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Review Article

THE ROLE OF MEDICINAL PLANTS IN DIABETES CONTROL: A REVIEW OF PHYTOCHEMICALS AND EFFICACY

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ABSTRACT

Diabetes mellitus (DM), a chronic metabolic disorder, has emerged as a global health crisis affecting approximately 25% of the population worldwide. Characterized by hyperglycemia resulting from defects in insulin secretion, insulin action, or both, DM leads to complications such as cardiovascular diseases, neuropathy, and renal failure. Modern therapeutic approaches, primarily allopathic drugs like insulin and metformin, are effective but are often associated with side effects, high costs, and limited accessibility in low-resource settings. Consequently, interest has surged in exploring herbal remedies for diabetes management, which are generally perceived as safer and more affordable alternatives. This review explores the antidiabetic potential of various medicinal plants such as fenugreek, garlic, mulberry, guava, and drumstick, highlighting their phytochemical constituents and mechanisms of action. Key bioactive compounds in these herbs, including flavonoids, alkaloids, and polyphenols, exhibit hypoglycemic effects through mechanisms like enhanced insulin sensitivity, inhibition of glucose absorption, and antioxidant activity. Clinical and preclinical studies underline their efficacy as complementary therapies in improving glucose metabolism and reducing complications associated with DM. The comparison between allopathic and herbal treatments reveals that while conventional drugs provide rapid and precise glucose control, herbal remedies offer multifaceted health benefits, particularly in mild or adjunctive diabetes care. This integrated approach could potentially optimize DM management, minimizing adverse effects and promoting sustainable healthcare practices. Future research should focus on standardizing herbal preparations and conducting rigorous clinical trials to validate their efficacy and safety.

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Introduction

DIABETES:

A serious, chronic, and complex metabolic disease with multiple etiologies, diabetes mellitus (DM) has substantial short- and long-term consequences.People in both developed and developing countries are affected by diabetes mellitus, or DM, and its complications, which present a serious socioeconomic challenge. It is estimated that 25% of people worldwide suffer from this illness. Diabetes is mostly brought on by a confluence of hereditary and environmental factors. Because insulin, a peptide hormone that regulates blood glucose, does not operate as it should on target tissues, diabetes impairs the body's cells' ability to effectively digest sugar.

Insulin cannot metabolize sugar when the pancreas produces insufficient amounts of it or when the body cannot effectively use the insulin that is generated. As a result, the body breaks down its own fat, protein, and glycogen to produce sugar, which raises blood sugar levels and leads the liver to produce an excessive amount of ketones, a byproduct.Persistently elevated blood sugar levels and abnormalities in macromolecule metabolism caused by deficiencies in either insulin secretion, insulin action, or both [1]are characteristics of diabetes mellitus (DM). The presence of DM increases the risk of numerous complications, including peripheral vascular diseases, stroke, neuropathy, renal failure, retinopathy, blindness, amputations, and cardiovascular diseases [2].

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HISTORY

One of the earliest recognized illnesses is diabetes mellitus (DM), which has been mentioned in Egyptian writings for more than 3,000 years. Around 1500 B.C., ancient Indian doctors noticed that diabetic patients' urine was sweet, and they came up with the moniker "Madhumeha."The Ebers Papyrus, a significant medical document from Egypt, also described frequent urination, hinting at diabetes.By the 5th and 6th centuries, Indian physicians Susruta and Sharuka had documented symptoms like extreme thirst and foul breath, distinguishing between Type I and Type II diabetes for the first time. The term "diabetes" was introduced by the Greek physician Aretaeus of Cappadocia, who observed the condition characterized by increased urination.

He also differentiated between diabetes mellitus (with sweet urine) and diabetes insipidus. In 1670, Thomas Willis added "mellitus," meaning "honey-sweet," after confirming the sweetness of diabetic urine was due to high blood glucose.In 1776, British physiologist Matthew Dobson established that this sweetness resulted from excess glucose. Aulus Cornelius Celsus provided a comprehensive clinical description of diabetes in Latin around 30 B.C. to 50 A.D.In the 19th century,

Claude Bernard made great strides in our understanding of diabetes by establishing the liver's function in glucose synthesis and glycogenesis in 1857. The vital role of the pancreas was highlighted in 1889 when Joseph von Mering and Oskar Minkowski showed that removing the organ in dogs caused diabetic symptoms. Their findings inspired Frederick Banting, who, along with Charles Best, isolated insulin from the pancreas in 1921, earning the Nobel Prize in 1923 for their groundbreaking work in diabetes treatment.[3]

