RESEARCH PAPER

MEDICINAL PLANTS WITH ANTIDIABETIC POTENTIAL: A COMPREHENSIVE REVIEW OF BIOACTIVE COMPOUNDS AND MECHANISMS OF ACTION.

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ABSTRACT

Diabetes mellitus is a complex metabolic condition that significantly affects the quality of life and people's health. In addition to lifestyle management, conventional agents are utilized to control diabetes. They are not totally successful, and it has not previously been reported that known to return to normal glycemic status Because medicinal plants contain a wide range of bioactive constituents, many have been found to be beneficial in diabetes management, they have been employed within numerous traditional healthcare practices worldwide to control diabetes mellitus. Due to their inexpensive cost and fewer adverse effects, herbal medicine with antihyperglycemic properties are becoming increasingly popular. The several plants that have been shown to be beneficial for diabetes are the main topic of this review. Numerous herbal medicine with proven antidiabetic and other health advantages have been documented. These include Tinospora cordifolia,Coscinium fenestratum, Dendrobium chrysotoxum, Anthocleista vogelii, Cararium schweinfurthi, Egyptian morus , Hontonia standleyana , Afzelia Africana , Magnifera indica , Terminalia superba. All have exhibited some degree of antidiabetic potential via different biological pathways.

Keywords: Diabetes mellitus, Medicinal plants, Antidiabetic activity, Phytochemicals, Herbal medicine.

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INTRODUCTION

Diabetes is a leading contributor to early mortality across the globe. It is estimated that every ten seconds, one individual dies as a result of diabetes or its associated complications, most commonly due to cardiovascular disorders. The disease disrupts the normal metabolism of carbohydrates, proteins, fats, electrolytes, and water, and comprises a group of metabolic conditions marked by persistently elevated blood glucose levels. In recent years, interest in plant-based therapies has increased because conventional oral hypoglycaemic drugs are often linked to adverse side effects. Diabetes mellitus, the most common endocrine disorder, affects over 100 million people worldwide, accounting for approximately six percent of the global population. The condition arises when the pancreas fails to produce sufficient insulin or when the body cannot effectively utilize the insulin produced. If left unmanaged, diabetes can cause serious damage to multiple organs, including the heart, blood vessels, kidneys, eyes, and nervous system. [1]

