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EVALUATION OF ANTIDIABETIC ACTIVITY OF AQUEOUS EXTRACT OF DIANTHUS BARBATUS LEAVES IN ALLOXAN INDUCED DIABETIC RATS

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Abstract

Diabetes mellitus is a rapidly growing public health concern in India, with the prevalence of the disease increasing steadily. Although several conventional antidiabetic drugs are available, their long-term use is often associated with adverse effects. Consequently, there is increasing interest in the use of ethnomedicinal plants as affordable and safer alternatives for diabetes management. *Dianthus barbatus*, a medicinal plant traditionally used for various therapeutic purposes, has not been extensively investigated for its antidiabetic potential. The present study aimed to evaluate the antidiabetic activity and phytochemical profile of the aqueous extract of *Dianthus barbatus* in alloxan-induced diabetic rats. Diabetes was induced by intraperitoneal administration of alloxan at a dose of 50 mg/kg body weight. The animals were randomly divided into five groups (n = 6): Group I served as the normal control and received the vehicle; Group II served as the diabetic control; Group III received the standard antidiabetic drug glibenclamide (1 mg/kg body weight, orally); and Groups IV and V received the aqueous extract of *Dianthus barbatus* at doses of 200 mg/kg and 400 mg/kg body weight, respectively, administered orally for 28 days. At the end of the treatment period, blood samples were collected to determine fasting blood glucose, serum glutamate pyruvate transaminase (SGPT), and serum glutamate oxaloacetate transaminase (SGOT) levels. The aqueous extract of *Dianthus barbatus* produced a significant reduction in blood glucose, SGPT, and SGOT levels at both dose levels compared with the diabetic control group. In addition, treatment with the extract improved body weight in diabetic animals throughout the study period. The findings of this study demonstrate that the aqueous extract of *Dianthus barbatus* possesses significant antihyperglycemic activity and may offer hepatoprotective benefits in alloxan-induced diabetic rats. These results support the potential of *Dianthus barbatus* as a promising natural therapeutic agent for the management of diabetes mellitus, warranting further phytochemical and pharmacological investigations to identify its active constituents and elucidate its mechanism of action.

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INTRODUCTION

Diabetes mellitus (DM) is a chronic metabolic disorder characterized by persistent hyperglycemia resulting from defects in insulin secretion, insulin action, or both [1]. It has emerged as one of the leading non-communicable diseases worldwide and represents a major public health challenge due to its increasing prevalence and associated complications. The disease affects carbohydrate, lipid, and protein metabolism, leading to long-term damage of vital organs such as the eyes, kidneys, nerves, heart, and blood vessels. The rapid rise in diabetes cases is primarily attributed to sedentary lifestyles, unhealthy dietary habits, obesity, aging, and genetic predisposition. Early diagnosis and effective management are essential to prevent disease progression and reduce the risk of severe complications [2-3].

The clinical manifestations of diabetes vary depending on the type and severity of the disease but are largely related to sustained hyperglycemia. The most common symptoms include polyuria (frequent urination), polydipsia (excessive thirst),

polyphagia (increased hunger), fatigue, unexplained weight loss, blurred vision, delayed wound healing, recurrent infections, and irritability [4]. In Type 1 diabetes mellitus, autoimmune destruction of pancreatic β -cells leads to absolute insulin deficiency, causing rapid onset of symptoms such as nausea, vomiting, dehydration, weight loss, and diabetic ketoacidosis. If untreated, the condition may progress to coma and death. In contrast, Type 2 diabetes develops gradually and is characterized by insulin resistance and relative insulin deficiency [5]. Patients often remain asymptomatic during the early stages, delaying diagnosis until chronic complications become evident [6].

The pathophysiology of diabetes involves an imbalance between insulin production and insulin demand. Under normal physiological conditions, insulin regulates glucose uptake by peripheral tissues, promotes glycogen synthesis, and suppresses hepatic glucose production. During fasting, glucagon maintains blood glucose levels by stimulating glycogenolysis and gluconeogenesis. In diabetes, inadequate

insulin activity disrupts these metabolic processes, resulting in reduced glucose utilization, increased hepatic glucose production, enhanced lipolysis, and protein catabolism. Consequently, blood glucose levels remain elevated while tissues experience an energy deficit. Excessive fatty acid oxidation also leads to ketone body formation, particularly in Type 1 diabetes, causing metabolic acidosis and electrolyte imbalance [7-8].