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CLASSIFICATION:[4]

Diabetes mellitus is mainly classified into 3 types

1.Type 1 diabetes:

The hallmark of type 1 diabetes, a chronic autoimmune disease, is insulin insufficiency and the resulting hyperglycemia. Complete insulin insufficiency is the result of autoimmune demise of beta cells in the pancreas. Globally,insulin-dependent diabetes affects many individuals and requires close monitoring to prevent serious complications like stroke, heart disease, and kidney and visual problems. Type 1 diabetes is generally treated with insulin therapy, which is based on "exogenic insulin substitution therapy."Regretfully, many people cannot attain ideal blood glucose control using this technique.

2.Type 2 diabetes:

The two main features of this common metabolic disorder are the tissues' inability to respond to insulin as it should and the pancreatic β-cells' insufficient production of insulin. This illness is associated with risk factors such as high blood sugar, obesity, hypertriglyceridemia, poor eating habits, inactivity, age, family history, stress, anxiety, and depression. In addition to metformin and other glucose-lowering drugs, insulin therapy is required for the treatment and management of type 2 diabetes.

3. Gestational diabetes:

Pregnant women who have high or increased blood sugar are said to have this disorder. It can impact both mother and child and only happens during pregnancy in certain women. It is caused by a number of factors, including maternal age, obesity, and a family history ofdiabetes.Ischemic heart disease and type 2 diabetes are linked to it. Patients without a history of diabetes prior to the gestational period are typically diagnosed with gestational diabetes in thepregnancy's second or third trimester. The most frequent pregnancy problem is this one. There are two ways to handle this disorder: dietary therapy, insulin therapy, and lifestyle changes

CAUSES OF DIABETES:

In the US, diabetes and obesity are the leading causes of morbidity and death. Both weight growth and obesity are linked to a higher risk of diabetes in individuals. In type 2 diabetes, there is a noticeable development in the impairment of pancreatic β cell activity over time. However, aging, obesity, inadequate energy intake, alcohol consumption, smoking, and other factors are risk factors for the development of type 2 diabetes mellitus on their own.

Diabetes mellitus (DM) can be brought on by smoking, overeating, excessive alcohol use, neurological and endocrine system abnormalities, elevated cortisol, abnormal sex hormone secretion, decreased energy intake from inactivity, and genetic factors like age. Type I or type II diabetes mellitus pathophysiology is thought to be significantly influenced by factors like aging, obesity, inadequate energy intake, smoking, and alcohol consumption, among others.[5]

SYMPTOMS:

a) Warning symptoms:

1. Inexplicable loss of weight
2. Constant exhaustion
3. Copyability
4. Frequently occurring infections, particularly in the genital areas The urinary tract Oral cavity and skin
5. Mouth dryness
6. Foot discomfort, numbness, and burning
7. Itching
8. Hypoglycemia that is reactive
9. Acanthoses nigricans: a sign of insulin resistance that manifests as velvety black patches on the neck, armpit, and groin
10. Diminished vision
11. Erectile dysfunction-related impotence

b)Classic symptoms:

Both type 1 and type 2 diabetes share similar symptoms, including frequent urination, excessive thirst, and increased hunger, all of which result from elevated blood sugar levels. Type 1 diabetes, however, typically causes a swift and severe increase in blood sugar, whereas type 2 diabetes leads to a more gradual escalation. Significant weight loss tends to occur primarily in individuals with type 1 diabetes or those who have had untreated type 2 diabetes for an extended time. Additionally, symptoms such as physical pain, tiredness, irritability, and unintentional weight loss may be present in undiagnosed diabetes. Subtle or slow-onset symptoms are often missed or ignored.[6]

PATHOPHYSIOLOGY OF DIABETES:

It depends on how much insulin the body uses and how much of it is present.Insulin is absent in type 1 diabetes mellitus, whereas peripheral tissues in type 2 diabetes mellitus are resistant to its effects. The release of pancreatic beta cells' production of insulin in reaction to high blood glucose levels serves the brain, an organ that is heavily reliant on blood glucose levels for optimal operation.