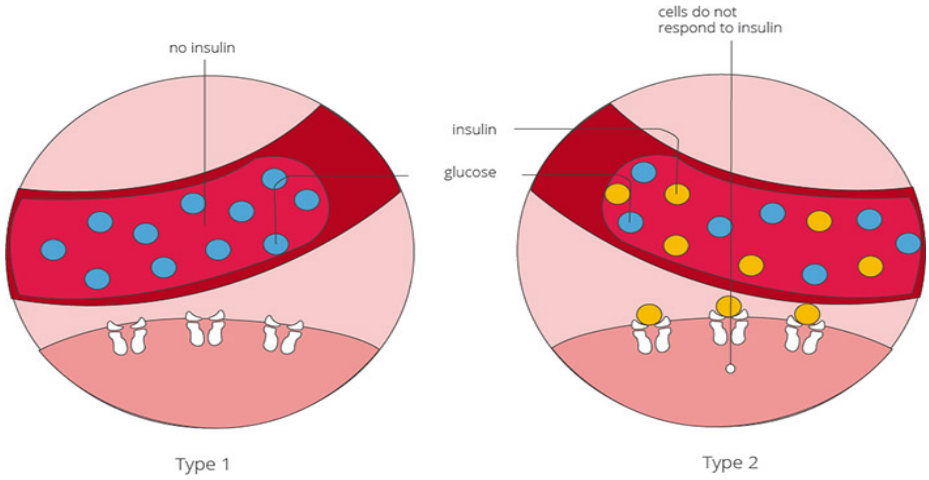

Figure 1 Diabetes

Diabetes mainly occurs in two major forms: Type I diabetes, which requires insulin for management, and Type II diabetes, which is generally controlled without insulin therapy. Inflammation surrounding the pancreatic islets causes the death of the insulin-secreting cells are destroyed in Type I diabetes, an autoimmune disease. Both decreased insulin output and Insulin resistance within the body is a key feature of Type II diabetes. [2] Diabetes mellitus increases the likelihood of developing complications such as peripheral vascular disease, cardiovascular disorders, stroke, kidney failure, nerve damage, eye issues, and amputations. [3] The primary aim of therapy is to minimize clinical symptoms, avoid long-term issues, and extend life. Insulin therapy is the primary treatment for insulin-dependent diabetes mellitus, but dietary together with daily habits modifications are the major emphasis of non–insulin-dependent diabetes mellitus. [4]

Biguanides as well as sulfonylureas are among that hypoglycemic medications used to treat diabetes, but none of them are perfect since they might have harmful side effects and become ineffective with time.[5] The requirement for lifetime medicine is a significant disadvantage. Particularly in areas with restricted access to traditional diabetic therapies, medicinal plants and their bioactive ingredients provide an alternative. The antidiabetic benefits of plants are assessed using a variety of experimental models.[6]

A better knowledge of diabetes mellitus, including its symptoms, epidemiology, consequences, and available treatments, is the goal of this study. [7,8]

LITERATURE SEARCH STRATEGY:

This review was conducted using scientific databases including PubMed, Scopus, Google Scholar, and ScienceDirect. Keywords such as “diabetes mellitus,” “antidiabetic medicinal plants,” “herbal hypoglycemic agents,” and “phytochemicals in diabetes” were used to identify relevant articles published between 2000 and 2024.

Studies reporting experimental, pharmacological, and clinical evidence of antidiabetic activity of medicinal plants were included. Articles lacking scientific validation or insufficient data were excluded.

SIGN AND SYMPTOMS:

Blood sugar levels have an impact on diabetes symptoms. Some patients, especially those with type 2 diabetes, gestational diabetes, or prediabetes, may not exhibit any symptoms at all. The symptoms of type 1 diabetes are usually more severe and appear more quickly.

❖ Common signs seen in insulin-dependent and non-insulin-dependent diabetes:

- Excessive thirst
- Frequent passage of urine
- Unexpected loss of body weight
- Presence of ketone bodies in urine (due to insufficient insulin)
- Fatigue and weakness
- Irritability or variations in emotional behavior
- Reduced clarity of vision
- Delayed wound healing
- Recurring infections [9]

CAUSES OF DIABETES MELLITUS:

Diabetes may develop due to several factors including:

- Genetic predisposition
- Autoimmune destruction of pancreatic β-cells
- Obesity and sedentary lifestyle
- Poor dietary habits
- Age-related metabolic changes

- Viral infections such as Coxsackie virus

Lifestyle modification, including balanced diet and regular physical activity, plays an important role in preventing the development of type 2 diabetes.

Diabetes having so many causes they include, in insulin-dependent diabetes mellitus also in part hereditary and after that caused because of specific illnesses, with certain findings suggesting a link to the Coxsackie B4 virus. In case of non-insulin-dependent diabetes mellitus, it is caused by a mix of habits and genetic variables the other causes include age, obesity, dietary habit alteration, etc.

Many people have changed their lifestyles and eating habits in the sake of current fashion and trends. According to one study, people with increased involvement in bodily movement, a nutritious intake, no smoking, and moderate ethanol-containing drinks use had an 82% lower incidence of diabetes. Including a normal weight reduced the rate by 89%. A diet that was high in fiber, had a greater proportion of polyunsaturated fats relative to saturated fats, and had a lower mean glycemic index was considered healthy in this study. Obesity is the other significant risk factor. It has been discovered to be a factor in about 55% of type 2 diabetes cases. [10]

MECHANISM OF ANTIDIABETIC ACTION OF PHYTOCHEMICALS

Medicinal plants exert antidiabetic effects through several biological mechanisms including:

• Stimulation of insulin secretion from pancreatic β-cells

• Enhancement of insulin sensitivity in peripheral tissues

• Inhibition of carbohydrate metabolizing enzymes such as α-amylase and α-glucosidase

• Reduction of intestinal glucose absorption

• Antioxidant activity protecting pancreatic β-cells

• Modulation of glucose transporters such as GLUT-4

Medicinal plants contain various phytoconstituents such as alkaloids, flavonoids, phenolics, terpenoids, and tannins that contribute to their antidiabetic effects. These compounds help regulate blood glucose levels through multiple mechanisms including:

Medicinal plants are important in managing diabetes mellitus, a serious metabolic disorder. Traditional plants possess antidiabetic properties with minimal side effects and contain naturally active substances like flavonoids, alkaloids, phenolics, as well as tannins. These substances help enhance the release of insulin or reduce uptake of glucose within the intestine, thereby improving pancreatic function. [11]

Since ancient times, herbal resources have been widely applied in healthcare practices, and they are commonly recognized as the cornerstone of contemporary pharmacy and medicine. Traditional herbal medicine knowledge, which has been passed down through the ages in various cultures, is based on locally accessible plants. These plants are a rich source of biologically active substances that have been shown to have therapeutic benefits and have been used historically and now to manage various health conditions. Nowadays, hundreds of species are grown all over the world to extract useful chemicals for the manufacture of pharmaceuticals. Thirty to fifty percent of current medications come from natural sources (mostly plants, but also microbes and others), either directly or through derived or synthetic compounds. More than 60% of anti-cancer medications used in cancer treatment come from plants, either directly or indirectly. This study investigates the therapeutic effects of a few medicinal species that were well researched and historically applied to treat diabetes because of their important role in medication discovery. [12,13]

CLASSIFICATION OF ANTIDIABETIC PLANTS

Classification Based on Mechanism

Mechanism	Examples of Plants
Insulin secretagogue	Tinospora cordifolia, Mangifera indica
Enzyme inhibition	Azadirachta indica, Bauhinia forficata
Antioxidant protection	Ficus racemosa, Aloe vera
Glucose uptake enhancement	Citrus paradisi, Anethum graveolens

List of Herbal Plants used in Antidiabetic Activity:

Sr. No	Botanical Name	Parts of Plant	Extract	Active Chemical Constituents	MOA	Effective Dose	LD50	Reference
1	***Coscinium fenestratum*** (Tree turmeric)	Stem	Aqueous	Berberine	Enhances glucose phosphorylation to glucose-6-phosphate, supporting greater intracellular glucose uptake and metabolism	250 mg/kg	**~1200 mg/kg** for stem extract	14
2	***Dendrobium chrysotoxum*****(Fried-Egg Orchid)**	Stem	Ethanol	polysaccharides	lowering blood sugar, decreasing inflammation, and adjusting the intestinal microbiome	**30 mg/kg to 300 mg/kg**	No clear LD_{50} value	15
3	***Tinospora Cordifolia*** (Giloy)	Stem	Methanolic	Alkaloids (Berberine)	Enhances the absorption of glucose, mimics the effect of insulin, and stimulates insulin secretion.	100–400 mg/kg	>1000 mg/kg	16
4	***Anthocleista vogelii*** **(Cabbage Tree)**	Stem	methanol	**Alkaloids**	By increasing insulin release and inhibiting the enzymes that break down carbohydrates, anthocyanin and leucoanthocyanidin glycosides help reduce blood sugar.	100–400 mg/kg	>5000 mg/kg	17
5	***Cararium schweinfurthi*** **(bush candle tree)**	Stem	Methanol	Terpenoids	It was equally successful as glibenclamide resulting in a 70–80% reduction in blood glucose along with improved lipid profiles in rats with STZ-induced diabetes.	300 mg/kg	**>5000 mg/kg.**	18
6	***Egyptian morus alba*** **(white**	Stem	70% alcoholic	flavonoids	Reduces hyperglycemia and lipid peroxidation.	100–500 mg/kg body	-	19

