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## Review: Some Herbal Medicinal Plant Used in Management Diabetes Mellitus

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### Abstract

High levels of sugar in the blood caused by elevated levels of insulin or insufficiency are a hallmark of diabetes mellitus, a chronic metabolic condition that affects millions of individuals worldwide. Diabetes typically requires long-term use of synthetic drugs, which may lead to complications and negative outcomes. Interest in the use of plant-based medications has increased since they are believed to be safer, cost-effective, and more effective than alternative options. Research is now being conducted on the potential therapeutic applications of numerous medicinal plants which have been extensively used for decades in conventional treatments for treating and controlling diabetes. Numerous plants are thought to have chemicals that can boost overall metabolic function, enhance insulin sensitivity, and assist control blood glucose levels. “These plants work in a number of ways, including as encouraging the release of insulin, enhancing the cells' ability to absorb glucose, and inhibiting the enzymes responsible for breaking down carbohydrates. Among the bioactive compounds included in these plants that support their antidiabetic effects are alkaloids, flavonoids, saponins, & polyphenols. The purpose of this study is to examine the use of plants used for medicinal purposes in the treatment of diabetes and to stress the significance of further research to completely comprehend their safety and effectiveness”. With the rising global prevalence of diabetes, plant-based treatments represent a promising complementary approach to conventional therapies, offering new hope in the management of this widespread condition.

**Keywords** - Traditional medicines, insulin, metabolic, alkaloids, flavonoids, Secretion.

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### INTRODUCTION

The chronic disease known as diabetes mellitus is characterized by elevated blood glucose levels. The underlying cause of this is the body's inability to produce adequate amounts of insulin as well as use it effectively. By promoting the absorption of glucose into cells for energy, the pancreatic hormone insulin helps control blood sugar levels. Hyperglycemia results from a disruption in this mechanism, which causes glucose to build up in the blood.<sup>[1]</sup>

A number of severe side effects, such as damage to the kidneys, nerve damage, cardiovascular illness, and vision issues, can result from persistently high blood sugar level. Diabetes affects billions of people globally and is on the rise, making it a major public health concern. It is often associated with several risk factors, such as poor diet, obesity, and a lack of activity but genetic susceptibility also plays a significant role. Successful oversight of diabetes requires blood glucose monitoring, lifestyle modifications, and possibly insulin therapy or medication. Early detection and appropriate treatment are crucial for lowering complications and improving the good quality of life for those who have diabetes.<sup>[2]</sup>

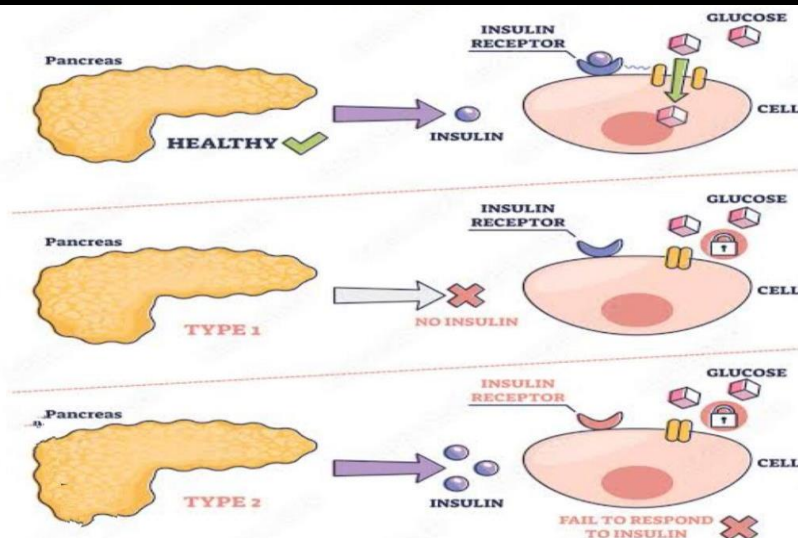


Figure 1: Diabetes Mellitus

**Categories for diabetes mellitus**

Diabetes mellitus is a chronic disease that affects how well the body regulates glucose, or blood sugar. Glucose is the main fuel used by cells, and the hormone that act insulin, which is secreted by the pancreas, helps the cells absorb glucose through the circulatory system. In diabetes, either inadequate insulin synthesis or inappropriate insulin utilization leads to elevated blood sugar. There are several types of diabetes, each with unique causes and treatments.