The pace at which β-cells in the pancreas are destroyed by the autoimmune process determines how type 1 diabetes mellitus develops. Patients with diabetes might develop the serious illness known as DKA, or diabetic ketoacidosis. The liver turns fat into ketones when the body breaks it down faster than normal, which makes the blood more acidic. But as insulin insufficiency progresses, they experience severe hyperglycemia, ketoacidosis, and insulin dependency.

Two of the main characteristics of the pathophysiology of type 2 diabetes mellitus are insulin resistance and insulin shortage. These disorders have been linked to higher plasma levels of inflammatory cytokines and fatty acids, which lead to increased hepatic glucose synthesis, accelerated breakdown of fat, and insufficient glucose delivery into target cells. Hyperglycemia results from the oversecretion of glucagon by the glucagon-secreting alpha cell and the absence of insulin by the beta cell.[4]

GENERAL COMPARISON BETWEEN ALLOPATHIC AND HERBAL DRUGS USED AS ANTIDIABETICS:

When comparing allopathic (conventional) drugs and herbal (natural) remedies for diabetes management, there are several factors to consider, such as effectiveness, safety, side effects, cost, availability, and mechanism of action. Here's a general comparison between the two:

Criteria	Allopathic Drugs	Herbal Drugs
Effectiveness	Pros: Proven efficacy in managing diabetes, fast-acting, reliable. Cons: May require adjustments over time.	Pros: Can support metabolic health, may modestly reduce blood sugar. Cons: May not be as potent, efficacy varies.
Examples	Metformin, Insulin, Sulfonylureas, SGLT-2 Inhibitors	Garlic, Fenugreek, Mulberry, Pomegranate, Guava, Drumstick
Mechanism of Action	Targets specific biological pathways like improving insulin sensitivity or reducing glucose production.	Works through multiple mechanisms like improving insulin sensitivity or slowing carb absorption.
Examples	Metformin: Reduces glucose production in the liver. Insulin: Directly replaces insulin.	Mulberry: Affects AMPK pathway for glucose uptake. Ashwagandha: Improves insulin sensitivity.

Safety and Side Effects	Pros: Well-regulated, established safety profiles. Cons: May cause hypoglycemia, weight gain, kidney/liver issues.	Pros: Generally safer, fewer severe side effects. Cons: Quality can vary; some herbs may cause indigestion or IBS.
Cost and Accessibility	Pros: Widely available with a prescription. Cons: Can be expensive, especially newer meds.	Pros: More affordable, widely available. Cons: Variable quality and potency.
Long-Term Use and Monitoring	Pros: Long-term use well documented, monitored with blood tests (e.g., HbA1c, glucose). Cons: May require dose adjustments, side effects with long-term use.	Pros: Suitable for long-term use, often used alongside conventional treatment. Cons: Limited studies on long-term effects.
Regulation and Standardization	Pros: Strictly regulated by health authorities (e.g., FDA). Cons: May not be affordable for all.	Pros: Seen as "natural" alternatives. Cons: Lack of regulation, quality can vary between brands.
Suitability for Different Types of Diabetes	Best for: Type 1 (insulin needed) or type 2 diabetes (medication required). Not suitable for: Some medications may not be appropriate for kidney/liver issues.	Best for: Mild diabetes or as complementary therapy for type 2. Not suitable for: Type 1 diabetes or severe cases.

HERBS USED IN DIABETES:

(Table a: Herbs used in Diabetes Mellitus)

SR.NO	HERBS	BOTANICAL NAME	FAMILY	PART USED	PICTORIAL REPRESENTATION
1	Fenugreek	*Trigonella-foenumgraecum*	Leguminosae	Leaves, seed	
2	Garlic	*Allium sativum*	Amaryllidaceae	bulb	
3	Mulberry	*Morus nigra*	Moraceae	leaves	

4	Promogrante	*Punica granatum*	Punicaceae	fruit	
5	Guava	*Psidium guajava L.*	Myrtaceae	Leaves,	
6	Drumstick	*Moringa oleifera*	Moringaceae	Leaves,pods	
7	Ashwagandha	*Withaniasomnifera*	Solanaceae	leaves	
8	Okra	*Abelmoschus esculentus*	Malvaceae	fruit	
9	Onion	*Allium cepa*	Amaryllidaceae	bulb	

PHYTOCHEMICAL SCREENING:

(Table b: Phytochemical test of Antidiabetic Herbs)

