IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 2, June 2026
Impact Factor: 8.2

Studies on Biomarkers and Antidia Betic Activity of Herbal Drugs

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Abstract: *Diabetes mellitus (DM), also known as insulin-dependent diabetes mellitus (IDDM) and noninsulin dependent diabetes mellitus (NIDDM), is a common and serious metabolic condition that affects people all over the world. Traditional herbal plants have been utilized to treat diabetes mellitus all throughout the world. Several herbs have been found to treat and control diabetes among numerous medicines and poly herbal plants; they also have no adverse effects. Thus, herbal plants may be a possible source of anti-diabetic medicines, with ethno botanical data indicating that around 800 plants may have anti-diabetic potential. Although synthetic oral hypoglycemic agents/insulin are a popular diabetes therapy and are effective in controlling hyperglycemia, they have significant side effects and do not significantly modify the course of diabetic complications.1 This is the primary reason why an increasing number of individuals are looking for alternative medicines with fewer or no adverse effects. The botanical name, common name, component, and mechanism of action for anti-diabetic activity were provided in this review study, as well as plant-based commercial poly herbal formulations .2*

Medicinal plants contain various bioactive constituents including alkaloids, flavonoids, glycosides, terpenoids, and phenolic compounds which exhibit antidiabetic activity through different mechanisms such as stimulation of insulin secretion, improvement of insulin sensitivity, inhibition of glucose absorption, and antioxidant action. Herbal drugs may serve as promising alternatives or complementary therapies for diabetes management.3 The present study focuses on biomarkers and antidiabetic activity of herbal drugs. Various medicinal plants such as Gymnema sylvestre, Momordica charantia, Trigonella foenum-graecum, Azadirachta indica, Syzygium cumini, Ocimum sanctum, and Aloe vera have been reviewed for their antidiabetic properties and mechanisms of action. The study also highlights the importance of biomarkers in early diagnosis and monitoring of diabetes mellitus.4.

Keywords: Diabetes mellitus, Medicinal plants, glucose, poly herbal plants

I. INTRODUCTION

Diabetes is a metabolic disease characterized by alterations in glucose, lipid, and protein metabolism, resulting in hyperglycemia and inadequate insulin production, action, or both.1,2 It is one of the stubborn illnesses recognized by the Indian Council of Medical Research for which a replacement drug is required for diabetic therapy. Diabetes mellitus is a major problem in today's world.3 In diabetes, the biochemical parameters of the poly herbal formulation (glucose, urea,
creatinine, serum cholesterol, serum triglyceride, high density lipoprotein, low density lipoprotein, hemoglobin, and glycosylated hemoglobin) were calculated. Although this product performed well in an oral glucose tolerance test, it does not have a hypoglycemic impact.1

The treatment of diabetic rats with herbal products resulted in substantial improvements in biochemical markers. According to the current study, the herbal substance can be used as an anti- diabetic.2

The number of persons suffering from diabetes is steadily growing, Aging, urbanization, and the rising prevalence of obesity and physical inactivity are the primary causes of this disease. Estimate the diabetic burden and the number of people affected by diabetes; today and in the future, it is critical to have logical planning and allocation of resources for

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diabetes treatment and prevention. Diabetes is a metabolic condition in which the human body does not generate enough insulin, a hormone needed to convert sugar, starches, and other carbohydrates into energy.3

Diabetes is characterized by abnormal glucose levels in the bloodstream. Herbal plants may be found in abundance in our daily lives. These herbs are ingested by both the ill and the healthy individual as a nutrient or a source of nourishment. Herbal plans are widely available, may be consumed uncooked, have little adverse effects, and are inexpensive. Herbal medicines reign supreme over all other remedies.4

The majority of diabetes cases fall into one of two basic etio pathogenic groups. Diabetes mellitus is mainly classified into Type 1 Diabetes Mellitus (T1DM) and Type 2 Diabetes Mellitus (T2DM). Type 1 diabetes occurs due to destruction of pancreatic β-cells leading to insulin deficiency, whereas Type 2 diabetes is mainly associated with insulin resistance and impaired insulin secretion. Among these, Type 2 diabetes is more common and accounts for the majority of diabetic cases worldwide.5

The first is type 1 diabetes, which is characterized by an apparent lack of insulin secretion. On the other hand, much more widespread category is type 2 diabetes; the main cause is a combination of resistance to insulin action and an inadequate compensatory insulin-secretary response (American Diabetes Association, 2005)6 Biomarkers play an important role in the diagnosis, monitoring, and management of diabetes mellitus. A biomarker is a measurable biological indicator that reflects normal biological processes, disease conditions, or therapeutic responses. In diabetes, biomarkers help in early diagnosis, prediction of complications, and evaluation of treatment effectiveness. Common biomarkers used in diabetes include fasting blood glucose, postprandial blood glucose, glycated hemoglobin (HbA1c), insulin levels, lipid profile, C-reactive protein (CRP), and inflammatory markers. Among these, HbA1c is considered one of the most reliable biomarkers because it indicates the average blood glucose level over the previous two to three months.7

The growing burden of diabetes and the side effects associated with synthetic antidiabetic drugs have increased interest in herbal medicines and natural therapies. Medicinal plants contain various bioactive compounds such as flavonoids, alkaloids, glycosides, terpenoids, and phenolic compounds which possess antidiabetic activity. Herbal drugs help in reducing blood glucose levels, improving insulin sensitivity, regenerating pancreatic β-cells, and reducing oxidative stress. They are also considered safer, cost-effective, and easily available compared to synthetic drugs.8

Several medicinal plants such as Gymnema sylvestre, Momordica charantia, Trigonella foenumgraecum, Azadirachta indica, Syzygium cumini, Ocimum sanctum, and Aloe vera have shown significant antidiabetic potential in various experimental and clinical studies. These plants also possess antioxidant and anti-inflammatory properties which help in preventing diabetic complications. Therefore, the present study focuses on biomarkers and antidiabetic activity of herbal drugs, highlighting the importance of biomarkers in diabetes diagnosis and the therapeutic potential of medicinal plants in diabetes management.9

PLAN OF WORK

1) Selection of Topic Selection of the project topic “Studies on Biomarkers and Antidiabetic Activity of Herbal Drugs”.

2) Literature Survey Collection of information from textbooks, journals, review articles, research papers, and online scientific databases related to diabetes mellitus and herbal medicines. 2

3) Study of Diabetes Mellitus Detailed study of diabetes mellitus including causes, symptoms, classification, pathophysiology, and complications associated with the disease.

4) Study of Biomarkers Study of important biomarkers such as blood glucose, HbA1c, cholesterol, triglycerides, creatinine, and urea used for diagnosis and monitoring of diabetes mellitus.3

5) Collection of Medicinal Plants Collection and review of medicinal plants having antidiabetic activity based on traditional and scientific evidence.

6) Study of Phytoconstituents Study of active phytochemical constituents present in medicinal plants responsible for antidiabetic activity.4

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7) Mechanism of Action Study of various mechanisms of action of herbal antidiabetic drugs such as stimulation of insulin secretion, reduction in insulin resistance, antioxidant activity, and inhibition of glucose absorption. 5
8) Pharmacological Evaluation Evaluation of pharmacological and therapeutic activities of selected herbal plants used in diabetes management.
9) Comparative Study Comparative study of herbal antidiabetic drugs and synthetic antidiabetic medicines based on efficacy, safety, side effects, and cost effectiveness.
10) Study of Marketed Formulations Collection of information regarding marketed herbal antidiabetic formulations available in the market.6
11) Preparation of Tables and Figures Preparation of tables, graphs, charts, and figures related to biomarkers and medicinal plants with antidiabetic activity.
12) Data Compilation and Analysis Compilation, organization, and analysis of collected literature data from various scientific sources.7
13) Conclusion and Report Preparation Preparation of conclusion, references, annexures, and final project report based on collected information and literature review.

REVIEW OF LITERATURE

Several researchers and scientists have previously carried out studies on biomarkers and the anti- diabetic activity of herbal drugs

1) Study by Joseph B. and Jini D. et al., (2011)

Joseph B. and Jini D. reviewed traditional Indian medicinal herbs used in the treatment of diabetes mellitus. They reported that several herbal plants effectively reduce blood glucose levels and possess fewer side effects compared to synthetic antidiabetic drugs. Their study highlighted the importance of herbal medicines such as Gymnema sylvestre, Momordica charantia, and Trigonella foenum-graecum in diabetes management. They concluded that herbal therapy may provide safer and economical treatment options for diabetic patients.2

2) Study by Grover J.K., Yadav S., and Vats V. et al., (2002)

Grover J.K., Yadav S., and Vats V. studied medicinal plants of India having antidiabetic potential. Their review concluded that many medicinal plants improve insulin secretion, enhance glucose metabolism, and show antioxidant properties. They also emphasized that herbal plants can help reduce oxidative stress and diabetic complications. Their work provided scientific support for the traditional use of medicinal plants in diabetes treatment.3

3) Study by Rao M.U., Sreenivasulu M., Chengaiah B. et al., (2010)

Rao M.U. and co-workers reviewed herbal medicines used in diabetes mellitus and stated that herbal therapies are becoming popular because of their safety, affordability, and effectiveness in long-term treatment. They observed that herbal drugs possess hypoglycemic and hypolipidemic activities which are useful in controlling diabetes and related complications. Their review suggested that herbal medicines are promising alternatives to synthetic drugs.4

