INTERNATIONAL JOURNAL OF PHARMACEUTICAL SCIENCES
[ISSN: 0975-4725; CODEN(USA): IJPS00]
Journal Homepage: https://www.ijpsjournal.com

OPEN ACCESS

Review Article

Antidiabetic Potential of Geodorum Densiflorum: A Comprehensive Review

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ARTICLE INFO

Published: 08 Jul. 2025

Keywords:

antidiabetic properties, diabetes control Geodorum densiflorum, herbal remedy, therapeutic plant, insulin signaling mechanisms, glucose processing, oxidative stress pathways.

DOI:

10.5281/zenodo.15833611

ABSTRACT

Diabetes mellitus is a metabolic disorder affecting the metabolism of carbohydrates, proteins, and fats due to a relative deficiency or complete lack of insulin effectiveness. It is marked by elevated blood glucose levels. Symptoms associated with diabetes include fatigue, intense thirst, frequent urination, blurred vision, and mood fluctuations. Diabetes leads to specific long-term complications that impact the retina, kidneys, and nervous system. There is growing scientific and commercial interest in medicinal and aromatic plant species. The contribution and significance of medicinal herbs to society are profound. Many of these herbs serve as vital sources of medicines. India has played a key role in supplying herbal products to satisfy both domestic demand and export needs to various countries around the world. In the global market, the majority of plant materials come from developing nations. Besides the existing various synthetic medications, numerous herbal remedies have been suggested for treating diabetes. Literature indicates that over 400 species of medicinal plants possess hypoglycemic properties. Throughout the world, traditional medicinal plants are widely utilized for managing diabetes. This review intends to offer a thorough analysis of the antidiabetic properties of Geodorum densiflorum, along with its possible mechanisms of action and therapeutic uses. The bioactive compounds present in the plant might influence insulin signaling pathways, glucose metabolism, and oxidative stress pathways, suggesting it could serve as a beneficial natural treatment for managing diabetes. Although additional research is required to fully assess its therapeutic potential, Geodorum densiflorum may prove to be a useful component in diabetes management.

INTRODUCTION

Overview of Diabetes Mellitus

Diabetes mellitus (DM) is a habitual metabolic complaint characterized by patient hyperglycaemia performing from blights in insulin

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Relevant conflicts of interest/financial disclosures: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

stashing, insulin action, or both. The condition is associated with disturbances in carbohydrate, fat, and protein metabolism and frequently leads to long- term damage, dysfunction, and failure of colourful organs, particularly the eyes, feathers, jitters, heart, and blood vessels. The term" diabetes" is deduced from the Greek word meaning" to siphon," representing the inordinate urination seen in unbridled cases, while" mellitus" refers to the sweet taste of urine due to the presence of glucose, an individual hallmark since ancient times. Despite its literal roots, diabetes is now honoured as one of the swift- growing global health extremities of the 21st century. (Bereda, 2021; Dreyer, 2019; Katsarou et al., 2017; A. A. Yameny, 2024) The bracket of diabetes has evolved to accommodate its complex and multifactorial nature. According to the American Diabetes Association (ADA) and the World Health Organization (WHO), diabetes is distributed into four major types

Type 1 diabetes mellitus (T1DM) is primarily autoimmune in nature, involving T- cell mediated destruction of pancreatic β- cells. It leads to absolute insulin insufficiency and generally manifests in children and adolescents, although adult- onset T1DM is decreasingly honored.(Dreyer, 2019; Katsarou et al., 2017; Rajashree et al., 2012)

Type 2 diabetes mellitus (T2DM), the most current form, is caused by a combination of insulin resistance and relative insulin insufficiency. It has a strong inheritable predilection and is heavily told by environmental and life factors similar as rotundity, physical inactivity, and unhealthy diets. (Chatterjee et al., 2017; Olokoba et al., 2012)

Gravid diabetes mellitus(GDM) develops during gestation, generally in the alternate or third trimester, and is associated with an increased threat of perinatal complications and unborn T2DM for both mama and child.(Deshmukh and Jain, 2015; Saha et al, 2020; A. A. Yameny, 2024)

Other specific types include monogenic diabetes runs(similar as MODY — maturity- onset diabetes of the youthful), conditions of the exocrine pancreas(e.g., cystic fibrosis- related diabetes), and medicine- or chemical- convinced diabetes(e.g., from corticosteroids or antipsychotics).(Chatterjee et al., 2017; Kumar et al., 2020; Saha et al, 2020)

Figure 1: Types of Diabetes

Global Overview of Diabetes Mellitus (2015–2025)