Table b) :Phytochemical screening

Phy-to-Chemical Compound	Fenu-greek	Garlic	Mulberry	Pro-mogran-te	Guava	Drum-stick	Ash-wagnd-ha	Okra	Onion
Tannins	-	-	+	-	+	+	+	+	-
Steroids	+	-	+	-	-	+	+	+	-
Flavonoids	-	+	+	+	+	+	+	+	+
Carbohy-drates	+	+	+	+	+	+	+	+	+
Glycosides	-	+	+	-	+	-	+	+	+
Saponins	+	+	+	+	+	-	+	+	-
Proteins	+	-	-	+	-	+	+	+	+
Phenols	-	-	+	+	+	+	+	+	+
Alkaloids	+	+	+	+	+	+	+	+	+
Terpenoids	-	-	-	-	+		+	+	-
Essential Oils	+	+	+	-	-	+	-	-	-
Cumurins	-	-	-	-	-	-	-	-	-
Fatty Acid	+	-	+	+	+	-	+	-	-
Reference	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]

Chemical constituents :

(Table c: Chemical constituents of antidiabetic herbs)

Sr.no	Herbs	Chemical constituents	Refer-ence
1	Fenugreek	Trigonelline, diosgenin, 4-hydroxy-isoleucine, 3-hydroxyisoleucine, fenugreekineThe seeds are rich in flavonoids (quercetin, kaempferol), saponins, phenolic compounds (gal-lic acid), alkaloids (trigonelline), and terpenoids (steroidal saponins)	[16]
2	Garlic	Allyl propyl disulfide, cysteine sulfoxide, S-allyl cysteine sulfoxide, and allicin.	[17]
3	Mulberry	flavonoids (MF), polysaccharides (MP) and alkaloids (MA) ,phenolic compound are 1-deoxynojirimycin ,chlorogenic acid ,garlic acid,p-cou-maric acid	[18]
4	Promogrante	Punicalagin and the acids ursolic, oleanolic, gallic, ellagic, and uallic.	[19]
5	Guava	Polysaccharides, Flavonoids such as guaijaverin, kaempferol	[20]
6	Drumstick	flavonoids, namely myricetin, quer-cetin and kaempferol. β-carotene, and vitamin C	[21],[22]
7	Ashwagandha	withaferin A, withanolide B, with-anolide A, and with- anoside IV, flavonoids.	[23]
8	Okra	67.5% a-cellulose, 15.4% hemicel-luloses, 7.1% lignin, 3.4% pectic matter, 3.9% fatty and waxy matter and 2.7% aqueous extract and the rest are very minor in proportion. . Quercetin play the major role in treatment of diabetes in okra.	[24]
9	Onion	S-methyl cysteine sulfoxide, S-allyl cysteine sulfoxide,allylpropyldisul-fide,alliin.	[25]

1. Fenugreek:

Trigonella foenumgraecum, or fenugreek, is an annual plant that is a member of the Leguminosae family. Fenugreek seeds and green leaves are utilized in food and medicinal, as they have been throughout human history.Extracts from fenugreek seeds have been shown to reduce blood glucose levels, and the seeds themselves have been used as an oral insulin alternative.Fenugreek seeds may have an antidiabetic impact because of their high galactomannan content in their soluble fiber fraction.[26] Alloxan-induced subdiabetic and overtly diabetic rabbits of varying severity were used to study the mechanism of action of an oral active hypoglycemic component that was extracted from aqueous extract of Trigonella foenumgraecum (fenugreek) seeds.The risk of developing severe hypoglycemia was low, and the hypoglycemic effect was shown to be slow but persistent.[27]24 type 2 diabetic patients were given 10 grams of powdered fenugreek seeds per day, either steeped in hot water or combined with yoghurt, for eight weeks as part of a clinical trial investigation. It is possible to utilize fenugreek seeds as an adjuvant to help manage type 2 diabetes.[28]Individuals suffering from type II diabetes who received a solution of Powdered Trigonella foenum-graecum seeds showed significant improvements in lipid metabolism with no negative side effects. Thus, Trigonella foenum-graecum seed might offer fresh options for the therapy of type II diabetes instead[(29]

2.Garlic:

Allium sativum, or garlic, is a significant plant in the Amaryllidaceae family. There are two main types of garlic: hardneck (Allium ophioscorodon) and softneck (Allium sativum).[30]Around the world, people have used garlic (Allium sativum) as a traditional medicine to treat and prevent a variety of illnesses. Garlic has been shown to have antiviral, antibacterial, anticancer, antioxidant, hepatoprotective, cardioprotective, anti-diabetic, anti-hypertensive, and hypolipidemic qualitiesin addition to immune-boosting benefits.[31]