Chronic hyperglycemia contributes to several biochemical abnormalities and systemic complications. Elevated blood glucose increases osmotic pressure, resulting in glycosuria and polyuria, which subsequently cause dehydration and electrolyte imbalance. The inability of cells to utilize glucose effectively forces the body to metabolize fats and proteins for energy, leading to muscle wasting, weight loss, and increased production of ketone bodies. Persistent hyperglycemia also induces oxidative stress, inflammation, and endothelial dysfunction, contributing to both microvascular and macrovascular complications. These include diabetic nephropathy, retinopathy, neuropathy, cardiovascular diseases, peripheral vascular disease, and diabetic foot ulcers, all of which significantly impair the quality of life and increase mortality [8].

The diagnosis of diabetes mellitus is established using standardized biochemical criteria. Fasting plasma glucose levels of ≥ 126 mg/dL, two-hour plasma glucose values of ≥ 200 mg/dL following an oral glucose tolerance test, random plasma glucose levels of ≥ 200 mg/dL in the presence of classic symptoms, or glycated hemoglobin (HbA1c) levels of $\geq 6.5\%$ are considered diagnostic. Individuals with impaired fasting glucose or impaired glucose tolerance are classified as prediabetic and are at increased risk of developing Type 2 diabetes and cardiovascular disease. Therefore, early screening and timely intervention are essential to prevent disease progression and associated complications [9-10].

Current management of diabetes includes lifestyle modification, insulin therapy, and oral hypoglycemic agents. Insulin remains the primary treatment for Type 1 diabetes and advanced Type 2 diabetes. Common oral antidiabetic drugs include sulfonylureas, metformin, thiazolidinediones, and α -glucosidase inhibitors. These medications improve glycemic control through different mechanisms such as stimulating insulin secretion, enhancing insulin sensitivity, reducing hepatic glucose production, or delaying carbohydrate absorption. Although effective, prolonged use of synthetic antidiabetic drugs is often associated with adverse effects including hypoglycemia, gastrointestinal disturbances, weight gain, hepatic dysfunction, renal impairment, and cardiovascular risks. Furthermore, these therapies primarily control hyperglycemia without addressing the underlying pathological changes of the disease [11-12]. Diabetes also produces significant alterations in biochemical markers related to liver and kidney function. The liver plays a central role in maintaining glucose homeostasis and is severely affected by diabetic metabolic disturbances. Increased gluconeogenesis, reduced glycogen synthesis, and impaired glycolysis contribute to persistent hyperglycemia. Elevated serum levels of alanine aminotransferase (ALT/SGPT) and aspartate aminotransferase (AST/SGOT) indicate hepatic injury associated with diabetes.

Similarly, renal dysfunction is reflected by increased serum creatinine and urea levels resulting from diabetic nephropathy. Lipid abnormalities including elevated total cholesterol, triglycerides, low-density lipoprotein (LDL), and reduced high-density lipoprotein (HDL) further increase the risk of atherosclerosis and cardiovascular disease in diabetic patients [13].

Experimental animal models play a crucial role in evaluating potential antidiabetic agents. Among these, alloxan-induced diabetes is one of the most widely used models because alloxan selectively destroys pancreatic β -cells through the generation of reactive oxygen species and oxidative stress, resulting in insulin deficiency and sustained hyperglycemia. The alloxan-induced diabetic rat model closely resembles human diabetes with respect to metabolic disturbances and biochemical changes. Consequently, it is extensively employed to investigate the efficacy and mechanism of action of novel antidiabetic compounds and medicinal plant extracts [14].

The limitations of currently available therapies have stimulated increasing interest in herbal medicine as an alternative approach for diabetes management. Medicinal plants have been used in traditional healthcare systems for centuries and are recognized as valuable sources of bioactive compounds with antidiabetic potential. Phytochemicals such as flavonoids, alkaloids, tannins, saponins, terpenoids, glycosides, phenolic compounds, and polysaccharides exhibit antihyperglycemic, antioxidant, anti-inflammatory, and insulin-sensitizing activities. Compared with synthetic drugs, herbal medicines are generally considered safer, more affordable, and associated with fewer adverse effects. The World Health Organization has also emphasized the importance of scientifically validating medicinal plants traditionally used in diabetes management.