Diabetes mellitus has surfaced as one of the most significant non-communicable conditions worldwide, with its frequence steadily rising over the last decade. Encyclopaedically, the number of grown-ups progressed 20 – 79 times living with diabetes increased from roughly 415 million in 2015 to 537 million in 2021, and it's estimated to have reached 589 million by 2024, reflecting an intimidating 11.1 frequency rate among grown-ups. This swell represents a 40 rise in global diabetes cases within ten times. vaticinations by the International Diabetes Federation(IDF) suggest that this figure may surpass 640 million by 2030 and reach over 850 million by 2050. The Western Pacific and South- East Asia regions, driven by vibrant nations like China and India, contribute the loftiest number of diabetes cases encyclopedically. Still, the loftiest frequence rates are recorded in the Middle East and North Africa (MENA), where over 16 of the adult population is diabetic. China leads encyclopedically with over 140 million diabetics, followed by India and Pakistan. Despite a slightly lower frequence, Africa is anticipated to see the most rapid-fire rise due to urbanization and salutary shifts.(Abuelgasim et al., 2021; Canto et al., 2019; Irakoze, 2024; Jakhar et al., n.d.; Namazi et al., 2024; A. Yameny, 2024). Type 2 diabetes constitutes further than 90 of all global diabetes cases and is primarily associated with life and inheritable factors. In discrepancy, Type 1 diabetes, which is autoimmune in origin, affects around 8.4 million people worldwide, and this number is projected to nearly double by 2040. Encyclopedically, diabetes was responsible for about 5 million deaths in 2015, which rose to 6.7 million by 2021. Recent estimates in 2024 report over 3.4 million deaths, making it one of the top ten causes of death worldwide. Beyond mortality, diabetes leads to severe complications including cardiovascular conditions, order failure, neuropathy, retinopathy, and lower branch amputations. These complications not only dwindle the quality of life but also put a significant fiscal burden on individualities and healthcare systems. As of 2024, the global expenditure on diabetes care has surpassed$ 1 trillion USD annually, a stunning increase from$ 232 billion in 2007. This cost includes drug, diagnostics, hospitalizations, and long- term complication operation. (Deng et al., 2024; Liu et al., 2020; Namazi et al., 2024; Ong et al., 2023)

Indian Perspective on Diabetes Mellitus (2015 – 2025)

India holds the alternate-loftiest number of diabetes cases encyclopedically, after China. In 2015, around 69 million Indians were diagnosed with diabetes, which surged to 77 million in 2019. Still, the corner ICMR – INDIAB study published in 2023 reported a shocking rise to 101 million diabetics in India, equating to an 11.4 frequence among grown-ups. This marks a 44 increase in just four times. Also, about 136 million Indians are presently classified aspre-diabetic, posing a serious threat of unborn conversion to diabetes. Specially, over 60 ofpre-diabetics in India are likely to develop full-bloated diabetes within five times without intervention. protrusions suggest that India could witness over 134 million diabetes cases by 2045, with recent trends intimating that the factual figures may be indeed advanced.(Chauhan et al., 2025; Ding et al., 2025; Kyu et al., 2016; Tandon et al., 2018; Xu et al., 2025). India's diabetes epidemic is driven by multiple threat factors, including inheritable predilection, urbanization, poor salutary habits, physical inactivity, and rising rotundity rates. The Asian Indian phenotype — characterized by a advanced body fat chance at lower BMI — makes Indians innately more susceptible. According to the ICMR study, nearly 29 of Indians are fat and around 40 exhibition abdominal rotundity. Comorbid conditions similar as hypertension (present in 35.5 of grown-ups) and dyslipidaemia (affecting 81.2) further amplify the threat of cardiovascular complications. Gravid diabetes is also decreasingly common among Indian women, contributing to unborn Type 2 diabetes in both mama and child. (Liu et al., 2024; Tandon et al., 2018; Xie et al., 2022; Xu et al., 2025)

PATHOPHYSIOLOGY OF DIABETES:-

Diabetes mellitus (DM) is a habitual, progressive metabolic complaint marked by habitual hyperglycaemia and disturbances in the metabolism of carbohydrates, lipids, and proteins. The pathological hallmark of diabetes lies in the imperfect regulation of insulin, the hormone central to energy homeostasis. This dysregulation arises due to shy insulin stashing, bloodied insulin action, or a combination of both. The complaint, though unified under the term “diabetes,” is largely miscellaneous in its etiology, clinical donation, and pathophysiology. An in- depth understanding of the distinct pathological mechanisms underpinning different types of diabetes is essential not only for accurate opinion and operation but also for relating new remedial targets including those from medicinal factory sources.(Bereda, 2021; Deshmukh and Jain, 2015; Kumar et al., 2020; Olokoba et al., 2012; Saha et al, 2020)

Type 1 Diabetes Mellitus (T1DM)

Type 1 diabetes mellitus is an organ-specific autoimmune complaint characterized by vulnerable- mediated destruction of the insulin-producing pancreatic β- cells located in the islands of Langerhans. The condition leads to an absolute insulin insufficiency, rendering the individual insulin-dependent for life. It generally presents in childhood or adolescence, but adult- onset forms similar as idle autoimmune diabetes in grown-ups (LADA) are decreasingly honoured. The immunopathogenesis of T1DM involves both cellular and humoral impunity. $CD4^+$ coadjutor T cells and $CD8^+$ cytotoxic T lymphocytes insinuate the pancreatic islands in a process known as insulitis, feting and attacking β- cell autoantigens similar as insulin, glutamic acid decarboxylase(GAD65), insulinoma- associated antigen- 2(IA-2), and zinc transporter 8(ZnT8). These autoantigens also induce specific autoantibodies, which are measurable biomarkers for complaint vaticination. The presence of two or further autoantibodies predicts the progression to overt diabetes with high particularity.(Alam et al., 2014; Chatterjee et al., 2017; Katsarou et al., 2017; Korc, 2004; Nadhiya J et al., 2024; Surya et al., 2014)