In rats and mice with streptozotocin-induced and alloxan-induced diabetes mellitus, garlic and its derivatives lower blood glucose and insulin resistance.Raw garlic has been shown in type 2 diabetes trials to significantly reduce glycaemia and lipid metabolism while also improving redox metabolism.[32]In diabetic mice, garlic extract significantly decreased blood glucose levels, total cholesterol, triglycerides, urea, uric acid, aspartate aminotransferase, and alanine aminotransferase, while greatly increasing insulin levels in the blood.

The primary reason for garlic's antidiabetic effects is its volatile sulfur components.[33]When streptozotocin was administered to diabetic rats, the euglycemic condition was restored, and the increase in serum antioxidant levels was accompanied by a drop in serum glucose levels. [34]The antioxidant effect of garlic and aged black garlic in db/db mice, an animal model of type 2 diabetes that shows insulin resistance, hyperglycemia, and obesity.In rats with streptozotocin (STZ)-induced diabetes, injections of garlic extract reduced the progression of structural nephropathy and hypoglycemia, whereas consumption of an 80% ethanol extract of garlic reduced serum glucose. In db/db mice, an animal model of type 2 diabetes, consumption of a diet containing 5% garlic powder dramatically reduced blood glucose and total cholesterol.[35]

3.Mulberry:

Mulberry is a popular medicinal herb (Morus spp., Moraceae). The three most prominent species in the genus Morus are the Black mulberry (Morus nigra), red mulberry (Morus rubra), and white mulberry (Morus alba).[36] Mulberry leaves have been shown to have anti-inflammatory, anti-cancer,

anti-cardiovascular, antibacterial, anti-skin disease, and antidiabetic properties.The medicinal compounds in mulberry leaves are commonly utilized to treat metabolic illnesses like diabetes in both modern Chinese and Western medicine as well as traditional Chinese medicine.[37]

A significant amount of polysaccharides is present, which enhance glucose metabolism, protect the body from oxidative stress, and insulate the pancreatic islets from the negative effects of diabetic mellitus (DM). Hypoglycemic effects were observed after diabetic mice were given two dosages (150 and 300 mg/kg) of an ethanolic extract from Morus alba leaves over a 12-week period. Serum lipid values, such as triglycerides and total cholesterol, decreased in addition to blood glucose levels.[38]

Mulberry leaves improved the polyphagia and polyuria symptoms in T2D rats while also dramatically lowering their fasting blood glucose and also have an impact on immune and gluconeogenic processes, lessen oxidative stress and inflammation while enhancing insulin resistance (IR) and obesity. high-fat diet and streptozotocin was administered in the rat which cause type 2 diabetes in rat in that serum levels of several metabolites were changed by Mulberry leaves treatment.

These metabolites are involved innumerous metabolic processes, such as the metabolism of fats, carbohydrates, and amino acids.[39] Active ingredients in mulberry leaf extract (MLE) was found to be 1-deoxynojirimycin (1-DNJ, 5.47%) that DNJ ingestion lowers blood sugar levels because it inhibits intestinal α-glucosidase by preventing substrates from attaching to the enzyme, which increases hepatic glucose metabolism and decreases small intestine glucose absorption. The enhancement of insulin sensitivity and function is a further component in the antidiabetic effects of DNJ use.[40]

4.Pomegranate:

Since ancient times, humans have used the pomegranate *(Punica granatum L.),* a member of the *Punicaceae* family that grows in tropical and subtropical climates, as a crop.(41) Pomegranate fractions made from different parts of the fruit have been linked to the prevention and treatment of a number of illnesses and ailments, including diabetes, cancer, Alzheimer's disease, erectile dysfunction, male infertility, arthritis, brain ischemia, dental diseases, obesity, antioxidants, inflammation, infection, and cardiovascular disease. Pomegranate extracts and their constituents' impact on diabetes and other variables linked to the metabolic and biochemical aspects of the disease.[42]

Promegranate fruit extract polyphenols at 50 and 100 mg/kg in males for four weeks Sprague-Dawley rats.Rats' blood lipid profile, liver glycogen level, and antioxidant status all improved as a result. Similarly, pomegranate fruit Aqueous extract dramatically reduced fasting blood sugar levels and raised mRNA expression ofAkt, Glut-2, Glut-4, and IRS-1, indicating better glucose uptake and storage in alloxan-diabetic Wistar rats.(43)Pomegranate seed powder (PSP) supplementation was investigated in patients with type 2 diabetic mellitus (T2DM).

