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ANTI HYPERGLYCEMIC ACTIVITY OF POTENTIAL HERBAL PLANTS

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Diabetes mellitus, *Momordica charantia*, *Aloe barbadensis*, *Catharanthus roseus*, *Glycyrrhiza glabra*, *Syzygium cumini*, *Curcuma longa*, *Stevia rebaudiana*, *Senna auriculata*, *Cinnamomum cassia* and *Taraxacum officinale*, Phytoconstituent, Safe and cost effective

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ABSTRACT: Diabetes mellitus is a globally prevalent chronic metabolic disorder characterized by hyperglycemia due to insufficient insulin production or impaired insulin utilization. It is associated with various acute and chronic complications, including neuropathy, nephropathy, retinopathy, and cardiovascular diseases. With rising incidence rates, especially in urban regions of developing countries like India, diabetes poses a major public health challenge. While conventional treatments involve insulin therapy and oral hypoglycemics, herbal medicine offers a promising complementary approach. This study reviews the antidiabetic potential of several medicinal plants, such as *Momordica charantia*, *Aloe barbadensis*, *Catharanthus roseus*, *Glycyrrhiza glabra*, *Syzygium cumini*, *Curcuma longa*, *Stevia rebaudiana*, *Senna auriculata*, *Cinnamomum cassia*, and *Taraxacum officinale*. Each plant is explored for its phytoconstituents, such as alkaloids, flavonoids, glycosides, and terpenoids, which exhibit hypoglycemic, antioxidant, anti-inflammatory, and insulin-mimetic properties. Experimental evidence from *in-vivo* and *in-vitro* studies supports their efficacy in managing blood glucose levels, improving insulin sensitivity, and protecting pancreatic β-cells. This compilation emphasizes the therapeutic potential of herbal remedies as safe and cost-effective adjuncts in diabetes management and encourages further clinical validation for integration into standard care practices.

INTRODUCTION: Diabetes mellitus is indeed a major concern today characterized by hyperglycemia (elevated blood sugar level) and associated metabolic complications like glycosuria (excretion of glucose in the urine), polyuria (increased urination often leading to dehydration), polydipsia (excessive thirst as a result of dehydration), polyphagia (increased hunger), ketonemia (presence of ketone in the blood), negative nitrogen balance (loss of nitrogen, indicating protein breakdown and malnutrition) [1, 8].

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It is a non-infectious endocrine disorder caused by either the body's inability to produce enough insulin (type 1) or effectively use insulin (type 2). This results in a disturbance in the metabolism of carbohydrates, fats, and proteins, leading to elevated glucose levels in the bloodstream (1). It is a widespread chronic condition affecting people globally in developed and developing countries [2].

Diabetes mellitus is linked with the development of several serious complications in untreated cases, this involves both micro vascular and macro-vascular complications in nature. Micro vascular Complications include neuropathy (nerve damage), retinopathy (damage to the retina, leading to vision problems), and nephropathy (kidney damage, which can lead to chronic kidney disease). On the other hand, macro vascular complications, which

affect larger blood vessels, including peripheral vascular disease (reduced blood flow to limbs) and coronary heart disease (increased risk of heart attacks and other heart-related issues) [1, 3]. Diabetes mellitus is increasingly being recognized as a global health issue and is often mentioned alongside cancer and cardiovascular and cerebrovascular diseases due to its rising prevalence and severe complications [4]. Therefore, Understanding diabetes mellitus is essential for both its prevention and effective management [7].

EPIDEMIOLOGY: The term diabetes originates from the Greek word "Diab," which means "a siphon" or "to pass through," highlighting the excessive urination characteristic of the condition. "Mellitus," from Latin, means "honey-sweet," referring to the sweetness of the urine caused by excess sugar excretion, a feature of the disease [4]. So, this condition has been recognized for thousands of years, though our understanding of these causes and treatments have evolved significantly. The global prevalence of diabetes has been increasing at an alarming rate, with estimates suggesting significant growth in the coming years. In 2003, the World Health Organization (WHO) predicted that by 2030, the number of adults with diabetes would nearly double, increasing from 177 million in 2000 to 370 million. Experts further forecast that by 2025, the incidence of diabetes could rise by 64%, affecting an estimated 53.1 million people. In 2010, the worldwide prevalence of diabetes among adults was about 285 million (6.4%), and this number is expected to rise to 439 million (7.7%) by 2030 [6]. The prevalence of diabetes in urban areas is significantly higher compared to rural populations often due to lifestyle differences. In urban settings, diabetes is approx. 6 times more common, as modern urban lifestyles tend to promote risk factors like:

- ❖ Decreased physical activity
- ❖ Stress and tension
- ❖ Dietary changes
- ❖ Malnutrition
- ❖ Alcohol consumption
- ❖ Viral infections

These factors have become more prevalent over the past 20 years, contributing to the sharp rise in diabetes mellitus, particularly in rapidly urbanizing regions [1].

