World Journal of Pharmaceutical Science and Research
www.wjpsronline.com
Research Article
ISSN: 2583-6579
SJIF Impact Factor: 5.111
Year - 2025
Volume: 4; Issue: 5
Page: 496-504

EVALUATION OF THE ANTIOXIDANT AND HYPOGLYCEMIC ACTIVITIES OF CURCUMIN IN STZ-INDUCED DIABETIC RATS

Chikram Vigneshwar[1], Sirisha Macherla[2] B. Sudheer Kumar[1], G. Gomathi[1], P. Nagaraju[1*]

[1]Department of Pharmacology, Avanthi Institute of Pharmaceutical Sciences, Gunthapally, Hyderabad.
[2]School of Pharmacy, NNRG, Chowdariguda, Ghatkesar, Medchal, Hyderabad, Telangana - 500088.

Article Received: 08 September 2025 | | Article Revised: 29 September 2025 | | Article Accepted: 19 October 2025

***Corresponding Author: P. Nagaraju**
Associate Professor, Department of Pharmacology, Avanthi Institute of Pharmaceutical Sciences, Gunthapally, Hyderabad.
DOI: https://doi.org/10.5281/zenodo.17433383

How to cite this Article: Chikram Vigneshwar, Sirisha Macherla, B. Sudheer Kumar, G. Gomathi, P. Nagaraju (2025) EVALUATION OF THE ANTIOXIDANT AND HYPOGLYCEMIC ACTIVITIES OF CURCUMIN IN STZ-INDUCED DIABETIC RATS. World Journal of Pharmaceutical Science and Research, 4(5), 496-504. https://doi.org/10.5281/zenodo.17433383

ABSTRACT

Diabetes mellitus is one of the most prevalent chronic metabolic disorders worldwide, characterized by hyperglycemia due to impaired insulin secretion, insulin resistance, or both. Prolonged hyperglycemia is associated with oxidative stress, leading to severe complications such as neuropathy, nephropathy, cardiovascular disease, and retinopathy. Curcumin, the principal bioactive constituent of Curcuma longa, has been widely studied for its antioxidant, anti-inflammatory, and antidiabetic properties. The present study was designed to evaluate the antidiabetic and antioxidant effects of curcumin extract in streptozotocin (STZ)-induced diabetic albino rats. Male Wistar rats were divided into four groups: normal control, diabetic control, and two treatment groups receiving oral curcumin extract at doses of 150 mg/kg and 300 mg/kg, respectively. Diabetes was induced by intraperitoneal administration of STZ at 90 mg/kg body weight for three consecutive days. Biochemical parameters including fasting blood glucose, serum insulin, lipid profile (triglycerides, cholesterol, LDL-C, HDL-C), renal markers (urea, creatinine, microalbumin, total protein), and oxidative stress markers (MDA, SOD, GSH, CAT) were assessed. Histopathological analysis of kidney tissue was also performed. Results revealed significant weight loss, hyperglycemia, dyslipidemia, elevated renal biomarkers, and increased oxidative stress in diabetic control rats compared to normal controls. Curcumin treatment demonstrated a dose-dependent improvement in glycemic control, restoration of lipid profile, reduction in renal biomarkers, and significant enhancement of antioxidant enzyme levels. Histopathological findings confirmed a protective effect of curcumin on renal tissue integrity. In conclusion, curcumin extract exhibited significant antihyperglycemic, antihyperlipidemic, and antioxidant activities in STZ-induced diabetic rats. These findings suggest its therapeutic potential as an adjunctive agent in the management of diabetes and its complications. Further clinical investigations are warranted to overcome curcumin's bioavailability challenges and to validate its translational relevance in human diabetes management.

KEYWORDS: Curcumin, Curcuma longa, Diabetes mellitus, Streptozotocin, Oxidative stress, Antioxidant.

