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Review Article

A Comprehensive Review of Role of Herbal Medicines in Management of Diabetics Activity

Vaishnavi Shindikar*, Priyanka Pachorkar, Rishikesh Bacchav, Santosh Deshmukh

R.G Sapkal College of Pharmacy, Sapkal Knowledge Hub, Kalyani Hills, Anjaneri, Trimbakeshwar Rd, Nashik, 422213, Maharashtra, India.

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ABSTRACT

Diabetes mellitus is a chronic metabolic disorder characterized by persistent hyperglycemia resulting from impaired insulin secretion, insulin action, or both. Despite the availability of conventional antidiabetic drugs, their long-term use is often associated with adverse effects, prompting interest in herbal medicines as safer alternatives. Numerous medicinal plants have demonstrated significant antidiabetic potential through mechanisms such as enhancing insulin secretion, improving insulin sensitivity, inhibiting carbohydrate-digesting enzymes, reducing oxidative stress, and protecting pancreatic β-cells. This comprehensive review summarizes the antidiabetic activities of commonly used medicinal plants, including Syzygium cumini, Zingiber officinale, Acorus calamus, Symplocos racemosa, Piper longum, and other herbal species. The review highlights their phytochemical constituents, pharmacological actions, experimental and clinical evidence, and underlying mechanisms involved in glycemic control. Available studies indicate that herbal medicines may effectively reduce blood glucose levels and improve associated metabolic abnormalities. These findings support the potential role of medicinal plants as complementary therapeutic agents in diabetes management. However, further clinical studies are required to establish their safety, efficacy, and standardized therapeutic use.

INTRODUCTION

Over the past several years, the use of herbal medicines has increased significantly worldwide. These remedies have become increasingly popular in both developed and developing nations due to their natural sources and relatively fewer adverse effects. A large number of traditional therapeutic preparations are obtained from medicinal plants, minerals, and various natural organic substances [1]. Traditional healthcare practitioners often prepare and provide their own herbal formulations

***Corresponding Author:** Vaishnavi Shindikar
Address: *R.G Sapkal College of Pharmacy, Sapkal Knowledge Hub, Kalyani Hills, Anjaneri, Trimbakeshwar Rd, Nashik*
Email : vaishnavishindikar2111@gamil.com

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based on established therapeutic practices[3] . According to the World Health Organization (WHO), approximately 21,000 plant species are utilized for medicinal purposes globally. Of these, around 2,500 species are found in India, with nearly 150 being used extensively for commercial applications. Owing to its rich diversity of medicinal plants and large-scale production of herbal resources, India is widely recognized as a major producer of medicinal herbs and is often referred to as the "Botanical Garden of the World." Diabetes mellitus (DM) represents a heterogeneous group of metabolic disorders characterized by chronic hyperglycemia resulting from defects in insulin secretion, insulin action, or both. The disease is associated with disturbances in carbohydrate, lipid, and protein metabolism and remains one of the leading causes of morbidity and mortality worldwide. The persistent elevation of blood glucose levels contributes to progressive damage of various organs including the pancreas, kidneys, liver, eyes, nervous system, and cardiovascular system, ultimately leading to severe complications and reduced quality of life

Medicinal Plant with Antidiabetic Activity

***Plumabago zeylanica* (chitrak) :**

Among the various species, Plumbago zeylanica L. is the most widely recognized because of its significant medicinal value. In Ayurveda, it is commonly known as Chitrak or Chitramula. Chitrak is a perennial medicinal herb that is often grown in shaded garden areas due to its attractive flowering clusters. The plant is extensively found across different regions of India and also occurs naturally in Sri Lanka. Plumbago zeylanica root contains plumbagin(15 and 30 mg/kg bw), a bioactive compound that showed significant antidiabetic activity in streptozotocin-induced diabetic rats. Oral administration of plumbagin for 28 days reduced blood glucose levels, improved insulin levels, normalized biochemical markers, enhanced liver glycogen content, and increased GLUT4 expression in skeletal muscles, indicating improved glucose uptake and carbohydrate metabolism[7]. The similar study conducted by (vishwanathan and kumar in 2010) The ethanolic root extract of Plumbago zeylanica demonstrated significant antidiabetic activity in streptozotocin-induced diabetic rats. Treatment reduced blood and urine glucose levels and improved hepatic enzyme activity, including hexokinase and glucose-6-phosphatase. The extract also showed hepatoprotective effects, suggesting its potential role in managing diabetes and associated liver dysfunction.[8]ethanolic extract(100mg -200mg /kg)different doses of plumabago zeylanica extract modulate antidiabetic activity in rat thereby providing a strong defecnce hyperglycemic effect . Oral administration of the extract reduced blood glucose levels, improved lipid profiles, enhanced antioxidant enzyme activities (superoxide dismutase, catalase, and glutathione), and decreased oxidative stress markers. Histopathological studies also demonstrated protection of pancreatic tissue. The findings suggest that P. zeylanica may serve as a promising natural therapeutic agent for diabetes management[9].