Type 2 Diabetes Mellitus (T2DM)

Type 2 diabetes mellitus is the predominant form of diabetes worldwide, counting for roughly 90 – 95 of all cases. The pathophysiology of T2DM is complex and involves a binary disfigurement originally, insulin resistance in supplemental apkins (muscle, liver, and adipose towel), followed by progressive β- cell failure. This binary disfigurement results in an incapability of the body to regulate blood glucose effectively, indeed in the presence of elevated insulin situations. Insulin resistance in T2DM is multifactorial. It arises from post-receptor signalling blights in insulin-responsive apkins, frequently aggravated by intracellular lipid accumulation (lipotoxicity), pro-inflammatory cytokines, and mitochondrial dysfunction. In cadaverous muscle, glucose uptake via GLUT4 transporters is bloodied; in the liver, unbounded gluconeogenesis contributes to dieting hyperglycemia. Adipose towel contributes to metabolic dysregulation by concealing seditious adipokines similar as TNF- α, IL- 6, and resistin, while situations of insulin- sensitizing adiponectin are generally reduced.(Alam et al., 2014; Dahms, 1991; Deshmukh and Jain, 2015; Janghorbani et al., 2007; Saha et al, 2020; A. A. Yameny, 2024) Originally, pancreatic β- cells compensate by adding insulin affair (hyperinsulinemia), but over time, habitual metabolic stress induces oxidative stress, endoplasmic reticulum(ER) stress, and β-cell apoptosis, leading to relative insulin insufficiency. The decline in β- cell mass and function marks the transition from disabled glucose forbearance (IGT) to foursquare diabetes. Genetically, T2DM is associated with polymorphisms in genes similar as TCF7L2, SLC30A8, and KCNJ11, but environmental factors sedentary geste , high- fat diets, and rotundity — are the dominant threat determinants. Unlike T1DM, T2DM has an insidious onset, frequently remaining undiagnosed until complications manifest. Therefore, early intervention strategies, including life revision and pharmacotherapy, are vital to delay or help complaint progression. (Chatterjee et al., 2017; Katsarou et al., 2017; Olokoba et al., 2012)

Other Specific Types of Diabetes

Allow successful operation with sulfonylureas rather of insulin. (Beltrand et al., 2020; Korc, 2004) In addition to T1DM and T2DM, several other forms of diabetes live, each with distinct etiopathological features.

Gravid Diabetes Mellitus (GDM) is defined as glucose dogmatism with onset or first recognition during gestation. GDM results from placental hormone- convinced insulin resistance combined with shy β- cell compensation. Hormones similar as mortal placental lactogen, estrogen, and progesterone envenom insulin action, particularly in the third trimester. Women with GDM are at high threat for preeclampsia, macrosomia, and unborn development of T2DM. Babies born to maters With GDM are fitted to rotundity and glucose dogmatism, immortalizing an intergenerational cycle of metabolic complaint. (Deshmukh and Jain, 2015; Saha et al, 2020; A. A. Yameny, 2024)

Neonatal Diabetes Mellitus (NDM) is a rare form of monogenic diabetes presenting in the first six months of life. Mutations in genes similar as KCNJ11, ABCC8, and INS vitiate insulin stashing. NDM can be flash or endless. Remarkably, some mutations

INSULIN RESISTRANCE AND β-CELL DYSFUNCTION: THE TWIN DEFECTS:

The dual pathology of insulin resistance and β-cell dysfunction lies at the heart of T2DM and is increasingly recognized in other forms such as GDM and some monogenic types. Insulin resistance occurs when normal its receptor activates the IRS-1/PI3K/Akt pathway, which promotes GLUT4 translocation and glucose uptake. In insulin-resistant states, serine phosphorylation of IRS-1 inhibits downstream signaling. Mitochondrial dysfunction, elevated free fatty acids, and inflammatory cytokines contribute to impaired insulin action. The JNK and NF-κB pathways, activated by oxidative and inflammatory stimuli, further exacerbate insulin resistance. As compensation, β-cells initially increase insulin output. However, chronic exposure to hyperglycemia (glucotoxicity), elevated lipids (lipotoxicity), and oxidative stress leads to β-cell exhaustion, ER stress, and apoptosis. Progressive loss of β-cell mass and functional impairment marks the clinical onset and deterioration of diabetes. Understanding this dual mechanism has prompted the development of therapies targeting both defects—metformin and TZDs improve insulin sensitivity, while GLP-1 analogs and DPP-4 inhibitors enhance β-cell function. (Deshmukh and Jain, 2015; Korc, 2004; Saha et al, 2020)