TABLE 1: TABLE BASED ON THE DATA PROVIDED ABOVE

S. no.	Year	Number of Adults With Diabetes (in million)	Notes
1.	2000	177 million	Initial Estimate
2.	2010	285 million	Reported Prevalence
3.	2025	338 million	Estimated Total after 53.1 million increase
4.	2030	370 million	WHO prediction
5.	2030	439 million	Project Prevalence

Types of Diabetes Mellitus:

- Type 1 (Insulin dependent)
- Type 2 (Non- insulin dependent)
- Gestational diabetes

Type 1 (Juvenile Diabetes Mellitus): Type 1 diabetes is characterized by the autoimmune destruction of insulin-producing beta cells in the pancreas. This leads to little or no insulin secretion, which is essential for regulating blood glucose levels [3]. Type 1 often referred to as "Juvenile diabetes mellitus", is indeed hereditary [4]. It accounts for about 5-10% of all diabetes cases globally. According to the American Diabetes Association (2001), approximately 20 million people worldwide were affected by type 1 diabetes at that time [6]. This type of diabetes is commonly diagnosed in children and young adults often presenting with a sudden onset of symptoms that can be severe and potentially life-threatening. Individuals with type 1 diabetes often have an increased risk of developing other auto immune disorders. This phenomenon is due to the underlying genetic and immunological factors that contribute to autoimmunity [7]. Thus, type 1 diabetes requires careful management to prevent serious complications over time if blood glucose levels are not properly controlled.

It includes cardiovascular disease, renal disease, Retinopathy, Neuropathy, Foot problems, and Stroke [9].

Sub-Type:

Type-1a (Auto Immune): This condition results from an auto immune response associated with other auto immune disorders such as Addison's disease, Grave's disease, and Hashimoto's thyroiditis.

Type-1b (idiopathic): This sub-type accounts for approx. 10% of type-1 cases. Patients with type 1 diabetes may experience significant insulin deficiency and are at risk for ketoacidosis.

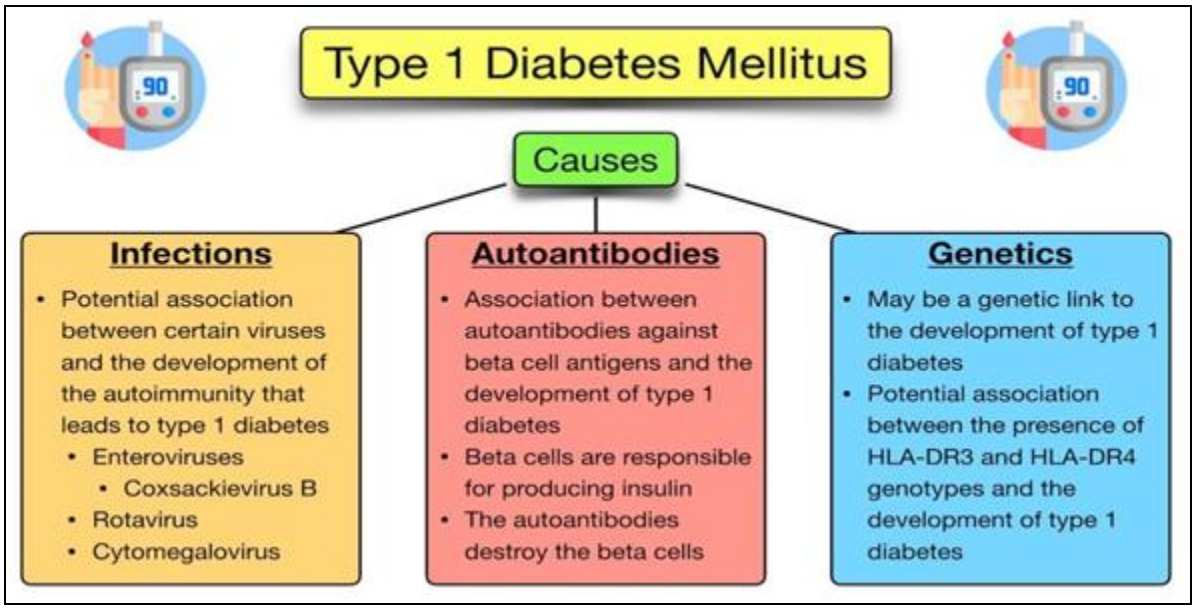

FIG. 1: CAUSES OF TYPE-1 DIABETES

Type 2 (Adult Type): Type-2 diabetes, also known as adult-onset or non-insulin dependent diabetes mellitus (NIDDM). It is often described as a multifactorial metabolic disorder, meaning that it results from a combination of genetic, environmental, and lifestyle factors that disrupt various metabolic pathways, particularly those involving glucose regulation [5]. It occurs in elderly people characterized by impaired insulin secretion and insulin resistance [6]. Insulin resistance is a key feature and is influenced by several factors, including oxidative stress, downregulation of insulin receptors, and reduction in the number of insulin receptors [8]. Type-2 diabetes is a growing global health concern according to the World Health Organization (WHO). The prevalence of type-2 affects over 422 million people worldwide, with the condition responsible for 1.6 million deaths each year [5]. People with type-2 diabetes often have a hard time with insulin's job because their bodies develop insulin resistance, leading to serious complications like kidney damage, eye problems, nerve damage, etc., [7]. There are several risk factors associated with type-2 diabetes, many of which are lifestyle related bust some are also tied to genetic and mental health [9].

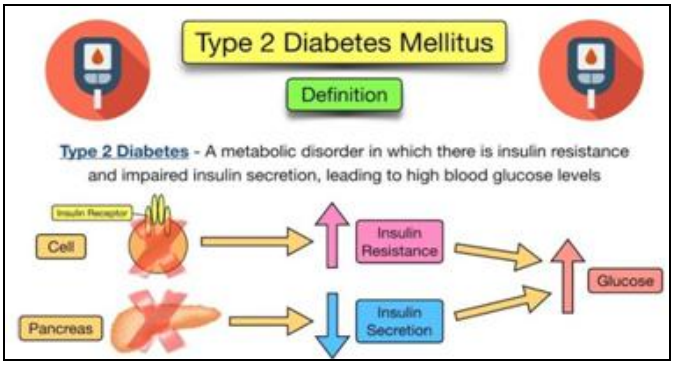

FIG. 2: TYPE-2 DIABETES

Gestational Diabetes: Gestational diabetes mellitus is indeed a form of glucose intolerance that is first diagnosed during pregnancy [3]. It usually develops in the second and third trimesters. During this time the body produces higher levels of certain hormones, which can lead to insulin resistance. If the pancreas cannot produce enough insulin to overcome this resistance, gestational diabetes can develop.