***Pipper longum* L.(pippali) :**

Piper longum L., commonly known as long pepper or Pippali, is a perennial medicinal climber belonging to the Piperaceae family. The fruit is a distinctive elongated spike made up of numerous tiny berries embedded closely together. As the fruit matures, its color changes from green to dark brown. the fruits have a characteristic pungent flavor mainly due to piperine, an important bioactive alkaloid[12].

This study investigated the antidiabetic and antihyperlipidemic effects of the aqueous root

extract of Piper longum in streptozotocin (STZ)-induced diabetic rats. Diabetes was experimentally induced in Wistar rats, and the pipper longum 200mg/lkgextract was administered to evaluate its therapeutic potential. The results showed that treatment with Piper longum significantly reduced elevated blood glucose levels and improved lipid abnormalities associated with diabetes. The extract also lowered total cholesterol, triglycerides, LDL, and VLDL levels while increasing HDL cholesterol[13]. Similarly study done by(zod and ingale 2024) This study examined the blood glucose-lowering effect of Piper longum dried fruit extract in diabetic rats. Administration of the ethanolic extract with different doses (100mg/kg, 200mg/kg)significantly reduced elevated glucose levels and improved overall diabetic status. The findings highlight the plant's potential as a natural antidiabetic remedy and suggest that it may help manage hyperglycemia [14]

Piperlongumine is an important bioactive alkaloid compound mostly present in the roots and fruits of the Piper longum plant. A study investigated the protective effect of piperlongumine in streptozotocin-induced diabetic rats. Rats received streptozotocin (45 mg/kg, intraperitoneally) to induce diabetes, followed by piperlongumine treatment for 8 weeks. Piperlongumine improved blood glucose and insulin levels, reduced kidney injury markers, and lessened renal tissue damage. The findings suggest that piperlongumine may help prevent diabetic kidney complications and support kidney function[15].

***Acorus calamus*(vekhand) :**

Acorus calamus L. (Sweet flag or Vacha) is a perennial, aromatic, semi-aquatic herb belonging to the family Acoraceae. The plant commonly grows in marshy and wetland habitats.

This study evaluated the antidiabetic activity of the ethyl acetate fraction of Acorus calamus (ACE). Oral administration of ACE at 100 mg/kg significantly reduced fasting blood glucose levels in streptozotocin-induced diabetic mice and improved glucose tolerance. ACE enhanced GLP-1 secretion, promoted insulin release, and activated signaling , suggesting its potential role in improving glycemic control and pancreatic function[16].

Prislila et al. investigated the antidiabetic potential of methanolic rhizome extract of Acorus calamus in streptozotocin-induced diabetic rats. The extract was administered orally at a dose of 200 mg/kg for 21 days. Treatment significantly lowered blood glucose levels, improved lipid abnormalities, increased insulin and glycogen content, and promoted pancreatic tissue recovery. The findings suggest that A. calamus possesses promising antihyperglycemic activity and may support diabetes management[17].

Prashanth et al. evaluated the hypoglycemic activity of methanolic root extract of Acorus calamus in alloxan-induced diabetic rats. Oral administration of 150 mg/kg showed significant blood glucose reduction and improved glycemic control over 28 days. Its effect was comparable to glibenclamide in later stages of treatment, indicating that A. calamus may be a promising natural option for diabetes management[18].

***Symplocos racemosa Roxb*(lodhra) :**

Symplocos racemosa Roxb., commonly known as Lodhra, is a small to medium-sized evergreen tree belonging to the family Symplocaceae. The species is widely distributed in the tropical and subtropical forests of India.

Jaha et al. investigated the antidiabetic and hepatoprotective effects of methanolic bark extract

of Symplocos racemosa in alloxan-induced diabetic rats. Oral treatment (200 and 400 mg/kg/day for 30 days) significantly reduced blood glucose levels and improved pancreatic tissue architecture. The extract also protected against paracetamol-induced liver injury, demonstrating promising antidiabetic and liver-protective properties comparable to standard therapy[19]. Sneka et al. evaluated the antidiabetic potential of silver nanoparticles synthesized using Symplocos racemosa (Lodhra) and Cinnamomum cassia bark extracts. The nanoparticle formulation demonstrated stronger α-amylase inhibitory activity than the crude herbal extracts, indicating enhanced antidiabetic efficacy. The findings suggest that plant-mediated silver nanoparticles may serve as a promising approach for developing novel antidiabetic therapeutics[22].