Among medicinal plants, *Dianthus barbatus* has attracted attention because of its rich phytochemical composition and potential therapeutic properties. However, scientific evidence supporting its antidiabetic activity remains limited. Therefore, evaluating its pharmacological efficacy is important to establish its therapeutic potential. The present study investigates the antihyperglycemic activity of the aqueous extract of *Dianthus barbatus* in alloxan-induced diabetic rats. The study also includes phytochemical screening to identify the bioactive constituents that may contribute to its pharmacological effects. Biochemical parameters including fasting blood glucose, serum SGPT, SGOT, and body weight were assessed to determine its protective effects against diabetes-induced metabolic alterations [15-16].

Overall, the growing global burden of diabetes, together with the limitations of existing pharmacological therapies, highlights the need for safer, cost-effective, and more efficient treatment strategies. Plant-derived medicines represent a promising source of novel antidiabetic agents capable of targeting multiple metabolic pathways while minimizing adverse effects. The present investigation aims to provide scientific validation for the traditional use of *Dianthus barbatus* and to explore its potential as a natural therapeutic agent for the management of diabetes mellitus [17-18]. The findings of this study may contribute to the development of effective herbal formulations and encourage further pharmacological and clinical investigations into its mechanism of action and therapeutic applications [19-20].

METHODOLOGY

The present study was undertaken to evaluate the phytochemical constituents and antidiabetic potential of the aqueous extract of *Dianthus barbatus*. Diabetes mellitus is a rapidly increasing metabolic disorder worldwide, largely attributed to sedentary lifestyles, unhealthy dietary habits, obesity, and reduced physical activity. Although synthetic antidiabetic drugs such as glibenclamide are effective, their long-term use is often associated with adverse effects. Therefore, the present research aimed to scientifically validate the traditional use of *Dianthus barbatus* as a potential herbal antidiabetic agent with improved safety and efficacy.

The study involved the collection and authentication of *Dianthus barbatus* leaves from Hyderabad, Telangana, followed by shade drying, powdering, and aqueous extraction using a Soxhlet apparatus. Preliminary phytochemical screening was carried out to identify the presence of major bioactive constituents, including alkaloids, flavonoids, tannins, glycosides, saponins, terpenoids, carbohydrates, and phenolic compounds. Acute oral toxicity studies were performed according to OECD-423 guidelines to establish the safety profile of the extract. The antidiabetic activity was evaluated in alloxan-induced diabetic Wistar rats [21-22]. Experimental animals were divided into five groups comprising normal control, diabetic control, standard drug (glibenclamide), and two treatment groups receiving low and high doses of the aqueous extract. Treatment was administered orally for 28 days, and fasting blood glucose, body weight, serum glutamate pyruvate transaminase (SGPT), and serum glutamate oxaloacetate transaminase (SGOT) levels were assessed to determine the therapeutic efficacy [23-24]. Statistical analysis was performed using one-way ANOVA followed by Dunnett's multiple comparison test, with $p < 0.05$ considered statistically significant. The study was designed to provide scientific evidence supporting the traditional use of *Dianthus barbatus* as a potential herbal antidiabetic agent.

RESULTS AND DISCUSSION

Phytochemical Screening

The preliminary phytochemical screening of the aqueous extract of *Dianthus barbatus* revealed the presence of several bioactive phytoconstituents (Table 7.1). The extract showed positive results for phenolic compounds, flavonoids, alkaloids, glycosides, saponins, and terpenoids, whereas carbohydrates, tannins, sterols, and amino acids were absent. The presence of flavonoids and phenolic compounds suggests significant antioxidant potential, while alkaloids, glycosides, saponins, and terpenoids are well known for their antihyperglycemic and protective pharmacological activities. These phytochemicals may act either individually or synergistically to produce the observed biological effects. The phytochemical profile therefore supports the traditional medicinal use of *Dianthus barbatus* and provides a scientific basis for evaluating its antidiabetic activity.

Table 01: Results of Aqueous extract of *Dianthus Barbatus*

Class of compounds	Tests performed	Results
Carbohydrates	Molisch's test Fehling's test	-
Phenols	Phosphomolybdic acid test	+
Flavonoids	Shinoda test Lead acetate test	+
Tannins	Braemer's test	-
Alkaloids	Wagner's Mayer's Draggendorf's test	+
Glycosides	Legal's test Brontranger's test	+
Saponins	Foam test	+
Sterols	Salkowski's test	-
Amino acids	Ninhydrin test	-
Terpenoids	Lieberman Burchardt test	+