4) Study by Edwin Jarald, Joshi S.B., and Jain D.C. et al., (2008)

Edwin Jarald and colleagues studied diabetes and herbal medicines. They reported that many medicinal plants possess hypoglycemic and hypolipidemic activities which help in preventing diabetic complications such as cardiovascular diseases and neuropathy. Their study also explained the role of herbal medicines in improving overall metabolic function and reducing oxidative damage.5

5) Study by Shukla R., Sharma S.B., Puri D. et al., (2000)

Shukla R. and co-workers studied medicinal plants used in diabetes mellitus and concluded that herbal plants effectively lower blood glucose levels and improve diabetic conditions. Their research highlighted the role of medicinal plants in improving insulin activity and reducing complications associated with diabetes mellitus.6

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6) Study by Dahanukar S.A., Kulkarni R.A., and Rege N.N. et al., (2000)
Dahanukar and colleagues reviewed the pharmacology of medicinal plants and natural products. Their study reported that many herbal plants possess antidiabetic, antioxidant, and anti-inflammatory activities. They emphasized the importance of medicinal plants as safer therapeutic agents for chronic diseases like diabetes mellitus.7
7) Study by Piyush M.P., Natvarlal M.P., and Ramesh G.K. et al., (2006)
Piyush M.P. and co-workers reviewed herbal antidiabetic drugs and provided a holistic classification of medicinal plants used in diabetes treatment. They concluded that herbal medicines act through different mechanisms such as stimulation of insulin secretion, reduction in insulin resistance, and inhibition of glucose absorption.8
8) Study by Pulok K.M., Kuntal M., Kakali M. et al., (2006)
Pulok K.M. and co-workers reviewed Indian medicinal plants with hypoglycemic potential. They found that many medicinal plants contain bioactive compounds which help regulate blood glucose levels naturally. Their study also suggested that medicinal plants may help delay diabetic complications by improving antioxidant defense mechanisms.9
9) Study by Mutalik S., Sulochana B., Chetana M. et al., (2003)
Mutalik and co-workers carried out acute and subacute toxicity studies on an antidiabetic herbal preparation called Dianex. They observed that the herbal formulation was safe and effective for diabetes management. Their study supported the use of polyherbal formulations in controlling blood glucose levels with minimal toxicity.10
10) Study by Sharma R. and Arya V. et al., (2011)
Sharma R. and Arya V. reviewed fruits having antidiabetic potential and reported that several fruits possess hypoglycemic, antioxidant, and hypolipidemic activities. They highlighted the role of natural fruits in reducing blood glucose levels and improving overall metabolic health in diabetic patients. 11
11) Study by Tanaka K., Nishizono S., Makino N. et al., (2008)
anaka and co-workers studied the hypoglycemic activity of Eriobotrya japonica seeds in diabetic rats and mice. They reported significant reduction in blood glucose levels and improvement in glucose metabolism. Their study suggested that herbal seeds possess strong antidiabetic potential.12
12) Study by Deb L. and Dutta A. et al., (2006)
Deb L. and Dutta A. reviewed diabetes mellitus and its pharmacological evaluation techniques along with naturopathy. They reported that natural and herbal therapies are effective in diabetes management and may help reduce dependence on synthetic drugs.13
13) Study by Dey L., Attele A.S., and Yuan C. et al., (2002)
Dey L. and co-workers reviewed alternative therapies for type 2 diabetes mellitus. Their study suggested that herbal medicines improve insulin sensitivity and help maintain blood glucose control. They also highlighted the growing importance of alternative medicine in diabetes treatment.14
14) Study by Eddouks M. and Maghrani M. et al., (2004)
Eddouks M. and Maghrani M. studied the phlorizin-like effect of Fraxinus excelsior in normal and diabetic rats. Their research demonstrated that herbal extracts reduce glucose reabsorption and lower blood glucose levels effectively.15
15) Study by Mohamed B., Abderrahim Z., Hassane M. et al., (2006)
Mohamed B. and colleagues reviewed medicinal plants with potential antidiabetic activity based on ten years of herbal medicine research. They concluded that medicinal plants possess strong therapeutic potential in diabetes management and require further scientific investigation.16

AIM, NEED OF STUDY AND OBJECTIVES

AIM : STUDIES ON BIOMARKERS AND ANTIDIABETIC ACTIVITY OF HERBAL DRUGS

NEED OF STUDY

Diabetes mellitus is one of the most common metabolic disorders affecting millions of people worldwide. The increasing prevalence of diabetes, associated complications, high treatment cost, and side effects of synthetic antidiabetic drugs have created a need for safer and more effective alternative therapies. Herbal medicines are widely

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used because they are natural, economical, easily available, and possess fewer adverse effects. Biomarkers play an important role in the early diagnosis, monitoring, and management of diabetes mellitus. Evaluation of biomarkers such as blood glucose, HbA1c, cholesterol, triglycerides, and creatinine helps in assessing disease progression and treatment effectiveness. Therefore, the present study is necessary to understand the therapeutic importance of medicinal plants, their antidiabetic mechanisms, and the role of biomarkers in improving diabetes management and preventing diabetic complications.1

OBJECTIVES OF STUDY

1. To study diabetes mellitus and its classification, causes, symptoms, and complications.
2. To study various biomarkers used in the diagnosis and monitoring of diabetes mellitus.
3. To evaluate the antidiabetic activity of medicinal plants and herbal drugs.
4. To study the phytochemical constituents responsible for antidiabetic activity.
5. To understand the mechanism of action of herbal antidiabetic drugs.
6. To review the pharmacological and therapeutic activities of medicinal plants used in diabetes management.
7. To compare herbal antidiabetic drugs with synthetic antidiabetic medicines.
8. To study the role of herbal medicines in reducing diabetic complications.
9. To collect information regarding marketed herbal antidiabetic formulations.
10. To compile and analyze scientific literature related to biomarkers and herbal antidiabetic drugs.3,4

HISTORY OF DIABETES MELLITUS

 Diabetes mellitus is one of the oldest known metabolic disorders in the history of medicine. The disease has been recognized for thousands of years, and its understanding has gradually evolved through scientific discoveries and medical advancements. Diabetes is characterized by abnormal elevation of blood glucose levels due to insufficient insulin secretion, impaired insulin action, or both.2

 Over time, researchers and physicians have contributed significantly to understanding the causes, symptoms, diagnosis, biomarkers, and treatment of diabetes mellitus. The earliest description of diabetes was found in ancient Egyptian medical literature around 1500 BC in the famous Ebers Papyrus. At that time, no proper treatment was available, and the disease was considered life-threatening. 5

 In ancient India around 600–400 BC, the disease was described in Ayurvedic texts by physicians Charaka and Sushruta. They used the term “Madhumeha”, meaning “honey urine,” because the urine of diabetic patients attracted ants due to the presence of excess sugar. Ayurvedic physicians also recognized symptoms such as excessive thirst, excessive urination, weakness, and weight loss. They recommended dietary control, exercise, and herbal medicines for treatment, many of which are still used in modern herbal therapy. Around the 2nd century AD, the Greek physician Aretaeus of Cappadocia introduced the term “Diabetes,” which means “to pass through” or “siphon,” referring to excessive urination observed in affected individuals. He described diabetes as a severe disease associated with intense thirst and wasting of the body. 6

 In the 17th century (1675), the English physician Thomas Willis added the word “Mellitus” to diabetes after noticing that the urine of diabetic patients had a sweet taste. The term “Diabetes Mellitus” therefore means “sweet urine.” This discovery helped distinguish diabetes mellitus from another condition called diabetes insipidus, which also causes excessive urination but without sugar in the urine. During the 18th and 19th centuries, several important scientific advancements improved the understanding of diabetes.9

 In 1776, Matthew Dobson confirmed that the sweetness of diabetic urine was due to the presence of sugar. Later, in 1869, the German scientist Paul Langerhans discovered clusters of cells in the pancreas, later named the Islets of Langerhans, which are responsible for insulin secretion.11

 A major breakthrough occurred in 1889 when scientists Oskar Minkowski and Joseph von Mering demonstrated the role of the pancreas in diabetes. They observed that removal of the pancreas in dogs caused symptoms similar to

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diabetes mellitus, proving that the pancreas plays a crucial role in blood glucose regulation. The most revolutionary discovery in diabetes treatment occurred in 1921, when Frederick Banting and Charles Best successfully isolated insulin from the pancreas.12

 In 1922, insulin was first used to treat a diabetic patient, leading to dramatic improvement in survival and quality of life. This discovery transformed diabetes from a fatal disease into a manageable condition and earned Banting and Macleod the Nobel Prize in Medicine in 1923. During the mid-20th century, researchers developed oral hypoglycemic agents for Type 2 diabetes mellitus.16

 In the 1950s, sulfonylureas and biguanides were introduced as oral antidiabetic drugs. Advances in biotechnology later led to the development of recombinant human insulin, insulin analogs, and modern glucose monitoring systems. In recent decades, biomarkers have become extremely important in diabetes diagnosis and management.