	mulberry)		extract			weight		
7	***Hontonia standleyana*** **(Copalchi)**	Stem	Aqueous	4-phenylcoumarins	Insulin and hepatic glucose regulation may have hypoglycemic or antihyperglycemic effects.	~100 mg/kg extract; 10–30 mg/kg isolated compounds	>5000 mg/kg in mice (aqueous extracts)	20
8	***Afzelia Africana*** **(African mahogany)**	Stem	Aqueous	Flavonoids	By enhancing insulin secretion from pancreatic β-cells or promoting glucose uptake in peripheral tissues.	200 mg/kg	≤5000 mg/kg	21
9	***Bougainvillea spectabilis*** (Paper flower)	Stem	Ethanol	Flavonoids	a mechanism of action similar to that of glibenclamide, along with extra pancreatic activities	250 mg/kg	>5000 mg/kg	22
10	***Magnifera indica*** (Mango tree)	Stem	Aqueous Ethanol Methanol	Mangiferin, flavonoids	Insulin secretion, antioxidant effect, glucose uptake	100–400 mg/kg (extract), 10–40 mg/kg (mangiferin)	>2000–5000 mg/kg (oral)	23
11	***Terminalia superba*** **(Shinglewood)**	Stem	Methanol	Flavonoids,	Antihyperglycemic, antioxidant, insulin sensitization	300 mg/kg	> 5000 mg/kg (oral)	24
12	***Berberis aristate*** **(tree turmeric)**	Stem	Aqueous	Berberine,	AMPK activation, insulin sensitization, enzyme inhibition	100–500 mg/kg (extract); 25–50 mg/kg (berberine)	> 2000 mg/kg (oral extract)	25
13	***Exostema mexicanum*** (Central America)	Stem	Aqueous	Coumarins	Antihyperglycemic, antioxidant, insulin sensitization	100–300 mg/kg (oral, rats)	> 5000 mg/kg (oral)	26
14	***Exostemac arbibaeum*** **(Caribbean princewood)**	Stem	Aqueous	4-phenylcoumarins,	↓Blood glucose, α-glucosidase inhibition, antioxidant effects	~100–500 mg/kg (rodent studies)	>5000 mg/kg (oral, mice)	26
15	***Ficus racemosa*** **(Cluster Fig)**	Stem	Methanolic	Flavonoids (quercetin)	↓Blood glucose, enzyme inhibition (α-amylase/α-glucosidase), PPAR-γ/GLUT1 modulation,	200–400 mg/kg (crude extract); ~100 mg/kg	Not systematically reported	27

					antioxidant activity	(isolated flavonoids)		
16	***Ficus glomerate*** **(Cluster Fig)**	Stem	Aqueous	β-Sitosterol,	Enhances insulin secretion and sensitivity and Increases glucose uptake and glycogen synthesis	100–500 mg/kg body weight	LD50 = 850 µg/mL	28
17	***Kalopanax pictus*** **(Castor Aralia)**	Stem	Methanolic	saponins: Kalopanaxsaponin)	Potent hypoglycemic effect		LD50 > 4033 mg/kg	29
18	***Acacia arbica*** (Babool)	Seeds	Powdered seeds	tannins	Reduces blood glucose in healthy animals, promotes insulin release from active pancreatic β-cells.	Powdered seeds: 2–4 g/kg body weight	No specific LD50 reported for seeds; doses up to 4 g/kg showed	30
19	***Citrus paradise*** (Grape fruit)	Seeds	Methanolic	Flavonoids (naringin, hesperidin),	increases peripheral glucose absorption, antioxidant activity, insulin secretion, and potential α-glucosidase inhibition	100–400 mg/kg body weight	>2000 mg/kg	31
20	***Aleo vera*** (Aloe)	Leaves	Aqueous	Polysaccharides (acemannan, glucomannan),	Enhances peripheral tissue glucose absorption, boosts insulin production from pancreatic β-cells, helping to prevent oxidative stress–induced damage, and inhibits gluconeogenesis.	200–500 mg/kg	>2000 mg/kg	32