+Present in moderate amount

Effect of *Dianthus barbatus* on Blood Glucose Levels

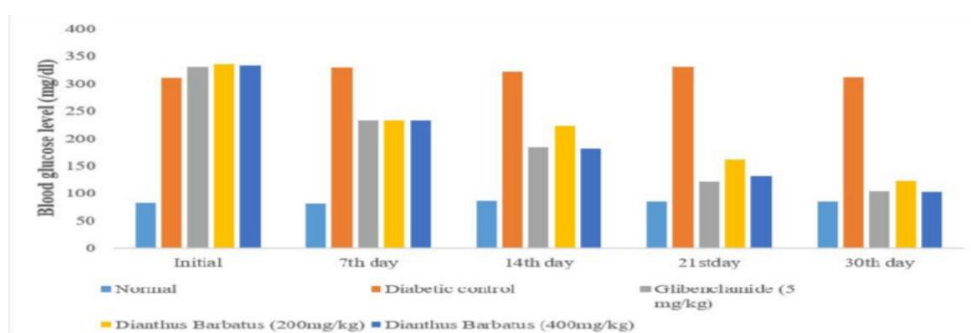
The effect of the aqueous extract of *Dianthus barbatus* on fasting blood glucose levels in alloxan-induced diabetic rats is presented in **Table 02** and **Figure 01**. Administration of alloxan markedly increased blood glucose levels in the diabetic control group compared with the normal control group throughout the experimental period. Treatment with the standard drug glibenclamide significantly reduced blood glucose levels from the 7th day onward, confirming the successful induction of diabetes and validating the experimental model.

Similarly, oral administration of the aqueous extract at doses of 200 mg/kg and 400 mg/kg produced a significant and dose-dependent reduction in blood glucose levels throughout the 30-day treatment period. The higher dose (400 mg/kg) demonstrated greater antihyperglycemic activity, reducing blood glucose levels to values comparable with those observed in the glibenclamide-treated group by the end of the study. These findings indicate that the aqueous extract possesses potent antihyperglycemic activity, possibly through stimulation of residual pancreatic β -cells, enhancement of insulin secretion, improvement in peripheral glucose utilization, or inhibition of oxidative stress-induced pancreatic damage [25].

Table 02: Effect of *Dianthus Barbatus* extract on blood glucose level in alloxan induced diabetic rats

Groups	Blood glucose level (mg/dl)				
	Initial	7th day	14th day	21st day	30th day
Normal	82.12±2.111	81.10±2.101	86.10±2.256	84.12±2.314	84.03±2.501
Diabetic control	310.2±1.125	330.2±1.215	320.8±1.002	330.8±1.213	312.1±10.51
Glibenclamide (5 mg/kg)	330.5±3.261	233.3±1.110***	183.1±10.25***	120.2±1.301***	103.3±1.257**
<i>Dianthus Barbatus</i> (200mg/kg)	336.2±1.415	283.1±1.601**	222.1±2.202*	161.2±12.02*	122.3±1.216*
<i>Dianthus Barbatus</i> (400mg/kg)	333.2±1.301	280.2±2.255**	181.5±2.512**	132.2±1.109**	102.2±1.319**

Values are expressed as mean±S.E.M, n=6 in all except in diabetic control, one way ANOVA followed by Dunette's test. *p<0.05, **p<0.01 and ***p<0.001 when compared to diabetic control.

Figure 01: Effect of *Dianthus Barbatus* on blood glucose level in alloxan induced diabetic rats