Type 1 diabetes happens when an individual's immune system attacks the cells in the pancreas that make insulin, resulting in hardly any insulin being generated at all. Usually affecting infants or children, this type of diabetes requires daily insulin administration to regulate blood sugar levels. Type 2 diabetes is more common and is usually linked to lifestyle decisions including eating poorly, exercising infrequently, and being overweight. This type occurs when the body becomes resistant to insulin or when the pancreas manufactures insufficient amounts of it. The condition usually affects adults, but because of bad lifestyle choices, more and more young individuals are getting diagnosed. Diabetes type 2 can frequently be controlled with insulin therapy, oral medicines, and lifestyle modifications.<sup>[3]</sup>

**Gestational Diabetes**

Pregnant women with no prior history of diabetes may develop gestational diabetes. It is brought on by pregnancy-related hormonal changes that reduce the body's sensitivity to insulin. Despite the fact that gestational diabetes usually goes away after the baby is born, women who develop it are at an increased risk of developing type 2 diabetes later on. Other specific types of diabetes can result from genetic factors, certain medications, or other health conditions that affect insulin production or use.<sup>[4]</sup>

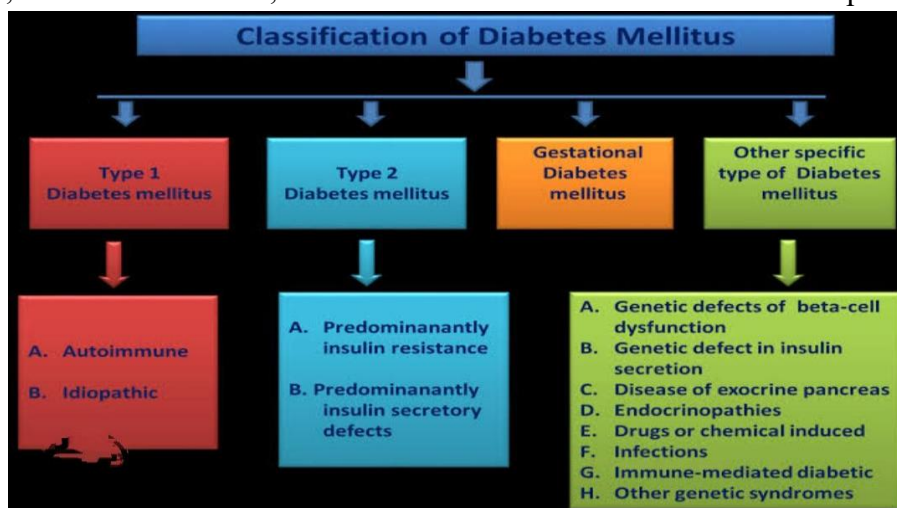


Figure 2: Classification of Diabetes

## Diabetes Mellitus Symptoms and Signs: Early Warning Symptoms

Prolonged hunger and thirst

Urinating frequently

Lethargy or fatigue

Visual impairment

Slowly healed injuries

Extremity tingling or numbness

### Advanced Symptoms

Unexplained weight loss

Recurring infections (skin, gum, or bladder)

Swelling in hands and feet

Confusion, dizziness, or shakiness

Rapid heartbeat

### Type 1 Diabetes Specific Symptoms

Symptoms that appear suddenly

Extreme urination and thirst

Loss of weight in spite of heightened hunger

Pain in the abdomen

Experiencing nausea and vomiting

### Type 2 Diabetes Specific Symptoms

Gradual onset of symptoms

Increased risk of infections

Dark, velvety skin patches

Erectile dysfunction (in men)

Polycystic ovary syndrome (PCOS) symptoms (in women)

