



**BRIDGING TRADITION AND MODERN SCIENCE: A REVIEW OF HERBAL
REMEDIES FOR THE TREATMENT OF DIABETES**

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ABSTRACT

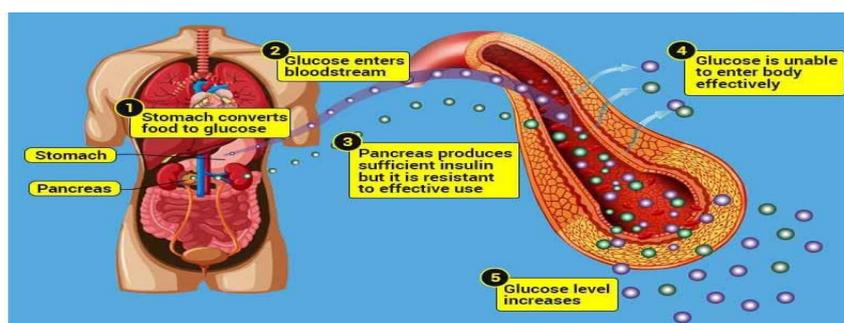
Diabetes mellitus, a metabolic disorder characterized by chronic hyperglycemia, has become a global health concern due to its rising prevalence and associated complications. While conventional therapies such as insulin and oral hypoglycemic agents remain central to diabetes management, the role of herbal remedies has gained renewed interest in recent years. This review **aims** to bridge traditional knowledge with modern scientific findings by exploring the therapeutic potential of medicinal plants in the treatment of diabetes. Drawing on ethnobotanical sources and contemporary research, we examine key plants known for their hypoglycemic properties, such as *Magnifera indica* (mango), *Embllica officinalis* (amla), *Aloe ferox*, *Eugenia jambolana* (jamun), and others, which have been traditionally used in different cultures. The review highlights the mechanisms of action through which these plants exert their anti-diabetic effects, including improved insulin sensitivity, regeneration of pancreatic beta cells, inhibition of glucose absorption, and modulation of oxidative stress. Furthermore, we discuss the pharmacological properties, safety profiles, and potential synergistic benefits of combining herbal remedies with conventional diabetes therapies. In **conclusion**, while traditional herbal remedies offer promising complementary treatments for diabetes, further clinical studies are required to validate their efficacy and ensure safety. By bridging the gap between ancient wisdom and modern science, this review provides a holistic perspective on the potential role of herbal medicine in diabetes management and offers avenues for future research in the field.

KEYWORDS: Diabetics, Insulin, Traditional medicine, Phyto-therapy and Herbal remedies.

INTRODUCTION

Diabetes mellitus is a metabolic disorder with multiple causes, characterized by chronic high blood sugar (Hyperglycemia) and disturbances in carbohydrate, fat, and protein metabolism due to defects in insulin secretion or action. This condition leads to microvascular complications such as retinopathy (Eye damage),

nephropathy (kidney damage), and neuropathy (Nerve damage), increasing the risk of foot ulcers, amputations, and autonomic dysfunction. Additionally, diabetes is linked to an elevated risk of macrovascular diseases, such as heart disease. The two most common types are Type 1 diabetes (5%), an autoimmune condition, and Type 2 diabetes (95%), often linked to obesity.^[1]



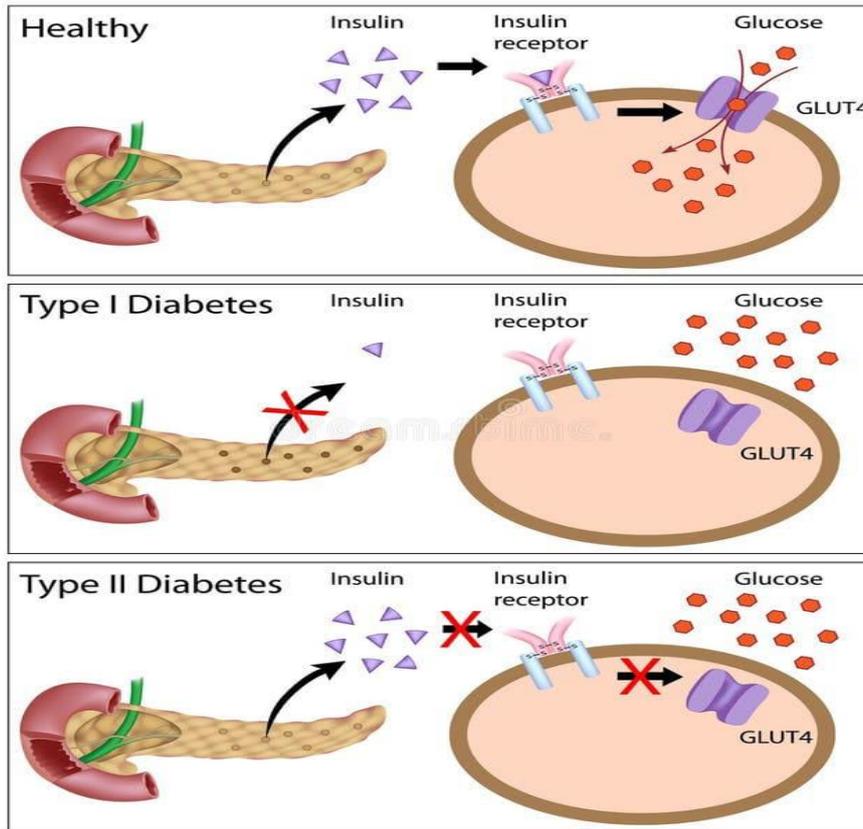


Figure 1: Diabetes mellitus.

Types of diabetes

1. Type 1 diabetes mellitus

Type 1 diabetes is an autoimmune condition where the body's immune system attacks insulin-producing cells in the pancreas, leading to little or no insulin production. This causes high blood sugar levels, requiring insulin injections for management. While commonly diagnosed

in children, it can occur at any age. In adults, it is sometimes called Latent Autoimmune Diabetes of Adults (LADA) and can be mistaken for Type 2 diabetes. Genetic factors and possible environmental triggers, such as viral infections, contribute to its development. About 10% of people with diabetes have Type 1.^[4]

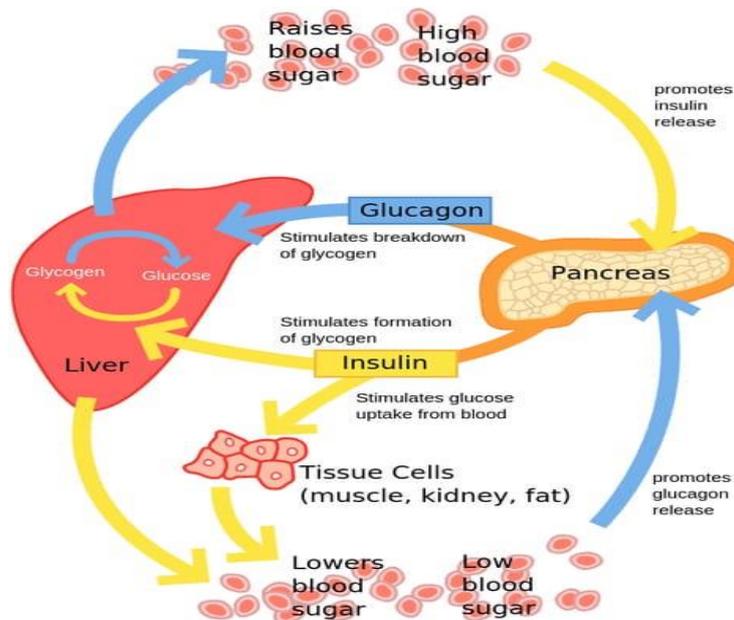


Figure 2: Type 1 Diabetes Mellitus.