ROLE OF OXIDATIVE STRESS AND INFALTION:-

Oxidative stress and low-grade inflammation are unifying mechanisms that contribute to both the development and progression of diabetes and its complications. In both T1DM and T2DM, excessive production of reactive oxygen species (ROS) overwhelms endogenous antioxidant defenses, leading to cellular damage. In β-cells, which are inherently low in antioxidant enzymes, ROS disrupt mitochondrial function, impair insulin gene expression, and initiate apoptotic pathways. Inflammatory cytokines such as IL-1β, TNF-α, and IFN-γ—secreted by infiltrating macrophages and T cells—further damage β-cells by activating NF-κB, enhancing nitric oxide production, and triggering ER stress.In peripheral tissues, oxidative stress interferes with insulin signaling via modification of proteins and lipids, leading to impaired glucose uptake. Inflammation in adipose tissue, characterized by macrophage infiltration and altered adipokine secretion, plays a pivotal role in systemic insulin resistance. Oxidative stress also contributes to vascular complications by promoting endothelial dysfunction, increasing vascular permeability, and inducing platelet aggregation. The formation of advanced glycation end-products (AGEs) and activation of the polyol pathway further link oxidative mechanisms to nephropathy, neuropathy, and retinopathy. Given their multitargeted antioxidant and anti-inflammatory properties, several medicinal plants and phytochemicals have shown promise in preclinical and clinical models. (Alam et al., 2019; Arumugam et al., 2013; Bushnak et al., 2021; Kumar et al., 2020; Sadino, 2018; Saha et al, 2020)

COMPLICATION OF DIABETES:-

Diabetes mellitus, if not properly managed, leads to a cascade of complications that compromise nearly every organ system. These complications, classified into acute and chronic, arise primarily from prolonged exposure to hyperglycemia and are amplified by oxidative stress, inflammation, dyslipidemia, endothelial dysfunction, and immune dysregulation. While acute complications demand immediate intervention to prevent mortality, chronic complications silently progress over years, culminating in disability and premature death. Both types impose an enormous burden on individuals, families, and healthcare systems globally. The World Health Organization (WHO) estimates that more than 1.6 million deaths per year are directly attributed to diabetes, with most resulting from long-term complications. Understanding these complications is critical for the justification and evaluation of plant-based therapeutic strategies. (Bereda, 2021; Deshmukh and Jain, 2015; Katsarou et al., 2017; Rajashree et al., 2012; Saha et al, 2020; A. A. Yameny, 2024)

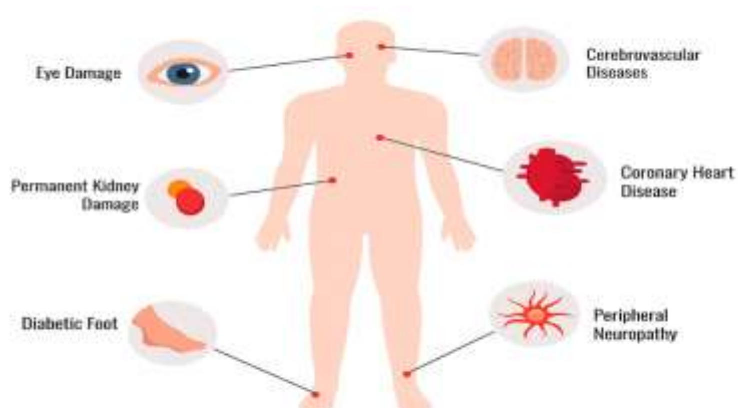

Figure 2: Complications of Diabetes

CURRENT TREATMENT MODALITIES:-

The management of diabetes mellitus has undergone significant transformation over the past few decades, evolving from simple glucose control to a comprehensive strategy targeting metabolic regulation, cardiovascular and renal protection, and long-term quality of life. Despite the development of numerous pharmacological options, diabetes remains a major global health concern, partly due to the inherent limitations of current therapies, including side effects, cost, drug resistance, and poor patient compliance. A better understanding of the existing therapeutic modalities is essential to identify opportunities for complementary approaches, including the integration of medicinal plant-based therapies. Insulin therapy is the cornerstone of treatment for type 1 diabetes mellitus (T1DM), where endogenous insulin secretion is virtually absent. It is also indicated in type 2 diabetes mellitus (T2DM) when oral medications fail or during special circumstances such as surgery, pregnancy, severe illness, or metabolic decompensation. Various insulin formulations are available to mimic normal physiological insulin secretion. These include basal insulins such as NPH and insulin glargine that provide long-acting background coverage, and rapid-acting insulins such as lispro and aspart that manage postprandial glucose spikes. Intensive regimens, such as multiple daily injections or continuous subcutaneous insulin infusion (insulin pumps), offer better glycemic control but require strict adherence, regular monitoring, and patient training. Insulin therapy can be highly effective, but it also poses several challenges including the risk of hypoglycemia, weight gain, injection-related discomfort, and fear or reluctance among patients—often termed psychological insulin resistance.