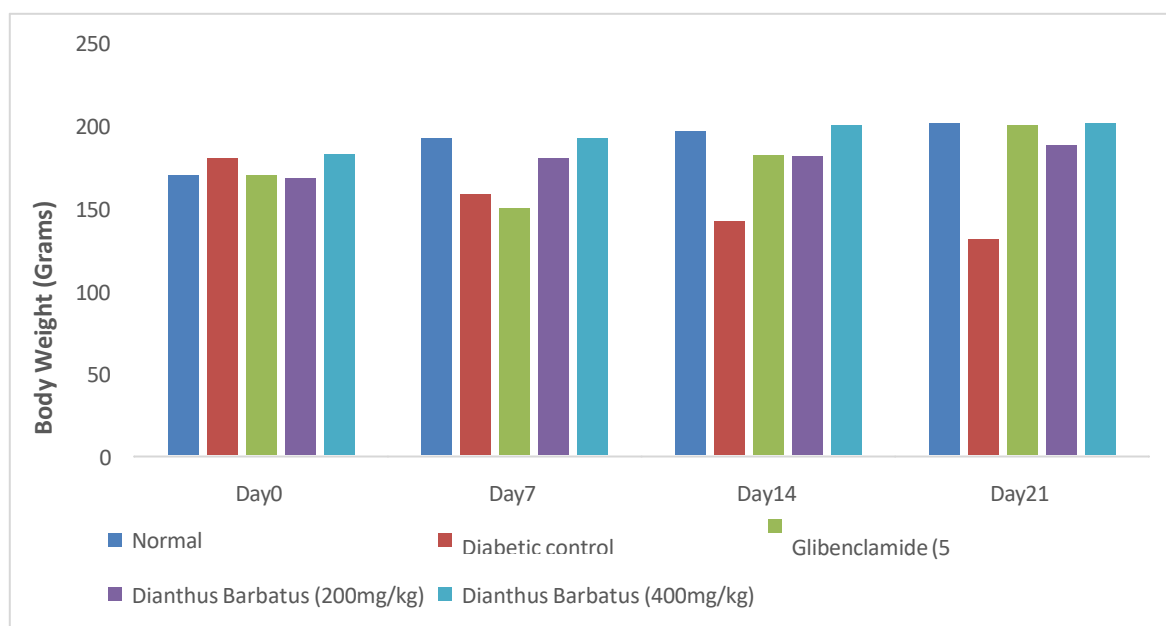
Effect of *Dianthus barbatus* on Body Weight

Changes in body weight during the experimental period are summarized in Table 03 and illustrated in Figure 02. The diabetic control animals exhibited progressive loss of body weight, which is a characteristic feature of uncontrolled diabetes resulting from enhanced protein degradation, muscle wasting, and increased fat catabolism. In contrast, rats treated with glibenclamide and the aqueous extract of *Dianthus barbatus* showed a gradual increase in body weight throughout the treatment period. The improvement in body weight was dose dependent, with the 400 mg/kg treated group exhibiting values close to those of the normal control group. Restoration of body weight indicates improved glycemic control and enhanced utilization of glucose by peripheral tissues. The findings also suggest that the extract may reduce protein catabolism and preserve body tissue, thereby improving the overall metabolic status of diabetic animals [26].

Table 03: Body weight in alloxan induced diabetic rats

Groups	Body Weight (Grams)			
	Day0	Day7	Day14	Day21
Normal control	170.1± 0.112	192.1± 0.202	196.2± 1.100	201.1± 0.0102
Diabetic control	180.1±0.151	158.2±0.101	142.0±2.111	131.1±0.610
Glibenclamide (5mg/kg)	170.0±0.124***	150.0±0.212**	182.2±1.059**	200.2±1.361***
<i>Dianthus Barbatus</i> (200mg/kg)	168.1±328*	180.0±0.576*	181.5±0.974*	188.3±1.051*
<i>Dianthus Barbatus</i> (400mg/kg)	182.8±1.453**	192.1±1.360**	200.0±0.321**	201.2±0.723**

Values are mean±SEM(n=6) one way ANOVA followed by Dunette's test. Where, #represents the comparison, *represents significant at p<0.05, **represents highly significant at p<0.01 and ***represents very significant at p<0.001.

Figure 02: Effect of *Dianthus Barbatum* on body weight in alloxan induced diabetic rats

Effect of *Dianthus barbatum* on Hepatic Biomarkers

The effects of the aqueous extract on serum hepatic marker enzymes are presented in **Table 04** and **Figure 03**. Diabetes induced by alloxan resulted in a marked elevation of serum SGPT and SGOT levels compared with the normal control group, indicating hepatic injury associated with oxidative stress and altered carbohydrate metabolism.

Treatment with the aqueous extract significantly reduced the elevated enzyme levels in a dose-dependent manner. The 400 mg/kg dose showed greater hepatoprotective activity than the 200 mg/kg dose and produced results approaching those observed with glibenclamide treatment. The reduction in SGPT and SGOT levels suggests stabilization of hepatocyte membranes and restoration of normal liver function. Since the liver plays a central role in glucose homeostasis, improvement in hepatic function may also contribute to the observed antihyperglycemic activity of the extract. The present investigation demonstrated that the aqueous extract of *Dianthus barbatum* possesses significant antidiabetic activity in alloxan-induced diabetic rats. Preliminary phytochemical analysis confirmed the presence of several pharmacologically important secondary metabolites, including flavonoids, phenols, alkaloids, glycosides, saponins, and terpenoids, which have previously been reported to exhibit antioxidant, antihyperglycemic, and cytoprotective activities. Administration of the aqueous extract significantly reduced fasting blood glucose levels (**Table 02**, **Figure 01**) and improved body weight (**Table 03**, **Figure 02**) compared with the diabetic control group. Furthermore, treatment restored elevated serum SGPT and SGOT levels toward normal values (**Table 04**, **Figure 03**), indicating protection against diabetes-induced hepatic damage. The observed dose-dependent response, particularly at 400 mg/kg, suggests that the extract effectively improves metabolic abnormalities associated with diabetes [27-29].