 Biomarkers such as fasting blood glucose, postprandial blood glucose, glycated hemoglobin (HbA1c), insulin levels, lipid profile, C-reactive protein (CRP), and inflammatory markers are widely used for early diagnosis, monitoring disease progression, and evaluating treatment response. Among these, HbA1c has become one of the most reliable biomarkers for long-term glucose monitoring. Modern research has also focused on herbal medicines and natural therapies for diabetes management.18

 Medicinal plants such as Gymnema sylvestre, Momordica charantia, Trigonella foenum- graecum, Azadirachta indica, Syzygium cumini, Ocimum sanctum, and Aloe vera have shown significant antidiabetic activity due to their ability to reduce blood glucose levels, improve insulin sensitivity, and provide antioxidant protection.

 Herbal medicines are gaining popularity because they are cost-effective, easily available, and associated with fewer side effects compared to synthetic drugs. Today, diabetes mellitus is considered a major global public health problem.20

 According to the International Diabetes Federation (IDF), millions of people worldwide are affected by diabetes, and the number continues to increase rapidly due to urbanization, unhealthy lifestyle, obesity, stress, and physical inactivity. Ongoing research in biomarkers, genomics, nanotechnology, and herbal medicine continues to improve the diagnosis, prevention, and treatment of diabetes mellitus.22

TYPES OF DIABETES MELLITUS

Diabetes mellitus is mainly classified into two major types:

1) Type 1 Diabetes Mellitus (T1DM)

2) Type 2 Diabetes Mellitus (T2DM)

Both types are characterized by increased blood glucose levels, but they differ in their causes, pathophysiology, insulin production, age of onset, and treatment methods.5

1) TYPE 1 DIABETES MELLITUS (T1DM) :

Type 1 Diabetes Mellitus is also known as Insulin Dependent Diabetes Mellitus (IDDM) or juvenile diabetes. It occurs due to autoimmune destruction of insulin-producing β-cells of the pancreas, resulting in complete or severe insulin deficiency. Because the body cannot produce sufficient insulin, glucose remains in the bloodstream leading to hyperglycemia.

Type 1 diabetes commonly develops during childhood or adolescence, although it may occur at any age. It accounts for approximately 5–10% of total diabetes cases worldwide.8

 Causes :

o Autoimmune destruction of pancreatic β-cells

o Genetic predisposition

o Viral infections

o Environmental factors

o Family history of diabetes9

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 Pathophysiology :

In Type 1 diabetes, the immune system attacks the β-cells present in the Islets of Langerhans of the pancreas. This leads to reduced or absent insulin secretion. Without insulin, glucose cannot enter body cells properly, causing increased blood glucose levels and energy deficiency.11

 Symptoms :

o Polyuria (frequent urination)
o Polydipsia (excessive thirst)
o Polyphagia (excessive hunger)
o Sudden weight loss
o Weakness and fatigue
o Blurred vision
o Nausea and vomiting15
o Lifelong insulin therapy
o Blood glucose monitoring
o Healthy diet
o Physical exercise
o Patient education17

2) TYPE 2 DIABETES MELLITUS (T2DM)

Type 2 Diabetes Mellitus is also known as Non-Insulin Dependent Diabetes Mellitus (NIDDM) or adult-onset diabetes. It is the most common form of diabetes and accounts for approximately 90– 95% of total diabetic cases worldwide.

In Type 2 diabetes, the body either does not produce enough insulin or becomes resistant to insulin action. This condition is mainly associated with obesity, sedentary lifestyle, stress, unhealthy diet, and aging.22

 Causes :

o Insulin resistance
o Obesity
o Lack of physical activity
o Genetic factors
o High-calorie diet
o Stress and aging Hypertension and hyperlipidemia

 Pathophysiology :

In Type 2 diabetes, insulin is produced by the pancreas, but body cells fail to respond properly to insulin. This condition is called insulin resistance. Initially, the pancreas produces more insulin to compensate, but over time β-cell function decreases, leading to persistent hyperglycemia.25

 Symptoms :

o Increased thirst
o Frequent urination
o Fatigue
o Delayed wound healing
o Frequent infections
o Numbness in hands and feet Blurred vision27
o Oral hypoglycemic agents
o Lifestyle modification
o Weight management
o Diet control
o Exercise Herbal antidiabetic drugs

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o Insulin therapy in severe cases

 Role of Herbal Drugs :

Various medicinal plants such as Gymnema sylvestre, Bitter gourd, Fenugreek, Neem, and Jamun help improve insulin sensitivity, reduce blood glucose levels, and prevent diabetic complications with few side effects.40

CAUSES AND RISK FACTORS OF DIABETES MELLITUS

o Diabetes mellitus is a chronic metabolic disorder caused by defects in insulin secretion, insulin action, or both. The occurrence of diabetes is influenced by several genetic, environmental, physiological, and lifestyle-related factors.

o The number of diabetic patients is increasing rapidly worldwide due to modernization, unhealthy food habits, physical inactivity, obesity, stress, and aging.

o Understanding the causes and risk factors of diabetes is important for early prevention, diagnosis, and effective disease management.9

o The causes and risk factors of diabetes mellitus vary depending on the type of diabetes. Type 1 diabetes is mainly associated with autoimmune destruction of pancreatic β-cells, whereas Type 2 diabetes is strongly linked with insulin resistance, obesity, and lifestyle factors.15

 Causes of Type 1 Diabetes Mellitus

Type 1 Diabetes Mellitus occurs due to destruction of insulin-producing β-cells of the pancreas. As a result, the body becomes unable to produce sufficient insulin, leading to hyperglycemia.16

1. Autoimmune Reaction :

The major cause of Type 1 diabetes is an autoimmune disorder in which the body's immune system mistakenly attacks and destroys pancreatic β-cells. This leads to severe insulin deficiency. 22

2. Genetic Factors :

Family history and genetic susceptibility play an important role in the development of Type 1 diabetes. Certain genes increase the risk of autoimmune destruction of β-cells.

3. Viral Infections :

Some viral infections such as mumps, rubella, and Coxsackie virus may trigger autoimmune reactions leading to diabetes.36

4. Environmental Factors :

Environmental triggers including toxins, dietary factors, and stress may contribute to the development of Type 1 diabetes in genetically susceptible individuals.40

 Causes of Type 2 Diabetes Mellitus

Type 2 Diabetes Mellitus develops mainly due to insulin resistance and impaired insulin secretion. It is more common in adults and elderly individuals but is now increasingly seen in younger populations due to lifestyle changes.5

1. Insulin Resistance :

In Type 2 diabetes, body cells fail to respond properly to insulin, resulting in reduced glucose uptake and increased blood sugar levels.

2. Obesity Obesity :

is one of the major causes of Type 2 diabetes. Excess body fat, especially abdominal obesity, increases insulin resistance and metabolic disturbances.6

3. Unhealthy Diet:

Consumption of high-calorie foods, junk food, sugary beverages, oily foods, and refined carbohydrates increases the risk of diabetes mellitus.

4. Aging :

The risk of Type 2 diabetes increases with age due to reduced insulin sensitivity and decreased pancreatic function.8

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5. Genetic Predisposition:
Individuals with a family history of diabetes are at higher risk of developing Type 2 diabetes.
6. Stress Chronic:
stress increases the release of stress hormones such as cortisol, which may increase blood glucose levels and insulin resistance.
7. Hormonal Disorders:
Hormonal imbalances such as Cushing's syndrome, thyroid disorders, and polycystic ovarian syndrome (PCOS) may increase the risk of diabetes.19

Risk Factors of Diabetes Mellitus
Several factors increase the probability of developing diabetes mellitus. These are known as risk factors.22
Major Risk Factors :
o Family history of diabetes
o Obesity and overweight
o Lack of exercise
o High blood pressure
o High cholesterol and triglyceride levels
o Smoking and alcohol consumption
o Unhealthy eating habits Stress and anxiety Increasing age Pregnancy-related hormonal changes33

SIGNS AND SYMPTOMS OF DIABETES MELLITUS
Diabetes mellitus is a chronic metabolic disorder characterized by elevated blood glucose levels due to defects in insulin secretion, insulin action, or both. The signs and symptoms of diabetes develop because glucose is unable to enter body cells properly, resulting in accumulation of sugar in the bloodstream. The severity of symptoms may vary depending on the type and duration of diabetes. Early identification of symptoms is important for proper diagnosis, biomarker evaluation, and prevention of diabetic complications. In many patients, especially those with Type 2 diabetes mellitus, symptoms may develop slowly and remain unnoticed for several years. However, uncontrolled diabetes can affect multiple organs and body systems, leading to severe health problems.9
Common Signs and Symptoms of Diabetes Mellitus
1) Polyuria (Frequent Urination):
Polyuria is one of the earliest and most common symptoms of diabetes mellitus. Due to increased blood glucose levels, excess glucose is excreted through urine, causing increased urination frequency. Patients may urinate several times during the day and night.11
2) Polydipsia (Excessive Thirst) :
Excessive urination leads to loss of body fluids and dehydration, causing intense thirst. Diabetic patients often feel the need to drink large amounts of water continuously. 22
3) Polyphagia (Excessive Hunger):
Although blood glucose levels are elevated, body cells cannot utilize glucose properly due to insulin deficiency or insulin resistance. As a result, the body experiences energy deficiency, leading to increased hunger. 27
4) Weight Loss :
Sudden and unexplained weight loss is commonly observed in Type 1 diabetes mellitus. Since glucose cannot be utilized for energy, the body starts breaking down fat and muscle tissue for energy production.36
5) Fatigue and Weakness:
Lack of proper glucose utilization reduces energy production in body cells, causing tiredness, weakness, and decreased physical performance.