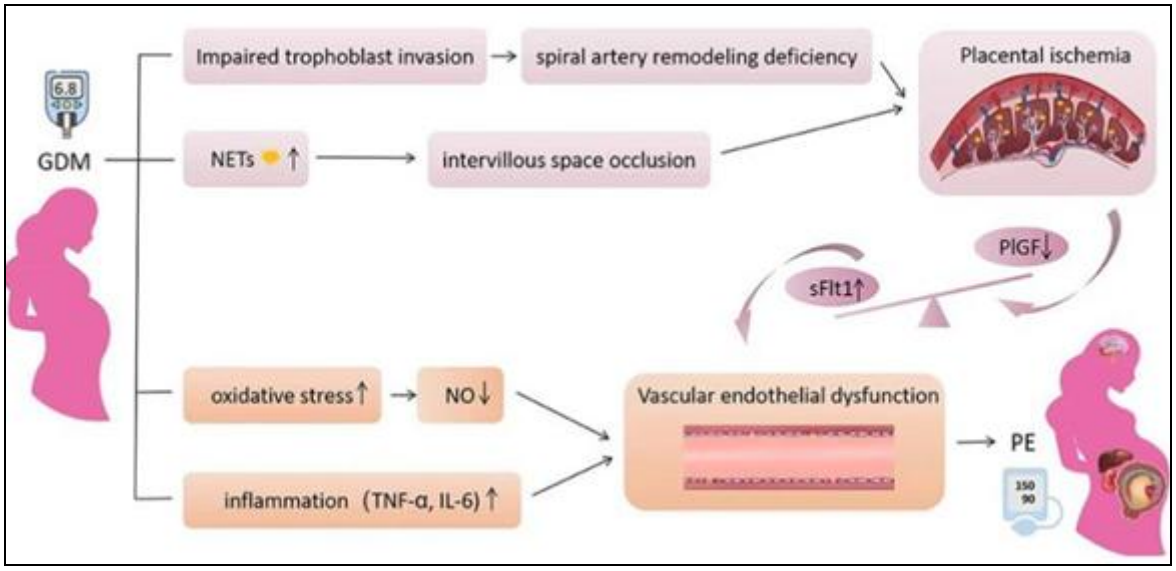

FIG. 3: GESTATIONAL DIABETES

Pathophysiology:

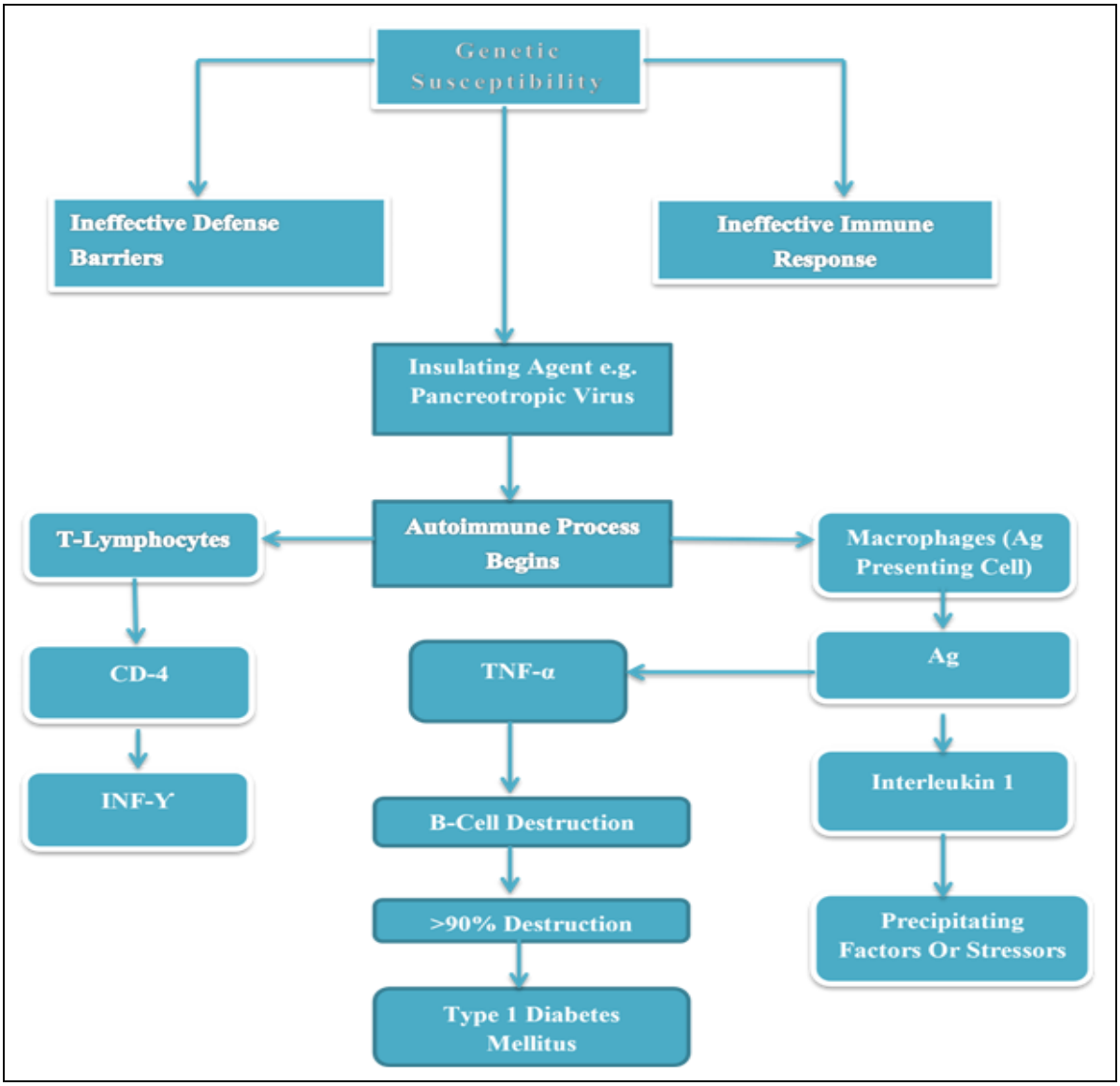

FIG. 4: PATHOPHYSIOLOGY OF TYPE 1 DIABETES MELLITUS

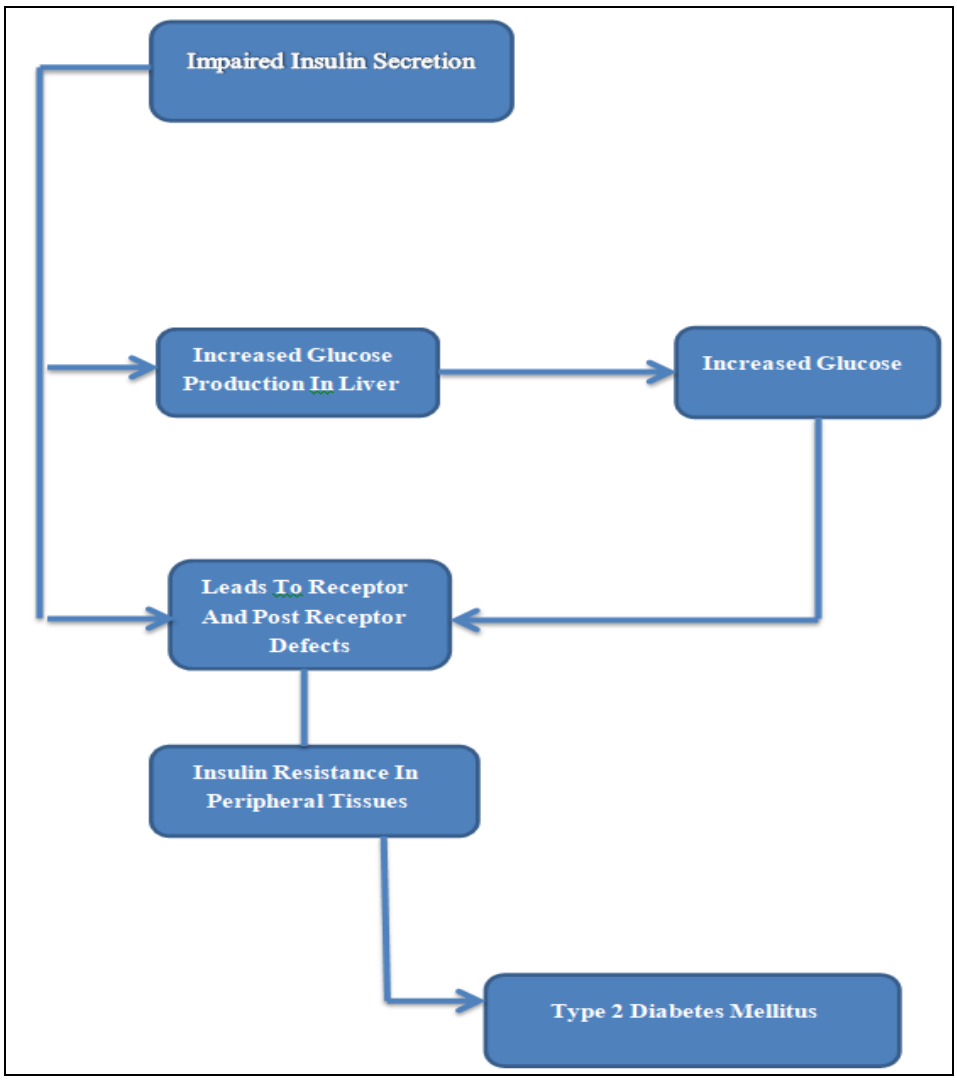

FIG. 5: PATHOPHYSIOLOGY OF TYPE 2 DIABETES MELLITUS

Herbal Remedies for Treatment of Diabetes Mellitus:

Momordica charantia: Bitter melon (*M. charantia*) is a flowering vine from the Cucurbitaceae family [10], known by several names such as *M. chinensis*, *M. elegans*, *M. indica*, *M. sinensis*, and *M. operculata* [11]. This tropical plant is extensively grown in Asia, India, East Africa, and South America, primarily for its extremely bitter fruits. While it's often used in cooking, it also serves as a natural remedy, particularly for diabetes [10]. The plant is a climbing perennial that can grow up to 5m.In addition to the fruit, other parts of the plant have also demonstrated significant health benefits and are used as a suppressant for toothache, diarrhea, and furuncle [13]. In a study involving Male Wistar rats, a diet containing 10% dried bitter gourd (*M. charantia*) improved diabetic condition [14]. This inclusion of bitter gourd in the diet was effective in preventing common diabetes-related symptoms such as polyuria and polydipsia. The active constituents of *Momordica charantia* 9 bitter melon) include momordic 1, momordic 2, and cucurbitacin B, which contributes to its medicinal properties, particularly in the treatment of diabetes [1]. Plant phenols present in bitter gourd have been studied for their hypolipidemic properties. These phenolic compounds can reduce cholesterol and triglyceride levels [12]. Studies indicate that oral administration of bitter melon fruit juice or seed powder can lead to a significant decline in fasting blood glucose (FBG) levels. This effect is attributed to several active compounds in bitter melon, including insulin secretagogues and Insulin mimetic activities [3].