Sixty patients received 5 g of PSP or a placebo twice daily for eight weeks.Total cholesterol, triglycerides (TG), glycated hemoglobin (HbA1c), and fasting blood glucose (FBG) all decreased considerably more in the PSP group than in the placebo group.[44]After ingesting 40 grams of concentrated pomegranate juice daily for eight weeks, patients with type 2 diabetes and hyperlipidemia had a significant reduction in their serum levels of low-density lipoprotein (LDL) and total cholesterol.[42] Pomegranate seed oil (PSO) is known for its anti-inflammatory qualitiesand potential benefits in improving glycemia and insulin resistance in diabetes mellitus.The purpose of this study was to evaluate how PSO affected the metabolic status of individuals with Type 2 diabetes.[45]

5.Guava:

Tropical and subtropical areas are home to Psidium guajava, or guava, one of the more reasonably priced fruit crops in the *Myrtaceae* family. Due to its high nutritional and culinary value, guava has been utilized for centuries. Guavas come in two popular varieties: the white as well as the red (P. guajava var. *pomifera*) and *pyrifera.* Rich in nutrients and useful elements like vitamins and phenolic compounds, guavas are well-liked by customers and contribute positively to human diets.Traditional medicine has traditionally utilized guava leaves and fruits to cure a wide range of ailments, such as wounds, diarrhea, flatulence, rheumatism, ulcers, and stomachaches. Guavas' anti-inflammatory, anti-cancer, anti-microbial, and antidiabetic qualities make them useful for a variety of medical purposes.[46]

Traditional medicine has long utilized guava leaves (GLs) to treat diabetes. Research shows that GL polysaccharides and flavonoids have antidiabetic properties. In diabetic mice, Flavonoids of avicularin and guaijaverinfrom GL extract have been associated with notable enhancements in hepatocyte shape and pancreatic β-cell function. Avicularin prevents intracellular lipid aggregation by preventing glucose uptake, whereas guaijaverin suppresses the activity of one important enzyme in the control of glucose is dipeptidyl-peptidase IV.[20]The methanolic and aqueous extracts of Psidium guajava demonstrated hypoglycemic action inrats with diabetes caused by alloxan by reducing blood glucose levels.

The ethanolic extract's hypoglycemic activity was found to be superior. pancreatic islets of albino rats treated with ethanolic extract had a significantly improved β-cell activity.The number of insulin granules and the β-cell population were both significantly higher.[47]Guavas' High fiber content and a low glycemic index considerably reduce the incidence of diabetes. The low glycemic index prevents a sharp rise in blood sugar levels, while the fiber content guarantees that blood sugar levels are suitably maintained.Oral administration of P. guajava leaf extract to streptozotocin-induced diabetic rats increased hemoglobin and plasma insulin levels while dramatically lowering blood glucose levels, according to the study.

This antihyperglycemic activity, which reduces the loss of insulin-positive β-cells and insulin output, may be due to protecting pancreatic tissues and islet β-cells against lipid peroxidation and DNA strand breakage.[48] Guava leaf extracts have been shown to raise plasma insulin levels and enhance the activity of important glucose metabolism-related enzymes, such as glucose-6-phosphate dehydrogenase, phosphofructokinase, and hepatic hexokinase, when taken over an extended period of time. The extract's antihyperglycemic qualities and protective actions against type 2 diabetes are reinforced by these improvements.[46]

6.Drumstick:

The leaves of the Moringa oleifera tree have been widely utilized as nutrients in recent years.[49]The monogeneric family's most widely grown species is *Moringa oleifera, the Moringaceae. Moringa oleifera* is the most famous for its thirteenThese species include *M. arborea, M. borziana, M. drouhardii, M. oleifera,* and *M. concanensis. M. rivae, M. ruspoliana, M. ovalifolia, M. peregrine, M. pygmaea, M. hildebrandtii, M. longituba, and M. stenopetala.*[50] Moringa leaves haveantimicrobial, anti-inflammatory, anti-diabetic, and anti-cancer properties, among other health benefits. [49]Powdered dried drumstick leaves may serve as a natural food source to treat type II diabetes since it can successfully block the activity of the α-glucosidase enzyme.[51]