***Zingiber officinale*(Ginger) :**

Zingiber officinale belongs to the Zingiberaceae family. It is a perennial herb with aromatic rhizomes. Ginger exhibits antidiabetic activity by reducing blood glucose levels, enhancing insulin sensitivity, improving glucose metabolism, and decreasing oxidative stress, thereby helping prevent diabetes-related complications and metabolic disorders. Al-Amin et al. investigated the antidiabetic and hypolipidaemic effects of raw ginger (Zingiber officinale) in streptozotocin-induced diabetic rats. Daily administration of ginger extract (500 mg/kg for 7 weeks) significantly reduced blood glucose, cholesterol, triglycerides, and urinary protein levels while helping maintain body weight. The findings suggest ginger may be beneficial in managing diabetes and associated metabolic complications[23]. Alshathly et al. evaluated the protective effects of ginger (Zingiber officinale) against streptozotocin-induced diabetic liver injury in rats. Ginger treatment significantly reduced blood glucose levels, improved antioxidant status, restored body and liver weights, and normalized liver enzyme markers. Histological and ultrastructural analyses confirmed reduced liver damage, suggesting that ginger may help protect hepatic function and alleviate diabetes-related complications[24].

***Syzygium cumini (L.)* Skeels (Black plum)**

Syzygium cumini (L.) Skeels, commonly known as Jamun in India, belongs to the family of Myrtaceae and has a wide distribution in the Indian sub-continent, eastern Africa and Southeast Asian countries [24]. Stem bark decoction is being consumed by the tribes of Sikkim and Darjeeling Himalaya, India, for the treatment of diabetes mellitus . Oral administration of ethanolic and aqueous extracts of the bark of S. cumini(500 mg/kg for 21 days) showed significant blood glucose lowering effects in diabetic Wistar rats [25]. Administration of aqueous extract of S. cumini seeds in high-fat-diet–streptozotocin-induced type 2 diabetic rats exhibited significant insulin sensitiz-ing, anti-oxidant, anti-dyslipidemic, anti-inflammatory and β-cell protective effects by overexpression of PPARα and PPARγ activity [26]. Administration of ethanolic extract of the seeds of S. cumini significantly decreased the blood sugar level accompanied by an increased body weight in alloxan-induced diabetic rats [27]. The aqueous seed extract of S. cumini (100 mg/kg for 21 days) exerts a modulatory effect on the hyperglycemic and inflammatory conditions observed in diabetes mellitus. It also exerts a protective effect against the pathophysiological manifestations triggered by the early stages of diabetes mellitus [28].

***Allium sativum L* :**

Allium sativum L., commonly known as garlic, belongs to the Allium genus in the family

Alliaceae that are known to contain a high concentration of non-protein sulfur amino acids that are responsible for their medicinal features [29]. Administration of A. sativum extract along with the commercially available drug glibenclamide resulted in increased weight and exhibited better hypoglyce-mic effect in streptozotocin-induced diabetic rats [30]. Similar results were observed in a study where diabetic patients when treated with combination of com-mercially available drug metformin and garlic supplemen-tation exhibited improved glycemic control in addition to antihyperlipidemic activity [31]. Treatment with fresh garlic homogenate (250 mg/kg b.w.) for 6 weeks resulted in better modulation of antioxidant status in blood and cardiac tissues of streptozotocin-induced diabetic-induced Wistar rats [32]. Administration of garlic extract resulted in reduction of blood glucose con-centration accompanied by downregulation of the adrenal and renal expression of angiotensin AT1 receptor in STZ-induced diabetic rats which explains its potential in reversing the harmful consequences of excessive Ang II signaling, manifested by the development of hypertension and nephropathy [33]. The anti-diabetic effect of garlic extract has been reported to be more effective than the standard drug glibenclamide [34].

CONCLUSION

Medicinal plants have emerged as promising therapeutic agents for the management of diabetes mellitus due to their diverse bioactive constituents and multifaceted mechanisms of action. Herbal species such as Syzygium cumini, Zingiber officinale, Acorus calamus, Symplocos racemosa, allium sativum and Piper longum have demonstrated significant antidiabetic potential in experimental studies by reducing blood glucose levels, enhancing insulin secretion and sensitivity, mitigating oxidative stress, and protecting pancreatic β-cells. In addition to glycemic control, many of these plants exhibit antioxidant, anti-inflammatory, hypolipidemic, and organ-protective properties that may help prevent diabetes-associated complications. Although the available evidence supports their therapeutic value, most findings are based on preclinical studies. Therefore, well-designed clinical trials, standardization of herbal formulations, and comprehensive safety evaluations are necessary to validate their efficacy and facilitate their integration into modern diabetes management. Herbal medicines may serve as valuable complementary therapies for improving the overall treatment and quality of life of diabetic patients.

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