Oral hypoglycemic agents remain the first-line treatment for most patients with T2DM. Metformin, a biguanide, is globally recommended as the initial pharmacological intervention. It works primarily by reducing hepatic glucose production and improving peripheral insulin sensitivity. It is associated with weight neutrality, a low risk of hypoglycemia, and modest cardiovascular benefits. However, gastrointestinal side effects and contraindications in renal impairment can limit its use. Sulfonylureas, such as glimepiride and glipizide, act by stimulating pancreatic insulin secretion. While effective, they are associated with hypoglycemia and weight gain and tend to lose efficacy over time due to β-cell exhaustion. Thiazolidinediones, including pioglitazone, improve insulin sensitivity through PPAR-γ activation but may cause fluid retention, heart failure, bone fractures, and weight gain. Alpha-glucosidase inhibitors like acarbose delay carbohydrate absorption and are particularly useful in carbohydrate-rich diets but often because bloating and flatulence, leading to poor adherence. Other agents like meglitinides and amylin analogs are used less frequently due to modest benefits and side effects.

In recent years, newer drug classes have emerged, offer control. Glucagon-like peptide-1 (GLP-1) receptor agonists, such as liraglutide and semaglutide, mimic the action of endogenous GLP-1. They enhance glucose-dependent insulin secretion, suppress glucagon release, slow gastric emptying, and promote weight loss. These agents have demonstrated significant cardiovascular and renal benefits in large clinical trials. However, they are injectable, costly, and often associated with nausea, which can limit their use. Sodium-glucose co-transporter-2 (SGLT2) inhibitors, including empagliflozin and dapagliflozin, lower blood glucose by inhibiting renal glucose reabsorption, thereby promoting glucosuria. In addition to modest HbA1c reductions, these agents offer robust cardioprotective and renoprotective effects and contribute to weight and blood pressure reduction. Their adverse effects include an increased risk of genital infections, dehydration, and rare occurrences of euglycemic diabetic ketoacidosis. Dipeptidyl peptidase-4 (DPP-4) inhibitors such as sitagliptin and linagliptin enhance endogenous incretin activity. They are weight-neutral, well tolerated, and suitable for elderly and renally impaired patients, although their glycemic efficacy is modest and cardiovascular effects are generally neutral.

Despite this diverse pharmacological arsenal, several limitations persist that impact long-term outcomes and patient satisfaction. Hypoglycemia remains a significant concern, especially with insulin and sulfonylureas. Weight gain associated with insulin, sulfonylureas, and thiazolidinediones can worsen insulin resistance. Gastrointestinal side effects are common with metformin, GLP-1 receptor agonists, and alpha-glucosidase inhibitors, often leading to discontinuation. Newer agents like SGLT2 inhibitors and GLP-1 agonists, though clinically advantageous, are prohibitively expensive for many patients in low- and middle-income countries. The ongoing cost of insulin therapy, glucose monitoring devices, syringes, and other supplies adds further financial burden. In many healthcare systems, including those in developing nations, cost-related non-adherence to diabetes medication is a growing challenge that directly contributes to suboptimal glycemic control and complications.

Another limitation is the progressive decline in β-cell function inherent to the natural history of T2DM. Many oral agents lose efficacy over time, necessitating combination therapy or eventual insulin initiation. Even with intensification, secondary failure may occur due to drug resistance, poor adherence, or immunological responses. The polypharmacy often required in advanced diabetes increases pill burden, raises the risk of drug-drug interactions, and compromises adherence.

Patient compliance is influenced by various factors, including regimen complexity, injection aversion, adverse effects, and psychosocial variables. Depression, common in diabetes patients, further reduces motivation for treatment adherence. Cultural beliefs, health illiteracy, stigma, and limited access to diabetes education programs also contribute to poor self-management. In many cases, the complexity of modern diabetes treatment itself becomes a barrier, especially for elderly patients or those with cognitive impairment. (Deshmukh and Jain, 2015; Jung et al., 2006; Kayarohanam, 2015; Olokoba et al., 2012)

PLANT PROFILE:-

Biological source: It is bulbs obatined from the plant, Geodorum densiflorum.

Family: Orchidaceae

Taxonomy

- Kingdom: Plantae
- Phylum: Tracheophytes
- Class: Monocots
- Order: Asparagales
- Family: Orchidaceae
- Genus: Geodorum
- Species: G. densiflorum

Figure 3 : Geodorum densiflorum

Common Name: Nodding Swamp Orchid; Slanting Gastrochilus; Walking-stick Orchid; Nodding Swamp Orchid

