morphological elements are 3 times less frequent (about 10% each).[19]

Alteration of glucose metabolism: inhibition of renal reabsorption of glucose [20], inhibition of  $\beta$ -galactosidase [21], inhibition of  $\beta$ -glucosidase [22], inhibition of  $\alpha$ -amylase [23], glycogenesis stimulation [24], hepatic glycolysis stimulation [24], starch conversion to glucose inhibited;

### **Hypolipidemic effect: lipid peroxidation decrease [25];**

Pancreatic effect: effect of regeneration/repairing of  $\beta$ -cells [25], protective effect on  $\beta$ -cells [26], effect of increasing number and/or size of cells in Langerhans islets, insulin resistance reduction [27], insulin secretion stimulation [28], inhibition of degradative processes of insulin [29];

Antioxidative effect: protection against the effects of oxidative stress responsible for  $\beta$ -cell dysfunction [30] by scavenging free radicals, reducing  $H_2O_2$  formation, inhibition of ROS production, modulation of enzymes (cyclooxygenase, microsomal monooxygenase, NADH oxidase, xanthine oxidase, lipoxygenase, succinoxidase) [39], regulation of antioxidant:oxidant balance in cells [31], induction of enzymes (glutathione peroxidase, catalase, superoxide dismutase) [32], improvement of antioxidant capacity in plasma [33];

Diabetes complication treatment: inhibition of pro-inflammatory pathway of  $NF-\kappa\beta$ , resulting in vascular complications;

### **Insulin-like effect.**

Alteration of glucose metabolism is the most common one. The use of medicinal plants based on this most common scheme is mainly based on supporting pancreatic function—increasing insulin secretion or decreasing intestinal glucose uptake [34].

Therefore, inhibitors that interfere with digestive enzymes, which are responsible for the hydrolysis and absorption of macromolecules, are important. The problems with the maintenance of normal glycaemia can be reduced by inhibition of enzymes digesting carbohydrates: pancreatic  $\alpha$ -amylase (breakdown of polysaccharides to oligosaccharides and disaccharides) and brush border  $\alpha$ -glucosidase (breakdown to monosaccharides) [34]. Some studies suggest that the most significant natural inhibitors, due to their presence in many antidiabetic plants, are terpenes, saponins, and polyphenols. The literature presents many medicinal plants with antidiabetic or antihyperglycaemic activity, used in different regions of the world. Recently, Salehi et al. [12] indicated 703 plants as being  $\alpha$ -amylase and/or  $\alpha$ -glucosidase inhibitors and most often discussed in the literature.

### **Mechanisms of action**

Herbal plants have been traditionally used for treating various ailments including diabetes. Several studies have shown that some of these plants possess potent antidiabetic properties. The antidiabetic activity of these plants can be attributed to their various bioactive compounds that act through different mechanisms of action. In this section, we will discuss some of the mechanisms of action of herbal plants that contribute to their antidiabetic activity.[35]

1. **Insulin secretion:** Some herbal plants have been shown to stimulate insulin secretion from pancreatic beta cells. For example, *Gymnema sylvestre* has been found to increase insulin secretion by promoting regeneration of beta cells and enhancing their function. Similarly, bitter melon (*Momordica charantia*) has been shown to stimulate insulin secretion through activation of AMP-activated protein kinase (AMPK) and peroxisome proliferator-activated receptor (PPAR) gamma pathways.[36]
2. **Insulin sensitivity:** Insulin resistance is a hallmark feature of type 2 diabetes. Herbal plants such as berberine and curcumin have been shown to improve insulin sensitivity by activating the insulin signaling pathway. Berberine, for instance, activates the AMPK pathway, which enhances glucose uptake and utilization in skeletal muscle and liver. Similarly, curcumin activates the insulin receptor substrate-1 (IRS-1) pathway, which increases insulin sensitivity.[37]
3. **Glucose uptake:** Some herbal plants have been shown to increase glucose uptake by skeletal muscle cells and adipocytes. For example, cinnamon (*Cinnamomum cassia*) has been found to increase glucose uptake by activating the insulin signaling pathway and enhancing translocation of glucose transporter type 4 (GLUT4) to the plasma membrane.[37]
4. **Inhibition of carbohydrate digestion and absorption:** Herbal plants such as fenugreek (*Trigonella foenum-graecum*) and *Salacia reticulata* have been shown to inhibit carbohydrate digestion and absorption, leading to a reduction in postprandial glucose levels. Fenugreek seeds contain soluble fiber and galactomannan, which delay gastric emptying and reduce carbohydrate absorption. *Salacia reticulata* contains alpha-glucosidase inhibitors, which prevent the breakdown of complex carbohydrates into simple sugars and reduce their absorption.[38]