SYMPTOMS OF TYPE 1 DIABETES

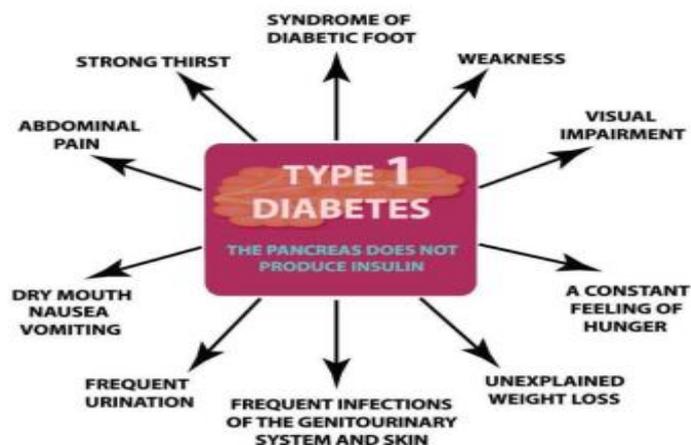


Figure 3: Causes of type 1 diabetes mellitus.

2. Type 2 diabetes mellitus

Type 2 diabetes mellitus is characterized by insulin resistance, where the body's tissues respond poorly to insulin, often accompanied by reduced insulin secretion. While insulin is produced, it either isn't sufficient or doesn't function properly. Early on, this condition can be managed or even reversed with lifestyle changes and

medications that improve insulin sensitivity or reduce liver glucose production. Type 2 diabetes is primarily influenced by genetics and lifestyle factors such as obesity, lack of physical activity, poor diet, stress, and urbanization. It accounts for 90% of diabetes cases and typically occurs in individuals over 40, though it can also develop in younger people with risk factors.^[2]

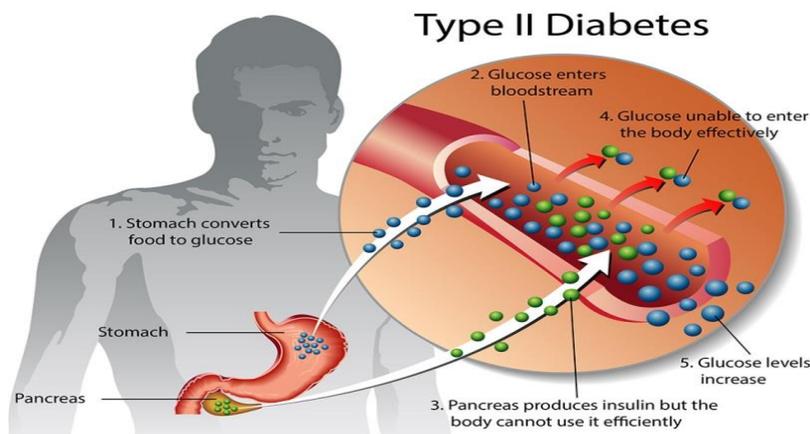


Figure 4: Type 2 diabetes mellitus.



Figure 5: Symptoms Type 2 Diabetes Mellitus.

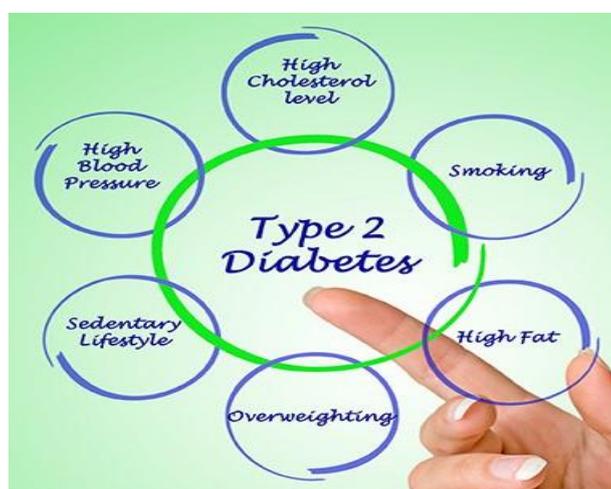


Figure 6: Causes of type 2 Diabetes Mellitus.

3. Gestational Diabetes Mellitus (GDM)

Gestational diabetes mellitus (GDM) is a type of diabetes that develops during pregnancy in women who previously had normal blood sugar levels. It often has no noticeable symptoms and is usually diagnosed through routine prenatal screening. GDM affects up to 16% of pregnancies and is more likely to occur in women with a family history of diabetes or certain ethnic backgrounds. Proper management is crucial to prevent complications for both the mother and baby, and the condition typically resolves after childbirth, though it increases the risk of Type 2 diabetes later in life. Managing GDM through diet, exercise, or medication is essential for a healthy pregnancy.^[6]

Epidemiology of diabetes mellitus

Diabetes mellitus stands as the most prevalent endocrine disorder globally. According to the International Diabetes Federation (IDF), over 366 million people were affected by diabetes in 2011, with projections suggesting that this number could reach 439 million by 2030. The

World Health Organization (WHO) forecasts a rise in global diabetes prevalence from 4% in 1995 to 5.4% by 2025, particularly impacting developing nations (IDF Diabetes Atlas.).

Global context

As of 2011, diabetes was responsible for approximately 4.6 million deaths, with more than half of these occurring in individuals under 60 years of age. The rise in Type 2 diabetes is notable worldwide, with about 80% of affected individuals living in low- and middle-income countries.

Diabetes in india

India is often referred to as the "diabetic capital of the world," with the highest number of diabetic patients globally. In 2013, it was estimated that around 65 million people in India were living with diabetes, and projections indicate that this figure could soar to 100 million by 2030. Alarmingly, more than 50% of individuals with diabetes in India are unaware of their condition.

Diabetes in tamil nadu

In Tamil Nadu, the prevalence of diabetes is particularly concerning. A study conducted in 2018 revealed that approximately 10.4% of adults in the state are affected by diabetes, with urban areas experiencing even higher rates, reaching around 15% in some cities. Chennai, the capital of Tamil Nadu, reported a diabetes prevalence of about 13.1% among adults aged 30 and above.

Complications and Health impact

In Nigeria, another country grappling with diabetes, approximately 105,091 deaths were attributed to diabetes in 2013. With a total adult population of about 79 million, one-third of diabetes cases occur in rural communities. Complications associated with diabetes are

significant in both Nigeria and India. Research shows alarming rates of complications among diabetes patients, including, Hypertension: over 50%, Peripheral Neuropathy: over 50%, Retinopathy: 35%, Cataracts: 25%, Cardiovascular Disease: 5%, Foot Ulcers: 16%, Nephropathy: 3%.