21	***Anethum graveolens*** (Dill)	Leaves	Aqueous	Flavonoids (quercetin, kaempferol),	Increases insulin production, increases insulin sensitivity, prevents intestinal glucose absorption, and has a hypolipidemic action that aids in glycemic management.	100–300 mg/kg	greater than 2000 mg per kilogram of body weight	33
22	***Annona squamosa*** (Sugar apple)	Leaves	Aqueous	Flavonoids (quercetin, kaempferol),	By boosting insulin secretion, preserving β-cells, decreasing hepatic glucose synthesis, and improving glucose absorption, it reduces blood sugar.	100–300 mg/kg	>2000 mg/kg	34
23	***Averrhwa bilimbi*** (Cucumber tree)	Leaves	Ethanolic	flavonoids	Antioxidant activity, enhanced insulin sensitivity and glucose absorption, β-cell protection, and inhibition of enzymes that metabolize carbohydrates are probably the reasons for its hypoglycemic impact.	~150–300 mg/kg body weight	LD_{50} **<5000 mg/kg**	35
24	***Azadirachta indica*** (Neem)	Leaves	aqueous	Flavonoids	Increases glucose uptake and glycogen production while inhibiting α-glucosidase/amylase, which lowers glucose absorption.	200–500 mg/kg oral.	>2,500–5,000 mg/kg	36

25	***Bauhinia forficate*** **(Brazilian Orchid Tree)**	Leaves	Aqueous	Flavonoids	Delays carbohydrate breakdown and reduces glucose uptake through inhibition of α-amylase and α-glucosidase.	Decoction ~150 g leaves/L water.	LD50 oral >2,000–5,000 mg/kg	37
26	***Bixa Orellana*** (Lipstick tree)	Leaves	Aqueous	Phenols	Offers antioxidant action to combat oxidative stress, and may improve peripheral glucose utilization.	125–500 mg/kg body weight	>700 mg/kg	38
27	***Brassica juncea*** (Mustard green)	Leaves	Methanolic	Flavonoids and flavonols	Slows the absorption of glucose by blocking the enzymes that break down carbs.	100–400 mg/kg/day (oral, in diabetic rats	No specific LD50 reported for leaf extracts 400 mg/kg/day	39
28	***Cassia auriculate*** **(Tanner's Cassia)**	Leaves	Aqueous	Flavonoids (quercetin, kaempferol),	Protects β-cells, promotes insulin release, and improves glucose metabolism.	100–400 mg/kg body weight (oral)	LD_{50} > 2000–5000 mg/kg (oral, rodents)	40

❖ ***Coscinium fenestratum:***

Tree turmeric, or Coscinium fenestratum (Menispermaceae), is a woody climbing shrub that is indigenous to Sri Lanka and the Western Ghats of India (Tamil Nadu, Kerala). It differs from berberis replacements with its cylindrical stem, which is yellowish-brown on the outside and yellow inside. It has big wood vessels, no yearly rings, and a crenate sclerenchyma ring under the cortex. The stem produces a yellow colour that may be used either by itself or in combination with turmeric.Alkaloids found in roots include berlambine (oxyberberine), dihydroberlambine, 12,13-dihydro-8-oxo-berberine, tetrahydroberberberine, and noroxyhydrastinine (with berberine being the main bioactive molecule in contemporary research). [41]

❖ ***Dendrobium chrysotoxum:***

Chinese Dendrobium species' stems are prized for their health advantages since they are high in polysaccharides and anthocyanins. Due to its similarities, D. thyrsiflorum is frequently used in place of D. chrysotoxum, which is known for its anti-inflammatory, anticancer, hypoglycemic, and antioxidant actions; nevertheless, nothing is known about the stem bioactive qualities of this plant. [42]