### Gestational Diabetes Symptoms

An increase in urination and thirst

The weariness

A blurry eyesight

Retching and nausea

Pregnancy-related excessive thirst<sup>[5]</sup>

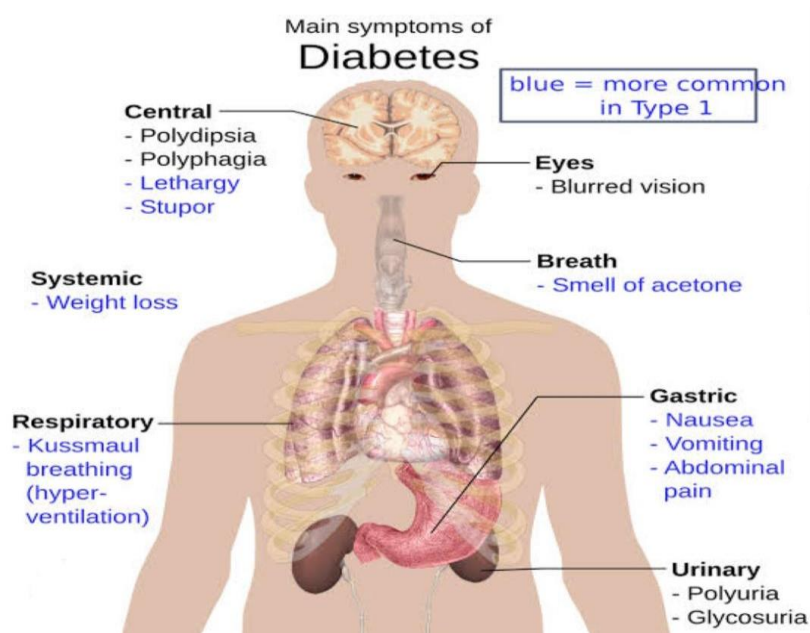


Figure 3: Symptoms of Diabetes Mellitus

### Management of Diabetes involves following components

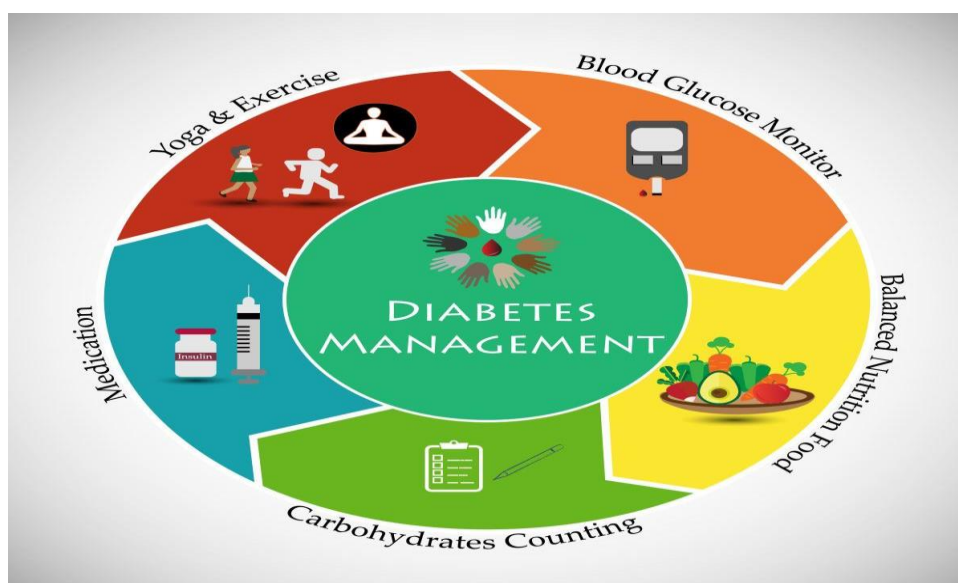
Throughout treatment, dietary changes and consistent exercise are essential for achieving and maintaining a healthy body weight, with modifications made as needed.

Strive to keep regular levels of blood sugar in order to avoid serious consequences brought on by elevated blood sugar.

Prevent long-term complications: Focus on delaying or preventing chronic issues such as microvascular (e.g., kidney, eye damage) and macrovascular (e.g., heart disease) complications.

Handle associated conditions: Take care of additional medical conditions including hypertension and excessive cholesterol, which frequently coexist with diabetes.

Adopt healthy lifestyle habits: Encourage positive changes like quitting smoking to improve overall health.<sup>[6]</sup>



*Figure 4: Diabetes Management*

### Treatment of Diabetes mellitus

#### Insulin therapy

Insulin therapy attempts to replicate the body's innate capacity to control blood sugar levels by preventing low plasma sugar in between meals and reducing post-meal hyperglycemia. For insulin injection to be both safe and effective, the location and technique are essential. Insulin can be given intravenously or intramuscularly. There are several different types of insulin, such as human, cow, and pork insulin. But there are hazards associated with insulin therapy. Common adverse effects include hypoglycemia and weight gain, especially when dosages are not appropriately matched with meal consumption. Weight gain is often a consequence of improved blood sugar control and a reduction in the energy lost through glycosuria, resulting in an increase in fat and muscle mass.

#### Oral hypoglycemic drugs

Oral hypoglycemic drugs like biguanides (like metformin) and sulfonylureas (like glibenclamide and glipizide) are substitutes for insulin therapy. Sulfonylureas work by promoting increased insulin secretion by the pancreatic  $\beta$ -cells. They bind to sulfonylurea receptors on the  $\beta$ -cell membrane, which closes ATP-sensitive potassium channels. Due to the membrane's depolarization, voltage-gated calcium channels open, causing stored insulin to be released. In those who have diabetes with type 2, sulfonylureas may potentially increase insulin levels by decreasing the liver's ability to remove it.<sup>[7]</sup> Biguanides, such as metformin, on the other hand, have an antihyperglycemic action without resulting in hypoglycemia. Metformin's main effect is to make the body more sensitive to insulin; it does not increase the release of insulin. It decreases the liver's synthesis of glucose by about 20–30% and

increases the absorption of glucose in peripheral tissues. Furthermore, a potential explanation for its efficacy has been proposed: reduced intestinal absorption of glucose.