The antihyperglycemic effect may be attributed to multiple mechanisms, including stimulation of insulin secretion from surviving pancreatic β -cells, enhancement of peripheral glucose uptake, reduction of oxidative stress, inhibition of hepatic gluconeogenesis, and improvement of antioxidant defense mechanisms. Flavonoids and phenolic compounds present in the extract may protect pancreatic β -cells from oxidative damage, while alkaloids, glycosides, and terpenoids may contribute to improved glucose metabolism and insulin sensitivity.

Table 04: SGPT and SGOT levels in diabetic rats

Group	Alloxan	
	SGPT	SGOT
Normal control	58.00 $\pm$ 0.3651	59.17 $\pm$ 0.3073
Diabetic control	103.3 $\pm$ 0.5578	115.7 $\pm$ 0.4216
Standard Glibenclamide	73.00 $\pm$ 0.3651***	69.67 $\pm$ 0.5578***
<i>Dianthus Barbatum</i> (200mg/kg)	98.50 $\pm$ 0.2236*	94.83 $\pm$ 0.3073*
<i>Dianthus Barbatum</i> (400mg/kg)	86.33 $\pm$ 0.5578**	78.83 $\pm$ 0.4014**

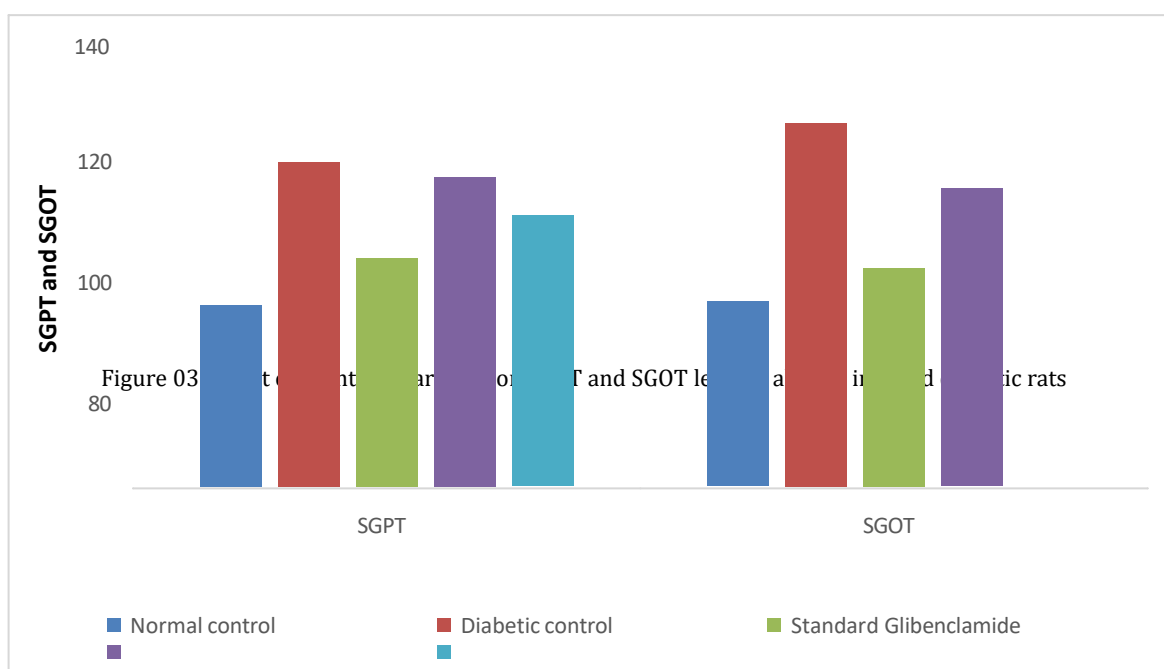


Figure 03: Effect of *Dianthus Barbatus* on SGPT and SGOT level in alloxan induced diabetic rats

Overall, the findings of the present study scientifically validate the traditional use of *Dianthus barbatus* as an antidiabetic medicinal plant. The aqueous extract exhibited significant antihyperglycemic and hepatoprotective effects comparable to the standard drug glibenclamide, particularly at the dose of 400 mg/kg. These results suggest that *Dianthus barbatus* may serve as a promising natural source for the development of safe and effective antidiabetic agents [30]. Further studies involving isolation of active phytoconstituents, elucidation of molecular mechanisms, and clinical evaluation are warranted to establish its therapeutic potential.