5. Antioxidant and anti-inflammatory activity: Oxidative stress and inflammation play important roles in the pathogenesis of diabetes and its complications. Some herbal plants possess potent antioxidant and anti-inflammatory properties, which can help mitigate these effects. For example, curcumin has been found to reduce oxidative stress and inflammation by suppressing the activity of nuclear factor-kappa B (NF-kB) and activating the nuclear factor erythroid 2-related factor 2 (Nrf2) pathway.[39,40]

In summary, herbal plants exert their antidiabetic activity through various mechanisms, including insulin secretion, insulin sensitivity, glucose uptake, inhibition of carbohydrate digestion and absorption, and antioxidant and anti-inflammatory activity. Understanding these mechanisms can help identify new targets for the development of antidiabetic agents based on herbal plants.

### **Effectiveness of herbal plants compared to standard diabetes medications**

Diabetes is a chronic metabolic disorder that requires long-term management to prevent complications. Standard diabetes medications are effective in managing blood glucose levels, but they may have side effects such as hypoglycemia, weight gain, and gastrointestinal problems. Herbal plants have been used for centuries in traditional medicine to treat diabetes and may offer an alternative or complementary approach to standard diabetes medications. In recent years, there has been increasing interest in exploring the effectiveness of herbal plants for diabetes treatment.[41,42]

Several studies have investigated the effectiveness of herbal plants in managing blood glucose levels in people with diabetes. For example, one study found that mulberry leaf extract improved blood glucose levels and restored arterial pressure in rats with diabetes (Naowaboot et al., 2009). Another study found that *Sutherlandia frutescens*, a traditional South African medicinal plant, had antidiabetic and antioxidant properties in a type 2 diabetes model (Oyenihni et al., 2016). Additionally, *nigella sativa* seed extract was found to have antidiabetic effects in diabetic obese rats (Hasan et al., 2015).[41,42,43]

Berberine, a plant alkaloid found in various herbs such as goldenseal, barberry, and Oregon grape, has been extensively studied for its antidiabetic properties. One study found that berberine improved glucose metabolism and insulin sensitivity in patients with type 2 diabetes (Yin et al., 2008). Another study found that berberine reduced hemoglobin A1c (HbA1c) levels, a marker of long-term blood glucose control, in patients with type 2 diabetes (Zhang et al., 2010).[44,45]

Several meta-analyses have also evaluated the effectiveness of herbal plants for diabetes management. For example, a meta-analysis of 17 randomized controlled trials found that cinnamon supplementation improved fasting blood glucose levels and HbA1c levels in patients with type 2 diabetes (Allen et al., 2013). Another meta-analysis of 16 randomized controlled trials found that ginseng supplementation improved fasting blood glucose levels and HbA1c levels in patients with type 2 diabetes (Shishtar et al., 2014).[46,47]

While herbal plants have shown promising results in managing blood glucose levels in people with diabetes, it is important to note that the quality and quantity of evidence is generally lower than that for standard diabetes medications. Additionally, herbal plants may interact with other medications, and their safety and effectiveness may vary depending on the plant species, dosage, and preparation method.[48]

In conclusion, herbal plants have shown potential as alternative or complementary treatments for diabetes



management. However, more research is needed to determine their safety and efficacy, as well as their optimal dosage and preparation methods. People with diabetes should consult with their healthcare providers before using herbal plants as a diabetes treatment. Additionally, herbal plants should not be used as a substitute for standard diabetes medications without medical supervision.[49]

### **III. Phytochemical Properties of Herbal Plants for Diabetes Treatment** **Identification and characterization of bioactive compounds**

The identification and characterization of bioactive compounds present in herbal plants is essential for understanding their potential therapeutic effects in treating diabetes. Phytochemical analysis involves the identification and quantification of chemical constituents present in plants, including alkaloids, flavonoids, terpenoids, and phenolic compounds, among others. These compounds have been shown to possess antidiabetic properties and are believed to contribute to the overall therapeutic effects of herbal plants.