Aloe barbadensis Mill.: *Aloe vera* (*Aloe barbadensis* Mill.), belonging to the Liliaceae family, is a succulent plant renowned for its health-enhancing properties. The Aloe genus thrives in

arid, tropical, and subtropical regions, encompassing approximately 450 species. Aloe vera can grow to a height of 60-100 cm, with fleshy, thick, triangular, and spiny leaves. It is widely used for treating dermatological conditions and promoting skin health, thanks to its therapeutic, emollient, antioxidant, anti-inflammatory, antimicrobial and depigmenting properties [16, 18]. Aloe gel can be applied topically to treat various skin conditions such as acne, eczema, and psoriasis, as well as burns and other skin wounds [16]. Aloe vera extract helps to restore FPG levels to normal in diabetes-induced rats, demonstrating its hypoglycemic effects. It may exert its effects by preventing the death of beta cells and potentially allowing the recovery of partially damaged beta cells [15]. Aloe supplements help lower blood sugar levels [16]. It stimulates insulin secretion and lowers blood sugar to a normal level [17].

The administration of Aloe vera extract demonstrated antidiabetic effects in alloxan-induced rats [19]. Aloe vera extracts rich in polysaccharides like Acemannan, Aloin, Glucuronic acid, Xyloglucans, Galactomannans can help regulate blood sugar levels, stimulate the production of antioxidants, and even reduce cholesterol [16]. Aloe vera methanol extract effectively inhibited the glycination reaction of proteins in the BCA/glucose system, likely due to the oxidative degradation of fructosamine [18]. It functions as a hypoglycemic agent by strongly inhibiting pancreatic alpha-amylase activity. This inhibition reduces carbohydrate breakdown, contributing to effective postprandial glycemic control [20].

***Catharanthus roseus*:** *Cathranthus rosea* (L.) commonly referred to as Vinca rosea, is a significant evergreen herb belonging to the Apocynaceae family, also known as the dogbane family. It is widely recognized by the names "Nayantara" or "Sadabahar". This annual herbaceous, and dicotyledonous plant is prized for its ornamental value, reaching a height of up to 1 m [21]. The leaves of *Catharanthus roseus* exhibit significant antidiabetic properties, as their extract has been shown to lower blood glucose levels in a dose-dependent manner in various studies, with effects comparable to the standard drug, glibenclamide. This antidiabetic activity is attributed to the alkaloids present in the leaves, which enhance insulin production. Additionally, the extract aids in the repair of pancreatic cells and improves glucose utilization in the liver [23]. The alkaloid-free aqueous stem fraction of *Catharanthus roseus* has demonstrated glycemic effects similar to those of tolbutamide, a standard control drug used to manage blood sugar levels [25]. Recent reports highlight the isolation of Vinculin, a plant-derived natural remedy, from *Catharanthus roseus*, a species known for its hypoglycemic properties. Vinculin has been utilized in diabetes management and is now commercially available. Studies suggest that the extract from *Catharanthus roseus* not only lowers blood sugar levels but also restores the number of beta cells, crucial for insulin production [21]. This makes it a promising therapeutic option for diabetes treatment. In a controlled clinical study, diabetic rats were administered a crude aqueous extract at an oral dose of 1 g/kg for 21 days. The treatment resulted in a notable 20.2% reduction in blood glucose levels when compared to the untreated diabetic rats [22]. Furthermore, in alloxan-induced diabetic rats, the aqueous extract demonstrated remarkable efficacy in lowering blood glucose levels. Additionally, it significantly reduced LDL, VLDL, total cholesterol (TC), and triglyceride levels (TC) bringing them close to normal values [24].

***Glycyrrhiza glabra*:** Liquorice (*Glycyrrhiza glabra*), a perennial herb from the legume family and part of the Glycyrrhiza genus [28], has long been a staple in traditional Chinese medicine. Known for its distinctively sweet flavor, licorice was historically referred to as "sweet root" by the Greek physician Pedanius Dioscorides. This sweetness is attributed to glycyrrhizic acid [26], one of its key active components. Licorice is widely cultivated across various countries, including Russia, the UK, the USA, Italy, France, Germany, Spain, China, and Northern India. Notably, large-scale commercial cultivation takes place in Spain, Sicily, and England [27]. Glycyrrhizic acid and its derivatives have demonstrated antidiabetic properties in *in-vivo* and *in-vitro* studies. These benefits are linked to several mechanisms, including the stimulation of insulin secretion, regulation of glucose homeostasis and lipid metabolism, and improvements in insulin sensitivity and glucose tolerance [28].