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6) Blurred Vision :
High blood glucose levels may affect the lens of the eye, causing blurred vision and difficulty in focusing. Long-term uncontrolled diabetes may damage retinal blood vessels leading to diabetic retinopathy.37
7) Delayed Wound Healing:
Diabetes affects blood circulation and immune function, resulting in slow healing of cuts, wounds, and infections. Diabetic patients are more susceptible to skin infections and ulcers.
8) Frequent Infections :
Patients with diabetes commonly suffer from bacterial and fungal infections due to impaired immunity. Common infections include skin infections, urinary tract infections, and gum infections.39
9) Numbness and Tingling :
Sensation Persistent hyperglycemia can damage nerves, causing numbness, tingling, burning sensation, or pain in hands and feet. This condition is known as diabetic neuropathy.
10) Dry Skin and Itching:
Loss of body fluids and poor circulation may cause dry skin, itching, and skin irritation in diabetic patients.40

COMPLICATIONS OF DIABETES MELLITUS

Diabetes mellitus is a chronic metabolic disorder characterized by prolonged elevation of blood glucose levels. If diabetes is not properly controlled, it can affect various organs and body systems, leading to serious complications. Persistent hyperglycemia damages blood vessels, nerves, kidneys, eyes, heart, and other tissues.1
Diabetic complications are one of the major causes of disability and mortality worldwide. Complications of diabetes mellitus are mainly classified into acute complications and chronic complications.2
Acute complications develop suddenly and may become life-threatening, whereas chronic complications develop gradually over a long period due to uncontrolled blood glucose levels.
1. Hypoglycemia :
Hypoglycemia refers to abnormally low blood glucose levels, usually below 70 mg/dL. It commonly occurs due to excessive insulin administration, overdose of oral hypoglycemic drugs, missed meals, or excessive physical activity5
2. Diabetic Ketoacidosis (DKA) :
Diabetic ketoacidosis is a severe complication mainly associated with Type 1 diabetes mellitus. Due to insulin deficiency, the body starts breaking down fats for energy, resulting in formation of ketone bodies and metabolic acidosis.8
3. Hyperosmolar Hyperglycemic State (HHS) :
HHS is a serious complication commonly seen in Type 2 diabetes mellitus. It is characterized by extremely high blood glucose levels and severe dehydration without significant ketoacidosis.9

CHRONIC COMPLICATIONS OF DIABETES

Chronic complications occur due to long-term uncontrolled hyperglycemia and damage to blood vessels and nerves.12
o Diabetic Neuropathy:
Diabetic neuropathy is nerve damage caused by prolonged high blood glucose levels. It commonly affects peripheral nerves of the hands and feet.
o Diabetic Retinopathy :
Diabetic retinopathy is damage to retinal blood vessels caused by chronic hyperglycemia. It is a major cause of blindness among diabetic patients.19
o Cardiovascular Diseases Diabetes:
significantly increases the risk of cardiovascular disorders such as hypertension, atherosclerosis, heart attack, and stroke.22

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TREATMENT OF DIABETES MELLITUS

The treatment of diabetes mellitus mainly aims to control blood glucose levels, prevent complications, and improve the quality of life of patients. Proper management includes lifestyle modification, diet control, exercise, oral hypoglycemic agents, insulin therapy, and herbal medicines.5

1. Diet Control :

o Diet plays an important role in diabetes management. Patients are advised to consume a balanced diet containing fibers, vegetables, fruits, and low-fat food. Excess intake of sugar, oily foods, refined carbohydrates, and alcohol should be avoided. Small and frequent meals help maintain normal blood glucose levels6

2. Physical Exercise :

o Regular physical exercise improves insulin sensitivity and glucose utilization in the body. Activities such as walking, jogging, yoga, and aerobic exercise help reduce blood sugar levels, obesity, and cardiovascular risk associated with diabetes mellitus.9

3. Oral Hypoglycemic Agents :

o Oral antidiabetic drugs are commonly used in Type 2 diabetes mellitus. These drugs help lower blood glucose levels by increasing insulin secretion, improving insulin sensitivity, or reducing glucose absorption.13

o Examples: Metformin, Glibenclamide, Glipizide ,Pioglitazone

4. Insulin Therapy :

o Insulin therapy is mainly used in Type 1 diabetes mellitus and severe cases of Type 2 diabetes. Insulin helps regulate blood glucose levels by facilitating glucose uptake into cells.

o Types of insulin: Rapid-acting insulin ,Short-acting insulin ,Intermediate-acting insulin ,Long-acting insulin16

5. Herbal Treatment :

o Herbal medicines are widely used because they are natural, economical, and possess fewer side effects. Many medicinal plants show significant antidiabetic activity.

o Common herbal drugs used in diabetes: Gymnema sylvestre ,Momordica charantia Trigonella foenum-graecum ,Azadirachta indica ,Syzygium cumini ,Ocimum sanctum ,Aloe vera 19

6. Lifestyle Modification

Healthy lifestyle changes are important for effective diabetes management:

o Regular exercise
o Stress reduction
o Weight management
o Avoid smoking and alcohol
o Proper sleep and healthy diet22

 Life style for patient :

• Some of the home and herbal remedies prescribed by Ayurveda are described below.

o Turmeric and cinnamon are included in diets.
o Oily, fried and starchy foodstuffs are avoided.
o Coffee, sugar, refined flour and alcohol are avoided.
o Eat smaller meals (low fat diet) five to six times a day instead of having three large meals.
o Intake of vegetables like spinach, cucumber, tomatoes, onion, sprouts, beans, garlic etc is increased.
o Refrain from taking stress.
o Regular exercise. Walk for at least 40 minutes a day.23

 Recent Regulatory Developments :

Herbal medications, as defined by regulatory standards, are traditional medicines that predominantly employ medicinal plants in their therapeutic formulations. Traditional medicine (including herbal medicines) has lately been described by the World Health Organization as therapeutic techniques that have been in use for hundreds of years or more before the

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International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429 Volume 6, Issue 2, June 2026 Impact Factor: 8.2

creation and spread of modern medicine, as well as others that are currently in use. In recent years, the FDA and EMEA have shown a great interest in botanical medicine research and have examined the regulatory frameworks controlling their use.29

BIOMARKER

A biomarker (Biological Marker) is a measurable indicator present in the body that helps to identify normal biological activities, disease conditions, or the body's response to a treatment or drug. Biomarkers are widely used in medicine, pharmacy, biotechnology, clinical diagnosis, and medical research because they provide important information about a patient's health status

Biomarkers play a major role in modern healthcare because many diseases can be detected at an early stage by measuring specific biological markers. They help doctors diagnose diseases accurately, predict disease progression, monitor treatment effectiveness, and evaluate the risk of developing certain disorders.3

Biomarkers also contribute significantly to personalized or precision medicine. Different patients may respond differently to the same treatment due to genetic and biological differences. Their importance continues to increase with advances in biotechnology, genomics, and personalized medicine, making them a crucial component of future medical science.Additional Points About Biomarkers.4

 Sources of Biomarkers :

Biomarkers can be obtained from different parts of the body. Common sources include:

o Blood
o Urine
o Saliva
o Tissue samples

BIOMARKERS IN DIABETES MELLITUS

1. Biomarkers are measurable biological indicators used to detect normal biological processes, disease conditions, and responses to therapeutic treatment. In diabetes mellitus, biomarkers play a very important role in diagnosis, monitoring disease progression, evaluating treatment effectiveness, and predicting complications.9

2. Biomarkers help clinicians assess metabolic abnormalities and provide proper therapeutic management for diabetic patients.11

3. Diabetes mellitus is associated with abnormalities in carbohydrate, lipid, and protein metabolism. Therefore, several biochemical and molecular biomarkers are used to evaluate glycemic control, insulin function, inflammation, oxidative stress, and organ damage.