Alkaloids are nitrogen-containing compounds found in many herbal plants and have been shown to possess antidiabetic properties. Berberine, a plant alkaloid found in various plants, including *Berberis aristata* and *Coptis chinensis*, has been extensively studied for its antidiabetic effects. Berberine has been shown to improve glucose metabolism, increase insulin sensitivity, and reduce fasting blood glucose levels in patients with type 2 diabetes.[50]

Flavonoids are polyphenolic compounds found in many herbal plants, including onion, garlic, and green tea. Flavonoids possess antioxidant and anti-inflammatory properties and have been shown to improve insulin sensitivity and reduce blood glucose levels in animal and human studies.[51] Quercetin, a flavonoid found in many plants, including onion and apples, has been shown to possess antidiabetic effects by improving glucose uptake and reducing insulin resistance.[52]

Terpenoids are a diverse class of compounds found in many herbal plants, including ginseng and ginger. Terpenoids have been shown to possess antidiabetic properties by improving insulin sensitivity and reducing oxidative stress.[53] One example is ginsenosides, the major active components of ginseng, which have been shown to possess antidiabetic effects by improving insulin secretion and sensitivity.[54]

Phenolic compounds are a group of aromatic compounds found in many plants, including cinnamon and blueberries. Phenolic compounds have been shown to possess antioxidant and anti-inflammatory properties and improve insulin sensitivity and glucose uptake. Cinnamon, for example, contains several phenolic compounds that have been shown to improve insulin sensitivity and reduce blood glucose levels in animal and human studies.[55]

Overall, the identification and characterization of bioactive compounds in herbal plants is critical for understanding their potential therapeutic effects in treating diabetes. These compounds possess antidiabetic properties and contribute to the overall therapeutic effects of herbal plants.

#### **Synergistic effects of multiple compounds in herbal plants**

Herbal plants often contain a complex mixture of bioactive compounds that can work synergistically to produce a more significant antidiabetic effect than any individual compound alone. Synergy occurs when the combined effect of two or more compounds is greater than the sum of their individual effects.

One example of synergistic effects is found in the herbal combination of *Gymnema sylvestre* and *Eugenia jambolana*. *Gymnema sylvestre* contains gymnemic acid, which has been shown to reduce blood glucose levels by inhibiting



glucose absorption in the intestine and stimulating insulin secretion. Eugenia jambolana contains iamboline, a compound that can stimulate insulin secretion and reduce glucose absorption. When used together, these two plants have been shown to produce a greater antidiabetic effect than when used separately.[56]

Another example is the synergistic effect of resveratrol and quercetin, two polyphenolic compounds found in many plants, including grapes and onions. Resveratrol and quercetin have been shown to possess antioxidant and anti-inflammatory properties and improve insulin sensitivity. When used together, these compounds have been shown to produce a greater antidiabetic effect than when used alone.[57]

Additionally, synergistic effects have been observed in the combination of berberine and curcumin, two compounds found in many plants, including Berberis aristata and Curcuma longa, respectively. Berberine and curcumin have been shown to possess antidiabetic effects by improving insulin sensitivity and reducing inflammation. When used together, these compounds have been shown to produce a greater antidiabetic effect than when used alone.[58]

Overall, the synergistic effects of multiple compounds in herbal plants can produce a more significant antidiabetic effect than any individual compound alone. The combination of bioactive compounds found in herbal plants can work together to improve insulin sensitivity, reduce glucose absorption, and reduce inflammation, among other effects.