Morphology and Occurrence

Terrestrial herbs, 60-70 cm tall; pseudobulb ovoid, 5 x 2.5 cm. Leaves 30-50 x 7-10 cm, elliptic-oblong or lanceolate, acuminate. Flowers white or pinkish, raceme 50-60 cm long, from the base of the pseudobulb; flower bearing portion about 5 cm long, strongly decurved. Floral bracts 15 x 4 mm, lanceolate, acuminate, 1-3-veined; dorsal sepal 13 x 4.5 mm, oblanceolate-oblong, acute, apiculate at apex, 5-veined; lateral sepals 13 x 5.1 mm, elliptic-oblong, acute, 7-veined; petals 12.5 x 6 mm, oblanceolate, obtuse; lip cymbiform, side margins incurved, apex faintly bilobed; disc with longitudinal callus. Geodorum densiflorum is a leafy, terrestrial herb with crowded pseudobulbs 30–50 mm (1–2 in) long and 20–30 mm (0.8–1 in) wide. There are between three and five dark green to yellowish pleated leaves 250–350 mm (9.8–14 in) long and 60–80 mm (2–3 in) wide with a stalk 20–80 mm (0.8–3 in) long. Between eight and twenty resupinate, pale pink flowers 18–20 mm (0.7–0.8 in) wide are borne on a flowering stem 200–400 mm (8–20 in) long. The flowers do not usually open widely. The sepals are 10–12 mm (0.4–0.5 in) long, 3–4 mm (0.1–0.2 in) wide and the petals are a similar length but wider. The labellum is pink with dark red veins, 10–11 mm (0.39–0.43 in) long and 5–10 mm (0.2–0.4 in) wide with the sides curved upwards. Flowering occurs between December and February in Australia and between June and July in Asia.

Distribution:

Global Distribution: Peninsular India, Myanmar, China and Sri Lanka

Indian distribution: State - Kerala, District/s: Kollam, Idukki, Pathanamthitta, Malappuram, Thiruvananthapuram, Kozhikkode, Palakkad, Thrissur, Wayanad

Chemical Constituants

Geodorum densiflorum is a phytochemically rich, endangered terrestrial orchid containing a variety of bioactive compounds that contribute to its wide pharmacological profile. Phytochemical investigations have identified the presence of flavonoids, alkaloids, terpenoids, glycosides, steroids, saponins, tannins, carbohydrates, and phenolic compounds. GC-MS analyses have revealed over 20 major compounds in the ethanol extract, including hexadecanoic acid, ethyl ester, ionone, and pyran-4-one derivatives, which are associated with antioxidant, anti-inflammatory, antimicrobial, and cytotoxic activities. Elemental analysis of the plant has confirmed the presence of essential elements like phosphorus, which plays a role in DNA synthesis and energy metabolism. Different solvent extracts—particularly ethanol, methanol, and ethyl acetate—demonstrated high antibacterial, antioxidant, and cytotoxic activities. Pharmacological screenings also revealed that extracts from this orchid show thrombolytic, analgesic, sedative, anxiolytic, and neuropharmacological effects in both in vitro and in vivo models.

Traditional / Ethno medicinal Uses

Geodorum densiflorum has a long history of use in traditional medicine across regions of India, Bangladesh, and Southeast Asia. The pseudobulbs and roots are the primary parts used medicinally. The plant is traditionally applied in the treatment of diabetes, dysentery, skin infections, carbuncles, and rheumatic pain, and is used to regulate the menstrual cycle in women and improve fertility in men. Root paste mixed with honey and ghee is taken orally for menstrual regulation, while powdered tubers are consumed with milk to treat impotency. Crushed roots are also applied to cattle to repel flies. In folk veterinary practices, the plant is used as a natural insect repellent. Additional uses include treatment of wounds, joint pain, gastrointestinal infections, and as a calming sedative for insomnia or anxiety-like symptoms. Modern studies have validated these traditional uses, revealing the plant's potent antibacterial, antifungal, analgesic, antioxidant, cytotoxic, and sedative properties.

PHAEMACILOGICAL STUDY REPORTED:-

1 Kabir et al. conducted a study titled *"Asparagus racemosus and Geodorum densiflorum lectins induce apoptosis in cancer cells by altering proteins and genes expression,"* focusing on isolating plant-derived lectins and evaluating their anticancer mechanisms against colorectal cancer cells. Lectins from *Asparagus racemosus* root (ARL) and *Geodorum densiflorum* rhizome (GDL) were purified using ion-exchange and gel filtration chromatography and characterized for molecular weight, hemagglutination activity, and sugar specificity. ARL (14.0 kDa) and GDL (12.0 kDa) exhibited strong hemagglutination activity, inhibited by specific sugars such as 4-nitrophenyl-α-D-galactopyranoside and methyl-β-D-glucopyranoside. In vitro cytotoxicity against human colorectal cancer (HCT-116) cells showed that 160 μg/mL ARL and 256 μg/mL GDL inhibited cell growth by 48% and 52.5%, respectively. Hoechst staining confirmed apoptosis, while only ARL induced ROS generation. Caspase inhibition assays revealed that ARL-induced apoptosis involves both intrinsic (caspase-9) and extrinsic (caspase-8) pathways, while GDL predominantly activates the extrinsic pathway. Gene expression studies showed upregulation of pro-apoptotic genes like *p53* and *BAX*, and downregulation of anti-apoptotic *PARP*. GDL also increased *FAS* and *FADD* expression while suppressing the WNT signaling pathway. In vivo, ARL significantly reduced Ehrlich ascites carcinoma (EAC) growth in mice (68% inhibition at 3 mg/kg/day) and caused S phase cell cycle arrest, while both lectins induced G2/M arrest in HCT-116 cells. The study concluded that both lectins possess significant anticancer potential via apoptotic and gene-regulatory mechanisms, suggesting their therapeutic promise in colorectal cancer treatment. (Kabir et al., 2021)