Licorice constituents, such as glabridin and glycyrrhizin, have been reported to stimulate in a dose-dependent manner [29]. Licorice has yielded numerous natural active compounds, including over 20 terpenoids and 300 flavonoids. Among these, five flavonoids—glabridin (GLD), liquiritigenin (LTG), isoliquiritigenin (ISL), liquiritin, and licochalcone (LCE)--as well as three terpenoids--18 beta-glycyrrhetenic acid (18beta-GC), 18alpha-glycyrrhizic acid (18beta-GC), and 18betaglycyrrhizic acid (18beta-GC), have been identified for their effectiveness in managing diabetes mellitus and its associated complications [30]. The ethyl acetate extract of licorice has shown significant activity in activating peroxisome proliferator-activated receptors (PPARs), which function as transcription factors regulating the expression of genes involved in glucose and lipid metabolism. This activation ultimately leads to a reduction in blood glucose levels in diabetic knockout rats [27].

***Syzygium cumini*:** *Syzygium cumini*, commonly known as Jambolam, Java plum, black plum, Indian blackberry, purple plum, or damson plum, is an evergreen tropical tree belonging to the Myrtaceae family [31, 35]. This species is widely found across the plains of India, ranging from the foothills of the Himalayas to the southern regions. Native to the Indian subcontinent, it also thrives in the nearby areas of Southeast Asia, China, and Queensland [31].

Syzygium cumini possesses astringent properties, making it effective in preventing acne, blemishes, wrinkles, and pimples. It is also known for its cardioprotective and anti-fungal benefits. One of the most significant medicinal advantages of Jamun are its antidiabetic properties. The black plum helps combat diabetes by aiding in the conversion of sugar into energy. The isolated extract of *Syzygium cumini*, Mycaminose, has shown promising antidiabetic effects. At a dose of 50 mg/kg, the ethyl acetate and methanol extract of *Syzygium cumini* seeds, administered at 200 mg/kg and 400 mg/kg, effectively counteracted diabetes in streptozotocin-induced diabetic rats [32]. A significant amount of flavonoids in the seeds contributes to these antidiabetic properties, further supported by strong alpha-amylase inhibitory effects [35]. Additionally, the ethanolic extract of jamun, at doses of 100 mg/kg and 200 mg/kg in Wistar rats, demonstrated a statistically significant antidiabetic activity, improving pancreatic weight, enhancing β-cell function, and reducing insulin resistance [33]. While jamun offers several health benefits, consuming it in excess or under certain conditions may lead to adverse effects [34]. The seed extract is known for its antidiabetic properties and has been used to manage blood sugar levels for over 130 years in the West. The seed powder and its extracts have demonstrated long-term antidiabetic effects, particularly in type-2 diabetic rats [36]. *Curcuma longa* Linn, commonly known as turmeric, is a spice that has been an integral part of South Asian and Middle Eastern cuisine throughout history. Widely used in Asian countries as a food spice, turmeric is also known for its therapeutic potential. It exhibits antimicrobial properties, aids in wound healing, and most notably, has a hypoglycemic effect that helps lower blood sugar levels.

The extensive use of this multi-functional plant is well documented in the Ayurvedic medical system, where its health benefits have been recognized for centuries [37]. It contains several active compounds, including curcumol, curcumin, and bismethoxy-curcumin, all of which have demonstrated potent antioxidant and antidiabetic properties. These components contribute to curcumin's therapeutic potential in managing oxidative stress and diabetes [41].

Its active compound has been shown to prevent body weight loss, lower blood glucose levels, reduce hemoglobin and glycosylated hemoglobin levels, and enhance insulin sensitivity. Curcumin has been found to improve lipid profile in animals with hyperglycemia, metabolic syndrome, and diabetes. It helps decrease plasma triglycerides (non-HDL) cholesterol while increasing levels of high-density lipoprotein (HDL) cholesterol, contributing to better cardiovascular health [38]. Dried rhizomes of turmeric are commonly used for their medicinal properties. Curcumin, extracted from these rhizomes has demonstrated strong antiinflammatory and antidiabetic effects. Studies have shown that the onset of type-2 diabetes improves β-cell function, prevents β-cell death, and reduces insulin resistance in animal models [39]. One of the key mechanisms behind curcumin's antidiabetic action is its ability to inhibit the

formation of advanced glycation end products (AGEs) induced by hyperglycemia. This inhibition plays a crucial role in managing diabetes and its related complications [40]. Volatile oils extracted from dried turmeric rhizomes have been found to inhibit glucosidase enzymes more effectively than the antidiabetic drug acarbose [41]. This suggests turmeric's potential as a natural alternative for managing blood sugar levels in diabetes.

***Stevia rebaudiana*:** *Stevia rebaudiana*, commonly known as sugar leaf, candy leaf, or sweet herb of Paraguay belongs to the Asteraceae family. Native to northeastern Paraguay, this plant is now cultivated in various regions worldwide, including Europe, Asia, and North America [42, 43, 46, 47]. Stevia is renowned for its remarkable sweetness, which is approximately 250-300 times sweeter than sucrose. For many years South Americans have utilized stevia for diabetes management [43]. This small perennial shrub typically reaches a height of up to 30 cm, though mature plants can grow as tall as 80 cm and feature woody stems [46]. Stevia contains a variety of essential phytochemicals and compounds known for their ability to lower blood cholesterol, sugar levels, and blood pressure [44]. It reduces postprandial blood glucose levels without triggering the release of insulin [44, 46]. In prediabetic women, it lowers blood glucose levels without affecting the 2-hour postprandial levels [44]. The flavonoids such as stevioside, steviol, and rebaudioside found in stevia leaves is dietary polyphenols with potent antidiabetic and antioxidant properties [44, 47, 48]. *Stevia rebaudiana* leaf extract has been shown to decrease random and fasting blood glucose levels in rats by revitalizing pancreatic β-cells. This, in turn, reactivates the glycogen synthase system, enhancing insulin secretion and increasing liver glycogen levels [45]. Natural sugar alternatives, such as stevia, are increasingly being used in place of synthetic sugars to help stabilize blood glucose levels in living organisms [46]. Stevia is not only an antihyperglycemic agent but also a potent cardioprotective tool, particularly in cardiac fibroblasts, which have recently been termed 'Renaissance Cells' due to their crucial role in maintaining cardiac function [49].