4. Early detection of abnormal biomarkers helps prevent severe diabetic complications such as neuropathy, nephropathy, retinopathy, and cardiovascular diseases.19

5. Importance of Biomarkers in Diabetes Biomarkers are important in diabetes management because they help in: Early diagnosis of diabetes mellitus Monitoring blood glucose control

Assessing disease progression Predicting diabetic complications Evaluating effectiveness of treatment Supporting personalized medicine22

 Types of Biomarkers in Diabetes

1. Diagnostic Biomarkers :

Diagnostic biomarkers are used for identifying and confirming diabetes mellitus in patients. Examples : Fasting Blood Glucose (FBG) ,Postprandial Blood Glucose (PPBG), Oral Glucose Tolerance Test (OGTT) ,Glycated Hemoglobin (HbA1c)32

2. Prognostic Biomarkers :

Prognostic biomarkers help predict disease progression and future complications in diabetic patients. Examples : HbA1c ,Lipid profile ,C-reactive protein (CRP) Inflammatory markers35

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3. Predictive Biomarkers:
Predictive biomarkers help determine the response of patients to specific therapeutic treatments.
Examples : Insulin levels ,C-peptide levels ,Genetic markers
4. Pharmacodynamic Biomarkers:
These biomarkers are used to evaluate the effect of antidiabetic drugs and herbal therapies on the body.39
Examples : Blood glucose reduction , Improvement in HbA1c ,Lipid profile changes
 Advantages Of Biomarkers :
o Early detection of diseases
o Accurate diagnosis
o Monitoring treatment effectiveness
o Prediction of disease outcome
 Limitations of Biomarkers :
o Some biomarkers are not disease-specific
o Laboratory testing may be expensive
o Results can vary due to environmental or lifestyle factors
o False positive or false negative results may occur40

FUTURE SCOPE OF BIOMARKERS IN DIABETES MELLITUS

 The future scope of biomarkers in diabetes mellitus is highly promising due to rapid advancements in biotechnology, molecular biology, genomics, proteomics, artificial intelligence, and personalized medicine. Biomarkers are becoming increasingly important in early diagnosis, disease monitoring, prediction of complications, and development of targeted therapies for diabetes mellitus.3

 Modern biomarker research is expected to improve the quality of diabetic care and reduce the burden of diabetic complications worldwide.

1. Early Detection of Diabetes
Future biomarker research aims to identify diabetes at a very early stage before the appearance of clinical symptoms. Advanced molecular biomarkers may help detect prediabetes and insulin resistance much earlier, allowing timely prevention and treatment.
Early diagnosis through biomarkers can help:
Prevent disease progression, Reduce complications ,Improve patient survival ,Lower healthcare costs6
2. Personalized Medicine
 Biomarkers are expected to play a major role in personalized or precision medicine. Different patients respond differently to antidiabetic drugs due to genetic and metabolic variations.
 Future biomarker-based personalized medicine may help:
o Select suitable drugs for individual patients
o Determine correct dosage
o Reduce adverse drug reactions
o Improve therapeutic effectiveness
3. Biosensors and Wearable Devices
 Future biomarker monitoring may become easier through advanced biosensors and wearable medical devices. Continuous glucose monitoring systems (CGMS) and smart biosensors can provide real-time monitoring of blood glucose levels.16
 Advantages include:
o Non-invasive monitoring
o Continuous glucose tracking
o Early warning of abnormal glucose

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o levels Better patient compliance

4. Nanotechnology in Biomarker Research

 Nanotechnology has opened new possibilities in diabetes diagnosis and treatment. Nanoparticles and nanobiosensors may improve the sensitivity and accuracy of biomarker detection.22

 Nanotechnology applications include:

o Targeted drug delivery

o Rapid biomarker detection

o Nano-based glucose sensors

o Improved herbal drug formulations26

MECHANISM OF ACTION OF HERBAL ANTIDIABETIC DRUGS

 Herbal antidiabetic drugs help in the management of diabetes mellitus through various pharmacological and biochemical mechanisms.6

 The anti-diabetic activity of herbal plant are depends upon various mechanisms.

 The mechanism of action of herbal anti-diabetic can be grouped as:

o Adrenomimeticism, pancreatic beta cell potassium channel blocking, cAMP (2nd messenger) Stimulation.9

o Inhibition of urinal glucose reabsorption.

o Stimulation of insulin secretion from beta cells of islets or/and inhibition of insulin degradative processes.

o Reduction in insulin resistance.11

o Providing certain necessary elements like calcium, zinc, magnesium, manganese and copper for the beta-cells .

o Regenerating and/or repairing pancreatic beta cells.

o Increasing the size and number of cells in the islets of Langerhans

o Stimulation of insulin secretion.

o Stimulation of glycogenesis and hepatic glycolysis.12

 Medicinal plants contain several bioactive compounds such as alkaloids, flavonoids, glycosides, terpenoids, saponins, tannins, phenolic compounds, and polysaccharides that contribute to their antidiabetic activity.

 These herbal drugs help reduce blood glucose levels, improve insulin secretion, enhance glucose utilization, and prevent diabetic complications with fewer side effects compared to synthetic drugs.22

 The mechanism of action of herbal antidiabetic drugs is complex and involves multiple pathways associated with carbohydrate metabolism, insulin function, oxidative stress, and lipid metabolism.25

1. Stimulation of Insulin Secretion

 Many herbal drugs stimulate insulin secretion from pancreatic β-cells present in the Islets of Langerhans. Increased insulin secretion helps transport glucose from blood into body cells, thereby lowering blood glucose levels.26

 Examples :

o Gymnema sylvestre

o Fenugreek ,Bitter gourd

These plants help regenerate pancreatic β-cells and improve insulin production.

2. Regeneration of Pancreatic

 β-Cells Certain medicinal plants possess regenerative properties that help repair damaged pancreatic βcells. Regeneration of β-cells improves endogenous insulin secretion and glucose regulation.29

 Examples: Gymnema sylvestre, Neem ,Aloe vera

This mechanism is especially beneficial in early stages of diabetes mellitus.

3. Improvement of Insulin Sensitivity

 Some herbal drugs increase the sensitivity of body tissues toward insulin. Improved insulin sensitivity enhances glucose uptake by muscle and adipose tissues and reduces insulin resistance.31

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 Examples : Fenugreek , Cinnamon, Tulsi

This mechanism is highly useful in Type 2 diabetes mellitus.

4. Antioxidant Activity

 Oxidative stress caused by free radicals contributes significantly to diabetic complications. Many medicinal plants possess strong antioxidant activity that protects pancreatic β-cells and body tissues from oxidative damage.33

 Antioxidant Herbal Plants : Tulsi ,Neem, Aloe vera, Jamun.

5. Anti-inflammatory Activity

 Chronic inflammation contributes to insulin resistance and progression of diabetes mellitus. Herbal drugs with anti-inflammatory activity help reduce inflammatory mediators and improve insulin action.

 Examples : Turmeric ,Neem, Tulsi39

PHYTOCHEMICAL CONSTITUENTS

Phytochemical constituents are naturally occurring bioactive compounds present in medicinal plants which are responsible for their therapeutic and pharmacological activities. These compounds possess antidiabetic, antioxidant, anti-inflammatory, and hypolipidemic properties.7

TYPES OF PHYTOCHEMICAL CONSTITUENTS

1. Alkaloids :

Alkaloids are nitrogen-containing organic compounds present in medicinal plants. They possess antidiabetic, analgesic, and antioxidant activities. Alkaloids help improve glucose metabolism and insulin secretion.9

Examples: Berberine, Quinidine

2. Flavonoids :

Flavonoids are polyphenolic compounds widely found in fruits, vegetables, and medicinal plants. They possess strong antioxidant and anti-inflammatory properties and help protect pancreatic beta cells from oxidative stress.11

Examples: Quercetin, Kaempferol

3. Glycosides :

Glycosides are compounds containing sugar molecules attached to non-sugar components. They help regulate carbohydrate metabolism and improve insulin action.15

Examples: Gymnemic acid, Stevioside

4. Saponins:

Saponins are naturally occurring glycosides that produce foam in water. They possess hypoglycemic and hypolipidemic properties and help reduce blood glucose and cholesterol levels.17

Examples: Diosgenin, Charantin

5. Tannins:

Tannins are polyphenolic compounds having antioxidant and antimicrobial activities. They help reduce oxidative stress and prevent diabetic complications.20

Examples: Catechin, Ellagic acid

6. Terpenoids:

Terpenoids are aromatic compounds found in essential oils and medicinal plants. They improve insulin sensitivity and reduce insulin resistance.22

Examples: Azadirachtin, Ursolic acid

7. Phenolic Compounds :

Phenolic compounds possess strong antioxidant activity and protect body tissues from free radical damage caused by diabetes mellitus.33

Examples: Rosmarinic acid, Gallic acid

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8. Anthraquinones :

Anthraquinones are bioactive compounds commonly present in Aloe vera and other medicinal plants. They possess antidiabetic, laxative, and wound-healing properties.

Examples: Aloin, Aloe-emodin36

9. Polysaccharides :

Polysaccharides are complex carbohydrates that help improve glucose metabolism and insulin sensitivity.