1. INTRODUCTION

Diabetes mellitus (DM) is a chronic metabolic disorder that has emerged as one of the most significant global health challenges of the 21st century. It is characterized by persistent hyperglycemia resulting from defects in insulin secretion, insulin action, or both (American Diabetes Association, 2019). According to the International Diabetes Federation (IDF, 2021), over 537 million people worldwide live with diabetes, with India accounting for nearly 77 million cases, placing it among the top countries affected by this epidemic. The burden of diabetes is further compounded by its associated complications, which include nephropathy, neuropathy, retinopathy, cardiovascular disease, and increased susceptibility to infections (Zimmet, Alberti, & Shaw, 2016). Type 1 diabetes results from autoimmune destruction of pancreatic β-cells, whereas type 2 diabetes is primarily linked to insulin resistance and relative insulin deficiency (Powers & D'Alessio, 2018). In addition to genetic predisposition, environmental and lifestyle factors such as obesity, physical inactivity, and dietary habits contribute to the rising prevalence of diabetes (Saeedi et al., 2019). Moreover, hyperglycemia-induced oxidative stress plays a central role in the pathophysiology of diabetic complications. Excess production of reactive oxygen species (ROS) and decreased antioxidant defense mechanisms contribute to cellular injury, lipid peroxidation, DNA damage, and protein glycation (Forbes & Cooper, 2013).

In recent years, significant attention has been directed toward natural phytochemicals for the management of diabetes and its associated oxidative stress. Among these, curcumin, the major bioactive constituent of turmeric (Curcuma longa), has gained prominence due to its pleiotropic pharmacological activities (Hewlings & Kalman, 2017). Turmeric has been used for centuries in traditional medicine systems such as Ayurveda and Chinese medicine for the treatment of inflammatory disorders, liver ailments, and metabolic diseases. Curcumin has demonstrated anti-inflammatory, antioxidant, anticarcinogenic, wound-healing, and neuroprotective effects (Aggarwal & Sung, 2009). Curcumin exerts its antidiabetic effects through multiple mechanisms, including modulation of insulin signaling pathways, improvement of pancreatic β-cell function, reduction of insulin resistance, and enhancement of antioxidant enzyme activity (Marton et al., 2021). However, its therapeutic use is limited by poor bioavailability due to low solubility, rapid metabolism, and systemic elimination (Anand, Kunnumakkara, Newman, & Aggarwal, 2007). Despite these limitations, several experimental and clinical studies have highlighted its potential in controlling hyperglycemia and preventing diabetic complications (Chuengsamarn et al., 2012). Streptozotocin (STZ), a nitrosourea derivative isolated from Streptomyces achromogenes, is commonly used to induce experimental diabetes in animal models due to its selective cytotoxicity toward pancreatic β-cells via GLUT2-mediated uptake and DNA alkylation (Lenzen, 2008). STZ-induced diabetic rats are widely used for evaluating the antidiabetic efficacy of natural products and pharmaceutical agents.

The present study was designed to evaluate the antidiabetic and antioxidant effects of curcumin extract in STZ-induced diabetic albino rats. Specific objectives included the assessment of body weight, blood glucose, serum insulin, lipid profile, renal function markers, oxidative stress parameters, and histopathological changes in kidney tissue.

2. MATERIALS AND METHODS

2.1 Chemicals and Reagents

Streptozotocin (STZ) was purchased from Sigma-Aldrich (USA). Curcumin was obtained as an ethanolic extract prepared from turmeric rhizomes. Diagnostic kits for the estimation of glucose, insulin, triglycerides, cholesterol, urea,

creatinine, HDL, LDL, MDA, SOD, GSH, and CAT were procured from Erba Transasia and Crest Biosystems. All other reagents used were of analytical grade.

2.2 Experimental Animals

Healthy male albino Wistar rats (160–240 g) were obtained from the National Institute of Nutrition, Hyderabad. Animals were housed in polypropylene cages under standard laboratory conditions (temperature 22±2°C, 12-hour light/dark cycle) with free access to standard pellet diet and water. The study was conducted in accordance with guidelines issued by the Committee for Control and Supervision of Experiments on Animals (CPCSEA), Government of India.