### Herbal treatments for Diabetes

For ages, people have utilized herbal remedies to manage diabetes, and more recent studies have looked into how well they may work to control blood sugar levels. It has been demonstrated that a number of herbs and their extracts can lower blood sugar, increase insulin sensitivity, and provide protection against complications from diabetes. A summary of common medicinal plants used for diabetes management is given in the table. It contains information about the names of the plants, their active ingredients, and their therapeutic uses in regulating blood sugar levels. Many cultures have long used these natural remedies for their antidiabetic qualities, providing an alternative to conventional diabetes treatment methods [8]

Sr. No	Scientific Identity	Local Name	Family
1	<i>Withania Somnifera</i>	Ashwagandha	Solanaceae
2	<i>Momordica charantia</i>	Bitter guard	Cucurbitaceae
3	<i>Allium sativum</i>	Garlic	Liliaceae
4	<i>Trigonella foenum graceum</i>	Fenugreek	Fabaceae
5	<i>Azadirachta indica</i>	Neem	Meliaceae
6	<i>Bryophyllum pinnatum</i>	Panfuti	Crassulaceae
7	<i>Zingiber officinale</i>	Ginger	Zingiberaceae
8	<i>Ocimum sanctum</i>	Tulsi	Lamiaceae
9	<i>Aloe barbadensis</i>	Aloevera	Liliaceae
10	<i>Allium cepa</i>	Onion	Liliaceae
11	<i>Curcuma longa</i>	Turmeric	Zingiberaceae
12	<i>Annona squamosa</i>	Custard apple	Annonaceae
13	<i>Caesalpinia bonducella</i>	Physic-Nut	Caesalpiniaceae
14	<i>Eugenia jambolana</i>	Jambhul	Myrtaceae
15	<i>Mangifera indica</i>	Mango	Anacardiaceae

**Table 1:** Plant and their active constituents used in management of diabetes mellitus

### Ashwagandha

*Withania somnifera*, often known as ashwagandha, is a commonly used medicinal plant in Ayurvedic medicine that has long been used for a number of therapeutic purposes. It has recently attracted a lot of attention due to its potential application in the management of diabetes, particularly in the regulation of blood sugar levels. Bioactive substances present in the plant, including saponins,

alkaloids, and withanolides, have been shown to have anti-diabetic effects. *Withania somnifera* improves insulin sensitivity, which is one of the main ways it helps treat diabetes. According to scientific research, this plant's root extract strengthens the signaling of insulin pathways, which helps cells absorb glucose and improve blood sugar homeostasis. Furthermore, *Withania somnifera* is an adaptogen—a chemical that benefits the body.<sup>[9]</sup>

There is strong evidence from animal preclinical research that *Withania somnifera* has hypoglycemic effects, or the capacity to reduce blood glucose levels. Studies have indicated consuming an extract of *Withania somnifera* may successfully decrease glycated hemoglobin (HbA1c) and fasting blood glucose levels, two important indicators for managing diabetes. Furthermore, since oxidative stress and inflammation are major contributors to the development of diabetes problems, the plant's strong anti-inflammatory and antioxidant qualities enhance its therapeutic potential. *Withania somnifera* supplements have showed potential to enhance glycemic control in people with type 2 diabetes in human clinical trials. Ashwagandha's involvement in treating diabetes and related metabolic illnesses was established by a study that showed significant drops in cholesterol and blood sugar levels following treatment.<sup>[10]</sup>



**Figure 5:** *Withania Somnifera*

### **Momordica charantia**

Known by many as a bitter melon or a bitter gourd, *Momordica charantia* has long been used in traditional medicine, particularly in Asian and African countries, to treat a number of illnesses, including diabetes. Its potential as an alternative therapy for diabetes is supported by scientific investigations that have emphasized its hypoglycemia (blood sugar-lowering) properties. In several animal models, it has been demonstrated that pulp extracts from seedlings, fruits, leaves, and the entire plant impact glucose metabolism. When given subcutaneously to humans and langurs, the polypeptide p—which was extracted from the fruit, seeds, and tissue of *M. charantia*—showed a markedly hypoglycemic impact. *M. charantia* ethanol extracts (200 mg) demonstrated hypoglycemic and antihyperglycemic effects in both healthy and diabetic rats given streptozotocin, a stimulant drug. The reason for this could be because the liver suppresses glucose-6-phosphatase and stimulates hepatic the enzyme glucose-6- activities in along with fructose-1,6-bisphosphatase.<sup>[11]</sup>