In Tamil Nadu, a 2019 study indicated that approximately 30% of individuals with diabetes experienced complications related to the disease, such as retinopathy and neuropathy.

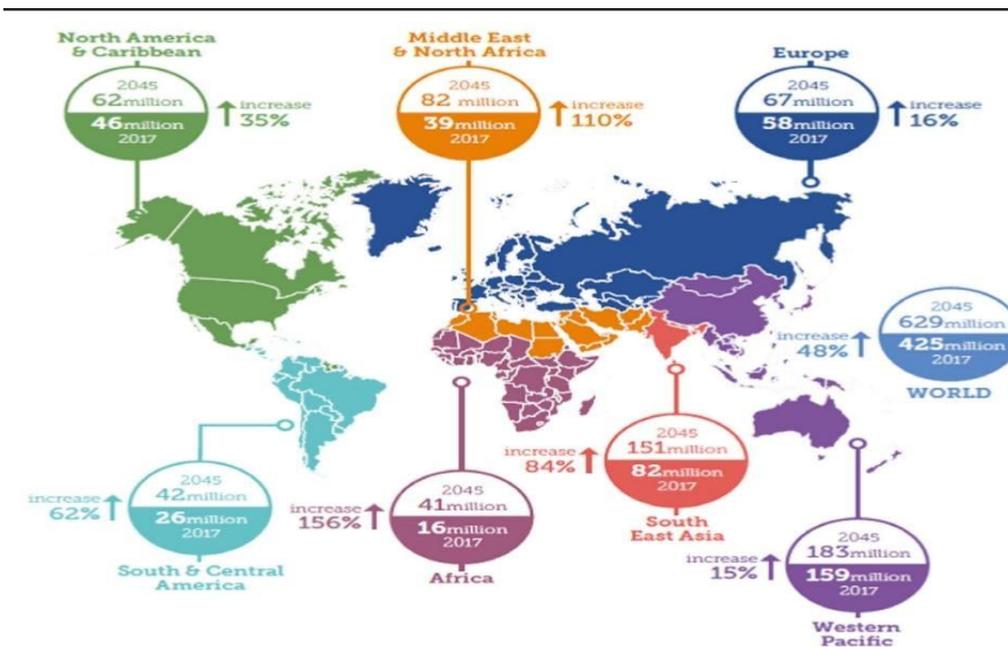


Figure 7: Future prediction of diabetes all over the world.

Signs and Symptoms of diabetes mellitus

Diabetes mellitus is often called a "silent killer" because its symptoms can be mistaken for other conditions or diseases. Some of the most common signs include:

- 1. Polyuria:** Excessive or frequent urination is the most common symptom of diabetes. High blood sugar causes the kidneys to produce more urine to eliminate excess glucose, leading to dehydration and frequent urination.
- 2. Polydipsia:** Excessive thirst accompanies polyuria due to the body's need to replace lost fluids. Despite drinking more water, the patient remains persistently thirsty.
- 3. Polyphagia:** Increased hunger is a result of the body's inability to use glucose for energy due to insufficient insulin or insulin resistance. This leads to excessive food intake and potential weight gain.
- 4. Blurred vision:** Fluctuating fluid levels can cause the lenses in the eyes to swell, altering their shape and causing difficulty in focusing.

Other notable symptoms include

- ❖ **Unplanned weight loss:** The body may burn muscle and fat for energy if it cannot access glucose, leading to weight loss despite unchanged eating habits.
- ❖ **Nausea and Vomiting:** The accumulation of ketones in the blood, due to the body burning fat instead of glucose, can cause nausea and a potentially life-threatening condition called diabetic ketoacidosis.
- ❖ **Slow-Healing wounds:** High blood sugar can impair circulation and nerve function, leading to slower healing of cuts and sores.

Additional symptoms include sexual dysfunction in men, vaginal infections in women, numbness or tingling in the hands and feet, frequent infections, itchy or flaky skin, and gum or bladder infections.^[6]

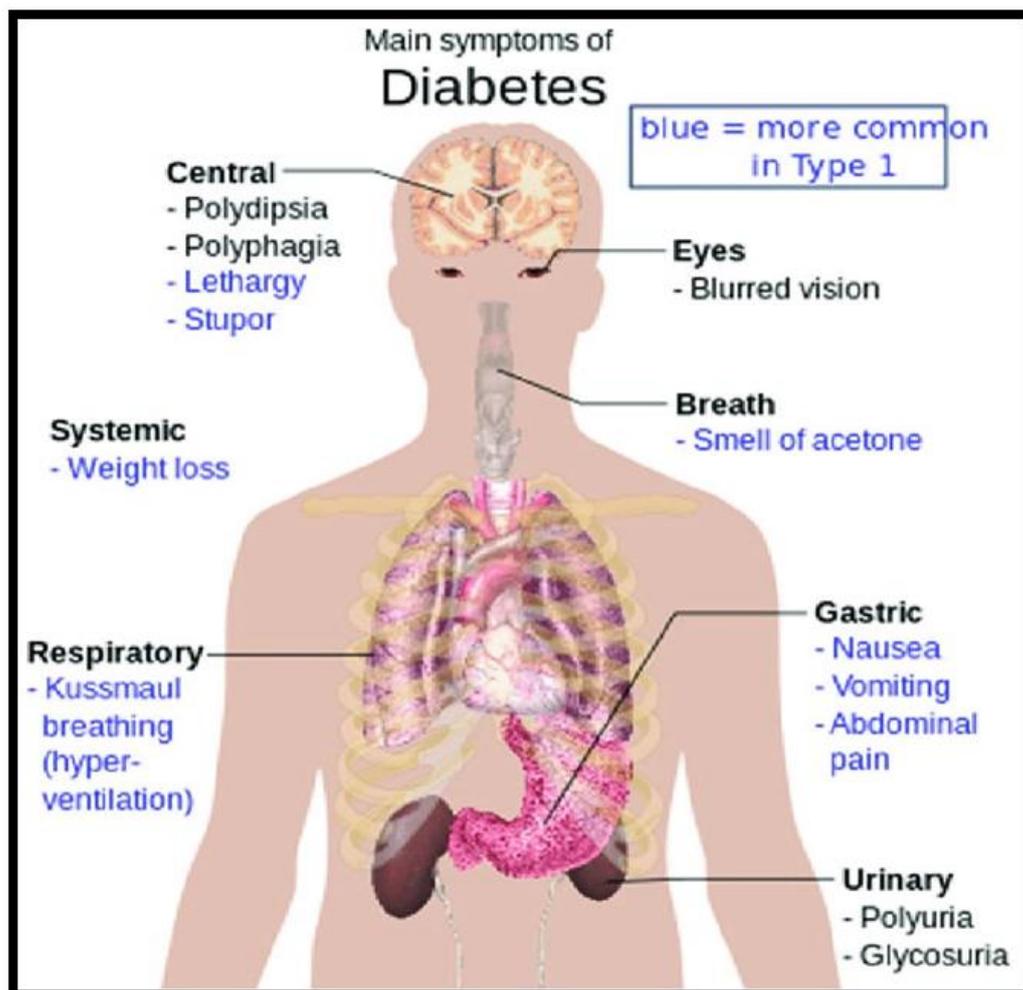


Figure 8: Symptoms of diabetes.