❖ ***Tinospora Cordifolia:***

Tinospora cordifolia, sometimes called Giloy or Guduchi, is a plant widely used in Ayurvedic medicine and classified under the family Menispermaceae. Research has indicated that it contains anti-cancer, immune-stimulating, anti-diabetic, cholesterol-lowering, liver-protective, and perhaps diabetic foot ulcer-healing effects. However, these findings are still preliminary. The study examined blood glucose–lowering and regenerative effects of stem extracts in both healthy rats and streptozotocin-induced diabetic rats over a 100-day period. [43]

❖ ***Anthocleista vogelii:***

Known in traditional medicine for its role in reducing inflammation, controlling blood sugar, and aiding wound healing, Anthracleista vogelii is a tropical African plant whose root extracts exhibit hypoglycemic action and in vitro α-amylase inhibition. The current

study examines the antidiabetic properties obtained from stem bark material in rats. [44]

❖ ***Canarium schweinfurthii:***

Canarium schweinfurthii belonging to the family Burseraceae, it is a prominent species within the genus Canarium, which has 75 warm-climate regions species of Asia, and the Pacific. It belongs to member of the tribe Canarieae, which is well-known for its culinary and medicinal purposes.Native to tropical woodlands in Western, Eastern, and Central Africa, this versatile tree is prized for its culinary and traditional medicinal qualities.Related species are used to treat respiratory, liver, and skin disorders (C. bengalense leaves/roots), fever/rheumatism (C. ovatum bark), and chest discomfort (C. indicum bark). [45]

❖ ***Hontonia standleyana:***

In Mexico, copalchi (Hintonia latiflora or Hintonia standleyana) stem-bark infusions have long been used for the management of diabetes and digestive disorders such as dyspepsia, ulcers, and gastric ailments discomfort. The plant was recorded in the Florentine Codex under Nahuatl names as a bitter, digestive-improving (eupeptic) medicine at least as early as the 16th century. This medical application is widely regarded today. [46]

❖ ***Afzelia Africana:***

Known by several regional names, *Afzelia africana* is a Fabaceae plant that is commonly used as a food thickening in southeast Nigeria. Although its stem and root bark extracts have shown antihyperglycemic activity, little is known about the effects of its various extract fractions and how they might improve reproductive dysfunctions related to diabetes. This study aimed to evaluate the phytochemical components of the active fraction and assess the antihyperglycemic and ameliorative effects of extract fractions. [47]

❖ ***Bougainvillea spectabilis:***

The study discovered that in both healthy animals and rats with alloxan-induced diabetes, ethanol extracts derived from the stem bark of Bougainvillea spectabilis dramatically lowered blood sugar concentrations. The most successful of the studied dosages was 250 mg/kg/day, which outperformed the common medication glibenclamide. The extract demonstrated substantial hypoglycemic action and restored hyperglycemia after a week. Despite utilizing a different species, the study's methodology and findings are comparable to prior research on Bougainvillea glabra. [48]

❖ ***Magnifera indica:***

Only a small number of the about 1,000 varieties of the Mangifera indica L. (mango), which is a popular tropical edible part from the Anacardiaceae taxonomic category, are marketed commercially. It is the national tree of Bangladesh and the national fruit of the Philippines and India. Rich in vitamins, minerals, dietary fiber, and phytochemicals, mangos are the second most popular tropical crop after bananas. Different parts of the mango plant, including the stems, bark, leaves, and seeds, have long been employed in traditional medicine for diabetes management. Mango is acknowledged as an affordable herbal alternative with possible blood-glucose-lowering benefits, and the WHO advocates the use of traditional and herbal remedies. [49]