2. Sonawane and Sonawane conducted a study titled "Geodorum densiflorum (Lam.) Schltr. – New Distributional Record from Yawal Wildlife Sanctuary, Jalgaon, Maharashtra, India", focusing on reporting the presence of the rare terrestrial orchid Geodorum densiflorum in the Yawal Wildlife Sanctuary, located in the Khandesh region of Maharashtra. The objective was to document and describe the species morphologically and ecologically, as it had not been previously recorded from this region. Field surveys were carried out in the Satpuda hill ranges, where plant specimens were collected, photographed, and analyzed in situ. Detailed morphological descriptions were noted, and voucher specimens were deposited at the herbarium of the School of Environment and Nature Conservation, Jalgaon. Geodorum densiflorum was found growing among moist deciduous and semi-evergreen forest vegetation at elevations of 400–800 meters, particularly forming colonies in partially shaded areas among bamboo and karvi plants. Morphologically, it is a 20–40 cm tall terrestrial herb with ovoid-conical pseudobulbs, elliptic to lanceolate plicate leaves, and erect inflorescence bearing compact racemes of pinkish-purple flowers. The study observed a noteworthy deviation from existing literature, as

the flowers were fully open (not partially open or nodding), indicating possible regional variation. The authors also documented the plant's flowering period from June to November. Significantly, the paper noted a traditional medicinal use, where a paste made from the pseudobulbs is mixed with sugar and administered for the treatment of diabetes, offering insight into its ethnopharmacological relevance. The study emphasized the rarity of the species in the region and called for conservation efforts to protect it from threats like habitat destruction and cattle grazing. This record extends the known distribution of Geodorum densiflorum and highlights the botanical richness of the sanctuary. (Sonawane and Sonawane, 2022)

3 Borkar and Masirkar conducted a study titled "Studies on Phytochemical Investigations and Antimicrobial Activity of an Endangered Orchid: Geodorum densiflorum (Lam.) Schltr." with the objective of assessing the phytochemical composition and antibacterial activity of the pseudobulbs of G. densiflorum, an orchid species of medicinal and nutritional relevance. The study used successive solvent extraction with petroleum ether, chloroform, methanol, ethanol, and water, and applied qualitative phytochemical tests to the extracts using standard methods. The presence of alkaloids, glycosides, phytosterols, tannins, and proteins was confirmed in various extracts, depending on the solvent used. Antibacterial screening was carried out against six bacterial strains, including Bacillus cereus, B. subtilis, Staphylococcus aureus, Escherichia coli, Pseudomonas aeruginosa, and Salmonella typhi, using the disc diffusion method. The methanolic extract showed the highest activity, with zones of inhibition ranging from 12 to 16 mm, followed by ethanol (10–13 mm), while petroleum ether and chloroform showed moderate effects, and the aqueous extract was the least effective. Notably, water extract exhibited no inhibition against B. subtilis and P. aeruginosa. The study concluded that Geodorum densiflorum pseudobulbs contain significant bioactive compounds responsible for antimicrobial activity, supporting its traditional use in treating stomach disorders, rheumatic swelling, wounds, diabetes, and gynecological issues. These findings validate the ethnomedicinal value of this endangered species and provide a foundation for future pharmacological exploration to isolate its active principles and develop potential therapeutic agents. (Borkar and Masirkar, 2015)

4.Akter et al. conducted a study titled "Analgesic Activities of Geodorum densiflorum, Diospyros blancoi, Baccaurea ramiflora, and Trichosanthes dioica," aiming to evaluate the peripheral and central analgesic potentials of methanol extracts from different plant parts, including the pseudobulb of G. densiflorum. The extracts were tested using two well-established models: acetic acid-induced writhing (for peripheral analgesic activity) and the tail immersion test (for central analgesic activity) in Swiss albino mice. The study compared plant extracts at 200 and 400 mg/kg with standard analgesics such as diclofenac sodium and morphine. The results revealed that the methanol extract of G. densiflorum (MPGD) produced a dose-dependent reduction in writhing, with 22.32% inhibition at 200 mg/kg and 58.03% at 400 mg/kg. In the tail immersion model, MPGD at 400 mg/kg significantly increased the tail withdrawal latency, indicating a moderate central analgesic effect. These effects, although lower than those of Baccaurea ramiflora and Trichosanthes dioica, still demonstrated notable analgesic potential. The observed activity is attributed to the presence of bioactive compounds such as flavonoids, alkaloids, terpenoids, and steroids previously reported in G. densiflorum. The study concluded that Geodorum densiflorum possesses both peripheral and central analgesic activity, thereby validating its traditional use in managing pain-related disorders. The findings support its use in folk medicine and provide a scientific rationale for further exploration of its pharmacologically active compounds. (Akter et al., 2015)