***Senna auriculata* (L.):** *Senna auriculata* (L.), also known by the synonym *Cassia auriculata*, is commonly referred to as Tanner's cassia, Avaram senna, mataratea, or styptic wood. This native Indian plant belongs to the Fabaceae family and is widely distributed across the hot, deciduous forests of India. It thrives in dry regions, particularly in states like Madhya Pradesh, Tamil Nadu, Rajasthan, and other parts of India [50].

It has been traditionally utilized in medicine for treating various conditions, including female fertility, leprosy, worm infection, diarrhea, and disorders related to pitta [51]. The flower extracts are specifically employed in managing diabetes. Additionally, the leaves, flowers, and fruits are valued for their anthelmintic properties [50, 51], while the seeds are used in the treatment of eye conditions and diabetes. The leaves of *Senna auriculata* (L.) Roxb. Contains various antidiabetic metabolites, including n-hexadecanoic acid, emodin, and squalene. These compounds have been evaluated for their antidiabetic potential, with studies reporting the mechanistic pathways through which they help alleviate diabetes [52]. The hypoglycemic ethanol extract of Senna auriculata insulin release has been found to stimulate insulin release from the pancreatic cells of diabetic rats, contributing to improved blood glucose regulation [53]. The aqueous extract of senna leaves has been reported to significantly lower blood glucose levels in diabetic rats induced by streptozotocin (STZ) [52]. The aqueous extract also demonstrated a reduction in free radical formation in the tissues studied, suggesting its potential antioxidant properties [54]. Oral administration of 0.45 g/kg body weight of the aqueous flower extract for 30 days resulted in a significant reduction in blood glucose levels and an increase in plasma insulin [54]. Flavonoids are known to regenerate damaged β-cells in alloxan-induced diabetic rats and function as insulin secretagogues, promoting the secretion of insulin [53].

***Cinnamonum cassia*:** *Cinnamon cassia*, commonly called cassia or Chinese cinnamon, is often confused with Ceylon cinnamon, though they are distinct spices. Cinnamon has a long history of use in traditional medicine, particularly in Korea, China and Russia, where it has been utilized as a remedy for managing diabetes mellitus [56]. Native to Sri Lanka, cinnamon thrives in Southeast Asia, flavoring regions with temperatures ranging from 10-23°C and temperatures from 100-200 meters

above sea level [57]. This evergreen tree, belonging to the Lauraceae family, can grow to heights of 20-30 feet [58]. Today, cinnamon is a globally popular spice [55], widely recognized for its aromatic qualities and culinary versatility. Cinnamon derived from the bark of *Cinnamonium cassia*, contains several key components, including cinnamic aldehyde, cinnamic acid, tannin, and methylhydroxychalcone polymer. The active ingredient in cinnamon also includes cinnamate, cinnamaldehyde, polyphenols, and flavonoids [56, 57]. Studies have indicated that cinnamaldehyde can enhance glucose transport *via* GLUT 4 in adipose and skeletal muscle cells, significantly lowering blood glucose levels [57].

Oral administration of Cinnamaldehyde, the primary active compound, has been shown to notably reduce serum glucose, glycosylated hemoglobin, total cholesterol, and triglyceride levels. Additionally, it promotes a significant increase in serum insulin, hepatic glycogen, and high-density lipoprotein (HDL) in a dose-dependent manner [3]. Cinnamon has been recognized as one of the traditional remedies for managing blood glucose levels in individuals with type 2 diabetes mellitus [57, 58]. Research suggests that cinnamon supplementation may positively impact anthropometric measurements, glycemic indices, and lipid profiles in patients with type 2 diabetes. Furthermore, cinnamon enhances the levels of beneficial antioxidants such as serum glutathione and superoxide dismutase, while reducing serum malondialdehyde levels. These effects suggest that cinnamon acts as an effective adjuvant in the treatment of poorly controlled type 2 diabetes, working alongside conventional therapies to provide antioxidant and antidiabetic benefits. Cinnamon powder is primarily used for this purpose [58].

***Taraxacum officinale*:** Dandelion (*Taraxacum officinale*) is a herbaceous perennial plant belonging to the Asteraceae family [62], commonly known as the composite family. This resilient weed features a sturdy taproot and long, green leaves arranged in a rosette formation. Its striking single yellow flowers give way to distinctive, cotton-like fruits that disperse numerous seeds through the wind. The growth of dandelions is widespread thriving across various regions, including Eurasia, the Americas, Africa, New Zealand, and Australia. Beyond its status as a weed, dandelion serves multiple purposes, being utilized both as a medicinal agent and as a nutritious food source [59]. Dandelion is a plant recognized for its beneficial effects on lipid and sugar metabolism [59, 63].