CONCLUSION

The findings of the present study demonstrate that the aqueous extract of *Dianthus barbatus* possesses significant antidiabetic activity in alloxan-induced diabetic rats, as evidenced by a statistically significant reduction in blood glucose levels ($p < 0.001$). The extract also improved body weight and restored elevated hepatic biomarkers (SGPT and SGOT) toward normal levels, indicating its beneficial effect on diabetes-associated metabolic disturbances and liver function. The observed antihyperglycemic activity may be attributed to its ability to enhance insulin secretion from the pancreatic β -cells, improve insulin action, and protect pancreatic tissue through the combined effects of its bioactive phytoconstituents. Preliminary phytochemical screening confirmed the presence of several biologically active compounds, including flavonoids, phenols, alkaloids, glycosides, saponins, and terpenoids, which are known to contribute to antidiabetic and antioxidant activities. These phytochemicals may act synergistically to produce the therapeutic effects observed in the study. Overall, the results provide scientific evidence supporting the traditional use of *Dianthus barbatus* as a potential herbal antidiabetic agent. However, further investigations are required to isolate and characterize the active phytoconstituents, elucidate their precise mechanisms of

action, and evaluate their efficacy and safety through advanced pharmacological and clinical studies. Such investigations may facilitate the development of novel, safe, and effective plant-based therapeutic agents for the management of diabetes mellitus.

AUTHOR CONTRIBUTIONS

Both authors contributed to equally.

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CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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REFERENCES

1. International Diabetes Federation. IDF Diabetes Atlas. 10th ed. Brussels: International Diabetes Federation; 2021.
2. Sun H, Saeedi P, Karuranga S, Pinkepank M, Ogurtsova K, Duncan BB, et al. IDF Diabetes Atlas: Global, regional and country-level diabetes prevalence estimates for 2021 and projections for 2045. *Diabetes Res Clin Pract.* 2022;183:109119.
3. American Diabetes Association Professional Practice Committee. Standards of Care in Diabetes—2024. *Diabetes Care.* 2024;47(Suppl 1):S1-S350.
4. American Diabetes Association Professional Practice Committee. Pharmacologic approaches to glycemic