Examples: Glucomannan

10. Steroids :

Plant steroids help regulate metabolism and possess anti-inflammatory and hypoglycemic properties.40

Examples: β-sitosterol, Stigmasterol

TABLE 1:MEDICINAL PLANT WITH PHYTOCHEMICAL CONSTITUENTS AND ACTIVITY

Medicinal Plant	Phytochemical Constituents	Activity
Gymnema sylvestre	Gymnemic acids, Gurmarin	Antidiabetic
Momordica charantia	Charantin, Vicine	Hypoglycemic
Trigonella foenum-graecum	Galactomannan, Saponins	Hypolipidemic
Azadirachta indica	Nimbin, Flavonoids	Anti-inflammatory
Syzygium cumini	Jamboline, Anthocyanins	Antioxidant
Ocimum sanctum	Eugenol, Ursolic acid	Antidiabetic
Aloe vera	Aloin, Glucomannan	Wound healing

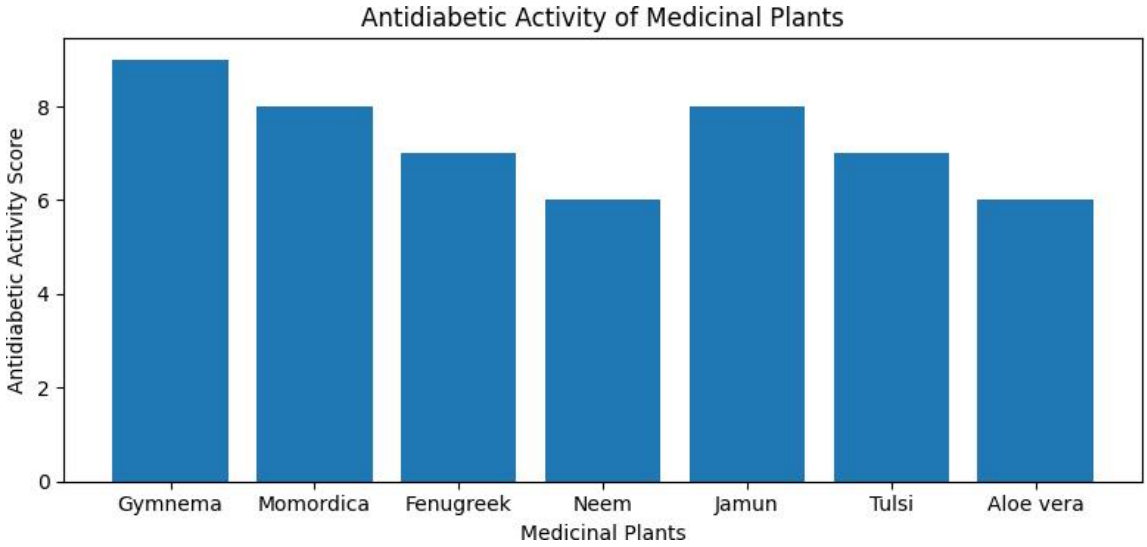

Chart: Antidiabetic Activity of Medicinal Plants

MEDICINAL PLANTS WITH ANTIDIABETIC AND RELATED BENEFICIAL PROPERTIES

Diabetes mellitus is one of the most common metabolic disorders characterized by high blood glucose levels caused by insufficient insulin secretion or improper utilization of insulin by the body.2 Medicinal plants have been used traditionally for the management of diabetes because they contain natural bioactive compounds that help regulate blood sugar levels, improve insulin sensitivity, reduce oxidative stress, and prevent diabetic complications. Many medicinal plants also possess antioxidant, anti-inflammatory, hypolipidemic, and cardioprotective properties which are beneficial in diabetic patients.5

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MEDICINAL PLANTS :

1) Gymnema Sylvestre
2) Momordica Charantia
3) Trigonella Foenum-Graecum
4) Azadirachta Indica
5) Syzygium Cumini
6) Ocimum Sanctum
7) Aloe Vera
8) Allium sativum
9) Zingiber officinale
10) Curcuma longa
11) Emblica officinalis
12) Cinnamomum verum
13) Tinospora cordifolia
14) Panax ginseng
15) VStevia rebaudiana

1. Gymnema sylvestre :

- Common Name: Gurmar
- Synonyms: Meshashringi, Sugar Destroyer
- Family: Apocynaceae
- Part Used: Leaves
- Active Constituents: Gymnemic acids, Gurmarin
- Properties : Antidiabetic ,Antioxidant ,Hypolipidemic And Anti-inflammatory3
- Uses :

o Management of diabetes mellitus
o Reduces sugar cravings
o Helps in obesity management
o Reduces cholesterol levels
o Improves pancreatic function.4

- Dose :

o Powder: 2–4 g/day
o Extract: 250–500 mg twice daily5

- Marketed Brands

o Diabecon
o Gurmar Capsules
o Madhunashini Tablets.9

DOI: 10.48175/IJARSCT-36307

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Figure 1 : Gymnema sylvestre

2. Momordica Charantia :

- Common Name: Bitter Gourd / Karela
- Synonyms: Bitter Melon
- Family: Cucurbitaceae
- Part Used: Fruit and Seeds
- Active Constituents: Charantin, Vicine, Polypeptide-P10
- Properties :

o Antidiabetic
o Antioxidant
o Anti-inflammatory
o Hypoglycemic

- Uses :

o Controls blood glucose levels
o Improves glucose utilization
o Helps in weight reduction
o Improves digestion
o Prevents diabetic complications .

- Dose :

o Juice: 50–100 mL/day
o Powder: 3–6 g/day
o Capsules: 500 mg twice daily12

- Marketed Brands :

o Himalaya Karela Tablets
o Baidyanath Karela Juice
o Patanjali Karela Juice.13

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Figure 2: Momordica Charantia

3. Trigonella Foenum-Graecum :

- Common Name: Fenugreek / Methi
- Synonyms: Greek Hay
- Family: Fabaceae
- Part Used: Seeds
- Active Constituents: Galactomannan, 4-Hydroxyisoleucine, Saponins14
- Properties :

o Antidiabetic
o Hypolipidemic
o Digestive
o Antioxidant

- Uses :

o Controls blood sugar levels
o Improves insulin sensitivity
o Reduces cholesterol
o Improves digestion
o Helps in constipation15

- Dose :

o Seed Powder: 5–25 g/day
o Capsules: 500–1000 mg/day16

- Marketed Brands :

o Fenfuro Capsules
o Methi Powder 17

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Figure 3 : Trigonella Foenum-Graecum

4. Indian Lilac :
 Common Name: Neem
 Synonyms: Indian Lilac
 Family: Meliaceae
 Part Used: Leaves, Bark, Seeds
 Active Constituents: Nimbin, Azadirachtin, Flavonoids18
 Properties :
o Antidiabetic
o Antimicrobial
o Antioxidant And Anti-inflammatory .19
 Uses :
o Treatment of diabetes
o Blood purification
o Treatment of skin diseases
o Wound healing and Improves immunity20
 Dose :
o Powder: 2–5 g/day
o Juice: 10–20 mL/day
o Capsules: 250–500 mg/day
 Marketed Brands :
o Neem Capsules Himalaya
o Baidyanath Neem Juice
o Patanjali Neem Capsules.21

Figure 4 : Neem

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5. Syzygium cumini :
 Common Name: Jamun
 Synonyms: Indian Blackberry, Java Plum
 Family: Myrtaceae
 Part Used: Seeds, Fruits
 Active Constituents: Jamboline, Ellagic acid, Anthocyanins21
 Properties : Antidiabetic ,Antioxidant ,Hypoglycemic .
 Uses :
o Controls diabetes mellitus
o Improves digestion
o Reduces excessive urination
o Antioxidant activity
o Supports liver function
 Dose :
o Seed Powder: 3–6 g/day
o Juice: 20–30 mL/day22
 Marketed Brands :
o Jamun Seed Powder
o Baidyanath Jamun Juice
o Patanjali Jamun Vinegar23

Figure 5 : Syzygium cumini

6. Ocimum Sanctum :
 Common Name: Tulsi / Holy Basil
 Synonyms: Sacred Basil
 Family: Lamiaceae
 Part Used: Leaves
 Active Constituents: Eugenol, Ursolic Acid, Rosmarinic Acid
 Properties : Antidiabetic ,Adaptogenic , Antioxidant And Antimicrobial.24

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 Uses:
o Management of diabetes
o Relief from cough and cold
o Reduces stress And Improves immunity
o Used in respiratory disorders26
 Dose:
o Powder: 2–3 g/day
o Juice: 10–20 mL/day
o Extract: 300–600 mg/day27
 Marketed Brands ;
o Tulsi Drops
o Organic India Tulsi Tea
o Himalaya Tulsi Tablets28

Figure 6 : Ocimum Sanctum

7. Aloe vera
 Common Name: Aloe Vera
 Synonyms: Kumari, Ghritkumari
 Family: Asphodelaceae
 Part Used: Leaf Gel
 Active Constituents: Aloin, Glucomannan, Anthraquinones, Aloe-emodin29
 Properties : Antidiabetic , Anti-inflammatory ,Antioxidant ,Wound Healing .
 Uses :
o Management of diabetes mellitus
o Promotes wound healing
o Used in burns and ulcers
o Skin care applications
o Boosts immunity31
 Dose :
o Juice: 15–30 mL/day
o Gel Extract: 100–200 mg/day32
 Marketed Brands :
o Patanjali Aloe Vera Juice
o Dabur Aloe Vera Juice

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o Himalaya Aloe Vera Gel

Figure 7 : Aloe vera

8. Allium sativum
 Common Name: Garlic
 Family: Amaryllidaceae
 Part Used: Bulb
 Active Constituents: Allicin, Sulfur compounds
 Properties: Antidiabetic, Hypolipidemic, Antioxidant Garlic helps reduce blood glucose and cholesterol levels. It improves cardiovascular health and reduces oxidative stress.33
 Uses :
o Controls blood sugar
o Reduces cholesterol o
o Improves heart health o
o Antioxidant activity 32
 Dose :
o Fresh Garlic: 2–5 g/day
o Capsules: 300–500 mg/day
 Marketed Brands :
o Garlic Pearls
o Himalaya Garlic Capsules
o Dabur Garlic Tablets33