*Figure 6: Momordica charantia*

### **Garlic**

Recent research has demonstrated the significant hypoglycemic effects of allicin, the active component of cloves of garlic, a perennial herb which is widely cultivated in India. Increased the production of insulin from pancreatic beta cells, improved hepatic metabolism, and insulin-sparing processes are thought to be the causes of allicin's blood sugar-lowering actions. It has been demonstrated that garlic extracts are useful in regulating blood sugar levels. When rabbits fed sucrose were given aqueous bulbs of garlic homogenization (10 ml/kg/day), for example, the amount of liver glycogen and free protein in their systems grew dramatically, while the levels of fasting blood sugar as well as cholesterol decreased. S-allyl cysteine sulfoxide (SACS), an amino acid rich in sulfur and the precursor to allicin, has also shown promise in the treatment of diabetes. SACS showed superior antioxidant properties when in contrast to insulin and glibenclamide. In vitro, SACS also increased the release of insulin from segregated rat beta cells.<sup>[12]</sup>



*Figure 7: Allium Sativum*

### **Trigonella foenum graecum**

A popular medicinal herb that may aid in the treatment of diabetes is Trigonella foenum-graecum, usually referred to as fenugreek. Because soluble fiber slows down the absorption of carbohydrates, fenugreek seeds are a great way to improve glycemic control. It is a well-liked option for diabetics because of its feature. According to a number of studies, the seeds of f have hypoglycemic qualities that assist lower blood sugar levels.<sup>[13]</sup>

It has been demonstrated that the active ingredients in fenugreek, including trigonelline, galactomannan, and 4-hydroxyisoleucine, improve insulin secretion and sensitivity. In particular, by stimulating the release of plasma hormones produced by pancreatic beta cells, 4-hydroxyisoleucine enhances glucose homeostasis. Fenugreek seeds also contain an antioxidant that may help improve insulin action by preventing pancreatic cells from being damaged by oxidative stress. Clinical research on fenugreek supplements has shown promising results. For example, in individuals with Type 2 diabetes, fenugreek seed powder decreased blood sugar levels during fasting and progressively enhanced glucose tolerance. According to a different study, those who eat fenugreek seeds with meals had lower postprandial blood sugar levels. Because of these benefits, fenugreek is a useful supplement in the treatment of diabetes. <sup>[14]</sup>



**Figure 8:** *Trigonella foenum graecum*

#### **Azadirachta indica**

The hypoglycemic qualities of *Azadirachta indica*, popularly known as neem, have made it well acknowledged that it may be used to treat diabetes mellitus. In classical Ayurvedic medicine, neem is a long-used medicinal herb that is particularly useful for treating diabetes and other metabolic diseases. The antidiabetic benefits of the plant are enhanced by the existence of bioactive substances such as flavonoids, glycosides, triterpenoids, and nimbidin. According to studies, neem leaves also extracts can improve insulin sensitivity and promote the release of insulin by pancreatic beta cells, which can help control blood sugar levels. Neem's phytochemicals have been found to enhance the absorption of glucose by muscles and tissues, hence reducing blood sugar levels. <sup>[27]</sup> This hypoglycemic effect has been attributed to the modulation of carbohydrate metabolism and the inhibition of enzymes like alpha-glucosidase, which plays a role in glucose absorption in the intestines. Neem's antioxidant qualities also aid in lowering oxidative damage, which is frequently increased in diabetics and supports the development of diabetic problems like nephropathy and neuropathy. Neem extracts also have the potential to improve the body's insulin response and the function of pancreatic islet cells by shielding them from harm. Additionally, it may help lower cholesterol levels in diabetic individuals, which would aid in managing the metabolic syndrome that is frequently linked to diabetes. <sup>[15]</sup>





**Figure 9:** *Azadirachta Indica*

### **Bryophyllum pinnatum**

*Bryophyllum pinnatum*, commonly called the "miracle leaf" or "life plant," is widely recognized in traditional medicine for its therapeutic properties, including its use in managing diabetes. The rich phytochemical content of the plant, which includes compounds called flavonoids phenolic compounds, and triterpenoids, is largely responsible for its anti-diabetic properties. One of the key ways *Bryophyllum pinnatum* helps in diabetes management is by lowering elevated blood glucose levels. Studies suggest that the plant works by inhibiting enzymes such as alpha-glucosidase and alpha-amylase, which are responsible for breaking down carbohydrates. Delaying the breakdown of carbs reduces the absorption of glucose, which lessens the rise in blood sugar that happens after meals. This process is comparable to that of various anti-diabetic medications, such as acarbose.<sup>[16]</sup>