- treatment: Standards of Care in Diabetes-2023. *Diabetes Care*. 2023;46(Suppl 1):S140-S157.
5. Davies MJ, Aroda VR, Collins BS, Gabbay RA, Green J, Maruthur NM, et al. Management of hyperglycemia in type 2 diabetes, 2022: a consensus report by the ADA and EASD. *Diabetes Care*. 2022;45(11):2753-2786.
 6. Saeedi P, Petersohn I, Salpea P, Malanda B, Karuranga S, Unwin N, et al. Global and regional diabetes prevalence estimates for 2019 and projections for 2030 and 2045. *Diabetes Res Clin Pract*. 2020;157:107843.
 7. Choudhury H, Pandey M, Hua CK, Mun CS, Jing JK, Kong L, et al. An update on natural compounds in the management of diabetes mellitus. *Front Pharmacol*. 2021;12:665546.
 8. Bhattacharya S, Prasanna A, Sinha A. Herbal medicines in diabetes management: current evidence and future prospects. *J Ethnopharmacol*. 2021;278:114295.
 9. Kooti W, Farokhipour M, Asadzadeh Z, Ashtary-Larky D, Asadi-Samani M. The role of medicinal plants in the treatment of diabetes: a systematic review. *Evid Based Complement Alternat Med*. 2021;2021:9923423.
 10. Tundis R, Loizzo MR, Bonesi M, Menichini F. Natural products as promising antidiabetic agents: recent advances. *Molecules*. 2021;26(7):2105.
 11. Oguntibeju OO. Type 2 diabetes mellitus, oxidative stress and inflammation: examining the links. *Int J Physiol Pathophysiol Pharmacol*. 2022;14(1):45-63.
 12. Li X, Wang Z, Zhou H, Chen J. Therapeutic potential of plant-derived flavonoids in diabetes mellitus. *Front Endocrinol (Lausanne)*. 2023;14:1182045.
 13. Chen J, Li Y, Tian Y, Zhang X. Phytochemicals targeting oxidative stress in diabetes mellitus: mechanisms and therapeutic perspectives. *Phytomedicine*. 2023;114:154780.
 14. Kumar S, Sharma A, Singh P. Advances in herbal medicine for diabetes mellitus: mechanisms and clinical prospects. *J Herb Med*. 2024;42:100726.
 15. Singh R, Verma N, Sharma P. Recent advances in phytochemical-based antidiabetic therapies: a comprehensive review. *Biomed Pharmacother*. 2024;170:116012.
 16. Patel M, Shah K, Joshi R. Medicinal plants as potential therapeutic agents for diabetes mellitus: recent pharmacological advances. *Phytother Res*. 2025;39(2):415-438.
 17. Kanwate GC, Vyas J, Paithankar V, Wankhede A. Antidiabetic activity of leaf extract of *Merremia dissecta* in alloxan-induced diabetic rats. *Int J Pharmacol Clin Res*. 2026;8(5):102-114.
 18. Sai Kishore T, Amos Babu J, Priyadarshini KA. Evaluation of antidiabetic activity of *Trigonella foenum-graecum* leaves in alloxan-induced type-II diabetic rats. *Int J Res Pharmacol Pharmacother*. 2025;14(1):1-10.
 19. Dhakad GG, Mohale DS, Chandewar AV. Evaluation of anti-diabetic activity of *Galinsoga parviflora* in diabetic rats. *Res J Pharmacol Pharmacodyn*. 2024;16(3):143-152.
 20. Derej B, Nardos A, Abdela J, Terefe L, Arega M, Yilma TM, et al. Antidiabetic activities of 80% methanol extract and solvent fractions of *Verbascum sinaiticum* Benth leaves in mice. *J Exp Pharmacol*. 2023;15:423-436.
 21. Akinyede KA, Oyewusi HA, Hughes GD, Ekpo OE, Oguntibeju OO. In vitro evaluation of the anti-diabetic potential of aqueous acetone *Helichrysum petiolare* extract with molecular docking relevance in diabetes mellitus. *Molecules*. 2022;27(1):155.
 22. Perumal N, Nallappan M, Shohaimi S, Kassim NK, Tee TT, Cheah YH. Synergistic antidiabetic activity of *Taraxacum officinale* and *Momordica charantia* polyherbal combination. *Biomed Pharmacother*. 2022;145:112401.
 23. Zhu Y, Gao H, Han S, Li J, Wen Q, Dong B. Antidiabetic activity and metabolite profiles of ascidian *Halocynthia roretzi*. *J Funct Foods*. 2022;93:105095.
 24. Ugochukwu AA, Anna IC. Phytochemical evaluation and antidiabetic effects of ethanolic leaf extract of *Petersianthus macrocarpus* on streptozotocin-induced diabetic rats. *J Adv Med Med Res*. 2021;33(3):39-47.
 25. Omonije OO, Saidu AN, Muhammad HL. Anti-diabetic activities of *Chromolaena odorata* methanol root extract and its attenuation effect on diabetic-induced hepatorenal impairments in rats. *Clin Phytosci*. 2019;5:23.
 26. Ardiana L, Sauriasari R, Elya B. Antidiabetic activity studies of white tea (*Camellia sinensis* (L.) O. Kuntze) ethanolic extracts in streptozotocin-nicotinamide induced diabetic rats. *Pharmacogn J*. 2018;10(1):186-189.
 27. Jangir RN, Jain GC. Evaluation of antidiabetic activity of hydroalcoholic extract of *Cassia fistula* Linn pod in streptozotocin-induced diabetic rats. *Pharmacogn J*. 2017;9(5):599-606.
 28. Haque MU, Sana S. Antidiabetic activity of plants, fruits and vegetables: a review. *Int J Biol Med Res*. 2016;7(1):5452-5458.
 29. Ghazanfar K, Ganai BA, Akbar S, Mubashir K, Dar SA, Dar MY, et al. Antidiabetic activity of *Artemisia amygdalina* Decne in streptozotocin-induced diabetic rats. *J Tradit Complement Med*. 2014;4(4):245-249.
 30. Misra H, Soni M, Silawat N, Mehta D, Mehta BK, Jain DC. Antidiabetic activity of medium-polar extract from the leaves of *Stevia rebaudiana* Bertoni on alloxan-induced diabetic rats. *J Pharm Bioallied Sci*. 2011;3(2):242-248.