2.3 Induction of Diabetes

Diabetes was induced by intraperitoneal administration of freshly prepared STZ (90 mg/kg body weight) dissolved in citrate buffer (pH 4.2) for three consecutive days after an overnight fast. To prevent sudden hypoglycemia, rats were given 5% glucose solution for the next 10 hours. Blood glucose levels were measured after 72 hours, and rats with fasting blood glucose levels above 200 mg/dL were considered diabetic and selected for further study.

2.4 Experimental Design

The animals were divided into four groups (n=6 per group):

- Group I (Control): Normal rats treated with saline
- Group II (Diabetic): STZ-induced diabetic rats
- Group III (Diabetic + Curcumin 150 mg/kg): Diabetic rats treated with curcumin 150 mg/kg orally
- Group IV (Diabetic + Curcumin 300 mg/kg): Diabetic rats treated with curcumin 300 mg/kg orally

Curcumin treatment was administered orally for 30 days using Tween-80 as a suspending agent.

2.5 Biochemical Analysis

Blood samples were collected via retro-orbital plexus under light ether anaesthesia. Serum was separated by centrifugation at 3000 rpm for 15 minutes. Biochemical parameters including blood glucose, insulin, total cholesterol, triglycerides, HDL, LDL, urea, creatinine, and oxidative stress markers (MDA, SOD, GSH, and CAT) were analyzed using standard methods described in diagnostic kits.

2.6 Oxidative Stress Parameters

Malondialdehyde (MDA) levels were estimated by thiobarbituric acid reactive substances (TBARS) assay. Superoxide dismutase (SOD) activity was determined by the inhibition of epinephrine autooxidation. Reduced glutathione (GSH) content was measured using DTNB reagent, and catalase (CAT) activity was measured by the decomposition rate of hydrogen peroxide at 240 nm.

2.7 Behavioural and Motor Coordination

Motor coordination was assessed using a rotarod apparatus. Rats were trained for two days and tested on the third day at a speed of 35 rpm. The time spent on the rotating rod was recorded over three trials per rat with a maximum duration of 60 seconds per trial.

2.9 Statistical Analysis

Data were expressed as mean ± SEM. Statistical significance was analyzed using one-way ANOVA followed by Tukey–Kramer post hoc test. $p < 0.05$ was considered statistically significant.

3. RESULTS

3.1 Effect on Body Weight

STZ-induced diabetic rats exhibited significant weight loss compared to the control group. Treatment with curcumin improved body weight in a dose-dependent manner, with the 300 mg/kg group showing values close to normal controls (Table 1, Figure 1).

Table 1: Effect of Curcumin on body weights in streptozotocin-induced diabetic rats.

S. No	Groups	Treatment	Duration	Results
1	Control	Normal Saline	30 Days	70.43±1.143
2	Diabetic	Streptozotocin (90mg/Kg)	3 Days	20.46±2.184
3	Dose-1	Curcumin (150mg/Kg)	30 Days	45.37±1.440
4	Dose-2	Curcumin (300mg/Kg)	30 Days	65.8±0.996

Values are expressed as mean ± S.E.M. (n = 6). Statistical analysis was performed using one-way ANOVA followed by Dunnett's test.

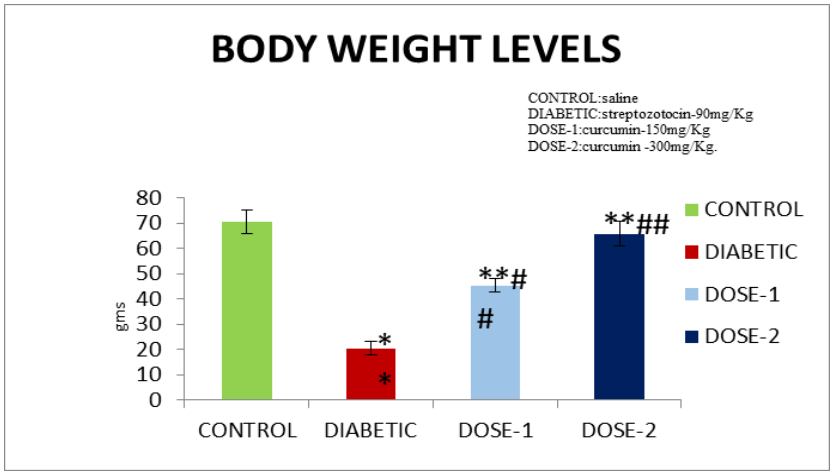

Fig. 1: Effect of curcumin on body weights in streptozotocin induced diabetic rats.