Treatment of diabetes

The treatment of diabetes involves both drug and non-drug strategies to maintain proper blood glucose levels. Here's an overview of the major components:

A) Drug treatment for diabetes

Anti-diabetic drugs are used to lower blood glucose levels, and they can be broadly divided into **insulin** and **oral medications**. The choice of medication depends on the type of diabetes and individual patient factors like age and overall health.

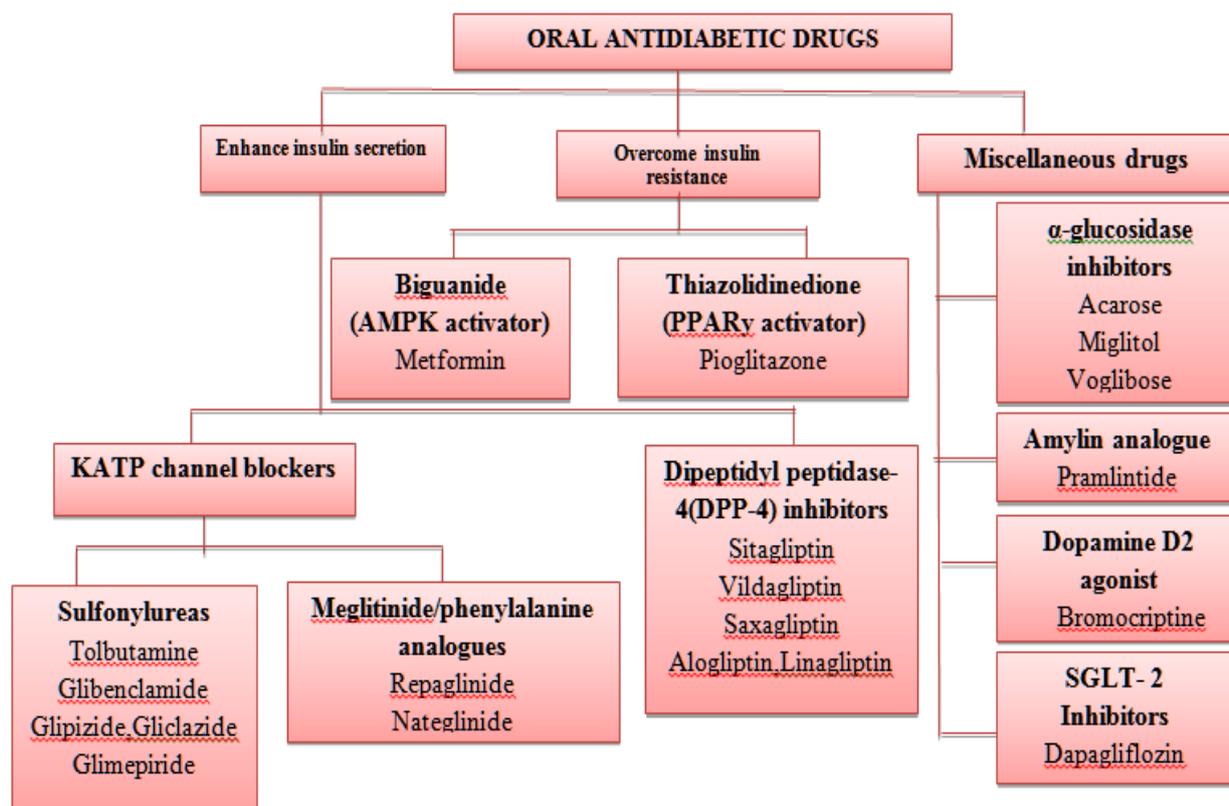
- 1. Type 1 Diabetes:** This is caused by the body's inability to produce insulin. Therefore, **insulin** therapy is mandatory for these patients. Insulin can be administered through injections or inhalation.
- 2. Type 2 Diabetes:** In type 2 diabetes, the body becomes resistant to insulin. Drug treatment for this type focuses on: Increasing insulin production from the pancreas (e.g., sulfonylureas, meglitinides), Enhancing the sensitivity of cells to insulin (e.g., metformin, thiazolidinediones), Reducing glucose absorption from the gastrointestinal tract (e.g., alpha-glycosidase inhibitors). Other injectable drugs like Exenatide (a GLP-1 receptor agonist) and Pramlintide (an amylin analogue) are also used, particularly in combination with other medications.

B) Non-Drug Treatment for Diabetes

Non-drug management is equally important for all types of diabetes. It includes:

- ❖ **Dietary management:** A balanced diet, low in refined sugars and rich in fiber, helps control blood sugar.
- ❖ **Exercise:** Regular physical activity improves insulin sensitivity and helps maintain healthy body weight.
- ❖ **Monitoring blood glucose levels:** This is crucial for adjusting treatment as needed and preventing complications.

Together, these strategies help maintain optimal blood glucose levels and reduce the risk of diabetes-related complications.

Classification of Anti- diabetics^[8]**1. Insulin**

Insulin is usually given subcutaneously, either by injections or by an insulin pump. Research is underway of other routes of administration. In acute care settings, insulin may also be given intravenously. There are several types of insulin, characterized by the rate which they are metabolized by the body. Insulin is essential for

the treatment of type1 diabetes. For many years it was assumed, as an act of faith, that normalizing plasma glucose would prevent diabetic complications. The diabetes control and complications trial (American diabetes association, 1993) showed that this faith was well placed: type diabetic patients were randomly allocated to intensive or conventional management.^[6]

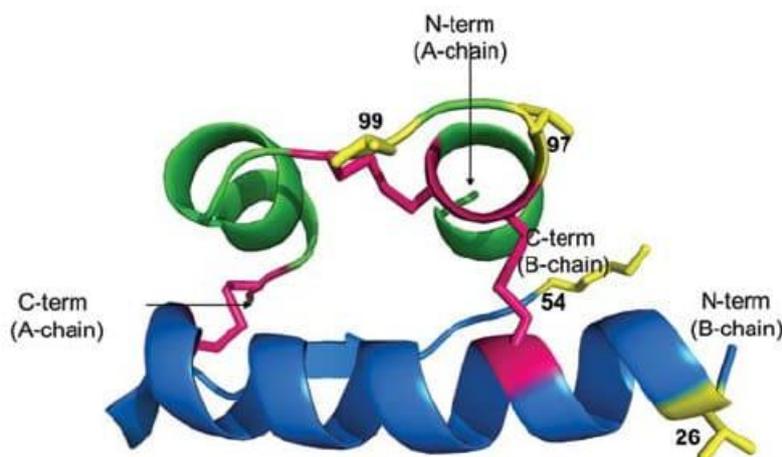


Figure 9: 3D Structure of insulin.