### Exploration of novel compounds for diabetes treatment

Diabetes is a chronic metabolic disorder characterized by high levels of blood glucose due to insulin resistance, insufficient insulin secretion, or both. The increasing prevalence of diabetes worldwide and the side effects of currently available treatments have led to the exploration of alternative therapies, including herbal medicines. Plants are a rich source of bioactive compounds that can be used to treat diabetes. However, the search for new and more effective natural products is ongoing.

#### Exploration of Novel Compounds for Diabetes Treatment:

Several studies have identified novel compounds from various plants with antidiabetic properties. These compounds may act by various mechanisms, such as enhancing insulin secretion, improving insulin sensitivity, inhibiting carbohydrate digestion, and reducing oxidative stress. Some of the compounds and their sources are listed below:

1. Saponins: Saponins are glycosides that have been identified in several plant species, such as ginseng, fenugreek, and bitter melon. They have been shown to reduce blood glucose levels by increasing insulin secretion, improving insulin sensitivity, and inhibiting glucose absorption in the intestine.[59]

Herbal Plant	Traditional Uses	Evidence from Preclinical Studies	Evidence from Clinical Studies
Gymnema Sylvestre[64]	Treat diabetes, reduce blood sugar levels	Improve insulin sensitivity, reduce blood glucose levels	Improve glucose control, reduce HbA1c levels, protect kidneys
Fenugreek[64]	Treat diabetes, reduce blood sugar levels	Improve insulin sensitivity, reduce blood glucose levels	Improve glucose control, reduce HbA1c levels, lower cholesterol levels
Cinnamon[65]	Treat diabetes, lower blood sugar levels	Improve insulin sensitivity, reduce blood glucose levels	Improve glucose control, reduce HbA1c levels, lower cholesterol



			levels
Bitter Melon[66]	Treat diabetes, lower blood sugar levels	Improve glucose uptake, improve insulin sensitivity	Improve glucose control, reduce HbA1c levels
Ginger[67]	Treat diabetes, reduce blood sugar levels	Improve insulin sensitivity, reduce oxidative stress	Improve glucose control, reduce HbA1c levels
Aloe Vera[68]	Treat diabetes, lower blood sugar levels	Improve insulin sensitivity, reduce oxidative stress	Improve glucose control, reduce HbA1c levels, protect liver
Indian Gooseberry[69]	Treat diabetes, reduce blood sugar levels	Improve glucose uptake, improve insulin sensitivity	Improve glucose control, reduce HbA1c levels
Ginseng[70]	Treat diabetes, improve glucose control	Improve insulin sensitivity, reduce blood glucose levels	Improve glucose control, reduce HbA1c levels, lower cholesterol levels

2. **Flavonoids:** Flavonoids are polyphenolic compounds that have been identified in various plants, such as onions, blueberries, and grapes. They have been shown to reduce blood glucose levels by improving insulin sensitivity, increasing glucose uptake in skeletal muscle, and reducing oxidative stress.[60]
3. **Alkaloids:** Alkaloids are nitrogen-containing compounds that have been identified in several plant species, such as berberine from *Berberis aristata* and *Catharanthus roseus*. They have been shown to improve insulin sensitivity, reduce blood glucose levels, and protect against diabetic complications.[61]
4. **Polysaccharides:** Polysaccharides are complex carbohydrates that have been identified in several plant species, such as *Astragalus membranaceus* and *Ganoderma lucidum*. They have been shown to reduce blood glucose levels by improving insulin sensitivity and increasing glucose uptake in skeletal muscle.[62]
5. **Terpenoids:** Terpenoids are a diverse group of compounds that have been identified in various plants, such as ginseng, fenugreek, and cinnamon. They have been shown to reduce blood glucose levels by enhancing insulin secretion, improving insulin sensitivity, and inhibiting carbohydrate digestion.[63]

#### IV. Herbal Plants with Antidiabetic Activity

Herbal plants have been used for centuries in traditional medicine to treat various ailments, including diabetes. The increasing prevalence of diabetes worldwide and the side effects of currently available treatments have led to the exploration of alternative therapies, including herbal medicines. Several herbal plants have been identified with antidiabetic properties, and their traditional uses have been validated by modern scientific studies.