❖ ***Terminalia superba:***

Large African forest plants called Terminalia superba and Canarium schweinfurthii have long been used to cure diabetes. While C. schweinfurthii is commonly used throughout tropical Africa, T. superba stem bark powder is utilized by the Sotho people of Southern Senegal. Both species are found in secondary, semi-deciduous, and humid forests, and the presence of alkaloid chemicals is linked to their antidiabetic properties. [50]

❖ ***Berberis aristate:***

Native to India, Berberis aristata DC. is an upright, prickly shrub that is typically found in tiny patches on hill slopes, particularly in the sub-Himalayan area. Because of its laxative and diaphoretic qualities, its yellow, rough stem and other portions are frequently employed in traditional and Ayurvedic medicine to treat rheumatism, skin conditions, infections, diarrhea, and eye ailments. This study examined the impact of the methanol-derived stem extract of Berberis aristata DC. On glucose concentrations in healthy rats as well as streptozotocin-induced diabetic models because there had been no documented pharmacological research on the stem. [51]

❖ ***Ficus racemose:***

Ficus racemosa (gular), a member of the Moraceae family, is extensively found in Australia, Southeast Asia, and regions of India.In Ayurvedic practice, it has been traditionally employed to manage diabetes and obesity. Polyphenols, triterpenes, sesquiterpenes, glycosides, and sterols are among the many bioactive substances found in the plant. With the help of β-sitosterol and other sterols that reduce blood glucose levels in rats with streptozotocin-induced diabetes, it demonstrates a variety of pharmacological actions, most notably antidiabetic benefits. [52]

❖ ***Kalopanax pictus:***

Kalopanax pictus (Araliaceae) has long been used in Korea to treat skin disorders, wounds, diarrhea, and rheumatic arthritis. Saponins, lignans, phenols, glycosides, polyacetylenes, and phenylpropanoids are

all present. Kalopanaxsaponin A and B are among the isolated chemicals and extracts that have shown anti-inflammatory, antidiabetic, and anti-rheumatic activities, with particular focus on macrophage behavior, immune signaling molecules, enzymatic responses, and phagocytic capacity in RAW 264.7 cells, this study examined its immune-enhancing potential. [53]

DISCUSSION:

Plant-based medicines have gained increasing attention in diabetes management because they provide multiple therapeutic benefits with fewer adverse effects. Many plants exhibit antihyperglycemic activity through modulation of insulin secretion, inhibition of carbohydrate metabolizing enzymes, and improvement of glucose uptake in peripheral tissues.

Phytochemicals such as flavonoids and alkaloids have been widely reported for their antioxidant and antidiabetic properties. These compounds may help protect pancreatic β-cells from oxidative damage and improve metabolic control in diabetic patients.

LIMITATIONS OF HERBAL ANTIDIABETIC THERAPY

Despite promising pharmacological effects, herbal medicines face several challenges:

- Lack of standardized dosage
- Variability in phytochemical composition
- Limited clinical trials
- Possible herb–drug interactions
- Quality control issues

FUTURE PERSPECTIVES

- Isolation and characterization of active phytochemicals
- Clinical trials to validate efficacy and safety
- Development of standardized herbal formulations
- Exploration of nanotechnology-based herbal drug delivery systems
- Integration of herbal medicines with modern pharmacotherapy

CONCLUSION:

Plants are the source of many modern medications. Given the growing popularity of herbal remedies, it is wise to look for novel hypoglycemic antidiabetic compounds from medicinal plant extracts. The present rate of urbanization may result in the irreversible loss of this priceless information, hence it is imperative to record traditional wisdom. Although there are issues with their safety, effectiveness, and quality, more work should be done to isolate, identify, and purify the active ingredients from the medicinal plant extracts as well as to carefully research the appropriate antidiabetic mechanisms. This will advance knowledge and open the door for high-quality traditional medicines. Appropriate regulation of the herbal medicine business is necessary. Because they have no known adverse effects and potentially lower the expenses of treating diabetes mellitus, plant products can be utilized as adjuvants or even as a substitute for synthetic medications in antidiabetic therapy.

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