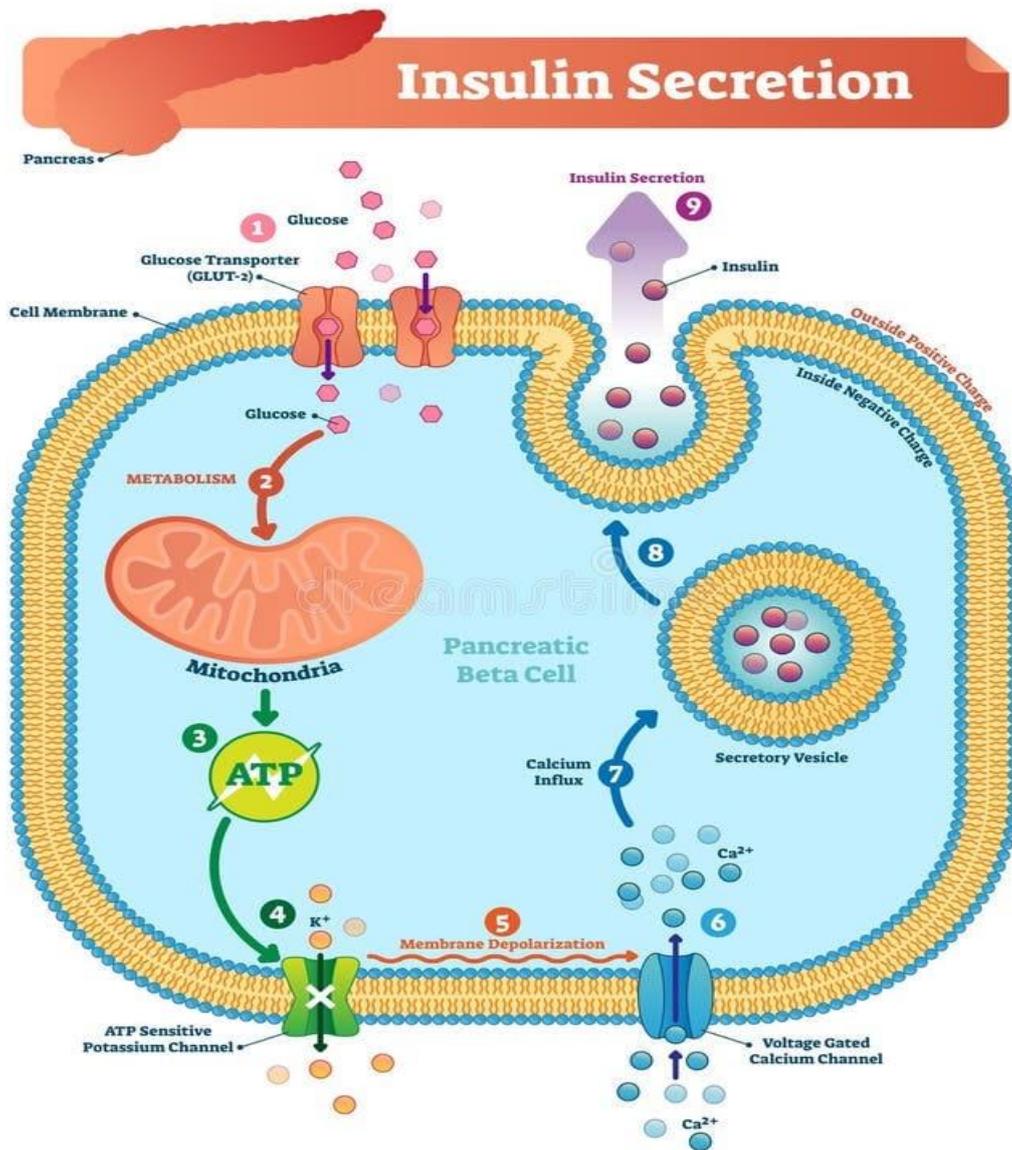
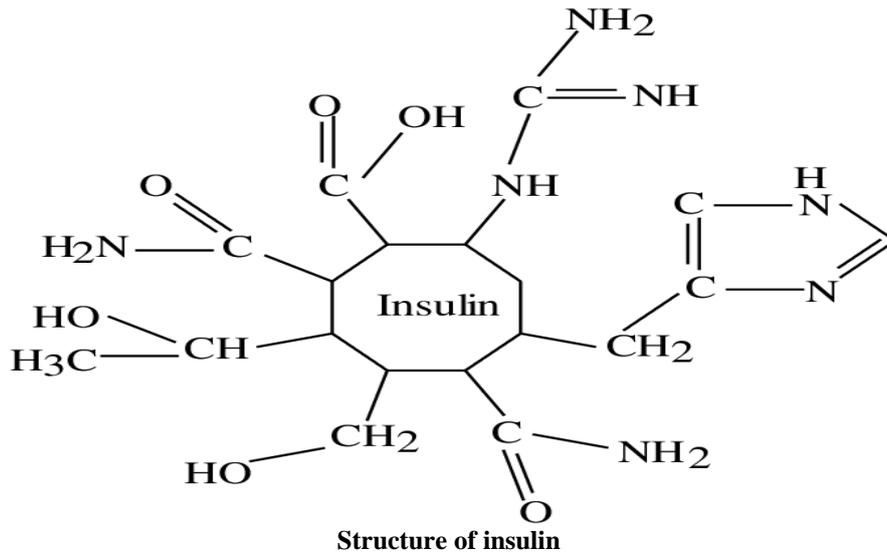


Figure 10: Insulin secretion.

2. Insulin sensitizers

Oral hypoglycemic agents including insulin are useful in the treatment of type 2 DM and those agents include Sulphonylureas, Alpha glycosidase inhibitors,

Biguanides and Thiazolidinediones. The main aim is to correct metabolic disorder like resistance to insulin and insufficient insulin secretion.^[6]

Mechanism of action

Table 1: Mechanism of action.^[7]

DRUG CLASS	MECHANISM OF ACTION	EFFECT ON PLASMA INSULIN	RISK OF HYPO-GLYCEMIA	COMMENTS
Sulphonylureas <i>Glimepiride</i> <i>Glipizide</i> <i>Glyburide</i>	Stimulates insulin secretion		Yes	Well-established history of effectiveness. Weight gain can occur. Hypoglycemia most common with this class of oral agents.
Glinides <i>Nateglinide</i> <i>Repaglinide</i>	Stimulates insulin secretion		Yes (rarely)	Taken with meals. Short action with less hypoglycemia. Postprandial effect.
Biguanides <i>Metformin</i>	Decreases hepatic production of glucose		No	Preferred agent for type 2 diabetes. Well-established history of effectiveness. Weight loss may occur. Monitor renal function.
Thiazolidinediones (glitazones) <i>Pioglitazone</i> <i>Rosiglitazone</i>	Binds to peroxisome proliferator-activated receptor-γ in muscle, fat and liver to decrease insulin resistance		No	Effective in highly insulin-resistant patients. Once-daily dosing for pioglitazone. Check liver function before initiation. Avoid in liver disease or heart failure.
α-Glucosidase inhibitors <i>Acarbose</i> <i>Miglitol</i>	Decreases glucose absorption		No	Taken with meals. Adverse gastrointestinal effects.
DPP-4 inhibitors <i>Alogliptin</i> <i>Linagliptin</i> <i>Sitagliptin</i> <i>Saxagliptin</i>	Increases glucose-dependent insulin release; decreases secretion of glucagon		No	Once-daily dosing. May be taken with or without food. Well tolerated. Risk of pancreatitis.
Incretin mimetics <i>Exenatide</i> <i>Liraglutide</i>	Increases glucose-dependent insulin release; decreases secretion of glucagon; slows gastric emptying; increases satiety		No	Injection formulation. <i>Exenatide</i> should be injected twice daily within 60 minutes prior to morning and evening meals. Extended-release <i>exenatide</i> is given once weekly. <i>Liraglutide</i> is dosed once-daily without regard to meals. Weight loss may occur. Risk of pancreatitis.
SGLT2 inhibitors <i>Canagliflozin</i> <i>Dapagliflozin</i>	Increases urinary glucose excretion		No	Once-daily dosing in the morning. Risk of hypotension, hyperkalemia. Avoid in severe renal impairment.