Another significant benefit of *Bryophyllum pinnatum* is its ability to enhance insulin sensitivity. By boosting the efficiency of insulin production, it helps the cells receive glucose more effectively, thereby decreasing the blood sugar levels. This can be especially advantageous for persons battling of type 2 diabetes, as their inability to respond toward hormone is a significant issue.<sup>[17]</sup>

*Bryophyllum pinnatum* also possesses strong antioxidant qualities. The development of diabetes and its consequences, including neuropathy and nephropathy, are significantly influenced by oxidative stress. *Bryophyllum pinnatum*'s antioxidants aid in the neutralization of free radicals, lowering oxidative damage and maybe easing some of the symptoms related to diabetes. *Bryophyllum pinnatum* extract significantly reduced the circulatory system levels of sugar of diabetic rats, which is in line with promising results from animal studies. More clinical studies with humans are needed to establish the plant's efficacy, but these findings suggest that it may be utilized as a natural and supplementary treatment for diabetes. *Bryophyllum pinnatum* extract significantly reduced the circulatory system levels of sugar of diabetic rats, which is in line with promising results from animal studies. More clinical studies with humans are needed to establish the plant's efficacy, but these findings suggest that it may be utilized as a natural and supplementary treatment for diabetes.<sup>[18]</sup>



**Figure 10:** *Bryophyllum pinnatum*

### **Zingiber officinale**

Ginger, like other herbs, has been demonstrated in numerous studies to have both therapeutic and preventative benefits in the treatment of diabetes. Ginger helps people with type 2 diabetes manage their blood sugar levels, according to research from the College of Sidney in Australia. Ginger extracts may help control high blood sugar levels, according to one study that showed they could boost the intake of glucose by muscle cells without the need for insulin. In one study, diabetics who consumed 3 grams of dried ginger root daily for 30 days experienced notable reductions in their blood glucose, triglycerides, and total as well as LDL cholesterol levels. Another study found that giving diabetic rats an ethanolic ginger extract for 20 days had a substantial anti-hyperglycemic impact ( $P < 0.01$ ). The ethanolic form of ginger has also been demonstrated to lower body mass index, triglycerides, free-fatty acid levels, insulin production, glucose levels, the phospholipids total cholesterol, low-density lipoproteins, and triglycerides in subjects following high-fat diets. Because ginger can improve lipid profiles, and inhibit enzymes that break down carbohydrates, and increase insulin sensitivity and release, it is believed to help manage diabetes. The low glycemic index (GI) of ginger indicates that Additionally, a number of studies have demonstrated that ginger may help to avoid complications related to diabetes. In diabetics, it may have protective benefits on the kidneys and liver, and the nervous system as a whole. It may also lower the incidence of cataract development, a common diabetic problem.<sup>[19]</sup>



*Figure 11: Zingiber officinale*

### **Ocimum Sanctum**

Ocimum sanctum, often known as tulsi, has been used for its medicinal properties since ancient times. In both normal and alloxan-induced diabetic mice, a based on water extract from the leaves has been shown to dramatically lower blood sugar levels. Tulasi causes hypoglycemic and lipid-lowering effects in diabetic rats, as evidenced by decreased fasting levels of glucose and uronic acid, overall amino acid formulation, cholesterol, triglycerides, and total lipids. Due to the oral plant extract (200 mg/kg), plasma glucose dropped by 9.06% after 15 days of medical care and by 26.4% after 30 days. When comparison to the control group, the amount of glycogen in the diabetic rats' liver and skeletal system muscles decreased by 75% and 68%, respectively, but the amount in the kidneys increased tenfold. Additionally, Tulsi is well-known for its many medicinal properties, including as its anti-stress, anti-asthmatic, antimutagenic, immunostimulant, anticancer, anti-fungal, antiviral in nature, anti-stress, and anti-ulcer properties.<sup>[20]</sup>



**Figure 12:** *Ocimum Sanctum*

### **Aloe barbadensis**

For decades, aloe, a common houseplant, has been utilized as a multipurpose traditional medicine. The two primary products produced by the plant are latex and gel. While aloe latex, also referred to by the term "the aloe juices," is a bitter yellow fluid derived by the pericyclic channels that are located underneath the outer covering of the leaf, aloe vera gel is created by mucilage, or pulp within the leaves. Studies have shown that aloe gum extracts increase the glucose tolerance of both healthy and rats that are diabetic.