Rats' blood antioxidant enzyme levels were also raised by a 500 mg/kg dosage of moringa seed powder. Therefore, when STZ is activated, the antioxidant chemicals in moringa may lessen the amount of ROS generated in betacells.[52]Insulin-Independent diabetes is caused by decreased insulin secretion, which raises blood sugar levels. A number of flavonoids are regarded as antioxidants in addition to scavenging ROS. These consist of phenolics and quercetin. Flavonoids found in moringa are thought to shield beta cells and regulate blood sugar levels by scavenging free radicals.[53]Rats with STZ-induced diabetes were given moringa seed powder, and after consuming it, their blood glucose levels decreased.[54]

Creating and giving obese people with Insulin-Independent diabetes a distinct mixture that includes 7% red chili powder, 7% coriander powder, 5% salt, and leaf powder. This mixture was cooked for a relatively short period of time without the use of oil. They received 50 g pouches and were told to continue eating normally for 40 days while taking them. In diabetics, the generated leaf powdersignificantly lower levels of serum blood glucose.[55]

Antioxidants and blood phenols are the reason of low blood sugar levels. The ability of moringa leaves to treat both types of diabetes has been shown in numerous research. The crude extract from M. oleifera leaves may be utilized to treatmetabolic syndrome in individuals with type 1 and type 2 diabetes, per a study conducted on rats given streptozotocin.[56]

Aqueous extract from M. oleifera has been found to be effective in treating rats with streptozotocin-induced type 1 diabetes and insulin-resistant type 2 diabetes.[57]

7) Ashwagandha:

Ashwagandha, or *Withaniasomnifera,* is a significant therapeutic shrub that has been utilized for over 3,000 years in indigenous and Ayurvedic therapy. Ashwagandha *(W. somnifera)* is a member of the Solanaceae family and genus *Withania.* India is home to two species, including W. *somniferaDunal* and *WithaniacoagulansDunal.(58)* Supplementing with ashwagandha may have neuroprotective effects, assist treat obsessive-compulsive disorder, and possess antimicrobial, immunomodulatory, and anti-inflammatory properties,stress-reduction, antidiabetic, cardioprotective, and sedative qualities.[59]

In Indian medicine and other traditional systems around the world, plants have been the primary source of medications used to treat diabetic mellitus (DM). Herbal medicines or their extracts have long been used to treat DM orally.[60]Extracts from *Withaniasomnifera* have the potential to prevent and treat mental health issues linked to diabetes because they are desensitizers of stress-induced biological reactions that involve the thermoregulatory system.[61]*Ashwagandha* (*Withaniasomnifera)* is very useful in reducing stress occurring in type-2-diabites milletus. It also reduces the other complains in patients. It also help in controlling tha diabetes and improve quality of life in Type-2 diabetus patients.[62] *Withaniasomnifera* when given to rat also prevented hyperinsulinemia as well as improve the glucose tolerance in NIDDM rat.it can improve insulin sensitivity.[63]Ashwagandha extracts in ethanol and chloroform were efficient at reducing stress-induced hyperglycemia at a minimum practical dosage of 10 mg/kg body weight.According to the study, *W. somnifera* has phytocomponents that can stop stress-induced hyperglycemia and uses a variety of methods to provide a hypoglycemic impact.[64].In cellular models of diabetes, The ability of *W. somnifera* leaf and root extracts to prevent diabetes were assessed. Since diabetes is a multifactorial disease, several cellular models were employed, includingBeta cells in the pancreas secrete insulin, and skeletal muscle and adipocytes absorb glucose. In rat myotubes (L6) and adipocytes, extracts from the leaves and roots both enhanced the absorption of glucose.[65]

8. Okra:

Okra (*Abelmoschus esculentus L.),* belonging to the family *Malvaceae*, is commonly known as Lady's finger, as well as by several vernacular names, including *okra, bhindi, okura, quimgombo, bamia, gombo*, and *lai long ma*, in the different geographical regions of its cultivation. The potential therapeutic effects of okra's phytochemicals on a number ofResearch has been done on its antifatigue, liver detoxifying, antibacterial, and chemopreventive qualities as well as its effects on chronic conditions such type-2 diabetes, heart disease, and digestive disorders. Okra has been utilized for its nutritional benefits as well as its nutraceutical and therapeutic qualities since it has a number of significant bioactive chemicals and the bioactivities that go along with them.[66]