The way forward: Herbal remedies for diabetes

In recent decades, herbal remedies have gained significant attention for their eco-friendly, cost-effective, and relatively safe properties. Plant-based medicines, long used in traditional practices, have moved into the mainstream due to increased research into their therapeutic potential. Many plants are reported to have anti-diabetic properties and are used across various cultures.

- ❖ **Historical and Ethnopharmacological evidence:** Ancient texts mention over 800 plants with purported anti-diabetic effects, while ethnopharmacological surveys report that more than 1,200 plant species are traditionally used to manage diabetes due to their alleged hypoglycemic activity.
- ❖ **Commonly used plants in diabetes treatment:** In various parts of the world, including India, several plants are popular for managing diabetes, *Magnifera indica* (mango), *Emblca officinalis* (amla or Indian gooseberry), *Aloe ferox* (a type of aloe), *Amaranthus cruentus* (amaranth), *Cocos nucifera* (coconut), *Eugenia jambolana* (jamun) and *Acacia nilotica* (babul tree)

These plants are commonly used for their hypoglycemic effects, meaning they help lower blood sugar levels.

- ❖ **Benefits of herbal remedies in diabetes:** Some herbal remedies not only help manage blood sugar levels but also provide symptomatic relief and aid in preventing secondary complications associated with diabetes, such as cardiovascular issues and neuropathy. Additionally, some herbs have been found to aid in the regeneration of beta cells in the pancreas, which are responsible for insulin production, and in reducing insulin resistance.
- ❖ **Additional health benefits:** Beyond blood sugar control, certain herbs are noted for their antioxidant properties, which can help combat oxidative stress, a factor that worsens diabetes complications. Some herbs also have cholesterol-lowering effects, which can help mitigate the cardiovascular risks often associated with diabetes. As more research continues to uncover the benefits of these plant-based therapies, herbal remedies may serve as valuable complementary treatments for diabetes management alongside conventional approaches.^[58,59,60]

<p>1) <i>Solanum incanum linnaeus</i></p> 	<p>Biological name: Solanum incanum linn. Family: Solanaceae</p>	<p>Parts of plant: Root</p>	<p>Phytomolecules: Flavonoids, tannins, terprnoids, phenol, alkaloid and anthraquinones</p>
<p>Description: Its bioactive compounds are reported to exhibit hypoglycemic activity by improving insulin sensitivity and modulating glucose metabolism, making it a promising plant for managing diabete.^[9]</p>		<p>Formulation: Crude drug</p>	<p>Types of diabetes: Type 2</p>
<p>2) <i>Eugenia jambolana</i></p> 	<p>Biological name: Syzygium cumini Family: Myrtaceae</p>	<p>Parts of plant: Seed kernals</p>	<p>Phytomolecules: Flavonoids, Saponins and Triterpenoids</p>
<p>Description: EJ kernel extract showed hypoglycemic Activity better than that of EJ whole seed or seed coat.^[10]</p>		<p>Formulation: Crude drug</p>	<p>Types of Diabetes: Type 2</p>
<p>3) <i>Ricinus communis</i></p> 	<p>Biological name: Ricinus communis Family: Euphorbiaceae</p>	<p>Parts of plant: Root</p>	<p>Phytomolecules: Alkaloids, Terpenoids, Flavonoids.</p>
<p>Description: It possess high margin of safety and promising value for development of potent medicine for diabetics.^[11]</p>		<p>Formulation: Crude drug</p>	<p>Types of Diabetes: Type 2</p>
<p>4) <i>Opuntia ficus indica</i></p> 	<p>Biological name: Opuntia ficus indica Family: Cactaceae</p>	<p>Parts of plant: Cladodes</p>	<p>Phytomolecules: Tannins, Saponins, Flavonoids.</p>
<p>Description: The opuntia ficus indica of aqueous extract shows the better hypoglycemic activity.^[12]</p>		<p>Formulation: Crude drug</p>	<p>Types of Diabetes: Type 2</p>
<p>5) <i>Momordica charantia</i></p> 	<p>Biological name: Momordica charantia Family: Curcubitaceae</p>	<p>Parts of plant: Fruit</p>	<p>Phytomolecules: Alkaloids Flavonoids, catechins</p>
<p>Description: The Momorandica charantia exhibit the hypoglycemic efficacy in patient and it shows the better diabetic activity.^[13]</p>		<p>Formulation: Crude drug</p>	<p>Types of Diabetic: Type 2</p>
<p>6) <i>Murraya koenigii</i></p> 	<p>Biological name: Murraya koengii linn Family: Rutaceae</p>	<p>Parts of plant: Leaves</p>	<p>Phytomolecules: Alkaloids, Flavonoids, Glycoside</p>
<p>Description: This plant extract shows the better hypoglycemic activity and it also gives the cellular oxidative damage.^[14]</p>		<p>Formulation: Crude drug</p>	<p>Types of Diabetic: Type 2</p>
<p>7) <i>Combretum micranthum</i></p> 	<p>Biological name: Combretum micranthus Family: Combretaceae</p>	<p>Parts of plant: Leaves</p>	<p>Phytomolecules: Alkaloids, Tannins, Glycoside and Flavonoids.</p>
<p>Description: It shows the Potent Antidiabetic effect and shows the other effect are such as hemantic, immune boosting, lipid lowering effect.^[15]</p>		<p>Formulation: Crude drug</p>	<p>Types of Diabetic: Type 2</p>
<p>8) <i>Lawsonia inermis</i></p> 	<p>Biological name: Lawsonia inermis Family: Lythraceae</p>	<p>Parts of plant: Leaves</p>	<p>Phytomolecules: Tanins, saponins, flavonoids, terprnoids</p>
<p>Description: It shows the significant hypoglycemic and hypoglycemic activity and it also gives the others activities antibacterial, antioxidant, burn healing, anti ulcer and diuretic.^[16]</p>		<p>Formulation: Crude drug</p>	<p>Types of Diabetes: Type 2</p>
<p>9) <i>Acacia nilotica</i></p>	<p>Biological name:</p>	<p>Parts of plant:</p>	<p>Phytomolecules:</p>