Figure 8 : Allium sativum

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9. Zingiber officinale
- Common Name: Ginger
- Family: Zingiberaceae
- Part Used: Rhizome
- Active Constituents: Gingerol, Shogaol, Zingerone
- Properties: Antidiabetic, Antioxidant, Anti-inflammatory

Ginger helps improve insulin sensitivity and glucose metabolism. It reduces oxidative stress and inflammation associated with diabetes mellitus. Ginger also supports digestion and cardiovascular health.34

- Uses :

o Controls blood glucose
o Improves digestion
o Reduces inflammation

- Dose :

o Powder: 1–3 g/day
o Juice: 10–20 mL/day

- Marketed Brands :

o Ginger Capsules
o Dabur Ginger Powder
o Patanjali Ginger Juice35

Figure 9 : Zingiber officinale

10. Curcuma longa
- Common Name: Turmeric
- Family: Zingiberaceae
- Part Used: Rhizome

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 Active Constituents: Curcumin, Turmerone
 Properties: Antidiabetic, Antioxidant, Anti-inflammatory

Turmeric contains curcumin which helps reduce inflammation and oxidative stress in diabetic patients. It improves insulin function and protects tissues from diabetic complications.36

 Uses :

o Controls diabetes
o Reduces inflammation
o Improves immunity

 Dose :

o Powder: 1–3 g/day
o Capsules: 250–500 mg/day

 Marketed Brands :

o Turmeric Capsules
o Curcumin Tablets
o Patanjali Haldi Powder37

Figure 10 : Curcuma longa

11. Emblica officinalis

 Common Name: Amla
 Synonyms: Indian Gooseberry
 Family: Phyllanthaceae
 Part Used: Fruits
 Active Constituents: Vitamin C, Gallic acid, Ellagic acid
 Properties: Antidiabetic, Antioxidant, Immunomodulatory

Amla possesses strong antioxidant activity and helps reduce blood glucose levels. It improves pancreatic function and protects body tissues from oxidative damage.39

 Uses :

o Controls blood sugar

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o Improves immunity
o Antioxidant activity
o Supports digestion
 Dose :
o Juice: 20–30 mL/day
o Powder: 3–5 g/day
 Marketed Brands :
o Amla Juice
o Dabur Amla Juice
o Patanjali Amla Powder40

Figure : Emblica officinalis

12. Cinnamomum verum
 Common Name: Cinnamon
 Cinnamon Family: Lauraceae
 Part Used: Bark
 Active Constituents: Cinnamaldehyde, Eugenol
 Properties: Antidiabetic, Antioxidant, Hypolipidemic

Cinnamon improves insulin sensitivity and enhances glucose uptake by body tissues. It also helps reduce cholesterol levels and oxidative stress.2

 Uses :
o Reduces blood glucose
o Improves insulin action
o Lowers cholesterol

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o Antioxidant activity
 Dose :
o Powder: 1–3 g/day
o Capsules: 250–500 mg/day
 Marketed Brands :
o Cinnamon Capsules
o Organic Cinnamon Powder
o Herbal Cinnamon Tablets 5

Figure : Cinnamomum verum

13. Tinospora cordifolia
 Common Name: Guduchi, Giloy
 Family: Menispermaceae
 Part Used: Stem
 Active Constituents: Berberine, Tinosporin, Alkaloids
 Properties: Antidiabetic, Immunomodulatory, Antioxidant9

Guduchi helps reduce blood glucose levels and improves immunity. It also protects pancreatic cells and reduces oxidative stress.

 Uses :
o Controls diabetes
o Improves immunity
o Antioxidant activity
o Reduces fatigue
 Dose :
o Juice: 15–30 mL/day
o Powder: 3–6 g/day
 Marketed Brands :
o Giloy Juice

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o Patanjali Giloy Ghanvati
o Himalaya Guduchi Tablets 16

Figure : Tinospora cordifolia

14. Panax ginseng
 Common Name: Ginseng
 Family: Araliaceae
 Part Used: Roots
 Active Constituents: Ginsenosides
 Properties: Antidiabetic, Adaptogenic, Antioxidant

Ginseng improves insulin secretion and energy metabolism. It also helps reduce fatigue and improves physical performance. 22

 Uses :
o Improves glucose metabolism
o Enhances energy
o Reduces stress
o Antioxidant activity
 Dose :
o Powder: 1–2 g/day
o Capsules: 200–400 mg/day
 Marketed Brands :
o Ginseng Capsules
o Herbal Ginseng Tablets
o Organic Ginseng Powder33

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Figure : Panax ginseng

15. Stevia rebaudiana
 Common Name: Stevia
 Family: Asteraceae
 Part Used: Leaves
 Active Constituents: Stevioside, Rebaudioside
 Properties: Antidiabetic, Natural Sweetener, Antioxidant

Stevia is a natural sweetener used by diabetic patients as a substitute for sugar. It helps maintain blood glucose levels without increasing calorie intake.19

 Uses :
o Sugar substitute for diabetics
o Controls blood glucose
o Weight management
o Antioxidant activity
 Dose :
o Leaf Powder: 1–2 g/day
o Tablets: As directed
 Marketed Brands :
o Stevia Powder
o Sugar Free Green
o Herbal Stevia Tablets20

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ISSN: 2581-9429
Volume 6, Issue 2, June 2026
Impact Factor: 8.2

Figure : Stevia rebaudiana

MARKETED HERBAL ANTIDIABETIC PRODUCTS

1. Diabecon Manufacturer: [Himalaya Wellness]
- Main Ingredients: Gudmar, Neem, Shilajit
- Properties: Antidiabetic, Antioxidant
- Dose: 1–2 tablets twice daily

Diabecon is a popular Ayurvedic antidiabetic formulation used for maintaining healthy blood glucose levels and improving insulin function.5

2. Madhumehari Manufacturer: [Baidaynath Ltd.]
- Main Ingredients: Jamun ,Karela , Methi
- Properties: Hypoglycemic, Digestive
- Dose: 1–2 tablets twice daily

Madhumehari helps regulate blood sugar levels and improves carbohydrate metabolism in diabetic patients.6

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3. BGR-34 Manufacturer: [CSIR India]
- Main Ingredients: Vijaysar ,Giloy ,Daruharidra
- Properties: Antidiabetic, Antioxidant
- Dose: 2 tablets twice daily

BGR-34 is a scientifically developed herbal formulation useful in controlling hyperglycemia and oxidative stress.8

4. Hyponidd Manufacturer: [Charak Pharma]
- Main Ingredients: Neem ,Gudmar,Karela
- Properties: Hypoglycemic, Antioxidant
- Dose:

1–2 tablets twice daily

Hyponidd supports healthy glucose metabolism and helps reduce diabetic complications.9

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5. Madhunashini Vati Manufacturer: [Patanjali Ayurved]
 Main Ingredients: Gudmar,Neem,Jamun
 Properties: Antidiabetic, Hypoglycemic
 Dose: 1–2 tablets twice daily
This Ayurvedic formulation helps improve pancreatic function and maintain normal blood sugar levels.11

6. Neem Capsules Manufacturer: [Organic India]
 Main Ingredients:
o Neem extract
 Properties: Antioxidant, Antidiabetic
 Dose: 1 capsule twice daily
Neem capsules are used to improve glucose metabolism and provide antioxidant protection.25

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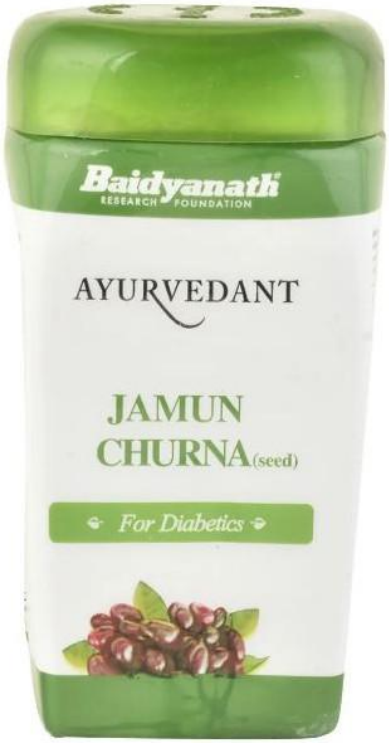
7. Jamun Seed Powder Manufacturer: [Baidyanath]

- Main Ingredients:

o Jamun seed powder

- Properties: Hypoglycemic, Antioxidant
- Dose: 3–5 g/day

Jamun seed powder helps regulate blood glucose and reduces excessive urination in diabetic patients.33



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ADVANTAGES OF HERBAL ANTIDIABETIC DRUGS

1. Natural Origin:

Herbal drugs are obtained from natural plant sources and are considered safer compared to synthetic chemical drugs.5

2. Fewer Side Effects :

Most herbal medicines produce fewer adverse effects and are generally well tolerated when used in proper doses.8

3. Cost Effective :

Herbal medicines are comparatively inexpensive and easily affordable, especially in developing countries.9

4. Easy Availability :

Medicinal plants are widely available and can be easily cultivated or obtained from natural sources.11

5. Improvement of Lipid Profile :

Several herbal drugs help lower cholesterol and triglyceride levels, thereby reducing cardiovascular risk in diabetic patients.22

6. Better Patient Compliance :

Because herbal medicines are natural and associated with fewer side effects, patients often show better acceptance and compliance.23

7. Synergistic Effects :

Combination of different medicinal plants in polyherbal formulations provides synergistic therapeutic effects and improves antidiabetic activity.25

LIMITATIONS OF HERBAL ANTIDIABETIC DRUGS

Although herbal antidiabetic drugs possess significant therapeutic benefits, they also have certain limitations and disadvantages. Lack of proper standardization, scientific validation, and quality control may affect their safety and effectiveness. Therefore, careful monitoring and proper clinical evaluation are necessary during herbal therapy.5

1. Lack of Standardization Different herbal preparations may contain varying amounts of active constituents, leading to inconsistent therapeutic effects7

2. Slow Onset of Action Many herbal drugs require prolonged use before showing significant antidiabetic effects compared to synthetic drugs.9

3. Limited Clinical Evidence Some medicinal plants lack sufficient clinical trials and scientific studies to confirm their efficacy and safety.11

4. Variability in Plant Composition Environmental factors such as climate, soil, harvesting, and storage conditions may alter the chemical composition of medicinal plants.