#### Review of commonly used herbal plants for diabetes treatment

##### Traditional and modern uses of herbal plants

Herbal plants have been used for centuries in traditional medicine to treat various ailments, including diabetes. In many cultures, herbal remedies have been passed down from generation to generation as a way of maintaining health and treating diseases. The traditional use of herbal plants for diabetes treatment has been validated by modern scientific studies.[71]

In traditional medicine, the use of herbal plants for diabetes treatment often involves the use of whole plants or plant





extracts. For example, in Ayurvedic medicine, *Gymnema sylvestre*, also known as gurmar, has been traditionally used to treat diabetes. The leaves of the plant are chewed, and it is believed to help control blood sugar levels. Similarly, in traditional Chinese medicine, various herbal plants are used to treat diabetes, including ginseng, aloe vera, and bitter melon.[72]

In modern medicine, herbal plants are often used in the form of dietary supplements or herbal medicines. These products are often standardized to contain specific amounts of active compounds, which allows for greater consistency in dosing. For example, fenugreek supplements are available in the form of capsules or tablets, and they are often standardized to contain a specific amount of the active compound, trigonelline.[73]

While the traditional and modern uses of herbal plants for diabetes treatment differ in some respects, both approaches rely on the same principles. The active compounds in herbal plants are believed to work together to produce beneficial effects, and they are often used in combination with other therapies, such as lifestyle modifications and conventional medications. The use of herbal plants in diabetes treatment should always be done under the guidance of a healthcare professional, and patients should be aware of the potential risks and benefits associated with their use.[74]

**Table: Evidence from preclinical and clinical studies**

Herbal plant	Type of study	Results	References
<i>Gymnema sylvestre</i>	Clinical	Reduced fasting blood glucose levels in diabetics	Baskaran et al., 1990.[75]
<i>Coccinia indica</i>	Preclinical	Increased glucose uptake in liver cells	Grover et al., 2000 [76]
<i>Momordica charantia</i>	Clinical	Reduced HbA1c levels in diabetics	Dans et al., 2007 [77]
<i>Trigonella foenum</i>	Clinical	Reduced fasting blood glucose levels in diabetics	Gupta et al., 2001[78]
<i>Allium sativum</i>	Clinical	Reduced fasting blood glucose levels in diabetics	Ashraf et al., 2005[79]
<i>Curcuma longa</i>	Preclinical	Improved insulin sensitivity in liver cells	Seo et al., 2008[80]
<i>Ocimum sanctum</i>	Preclinical	Increased insulin secretion in pancreas cells	Subramanian et al. 2013[81]
<i>Panax ginseng</i>	Clinical	Improved insulin sensitivity in diabetics	Vuksan et al., 2000[82]
<i>Berberis vulgaris</i>	Preclinical	Improved glucose uptake in muscle cells	Rashedinia et al., 2013[83]
<i>Salacia oblonga</i>	Clinical	Reduced postprandial glucose levels in diabetics	Jayawardena et al., 2005[84]



### **Safety and Adverse Effects of Herbal Plants for Diabetes Treatment**

Adverse effects and interactions of herbal plants for diabetes treatment are important to consider, as some herbal remedies can cause harmful effects or interact with prescription medications. Here are some examples of potential adverse effects and interactions, as well as strategies to minimize risks:

1. Hypoglycemia: Some herbal plants, such as bitter melon and fenugreek, have hypoglycemic effects, meaning they lower blood sugar levels. While this can be beneficial for individuals with diabetes, it can also cause hypoglycemia if blood sugar levels drop too low. Symptoms of hypoglycemia include sweating, shakiness, dizziness, and confusion. To minimize this risk, it is important for individuals with diabetes to monitor their blood sugar levels closely and consult with their healthcare provider before adding any herbal remedies to their treatment plan.[85]
2. Drug interactions: Herbal plants can interact with prescription medications, either by enhancing or inhibiting their effects. For example, ginseng can increase the effects of warfarin, a blood-thinning medication, and can also decrease the effectiveness of some diabetes medications. St. John's wort can interact with many medications, including antidepressants, birth control pills, and HIV/AIDS medications. To minimize this risk, it is important for individuals to disclose all medications and herbal remedies they are taking to their healthcare provider.[86]
3. Allergic reactions: Some individuals may be allergic to certain herbal plants, which can cause mild to severe allergic reactions. For example, chamomile can cause allergic reactions in individuals who are allergic to ragweed, while ginger can cause allergic reactions in individuals who are allergic to pollen. To minimize this risk, individuals should start with small doses of herbal remedies and watch for any signs of allergic reactions, such as itching, swelling, and difficulty breathing.[87]
4. Contamination: Herbal remedies are not regulated by the FDA, which means that the quality and purity of these products can vary widely. Some herbal remedies may be contaminated with heavy metals, pesticides, or other harmful substances. To minimize this risk, individuals should purchase herbal remedies from reputable sources and look for products that have been independently tested for purity and potency.[88,89]

In summary, while herbal plants can be a valuable addition to diabetes treatment, it is important to be aware of potential adverse effects and interactions. By working closely with a healthcare provider and taking steps to minimize risks, individuals can safely and effectively incorporate herbal remedies into their diabetes management plan.

### **VII. Conclusion**

#### **Summary of the pharmacological and phytochemical properties of herbal plants for diabetes treatment**

Herbal plants have been used for centuries in the treatment of diabetes, and modern scientific studies have confirmed their potential antidiabetic properties. These plants contain various bioactive compounds, including polyphenols, alkaloids, flavonoids, terpenoids, and glycosides, that exhibit antidiabetic activity through different mechanisms of action, such as enhancing insulin secretion, increasing insulin sensitivity, inhibiting carbohydrate absorption, and reducing oxidative stress and inflammation.



Some commonly used herbal plants for diabetes treatment include *Gymnema sylvestre*, *Momordica charantia*, *Trigonella foenum-graecum*, *Allium cepa*, *Allium sativum*, *Cinnamomum cassia*, and *Ocimum sanctum*. Preclinical and clinical studies have shown promising results in the antidiabetic effects of these plants, with some showing comparable or even superior efficacy compared to standard diabetes medications.

However, it is important to note that herbal plants can also pose potential adverse effects and drug interactions, especially when used in combination with other medications. Strategies to minimize risks include consulting with a healthcare professional before starting any herbal treatment, avoiding high doses, and monitoring blood glucose levels regularly.

Overall, herbal plants provide a promising alternative or complementary approach to standard diabetes treatment, but further research is needed to fully understand their mechanisms of action and ensure their safety and efficacy.

#### **Future directions for research and clinical practice**

Despite the promising results of preclinical and clinical studies on the antidiabetic properties of herbal plants, there is still much to learn about their mechanisms of action, optimal dosages, and potential side effects. Future research should focus on investigating the synergistic effects of multiple compounds in herbal plants, exploring novel compounds for diabetes treatment, and conducting larger, well-designed clinical trials to establish their safety and efficacy.

In addition, there is a need for standardized protocols for the identification and characterization of bioactive compounds in herbal plants, as well as for quality control measures to ensure their purity and consistency. Collaborative efforts between traditional medicine practitioners, pharmacologists, and clinicians can help bridge the gap between traditional and modern medicine and improve patient outcomes.

In terms of clinical practice, healthcare professionals should be knowledgeable about the potential benefits and risks of herbal plants for diabetes treatment and be able to provide evidence-based recommendations to their patients. Integrating herbal medicine into conventional diabetes management plans can offer a holistic and personalized approach to diabetes care.

In summary, further research is needed to fully understand the potential of herbal plants for diabetes treatment and to establish their safety and efficacy. Collaborative efforts and evidence-based recommendations can help integrate herbal medicine into conventional diabetes management plans and provide patients with a more personalized approach to diabetes care.

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#### **Conflict of interest**

The Authors declare no conflict of interest

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