Research has shown that dandelion can reduce complications associated with diabetes and improve lipid metabolism. This plant is rich in various chemical compounds that play a vital role in regulating blood glucose levels, protecting the liver, and aiding digestion, thereby contributing indirectly to weight management [59]. In addition to its metabolic benefits, dandelion is known for enhancing the immune response against upper respiratory tract infections, bronchitis, and pneumonia. It is also used as a topical compress for treating mastitis, anemia, and inflammation [62]. Studies of dandelion extract have revealed its potential to stimulate insulin release from pancreatic β-cells, which helps counteract hyperglycemia. Notably, the ethanolic extract of dandelion is more effective than aqueous extract, with the roots proving to be more beneficial than leaves in managing and treating diabetes. Further experimental findings indicate that the efficacy of *Taraxacum officinale* extracts is dose-dependent [61]. Dandelion roots contain insulin and are rich in fructooligosaccharides (FOS), a type of complex carbohydrate. The intake of FOS supports the growth of beneficial bifidobacteria, which helps eliminate pathogens in the GIT. Additionally, FOS stimulates the immune system and may suppress abnormal cell growth, contributing to overall health. This complex carbohydrate can also aid in normalizing blood sugar levels [62].

TABLE 2: SUMMARY OF HERBAL PLANTS FOR DIABETES MELLITUS

Plant Species	Family	Common Name	Parts Used	Active Constituents	Mode of Action
Momordica charantia	Cucurbitaceae	Karela, bitter melon, bitter gourd	Dried bitter gourd, leaves	Charatin, Momordic1, Momordic 2, Cucurbitacin B, Lectin,	Hypoglycemic action, Anticancer, Antivirus, Anti -

				Polypeptide - p, Insulin like peptide, alkaloid	inflammation, and Cholesterol lowering effects , Treating microbial infections, menstrual problems, digestive disorder
Aloe barbadensis Mill.	Liliacea	Aloe plant, Lilly of the dessert, Burn plant, soothe plant, True aloe.	Plant gel, dried sap of aloe plant.	Acemannon, Aloin, Glucuronic acid, Xyloglucans, Galactomannans	Promotes skin health, emollient, Antioxidant, Depigmenting properties, Moisturize dry skin, Heals wounds, alleviate side-effects associated with radiation therapy, Lowering blood sugar levels, Stimulates insulin secretion.
Catharanthus Roseus	Apocynaceae	Nayantara, Sadabahar, Cutkattumalli, Cayanne Jasmine, Old maid.	Leaf extract, Stem fraction, Aqueous extract	Viculin, Vinblastine Vincristine, Tannins.	Hypotensive activity, Lowers LDL, VLDL, TC and TG levels, Increases insulin production, Cells of pancreas are repaired.
Glycyrrhiza glabra	Leguminosae	Sweet root, Mulethi, Spanish licorice	Ethyl acetate extract of licorice	Liquiritigenin, Isoliquiritigenin, Liquiritin, Licochalcone and triterpenoids	Effective against diabetic complications, Regulates glucose homeostasis and lipid metabolism, improves insulin sensitivity.
Syzygium cumini	Myrtaceae	Jmbolan, black plum, java plum, Indian blackberry, purple plum, damson plum	Leaf and seed extract, seed powder.	Mycaminose	Antidiabetic effect, lowering insulin resistance, cardioprotective, blemishes, wrinkles, pimples, anti-diarrhea, helps to prevent acne, improves HDL, lowers LDL
Curcuma longa Linn.	Zingiberaceae	Turmeric, Indian saffron, yellow ginger, Haldi, curcumin.	Dried rhizomes of turmeric	Curcumin, curcumol, bisdemethoxy curcumin.	Wound healing effect, anti-angiogenic, prevent loss of bodyweight, reduce levels of glucose, improve insulin sensitivity, delay

					development of type 2 diabetes, improve β-cell function, prevent β-cell death.
Stevia rebaudiana	Asteraceae	Sugar leaf, Candy leaf, Sweet herb of Paraguay.	Leaf extract	Steviol, steviosides, rebaudiosides.	Decrease random and fasting blood glucose levels, revitalize β-cells of the pancreas, antioxidant activity, counteracting the glucotoxicity in β-cells.
Senna auriculata (L.)	Fabaceae	Avaram senna, mataratea, styptic wood, Tanner's cassia	Flower, fruit and leaf extract	n-hexadecanoic acid, emodin, squalene	Used to treat female antifertility, leprosy, worm infection, reduce blood glucose levels, increase plasma insulin secretion.
Cinnamomum cassia	Lauraceae	Cinnamon, Ceylon cinnamon, Chinese cinnamon	Bark	Cinnamaldehyde, polyphenols, Flavonoids, cinnamate, fructooligosaccharides.	It increases the level of serum glutathione, it can increase glycemic indices, lipid profile, glucose transport by GLUT-4 in seladipso and skeletal muscles, lowers blood glucose, increase hepatic glycogen,
Taraxacum officinale	Asteraceae (compositae)	Dandelion, Wild dandelion, taraxacum	Root extract, ethanolic extract of the plant	Inulin, chicoric acid, triterpenes, phenolic compounds	Reduces diabetic complications, improve lipid metabolism, stimulate the release of insulin in pancreatic β-cell.

CONCLUSION: Diabetes mellitus is a complex, chronic metabolic disorder with many different aspects of management strategies. While oral Hypoglycemic and insulin treatments exist. Medicinal plants and natural compounds have shown promising antidiabetic effects, offering

alternative therapies. These plants contain bioactive compounds such as alkaloids, flavonoids, phenolic extracts, and terpenoids, contributing to their antidiabetic activity. Additionally, these medicines have antioxidant, antimicrobial, anticancer, anti-inflammatory, antiviral, and hypotensive properties. As a result, many scholars, health professionals, and scientists have studied the Medicinal uses of these plants. Therefore, natural medicine obtained from plants is among the richest sources of treatment options for diabetes.

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