3.2 Effect on Blood Glucose and Insulin

Fasting blood glucose levels increased markedly in diabetic rats (221 ± 22.87 mg/dL) compared to controls (82.24 ± 8.34 mg/dL). Curcumin treatment reduced glucose levels significantly, with the 300 mg/kg group (97.3 ± 14.65 mg/dL) showing near-normal values. Serum insulin levels, reduced in diabetic rats, were significantly restored by curcumin treatment (Table 2, Figure 2).

Table 2: Effect of curcumin on glucose levels in streptozotocin-induced diabetic rats.

S. No	Groups	Treatment	Duration	Results
1	CONTROL	NS	30 Days	82.24±8.347
2	DIABETIC	STZ (90mg/Kg)	3 Days	221±22.87
3	Dose-1	Curcumin (150mg/Kg)	30 Days	147.66±9.342
4	Dose-2	Curcumin (300mg/Kg)	30 Days	97.3±14.65

Values are expressed as mean ± S.E.M. (n = 6). Statistical analysis was performed using one-way ANOVA followed by Dunnett's test.

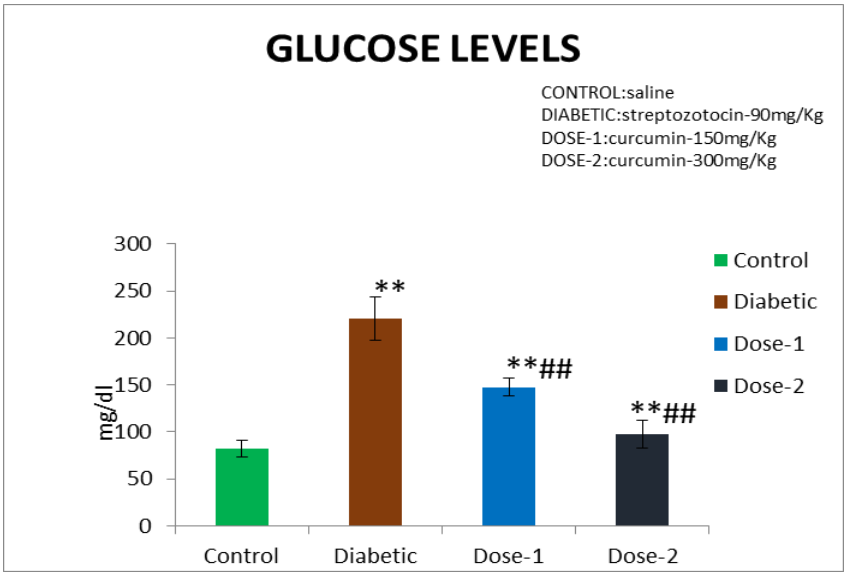

Fig. 2: Effect of Curcumin on glucose levels on streptozotocin induced diabetic rats.

3.3 Effect on Lipid Profile

Diabetic rats showed significant dyslipidemia, including increased cholesterol, triglycerides, and LDL-C, along with reduced HDL-C. Curcumin administration ameliorated these alterations in a dose-dependent manner, indicating hypolipidemic effects (Table 3, Figures 3–5).

Table: 3: Effect of Curcumin on insulin levels on streptozotocin induced diabetic rats.

S. No	Groups	Treatment	Duration	Results
1	Control	Normal Saline	30 Days	82.24±8.347
2	Diabetic	Streptozotocin(90mg/Kg)	3 Days	221±22.87
3	Dose-1	Curcumin (150mg/Kg)	30 Days	147.66±9.342
4	Dose-2	Curcumin (300mg/Kg)	30 Days	97.3±14.65

Values are expressed as mean ± S.E.M. (n = 6). Statistical analysis was performed using one-way ANOVA followed by Dunnett's test.