	Vacheilla nilotica Family: Fabaceae	Bark	Alkaloid, Saponins, Flavanoids
		Formulation: Crude drug	Types of Diabetes: Type 2
Description: It shows antidiabetic activity and also uses stomach aches, sexual disorder, tuberculosis. ^[17]			
10) <i>Mangifera indica</i> linn 	Biological name: <i>Mangifera indica</i> Family: Anacardiaceae	Parts of plant: Leaves/ Stem bark	Phytomolecules: Phenolic acid, benzophenones, flavonoids
		Formulation: Crude drug	Types of Diabetes: Type 2
Description: It shows antidiabetic activity atleast or partially inhibit the glucose absorbtion in gut. ^[18]			
11) <i>Azadirachta Indica</i> 	Biological name: <i>Azadirachta Indica</i> Family: Meliaceae	Parts of plant: Bark	Phytomolecules: Isoprenoids, alkaloid, flavnoids
		Formulation: Crude drug	Types of Diabetes: Type 2
Description: <i>Azadirachta indica</i> inhibit key enzyme linked to diabetes , ultimately reducing hyperglycemia. ^[19]			
12) <i>Boerhavia Diffusa</i> 	Biological name: <i>Purnarnava</i> Family: Nyctaginaceae	Parts of plant: Leaves	Phytomolecules: Ursosolic acid, hypoxanthine -9L arabinofuranoside
		Formulation: Crude drug	Types of Diabetes: Type 2
Description: <i>Boerhavia diffusa</i> leaves can produce an effect a decreasing a blood glucose level it become useful treatment for diabetes. ^[20]			
13) <i>Caesalpinia crista</i> linn 	Biological name: <i>Latakaranja</i> Family : Caesalpinaceae	Parts of plant: Seed	Phytomolecules: Flavonoid, tannins, alkaloids, saponins.
		Formulation: Crude drug	Types of Diabetes: Type 2
Description: it shows an antidiabetic activity of aques extract of <i>caesalpinia crista</i> linn and also used as wound healing and analgesic properties. ^[21]			
14) <i>Caesalpinia volkensii</i> 	Biological name: <i>Liane Caesalpinia volkensii</i> Family: Fabaceae	Parts of plant: Leaf	Phytomolecules: Sterols, flavaones, chalcones, flavonoids
		Formulation: Crude Drug	Types of diabetes: Type 2
Description: It shows an significant effect of antidiabetic properties and also effect on abdominal pain, malaria, leprosy. ^[22]			
15) <i>Sarcopoterium spinosum</i> 	Biological name: <i>Sarcopoterium</i> Family: Rosaceae	Parts of plant: Root	Phytomolecules: Corilagin, Pedunculagin, castalagin
		Formulation: Crude drug	Types of Diabetes: Type 2
Description: It is one of the tradtion method used for the antidiabetes and also used for the antiinflammation and wound repair. ^[23]			
16) <i>Cocus Nucifera</i> 	Biological name: <i>Cocous nucifera</i> Family: Arecaceae	Parts of plant: Flower	Phytomolecules: Alkaloids, flavonoids, triterpenoids.
		Formulation: Crude Drug	Types of Diabetes: Type 2
Description: <i>Cocus nucifera</i> shows better antidiabetic activity as well as antioxidant properties. ^[24]			
17) <i>Catharanthus roseus</i>	Biological name: <i>Catharanthus roseus</i> Family: Apocynaceae	Parts of plant: Leaves	Phytomolecules: Catharanthine, leurosine, vindoline and vindolinine
		Formulation: Crude drug	Types of Diabetes: Type 2

	Agirmonia eupatoria	plant: Leaves	Tannis, flavonoids, triterpenoids
	Family: Rosaceae	Formulation: Crude drug	Types of diabetics: Type 2
Description: Agirmonia eupatoria is used for treatment of diabetes mellitus. ^[33]			
26) Amaranthus cruentus 	Biological name: Amaranthus cruentus	Parts of plant: Leaves	Phytomolecules: Alkaloid, glycosides, phenolic compound and flavonoid
	Family: Amaranthaceae	Formulation: Crude drug	Types of diabetes: Type 2
Description: Amaranthus cruentus shows an effective anti-diabetic activity with no side effects. ^[34]			
27) Digeria muricata 	Biological name: False amaranth	Parts of plant: leaves	Phytomolecules: Alkaloid, glycosides, phenolic compound and flavonoid
	Family : Amaranthaceae	Formulation: Crude drug	Types of diabetes: Type 2
Description: Digeria muricata shows enzyme inhibitory activity and gives anti diabetic activity. ^[34]			
28) Aloe ferox 	Biological name: Aloe ferox	Parts of plant: Leaves	Phytomolecules: Phenolic acids, polyphenols, indoles
	Family: Asphodelaceae	Formulation: Crude drug	Types of diabetes: Type 2
Description: shows significant anti-diabetic effect over shorter intervention periods, however to lesser content. ^[35]			
29) Aloe greatheadii 	Biological name: Aloe greatheadii schonland	Parts of plant: Leaves	Phytomolecules: Phenolic acids, polyphenols, indoles
	Family: Asphodelaceae	Formulation: Crude drug	Types of diabetes: Type 2
Description: High dose over long period may result in more significant effect in diabetes. ^[35]			
30) Brassica juncea 	Biological name: Brassica juncea	Parts of plant: Leaves	Phytomolecules: Flavonoids and 13-hydroxy cinnamic acid
	Family: Gucifera	Formulation: Crude drug	Types of diabetes: Type 2
Description: The extract may potentiate secretion of insulin or increase the glucose uptake or may inhibit glucose absorption in gut and produces anti diabetic activity. ^[36]			
31) Berberis aristata 	Biological name: Berberis aristata	Parts of plant: Root	Phytomolecules: Berberine
	Family: Berberidaceae	Formulation: Crude drug	Types of diabetes: Type 2
Description: It shows clear hypoglycemic activity by enhance the intracellular calcium and release the insulin from beta cells. ^[37]			
32) Calamus tenuis 	Biological name: Cane palm plant	Parts of plant: Fruits	Phytomolecules: Polyphenols such as flavonoids & anthomycin
	Family: Arecaceae	Formulation: Crude drug	Types of diabetes: Type 2
Description: the extracts are most effective against gram negative bacteria and exert promising anti-hyperglycemic effect. ^[38]			
33) Euphorbia hirta linn.	Biological name: Euphorbia hirta linn.	Parts of plant: Leaves, flower and stem	Phytomolecules: Flavonoids and tannins
	Family: Euphorbiaceae		