NEED OF WORK:

Diabetes mellitus represents a significant and swiftly escalating global health issue. It is a metabolic condition that chiefly impacts the body's utilization of glucose. This condition arises when the pancreas insufficiently produces insulin or when the body fails to utilize the insulin it generates adequately. Consequently, blood glucose levels increase and remain elevated, resulting in a condition termed hyperglycemia. Chronic hyperglycemia progressively damages multiple organs, including the heart, eyes, kidneys, and nerves. The International Diabetes Federation (IDF) reports that, as of 2021, more than 537 million persons globally are afflicted with diabetes, with projections indicating a substantial rise in this figure in the forthcoming decades. Consequently, identifying novel, efficacious, and safe therapeutic alternatives for diabetes is paramount. Despite the availability of many pharmacological treatments such as insulin, sulfonylureas, biguanides, and DPP-4 inhibitors, they possess inherent limitations. These medications are frequently linked to negative effects including hypoglycemia, gastrointestinal distress, weight gain, hepatic toxicity, and potential pancreatic injury. Moreover, prolonged utilization of synthetic pharmaceuticals may result in resistance or diminished efficacy over time. Furthermore, the expense of continuous medicine is a significant hardship, particularly in developing and underdeveloped nations. This has led to an increasing interest in discovering natural, plant-derived treatments that offer comparable therapeutic advantages with reduced side effects. Historically, medicinal plants have been crucial in the treatment of numerous ailments, including diabetes. Plants provide a substantial repository of bioactive compounds, numerous of which remain scientifically unexamined. Their application in traditional medical systems including Ayurveda, Siddha, Traditional Chinese Medicine, and Folk Medicine demonstrates a profound comprehension of their therapeutic properties. Numerous plants have demonstrated potential in the context of diabetes owing to their antioxidant, anti-inflammatory, insulinotropic, and glucose-lowering capabilities. Nonetheless, merely a limited fraction of these plants has undergone comprehensive examination by contemporary pharmacological and biological techniques. *Geodorum densiflorum*, an orchid species, is a medicinal plant that remains underexplored and has been traditionally utilized for numerous diseases. The bulbs of this plant have been employed in traditional medicine, and initial ethnobotanical research indicates potential antidiabetic, wound healing, anti-inflammatory, and antioxidant qualities. Nonetheless, despite its historical importance, empirical evidence substantiating the antidiabetic efficacy of Geodorum densiflorum is limited. The deficiency of research constrains its capacity for development into a standardized herbal medication. An urgent investigation of this plant is necessary to validate its medicinal claims and to elucidate the mechanisms by which it may treat diabetic patients.

RESEARCH GAP:-

Geodorum densiflorum, an orchid species acknowledged in ethnobotany, is extensively utilized in traditional medicine throughout India and Southeast Asia for the treatment of several diseases. The pseudobulbs and roots encompass a range of phytoconstituents, such as flavonoids, alkaloids, saponins, terpenoids, glycosides, phenolics, and vital minerals. GC-MS analysis has detected more than twenty phytocompounds with established medicinal relevance. Nonetheless, a significant study deficiency exists in the scientific validation of its antidiabetic efficacy, especially from a mechanistic and integrative pharmacological viewpoint. Thus far, research has examined the antibacterial, neuropharmacological, and cytotoxic properties of several extracts of G. densiflorum; however, no thorough investigation has assessed its antidiabetic efficacy utislizing a validated in vivo model. Moreover, there has been no attempt to evaluate its capacity to influence blood glucose levels, enhance pancreatic histology, or alter metabolic indicators such as insulin, HbA1c, or lipid profile via controlled animal experiments. Investigations based on network pharmacology are deficient, as they concentrate on general pharmacological tests without addressing chronic metabolic disorders such as diabetes. The majority of research has utilized methanol, ethanol, or ethyl acetate extracts from whole plants or pseudobulbs, with no investigation explicitly addressing the hydroalcoholic extract of bulbs. The connection between traditional practices and scientific confirmation is tenuous, as ethnopharmacological assertions cannot be converted into evidence-based herbal preparations or medicinal molecules.

CONCULSION:-

Geodorum densiflorum may be a promising natural remedy for the management of diabetes. Further studies are needed to fully explore its therapeutic potential, including clinical trials and mechanistic studies.

ACKNOWLEDGEMENT:-

In this review the authors are grateful to all researchers whose valuable work has contributed to the understanding of Geodorum densiflorum and its pharmacological potential. We express our sincere thanks to our respective institutions for providing the necessary support and resources to carry out this review. Special thanks to the library and database services that facilitated access to the extensive scientific literature used in this study.

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HOW TO CITE: Rani Nandre, Aditi Mishra, Dr. Karna Khavane, Antidiabetic Potential of Geodorum Densiflorum: A Comprehensive Review, Int. J. of Pharm. Sci., 2025, Vol 3, Issue 7, 940-954. https://doi.org/10.5281/zenodo.15833611