Rats with diabetes produced by alloxan have shown a hypoglycemic response to the long-term, but not one-time, application of the aloe barbadensis leaf exudates. The plant's bitter component also caused a hypoglycemic impact in diabetic mice when given in single or chronic dosages [39]. Aloe vera is thought to work by promoting the creation and/or release of insulin by the beta cells of the pancreas. In diabetic mice, aloe vera also enhances wound healing and shows dose-dependent anti-inflammatory effects.<sup>[21]</sup>



**Figure 13:** *Aloe barbadensis*

### **Allium cepa**

Different dried onion powder fractions, both ether-soluble and insoluble, have shown anti-hyperglycemic benefits in rabbits with diabetes. The hypolipidemic and antioxidant attributes of onions, or *Allium cepa*, are also widely documented. When given at an amount of 200 mg/kg for 45 days, S-methyl disulfide sulphoxide (SMCS), an amino acid that contains sulfur and is present in *Allium cepa*, dramatically decreased blood glucose levels and fat contents in the bloodstream and muscle of animals with alloxan-induced diabetes. Important enzymes such as HMG-CoA reductase, glucose-6-phosphatase, and liver hexokinase also resumed their regular activities as a result.<sup>[22]</sup> In human trials, 50 g of juice made from onions administered orally as just one administration effectively reduced anticipatory the level of glucose in diabetic individuals. Frequent onion eating has

also been associated with increased insulin sensitivity, which is crucial for blood glucose regulation in type 2 diabetes. Moreover, its combined antioxidant and lipid-lowering effects offer protective benefits against cardiovascular complications, such as atherosclerosis and hypertension, which are common in diabetic individuals. *Allium cepa*, therefore, not only aids in blood sugar regulation but also supports overall health by mitigating diabetes-related complications. [23]



**Figure 14:** *Allium Cepa*

### **Curcuma longa**

A common spice in traditional medicine, turmeric (*Curcuma longa*) has drawn interest for its possible function in diabetes management because of its active ingredient, curcumin. Curcumin's medicinal effects are aided by its antioxidant, anti-inflammatory and antidiabetic qualities. Studies have shown that curcumin may improve insulin sensitivity, reduce blood glucose, and diminish complications associated with diabetes. Turmeric has several significant benefits in the treatment of diabetes by reducing oxidative stress. Free radicals are commonly produced as a result of diabetes, which oxidatively destroys cells. Curcumin's antioxidant qualities scavenge these free radicals, preventing damage to cells. Additionally, it has been shown that curcumin stimulates the pancreatic beta cells, that are essential for the synthesis of insulin. [24]

Diabetes and its effects can also be made worse by inflammation. Diabetes patients have higher levels of cytokines that promote inflammation, which curcumin's anti-inflammatory properties assist to inhibit. Insulin resistance is decreased as a result of better glucose metabolism and insulin signaling. Additionally, curcumin may help enhance cardiovascular health and decrease cholesterol, both of which are frequently challenged in diabetic people. Atherosclerosis is a common consequence of diabetes that it has been shown to lower the risk of. [25]



**Figure 15:** *Curcuma longa*

### ***Annona squamosa***

The tropical fruit known as an apple custard (*Annona squamosa*) has drawn interest due to its possible antidiabetic qualities. Its bioactive substances, including acetogenins, alkaloids, polyphenols, and flavonoids, are believed to have a part in controlling blood sugar levels. Custard apples could exhibit antidiabetic effects through a variety of methods, according to research, including boosting insulin secretion, encouraging tissue uptake of glucose, and inhibiting the breakdown of carbs by the enzymes known as alpha-amylase and alpha-glucosidase.<sup>[26]</sup>

There have also been investigations into the potential medical benefits of custard apple leaves, seeds, and bark. Custard apple leaves have been found to contain two flavonoids with antioxidant activity, quercetin and kaempferol, which may shield beta-cells from oxidative stress, a primary cause of diabetes. Extracts from *Annona squamosa* have demonstrated a hypoglycemic impact in animal studies, improving insulin sensitivity and significantly lowering fasting levels of blood glucose. Furthermore, custard apple seeds, which are high in acetogenins, have the potential to improve lipid metabolism and lower lipid peroxidation, thereby helping to manage the problems of diabetes.<sup>[27]</sup>

Despite their limitations, human clinical trials indicate promise in blood sugar regulation. The high fiber content of custard apples also helps to slow up the breakdown of glucose, avoiding sharp rises in the blood sugar level after meals. Despite the promising results, more clinical research is required to determine the safety and effectiveness of custard apples in the treatment of diabetes in humans.<sup>[28]</sup>