5. Drug Interactions Herbal medicines may interact with synthetic antidiabetic drugs and cause complications such as hypoglycemia.22

6. Dose Uncertainty Proper therapeutic dose may not be clearly established for many herbal medicines.

7. Possible Toxicity Excessive or prolonged use of certain herbal drugs may produce toxic effects on the liver, kidneys, or other organs.23

8. Poor Quality Control Contamination, adulteration, and improper processing may reduce the quality and safety of herbal products25

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ROLE OF PHARMACIST IN DIABETES MANAGEMENT

Pharmacists play an important role in the prevention, treatment, and management of diabetes mellitus. They help patients in proper medication use, lifestyle modification, monitoring of blood glucose levels, and prevention of diabetic complications. Pharmacists also create awareness regarding herbal and synthetic antidiabetic drugs and improve patient compliance with therapy.5

o Patient Counseling Pharmacists counsel diabetic patients regarding proper use of medicines, insulin administration, dose timing, diet control, and lifestyle modification. They educate patients about the importance of regular medication and monitoring of blood glucose levels.12

o Medication Management Pharmacists help in the selection, dispensing, and proper use of antidiabetic drugs. They monitor drug interactions, adverse drug reactions, and ensure safe and effective therapy for diabetic patients.15

o Monitoring of Blood Glucose Pharmacists guide patients in regular monitoring of blood glucose, HbA1c, cholesterol, and other biomarkers used in diabetes management. They also help interpret glucose monitoring reports.

o Promotion of Lifestyle Modification Pharmacists encourage healthy lifestyle practices such as balanced diet, regular exercise, stress management, smoking cessation, and weight control to improve diabetic conditions.

o Prevention of Diabetic Complications Pharmacists educate patients regarding prevention of complications such as neuropathy, nephropathy, retinopathy, cardiovascular diseases, and diabetic foot ulcers through proper medication adherence and lifestyle management.5

o Herbal Drug Guidance Pharmacists provide information about herbal antidiabetic medicines, their dose, mechanism of action, benefits, side effects, and possible interactions with synthetic drugs.25

o Pharmacovigilance Pharmacists monitor and report adverse effects associated with antidiabetic drugs and herbal formulations to improve patient safety and treatment outcomes.Public Health Education Pharmacists participate in health awareness programs, diabetes screening camps, and educational activities to spread awareness regarding diabetes prevention and management.23

o Improving Patient Compliance Pharmacists help improve patient adherence to therapy by simplifying medication schedules, counseling about regular treatment, and motivating patients for long-term disease management26

Table 2: Some Plants Having Hypoglycemic Activities.

Sr. No	Common Name	Botanical name and family	Parts used	Therapeutic action
1.	Asiatic ginseng	Panax ginseng (Araliac)	Roots	Reduces blood glucose levels via slowing the absorption of carbohydrates, enhancing glucose transport, and modulating insulin secretion
2.	Ashwagandha, winter cheery	Withania somnifera (Solanaceae)	Roots	Reduced blood sugar levels
3.	Banana	Musa sapientum Kuntz (Musaceae)	Fruits/flowers	Blood glucose and glycosylated hemoglobin levels are reduced.
4.	Banyan tree	Ficus bengalensis (Moraceae)	bark	Insulinase activity in the liver and kidneys is inhibited, and insulin secretion is stimulated
5.	Barbados	Aloe barbadensis Mill. (Liliaceae)	Leaves	Insulin production and release are stimulated.
6.	Betal, betal wine	Piper betle (Piperaceae)	Leaf	glucose metabolism, anti-hyperglycemic
7.	Bitter kola, false	Garcinia kola	Seed	Hypoglycemic and

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	kola	(Clusiaceae)		Hypolipidemic
8.	Black tea	Camellia sinensis (Theaceae)	Leaves	Leaves help to lower blood sugar levels.
9.	Asiatic sweet leaf	Symplocos Paniculata (Symplocaceae)	Leaves/ stems	1 and 2 inhibitors of protein tyrosine phosphatase 1B (PTP1B)
10.	Bilwa, bael fruit	Aegle marmelos (Rutaceae)	Leaf Extract	Decrease cholesterol and blood urea level

Table 3: Marketed Herbal Anti Diabetic Products

Sr.no.	Product	Manufacturer	Mechanism
1.	Sharang Dyab-Tea	Plant Med lab Pvt. Ltd.	Insulin synthesis should be encouraged.
2.	Herbal hills jambu	Isha Agro Developers	Blood and urine sugar levels should be lowered.
3.	Stevia-33	Vitalize Herbs Pvt. Ltd.	Beta cells in the pancreas should be activated.
4.	Diab-FIT	Herbal FIT	Maintain a normal blood sugar level
5.	Madhumar capsule	Kangrd Hills Care and Products	Control diabetes mellitus in people who have it for a long time.
6.	Daya Stone Powder	Jignesh and Co.	Reduce your blood glucose level
7.	Blue berry	Hikma FZCO	Antidiabetic
8.	Episulin	Varuna Biocell Pvt. Ltd.	Antidiabetic

Result and Observation

Various medicinal plants showed significant antidiabetic activity. Herbal medicines helped reduce fasting blood glucose and HbA1c levels. Improvement in insulin sensitivity and glucose metabolism was observed. Medicinal plants also showed antioxidant and anti- inflammatory activities. Herbal treatment helped improve lipid profile and reduce oxidative stress. Biomarkers such as blood glucose, HbA1c, and serum creatinine showed improvement. Herbal medicines may help prevent diabetic complications. Combination of herbal therapy, diet, and exercise provides better diabetes management.

II. CONCLUSION

The most prevalent and dangerous endocrine disease is diabetes mellitus. This illness affects more than 300 million people throughout the world. As a result, medicines based on western medical principles (allopathic) are generally ineffective, have a high risk of side effects, and are prohibitively expensive, especially in poor countries. Diabetes mellitus is becoming more common across the world, and treatment with oral hypoglycemic medications comes with a slew of adverse effects and a hefty price tag. Patients are increasingly requesting natural medicines with anti-diabetic properties. Various anti-diabetic herbs have been pharmacologically examined and proven to be of some use in the treatment of Diabetes Mellitus in this study. These plants' properties may help to postpone the onset of diabetes problems and rectify metabolic imbalances. However, further research is needed to determine the mechanism of action of medicinal herbs having anti-diabetic properties. The purpose of this review is to determine whether plants, plant parts, or extracts may be used to treat diabetes mellitus. It also compiles information on plants that have hypoglycemic properties. Experimental research on hypoglycemic plants and their bioactive components are the focus of the current inquiry. The kind of diabetes, associated physiological problems, and accessible herbal plants that might be further

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explored for anti-diabetic action are all briefly described. Overall, the profiles of plants with hypoglycemic characteristics documented in the literature are presented in this review. All of the herbal medicines that have been mentioned. These medicinal plants help reduce blood glucose levels by improving insulin secretion, enhancing insulin sensitivity, reducing glucose absorption, and protecting pancreatic β-cells. Herbal medicines also possess antioxidant and anti-inflammatory properties which help reduce oxidative stress and tissue damage associated with diabetes. Biomarkers such as blood glucose, HbA1c, lipid profile, serum creatinine, and urinary albumin are important for diagnosis and monitoring of diabetic patients. Herbal therapy may also help prevent diabetic complications and improve quality of life in diabetic patients. Combination of herbal medicines with proper diet, exercise, and lifestyle modification may provide better glycemic control.

FUTURE SCOPE OF HERBAL MEDICINE IN DIABETES

- Herbal medicines have a promising future in diabetes management due to fewer side effects and natural origin.
- Future research may help develop safer and more effective herbal antidiabetic drugs.
- Standardized herbal formulations and quality control methods may improve safety and efficacy.
- Nanotechnology may enhance herbal drug delivery and bioavailability.
- Personalized herbal therapy based on biomarkers and genetics may improve treatment outcomes.
- Combination therapy of herbal and allopathic medicines may provide better glucose control.
- Medicinal plants may help prevent diabetic complications like neuropathy, nephropathy, and retinopathy.
- Artificial intelligence and biotechnology may support discovery of new herbal drugs.
- Herbal medicines are expected to gain global acceptance in future healthcare systems.

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