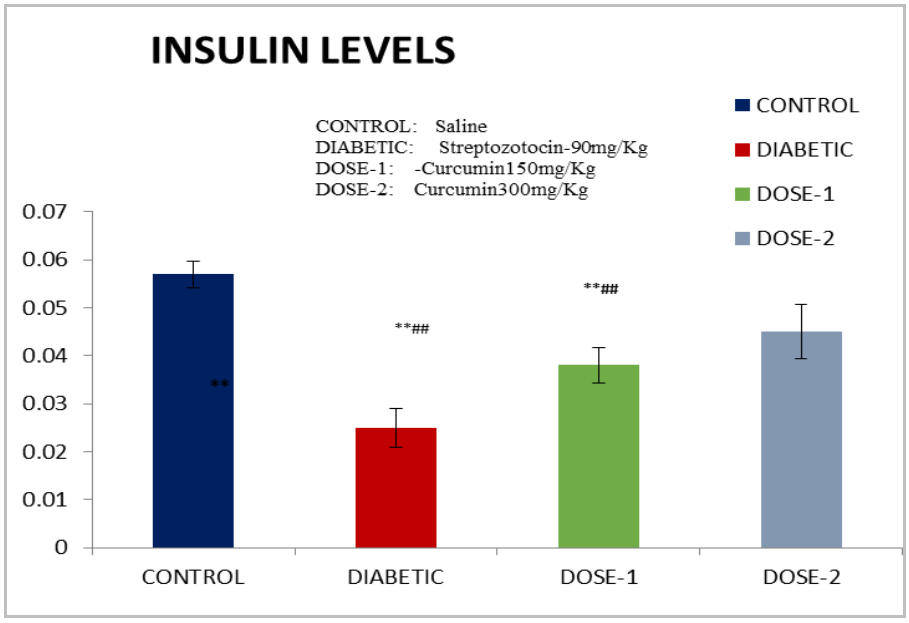

Fig. 3: Effect of Curcumin on insulin levels on streptozotocin induced diabetic rats.

Table 4: Effect of Curcumin on triglyceride levels in streptozotocin induced diabetic rats.

S. No	Groups	Treatment	Duration	Results
1	Control	Normal Saline	30 Days	41.4±1.301
2	Diabetic	Streptozotocin(90mg/Kg)	3 Days	88.74±2.536
3	Dose-1	Curcumin (150mg/Kg)	30 Days	72.27±1.224
4	Dose-2	Curcumin (300mg/Kg)	30 Days	58.8±1.573

Values are expressed as mean ± S.E.M. (n = 6). Statistical analysis was performed using one-way ANOVA followed by Dunnett's test.

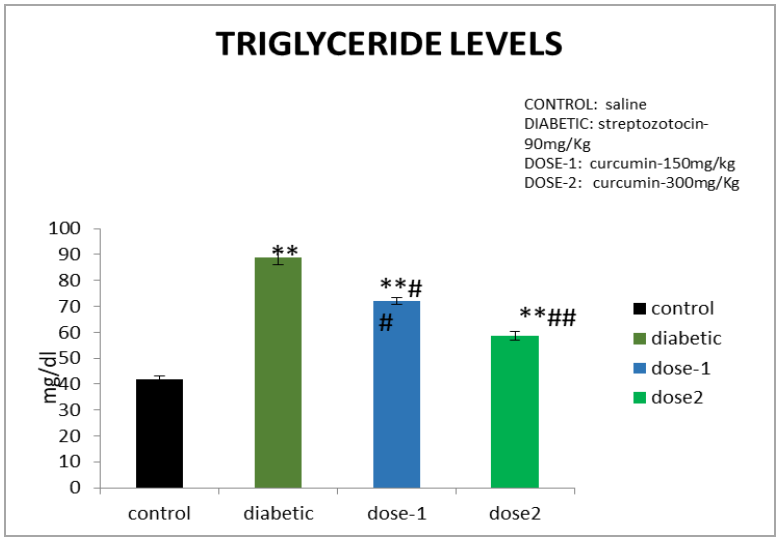

Fig. 4: Effect of Curcumin on TG levels on streptozotocin induced diabetic rats.

Table 5: Effect of Curcumin on LDL levels in streptozotocin-induced diabetic rats.