		Formulation: Crude drug	Types of diabetes: Type 2
	Description: It posses significant anti-diabetic activity and shows improvement in parameters like body weight, lipid profile, and other biochemical parameters. ^[39]		
34) Ferula asafoetida 	Biological name: Peucedanum assafoetida Family : Apiceae	Parts of plant: Root Formulation: Crude drug	Phytomolecules: Resins Types of diabetes: Type 2
	Description: Stimulatethe changes of functional state of pancreatic beta cells and capacity of the organisms to produce and secrete insulin is increasing, the glucose level in blood is decreasing shows anti-diabetic activity. ^[40]		
35) costus igneus 	Biological name: Chamaecostus cuspidatus Family: Costaceae	Parts of plant: Leaves Formulation: Crude drug	Phytomolecules: Steroids and alkaloids Types of diabetes: Type 2
	Description: Due to improving the glycemic control mechanism and insulin secretion from remnant pancreatic beta cells produce anti diabetic activity. ^[41]		
36) Ficus religiosa 	Biological name: Sacred fig Family : Moraceae	Parts of plant: Leaves & stem Formulation: Crude drug	Phytomolecules: Flavonoids, β -sitosteryl-D-glucoside Types of diabetes: Type 2
	Description: The extraction of fungi from plant mainly used for type-2 diabetes mellitus. ^[42]		
37) Helicteres isora 	Biological name: East Indian screw tree Family: Sterculiaceae	Parts of plant: Root Formulation: Crude drug	Phytomolecules: Carbohydrate, fat and protein Types of diabetes: Type 2
	Description: The root juice is shows the anti-diabetic activity. Repeated administration had decreased the blood glucose, urea, total cholesterol and triglycerides. ^[43]		
38) Ficus amplissima smith. 	Biological name: Indian bat tree Family: Moraceae	Parts of plant: Bark Formulation: Crude drug	Phytomolecules: Flavonoids, saponins, glycosides, alkaloids & phenolic compounds. Types of diabetes: Type 2
	Description: The presence of flavonoids & polyphenolic compounds shows the anti-hyperglycemic activity. ^[44]		
39) Justicia adhatoda 	Biological name: Adhatoda vasica nees Family: Acanthaceae	Parts of plant: Leaves and root Formulation: Crude drugs	Phytomolecules: Alkaloids like vasicine and vasicinone. Types of diabetes: Type 2
	Description: It have the potential to reduce the level of sugar in blood, urine, tissue lipids & protective mechanism against the development of atherosclerosis & other similar diseases. ⁴⁵		
40) Leucas aspera 	Biological name: Thumbai Family: Lamiaceae	Parts of plant: Stem, flower, fruit, leaves Formulation: Crude drug	Phytomolecules: Terpenoids, glycosides, flavonoids, alkaloids, saponins Types of diabetes: Type 2
	Description: Exhibit higher inhibition of glycosylation and decreases the haemoglobin to produce anti-diabetic effect. ⁴⁶		
41) Ocimum sanctum linn.	Biological name:	Parts of	Phytomolecules:

	<p>Ocimum tenuiflorum Family: Lamiaceae</p>	<p>plant: Leaves Formulation: Crude drug</p>	<p>Tetracyclic triterpenoid known as 16-hydroxy-4,4,10,13 tetramethyl 17(4-methyl-1-phenyl)-hexadecahydrocyclopenta. Types of diabetes: Type 2</p>
<p>42) Plantago major</p> 	<p>Biological name: Broadleaf plantain Family: Plantaginaceae</p>	<p>Parts of plant: Leaves Formulation: Crude drug</p>	<p>Phytomolecules: Phenol's flavonoids and terpenoids Types of diabetes: Type 2</p>
<p>43) Petrocarpus santalinus</p> 	<p>Biological name: Petrocarpus santalinus Family: Fabaceae</p>	<p>Parts of plant: Stem Formulation: Crude drug</p>	<p>Phytomolecules: Phenol & flavonoids Types of diabetes: Type 2</p>
<p>44) Petrocarpus marsupium</p> 	<p>Biological name: Petrocarpus marsupium Family: Fabaceae</p>	<p>Parts of plant: Stem Formulation: Crude drug</p>	<p>Phytomolecules: Phenolic-C-glycosides Types of diabetes: Type 2</p>
<p>45) Prunus armeniaca</p> 	<p>Biological name: Prunus armeniaca Family: Rosaceae</p>	<p>Parts of plant: Fruit Formulation: Crude drug</p>	<p>Phytomolecules: Carbohydrates, minerals, volatile compounds, β-carotene, vitamin B₁ Types of diabetes: Type 2</p>
<p>46) Rheum emodi</p> 	<p>Biological name: Rheum emodi Family: Polygonaceae</p>	<p>Parts of plant: Root Formulation: Crude drug</p>	<p>Phytomolecules: Stilbene, rhaponticin Types of diabetes: Type 2</p>
<p>47) Salacia chinensis</p> 	<p>Biological name: Salacia chinensis linn. wall Family: Hippocrateaceae</p>	<p>Parts of plant: Roots Formulation: Crude drug</p>	<p>Phytomolecules: Salacinol, kotalanol, neokotalanol, mangiferin, Foliachinenosides, pronthocyanidin. Types of diabetes: Type 2</p>
<p>48) salacia oblonga</p>	<p>Biological name: Salacia oblonga wall Family : Hippocrateaceae</p>	<p>Parts of plant: Root Formulation:</p>	<p>Phytomolecules: Salacinol, kotalanol, kotalgenin-16-acetate, alkaloids terpenoids, phenols. Types of diabetes:</p>

		Crude drug	Type 2
	Description: The decrease in blood glucose levels can be due to presence of α -glucosidase inhibitors in root extracts like salacinol and kotalanol. ^[54]		
49) Withania coagulans 	Biological name: Indian rennet Family: Solanaceae	Parts of plant: Fruit	Phytomolecules: Amino acid, fatty oils, essential oils.
		Formulation: Crude drug	Types of diabetes: Type 2
	Description: Extract normalizes hyperglycemia in type 2 diabetes by improving insulin sensitivity. ^[55]		
50) Buddleia indica 	Biological name: Buddleja indica Family: scrophulariaceae	Parts of plant: Leaves	Phytomolecules: Flavonoid, iridoidglycosides, polypropanioids, Verbascoside, kaempferol.
		Formulation: Crude drug	Types of diabetes: Type 2
	Description: Verbascoside display the highest fitting within human α -amylase active sites, kaempferol shows the best fitting in human α -glucosidase active sites to alleviate diabetes. ^[56]		
51) Sida acuta linn. 	Biological name: Sida acuta linn. Family: Malvaceae	Parts of plant: Root	Phytomolecules: Diterpenes, alkaloids, steroids, miscekanous lactones.
		Formulation: Crude drug	Types of diabetes: Type 2
	Description: Reduces the elevated blood glucose level, which implies it acts through the extra pancreatic pathways rather than stimulating insulin secretion & results in anti-hyperglycemic effect. ^[57]		

CONCLUSION

In conclusion, the integration of herbal remedies into diabetes management presents a promising avenue for enhancing patient care. Traditional medicine has long utilized various plant species for their anti-diabetic properties, and modern scientific research increasingly validates these practices. The review highlights several key medicinal plants—such as *Magnifera indica*, *Embllica officinalis*, and *Eugenia jambolana*—which demonstrate significant hypoglycemic effects through mechanisms like improving insulin sensitivity, promoting beta-cell regeneration, and exhibiting antioxidant properties.

While the potential of herbal remedies as adjunctive therapies in diabetes care is evident, it is essential to approach their use with caution. Rigorous clinical trials are necessary to establish the safety, efficacy, and dosage of these treatments. Furthermore, the interaction of herbal remedies with conventional medications must be thoroughly examined to avoid adverse effects.

Ultimately, bridging the gap between traditional herbal medicine and modern scientific inquiry can lead to more holistic and integrative approaches to diabetes management. By fostering collaboration between practitioners of traditional and conventional medicine, we can harness the full potential of both paradigms, ultimately improving the quality of life for individuals living with diabetes.

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