**Figure 16:** *Annona squamosa*

### ***Caesalpinia bonducella***

*Caesalpinia bonducella*, commonly found along India's coastal regions, has been traditionally utilized by indigenous tribes for managing blood sugar levels. Research has indicated that the plant's extracts made from ethanol and water significantly lower blood sugar levels in animals of chronic type II diabetic. Furthermore, in rats with diabetic complications caused by (STZ), extracts of *C. bonducella* seeds in aqueous and 50% ethanolic form have demonstrated antihyperglycemic and hypolipidemic properties. It is thought that the seed extracts' ability to inhibit glucose absorption accounts for their antihyperglycemic benefits. This plant holds promise as a dual-action remedy, functioning as both an antidiabetic and antihyperlipidemic agent.<sup>[29]</sup>



**Figure 17:** *Caesalpinia bonducella*

### **Eugenia jambolana**

Traditional medicine has long recognized *Eugenia jambolana*, frequently referred to called *Syzygium mini* or Jamun, because of its antidiabetic properties. Research has examined the potential of plant seeds, bark from trees, and leaves to help control blood sugar levels. The main processes include raising insulin sensitivity, raising insulin synthesis, and blocking enzymes that break down carbs, such as  $\alpha$ -glucosidase and  $\alpha$ -amylase.<sup>[30]</sup> The seeds of *Eugenia jambolana* include flavonoids, alkaloids, and glycosides that have been shown to have hypoglycemic properties.<sup>[31]</sup> The plant's antioxidant properties also protect pancreatic cells from oxidative damage, which may postpone the onset of diabetes.<sup>[32]</sup>

In clinical trials, extracts of *Eugenia jambolana* have been linked to reductions in HbA1c levels, suggesting improved long-term blood sugar control. This natural remedy has minimal side effects and is considered safe, making it popular in complementary and alternative treatments, particularly in Ayurveda. Research exploring other uses for controlling diabetes who have type 2 diabetes or its consequences is also ongoing.<sup>[33]</sup>



*Figure 18: Eugenia jambolana*

### **Mangifera indica**

Many cultures have long utilized mangos (*Mangifera indica*) to treat diabetes. The fruit itself and its components, including the leaves themselves, tree bark, & seeds, have therapeutic qualities that could help control blood sugar levels. Bioactive substances such tannins, and flavonoids, and polyphenols, which which have been investigated for their possible antidiabetic benefits, are abundant in the leaves of the mango tree in particular. It has been discovered that mango leaves improve glucose metabolism, lower hyperglycemia, and increase insulin sensitivity. They include mangiferin, a xanthonoid with antioxidant and anti-inflammatory qualities that may aid in lowering oxidative stress, a prevalent problem in diabetes.<sup>[34]</sup> Studies suggest that mangiferin stimulates glucose uptake by muscles and inhibits enzymes that break down carbohydrates, thereby reducing blood sugar spikes after meals.<sup>1</sup> When eaten in moderation, mango pulp, together with the leaves, has a glycemic index that is low (GI), meaning that blood sugar levels rise more slowly than with high-GI meals. Mangoes' fiber content also facilitates the sugars' slow absorption. Patients with diabetes are advised to take mango fruit in moderation, nevertheless, because of its inherent sugar content. Additionally, studies have suggested that mango seeds may help control diabetes. Their abundance of saturated fats and antioxidants aids in lowering inflammation and preserving insulin levels. Mango seed extracts have been studied for their hypoglycemic properties because they may promote the regrowth of the beta cells found in the pancreas, who create insulin.<sup>[35]</sup>



**Figure 19:** *Mangifera Indica*

## CONCLUSION

For those looking for complementary and alternative therapies, the utilization of medicinal plants holds great promise for the treatment of diabetes. Numerous plant-based treatments have hypoglycemic effects, increase insulin sensitivity, and have anti-inflammatory and antioxidant properties. Examples that have shown effectiveness in preclinical and clinical investigations include *Withania somnifera*, *Allium cepa*, *Trigonella foenum-graecum* (fenugreek), *Momordica charantia* (bitter melon), and *Allium sativum*.

While these natural treatments show potential in managing blood glucose levels and preventing complications, their effectiveness can vary due to differences in plant species, extraction methods, and individual patient responses. Furthermore, challenges such as a lack of standardized dosages and possible interactions with conventional medications must be addressed. All things considered, medicinal plants may be used as supplements to conventional treatments; nevertheless, more extensive clinical research is needed to determine long-term effectiveness, safety, and dosage recommendations. To guarantee the best results, integrating phytotherapy into diabetes treatment necessitates a thorough assessment conducted under physician supervision.

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