S.No	Groups	Treatment	Duration	Results
1	Control	Normal Saline	30 Days	88.21±1.956
2	Diabetic	Streptozotocin (90mg/Kg)	3 Days	124.34±2.547
3	Dose-1	Curcumin (150mg/Kg)	30 Days	99.92±2.126
4	Dose-2	Curcumin (300mg/Kg)	30 Days	87.51±1.934

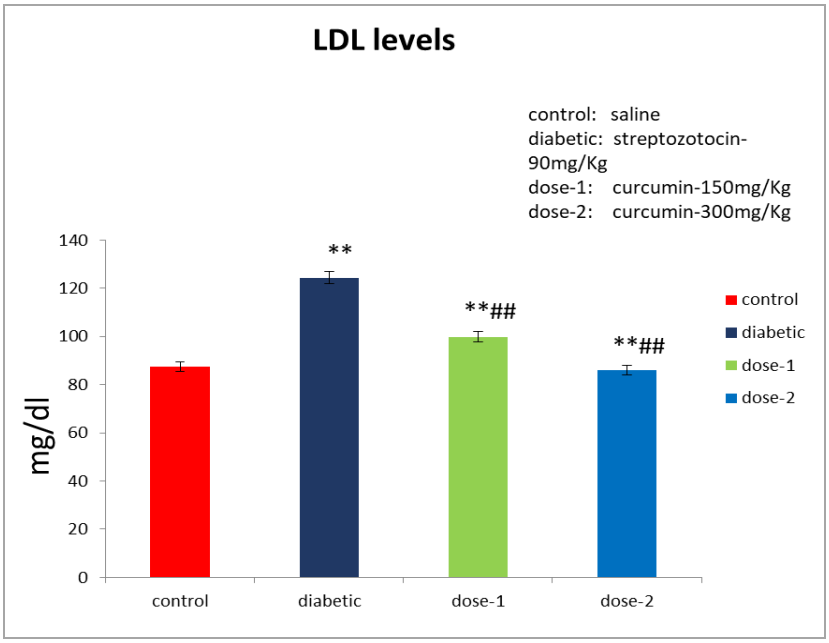

Fig. 5: Effect of Curcumin on LDL levels on streptozotocin induced diabetic rats.

Table 6: Effect of Curcumin on HDLlevels in streptozotocin induced diabetic rats.

S. No	Groups	Treatment	Duration	Results
1	Control	Normal Saline	30 Days	41.26±1.245
2	Diabetic	Streptozotocin (90mg/Kg)	3 Days	16.87±0.923
3	Dose-1	Curcumin (150mg/Kg)	30 Days	34.17±0.993
4	Dose-2	Curcumin (300mg/Kg)	30 Days	44.1±1.375

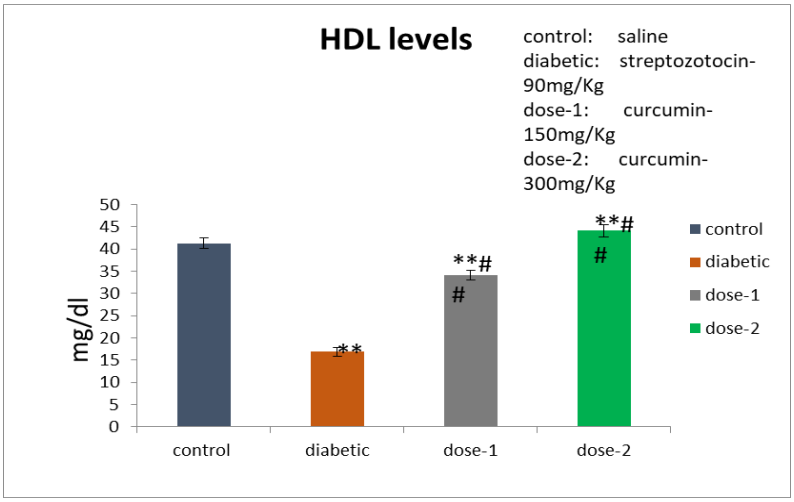

Fig. 6: Effect of Curcumin on HDL levels on streptozotocin induced diabetic rats.