Abelmoschus esculentus has been demonstrated to have anti-diabetic effects in both in vitro and animal studies. The strong antioxidant content of this vegetable is another well-known characteristic.Studies conducted on animals and in vitro have demonstrated the anti-diabetic qualities of Abelmoschus esculentus.[67]The lady finger seed extract showed antioxidant and anti-inflammatory effects, along with abilities to support cell growth, increase proliferation, and enhance glucose uptake and insulin sensitivity. Therefore, incorporating lady finger into your diet as a vegetable can be beneficial for controlling *hyperglycaemia* and diabetes. [68]Lady's finger's exceptional fiber and mucilage work to stabilize blood sugar by slowing down the pace at which sugar is absorbed from the digestive system.[69]Okra's high fiber content aids in blood sugar normalization by absorbing excess glucose from the blood and balancing the level.[70]

Additionally, Long Evans rats who received aqueous extracts from okra plant pods along with metformin also experienced hypoglycemia. The enzyme amylase has been regarded as an essential enzyme for meeting the body's energy needs since it breaks down polysaccharides with the help of glucose.A-glucosidase and a-amylase activities have also been shown to be inhibited by water-soluble extracts of okra plant seeds and peels. [71]A 50 mg/kg bw dose of okra (Abelmoschus esculentus L.) fruit extract had antidiabetic effects by increasing insulin secretion, improving insulin sensitivity, and preventing the intestinal absorption of carbohydrates; however, it had no effect on inhibiting the enzymes alpha glucosidase and alpha amylase.[72]

9. Onion :

The primary crop farmed worldwide, particularly in Asia, is theAllium cepa L., or onion. It is a member of the genus Allium and the family Amaryllidaceae.Onions come in red, yellow, white, and green kinds, each with a distinct flavor that ranges from mildly sweet to quite pungent.[73] Onions contain phenolics and flavonoids that have potential antioxidant, anti-inflammatory, anti-cholesterol, and anti-cancer qualities.Onions may be used to treat stomach cancer, hyperglycemia, and cardiovascular disease.[74]

Diabetes and its associated problems can be treated with onions.[75]. Consuming Regularly eating raw red onions benefits womenwho are overweight or obese lose weight and dissolve fat.[76]Type 2 diabetes mellitus and other lifestyle disorders can be managed with onion soup.[77] In the Sprague-Dawley rat model, its extract controls rises in postprandial blood glucose levels and restores intestinal α-glucosidases activity.[78] and treat mice with diabetic neuropathy.[79]

In individuals with Type 1 and Type 2 diabetes, red onion (A. cepa) exhibits hypoglycemic effects. It also improves glucose transport,restores normal blood glucose levels and lessens renal oxidative stress in rats with diabetes (A. cepa. Linn).[82]In aStreptozotocin-induced diabetes in mice fed a high-fat dietDietary A. cepa L. bulbs have demonstrated anti-diabetic qualities. [83,84]in aStreptozotocin-induced diabetes in mice fed a high-fat diet.[85] Patients with diabetes can be cured with onions, which are good medicinal herbs [86,87]. Among all Diabetes mellitus can be managed with anti-diabetic foods,onions are essential.[88,89]

The effects of A. cepa are hypoglycemia[90]in rats with diabetes caused by alloxan[91]By improving glucose tolerance, allyl propyl disulfide helps rabbits with alloxan-induced diabetes.S-methyl sulfoxide of cysteine, which was extracted from A. cepa Linn., exhibits anti-diabetic properties [92,93] In streptozotocin-induced diabetic rats, quercetin, an essential antioxidant found in onions, is synthesized from A. cepa and has an effect on hepatocyte apoptosis and aldehyde oxidase LDL.[94]

CONCLUSION:

•Allopathic drugs are the standard of care for managing diabetes, particularly in more severe cases. They offer proven effectiveness, consistency, and reliability but may come with side effects and require long-term monitoring.

•Herbal drugs can be a complementary option, offering natural, milder effects on blood sugar levels. They are often preferred by individuals looking for a more holistic or supportive approach. However, they may not provide the same level of control over diabetes as conventional treatments. In practice, many individuals may benefit from a combination approach, where herbal remedies are used to complement conventional medications, with careful monitoring by healthcare providers.

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