3.4 Effect on Renal Markers

Serum urea and creatinine levels, as well as urinary microalbumin, were significantly elevated in diabetic controls. Curcumin-treated groups exhibited a marked reduction in these parameters, reflecting renoprotective potential (Table 4, Figures 6–8).

Table 7: Effect of Curcumin on urea levels in streptozotocin induced diabetic rats.

S. No.	Groups	Treatment	Duration	Results
1	Control	Normal Saline	30 Days	20.14±2.374
2	Diabetic	Streptozotocin(90mg/Kg)	3 Days	53.46±2.302
3	Dose-1	Curcumin (150mg/Kg)	30 Days	42.37±1.776
4	Dose-2	Curcumin (300mg/Kg)	30 Days	26.8±3.04

Values are expressed as mean ± S.E.M. (n = 6). Statistical analysis was performed using one-way ANOVA followed by Dunnett's test.

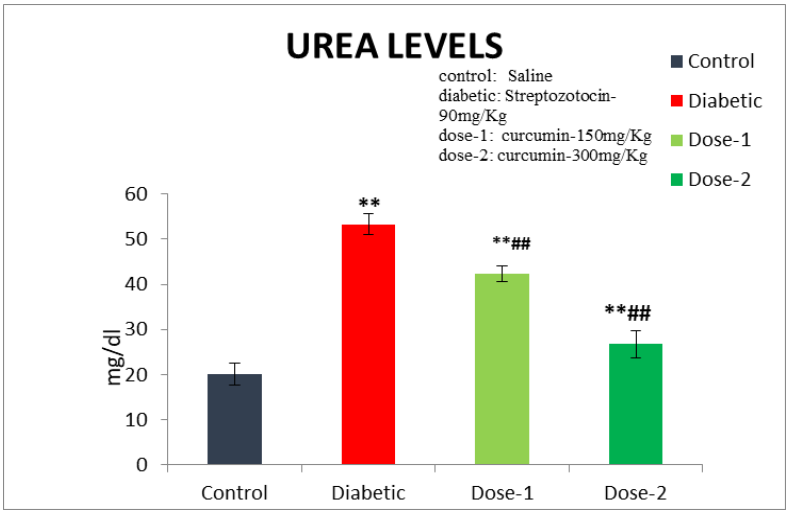

Fig. 7: Effect of curcumin on urea levels in streptozotocin induced diabetic rats.

4. DISCUSSION

The present study demonstrates the therapeutic efficacy of curcumin in alleviating multiple biochemical and histological disturbances associated with STZ-induced diabetes. Curcumin's hypoglycemic effect is likely mediated by enhancing insulin secretion or improving peripheral insulin sensitivity. The observed improvement in renal parameters supports its nephroprotective role, possibly through inhibition of oxidative stress-mediated damage.

The significant modulation of lipid profile parameters implies that curcumin may mitigate diabetes-related dyslipidemia. Elevated oxidative stress is a hallmark of diabetic pathology, and curcumin's potent antioxidant properties were evident from the restored levels of MDA, SOD, GSH, and CAT. The improvement in motor coordination suggests a broader neuroprotective potential, warranting further neurochemical studies.

Our histopathological analysis aligns with previous reports that highlight curcumin's ability to preserve tissue integrity under oxidative and inflammatory insults. Curcumin's multi-targeted actions make it a compelling candidate for adjunctive diabetes therapy. However, its limited bioavailability remains a challenge and should be addressed through novel formulations such as nanoparticles, liposomes, or adjuvants like piperine.

5. CONCLUSION

This study provides comprehensive evidence that curcumin exerts significant protective effects against STZ-induced diabetes in rats. It alleviates hyperglycemia, restores insulin and lipid profile, enhances antioxidant defenses, and prevents renal tissue damage. These findings underscore the potential of curcumin as a supportive therapy in diabetes management. Future studies should focus on enhancing bioavailability and evaluating long-term effects in clinical settings.

ACKNOWLEDGEMENT

The authors would like to thank Avanthi Institute of pharmaceutical sciences for supporting this work.

CONFLICT OF INTEREST

The authors do not have any conflicts of interest.

6. REFERENCES

1. Aggarwal, B. B., & Sung, B., Pharmacological basis for the role of curcumin in chronic diseases: An age-old spice with modern targets. *Trends in Pharmacological Sciences,* 2009; *30*(2): 85–94.
2. American Diabetes Association, 2. Classification and diagnosis of diabetes: Standards of medical care in diabetes-2019; *Diabetes Care*, *42*(Supplement 1): S13–S28.
3. Anand, P., Kunnumakkara, A. B., Newman, R. A., & Aggarwal, B. B., Bioavailability of curcumin: Problems and promises. *Molecular Pharmaceutics,* 2007; *4*(6): 807–818.
4. Balskus, E. P., et al., Biosynthesis of the DNA-damaging agent streptozotocin. *Nature Chemistry*, 2011; 3(10): 917-923.
5. Chuengsamarn, S., et al., Curcumin extract for prevention of type 2 diabetes. *Diabetes Care*, 2012; 35(11): 2121–2127.
6. Chuengsamarn, S., Rattanamongkolgul, S., Luechapudiporn, R., Phisalaphong, C., & Jirawatnotai, S., Curcumin extract for prevention of type 2 diabetes. *Diabetes Care*, 2012; *35*(11): 2121–2127.

7. Forbes, J. M., & Cooper, M. E., Mechanisms of diabetic complications. *Physiological Reviews*, *93*(1), 137–188. https://doi.org/10.1152/physrev.00045.2011
8. Hewlings, S. J., & Kalman, D. S., Curcumin: A review of its effects on human health. *Foods*, 2017; 6(10): 92.
9. Hewlings, S. J., & Kalman, D. S., Curcumin: A review of its effects on human health. *Foods*, 2017; *6*(10): 92.
10. International Diabetes Federation, *IDF Diabetes Atlas* (10th ed.). Brussels, Belgium: International Diabetes Federation, 2021 Retrieved from https://www.diabetesatlas.org
11. Lenzen, S., The mechanisms of alloxan- and streptozotocin-induced diabetes. *Diabetologia*, 2008; *51*(2): 216–226.
12. Marton, L. T., et al., The effects of curcumin on diabetes mellitus: A systematic review. *Frontiers in Pharmacology*, 2021; 12: 675197.
13. Marton, L. T., Goulart, R. A., Carvalho, A. C. A., Barbalho, S. M., & Sloan, K. P., Curcumin and diabetes mellitus: From basic to clinical evidence. *Current Topics in Medicinal Chemistry*, 2021; *21*(14): 1237–1250.
14. Pivari, F., et al., Curcumin and type 2 diabetes mellitus: Prevention and treatment. *Nutrients*, 2019; 11(8): 1837.
15. Powers, A. C., & D'Alessio, D., Endocrine pancreas and pharmacotherapy of diabetes mellitus and hypoglycemia. In L. L. Brunton, R. Hilal-Dandan, & B. C. Knollmann (Eds.), *Goodman & Gilman's The Pharmacological Basis of Therapeutics*, 2018; (13th ed., pp. 705–747). New York, NY: McGraw-Hill Education.
16. Quispe, C., et al., Therapeutic applications of curcumin in diabetes: A review and perspective. *Pharmaceuticals*, 2022; 15(2): 219.
17. Saeedi, P., Petersohn, I., Salpea, P., Malanda, B., Karuranga, S., Unwin, N., ... Williams, R., Global and regional diabetes prevalence estimates for 2019 and projections for 2030 and 2045: Results from the International Diabetes Federation Diabetes Atlas, 9th edition. *Diabetes Research and Clinical Practice*, 2019; *157*: 107843.
18. Zhang, D. W., Fu, M., Gao, S. H., & Liu, J. L., Curcumin and diabetes: A systematic review. *Evidence-Based Complementary and Alternative Medicine*, 2013; 2013: 636053.
19. Zimmet, P., Alberti, K. G. M. M., & Shaw, J., Global and societal implications of the diabetes epidemic. *Nature*, 2016; *414*(6865): 782–787.