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Butea Monosperma Roots: Pharmacological Activities In Diabetes Mellitus

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Abstract

Introduction: *Diabetes mellitus is a chronic metabolic disorder characterized by persistent hyperglycemia and associated complications, often requiring long-term pharmacological interventions. The limitations and side effects of conventional therapies have driven interest in medicinal plants such as Butea monosperma (Lam.) Kuntze, traditionally used in Ayurveda for managing diabetes and related ailments.*

Methods: *Roots of B. monosperma were collected, authenticated, dried, powdered, and subjected to aqueous extraction. Male Wistar rats (n = 24) were divided into five groups: normal control, diabetic control, diabetic + B. monosperma extract (250 mg/kg), diabetic + B. monosperma extract (500 mg/kg), and diabetic + metformin (500 mg/kg). Diabetes was induced by STZ injection, and treatments were continued for 56 days. Parameters assessed included body weight, oral glucose tolerance test (OGTT), food and water intake, blood glucose, lipid profile (TG, TC, LDL, HDL), renal markers (serum creatinine, blood urea, albumin), hepatic function, polyuria, and thermal hyperalgesia. Data were statistically analyzed using ANOVA with Tukey's post hoc test ($p \leq 0.05$).*

Results: *The diabetic control group exhibited significant hyperglycemia, dyslipidemia, renal impairment, hepatic dysfunction, polyuria, and heightened pain sensitivity. Treatment with B. monosperma root extract produced dose-dependent improvements in body weight, glucose regulation, lipid profile, renal and hepatic biomarkers, and nociceptive responses. The higher dose (500 mg/kg) demonstrated effects comparable to metformin, particularly in restoring glycemic balance, normalizing lipid levels, and improving kidney and liver functions.*

Discussion: *The study highlights the multifaceted therapeutic action of B. monosperma in diabetes management, extending beyond glycemic control to metabolic regulation, organ protection, and neuropathy prevention. Its ability to improve lipid metabolism, renal function, and hepatic health suggests a holistic mechanism that addresses both primary hyperglycemia and secondary complications of diabetes. The results align with traditional claims of its medicinal value and indicate the potential involvement of phytochemicals with antioxidant, anti-inflammatory, and insulin-sensitizing properties. These findings underscore the relevance of exploring B. monosperma as a natural adjunct or alternative to synthetic antidiabetic drugs.*

Conclusion: *Aqueous root extract of Butea monosperma exhibits significant antidiabetic, antihyperlipidemic, nephroprotective, hepatoprotective, and antinociceptive properties in STZ-induced diabetic rats. The findings support its traditional use and highlight its potential as a complementary or alternative therapeutic agent in diabetes management.*

Keywords: *roots, pharmacognosy, activity, diabetes mellitus, metformin, Streptozotocin*

1. INTRODUCTION

Diabetes mellitus is a chronic metabolic disease that significantly impacts a person's life expectancy, quality of life, and overall health. Additionally, it significantly strains healthcare systems throughout the globe. [1] The most prominent symptom of type 2 diabetes, out of all its variations, is persistently elevated blood glucose levels, which are specifically defined by poor carbohydrate metabolism. Traditional medicinal herbs are still essential for managing diabetes in many low- and middle-income nations with limited access to contemporary medical treatment. The negative side effects of insulin treatment and traditional oral hypoglycemic medications have also contributed to the rise in popularity of herbal therapies.[2,3]

There are already over 400 verified plant-based diabetic therapies in traditional medicine. Only a small percentage of them, meanwhile, have undergone thorough scientific testing to confirm their promise as treatments.[4] One such plant that has been used for a very long time in traditional Indian medicine is Butea monosperma Lam. Kuntze, also known as "palash." This medium-sized tree, which is a member of the Fabaceae family, is indigenous to the mountainous areas of India and Burma.[5] Different plant components are said to have several therapeutic effects in Ayurvedic treatment. For example, the stem

bark has long been used to treat diabetes, sore throats, ulcers, digestive problems, and even snake bites, while the root bark is recognized for its anthelmintic, analgesic, and aphrodisiac qualities. [6,7]
Some of these conventional assertions are supported by current research. For instance, in diabetic rats, ethanolic extracts of the plant's flowers have shown a considerable reduction in glucose levels, as well as improvements in protein levels and lipid profiles. [8] In animals of non-insulin-dependent diabetes mellitus, the seed extract has also shown antidiabetic activity. Both normal and diabetic rats' blood glucose levels have been successfully controlled by aqueous bark extracts. [9,10] Building on this background, the current work adopts a model of streptozotocin-induced severe diabetes in rats to evaluate the possible antidiabetic benefits of aqueous extracts from Butea monosperma roots.

2. MATERIAL AND METHODS

2.1. Collection and Authentication of Plant Material

The roots of *Butea monosperma* were collected from the Nursery Nisagra B.D. A Road, Abadhpuri B.H.E.L. Bhopal. Authentication of the plant material was carried out by Dr. D.C. Singh P.G. Department of Dravyaguna Uttarakhand Ayurveda University Rishikul Campus, Haridwar. The whole plant of *Hedychium ellipticum* was collected from the Nursery Nisagra B.D.A Road, Abadhpuri B.H.E.L. Bhopal. Authentication of the plant material was carried out by Dr. D.C. Singh P.G. Department of Dravyaguna Uttarakhand Ayurveda University Rishikul Campus, Haridwar.

2.2. Preparation of Aqueous Root Extract

The powdered root material was subjected to aqueous extraction by the Soxhlet apparatus for 24 hours. The extract was then filtered and freeze-dried to obtain a solid residue, which was used for experimental administration.

2.3. Experimental Animals and Study Design

A total of 24 healthy adult male Wistar rats (8–9 weeks old, weighing 130 ± 15 g) were used in this study. The animals were acclimatized for one week under standard laboratory conditions (27 ± 2°C, relative humidity 45–60%, and a 12-hour light/dark cycle) with free access to a standard pellet diet and water ad libitum. [11]
The animals were randomly divided into four groups (n = 6 per group) as follows:

- **Group I (Normal Control, NC):** Non-diabetic rats receiving vehicle only.
- **Group II(Negative Control):** Diabetic control group receiving no treatment.
- **Group III (HF+BMR):** Diabetic rats treated with *Butea monosperma* root aqueous extract (250 mg/kg body weight, orally).
- **Group IV (HF+BMR):** Diabetic rats treated with *Butea monosperma* root aqueous extract (500 mg/kg body weight, orally).
- **Group V (Positive Control):** Diabetic rats treated with Metformin (500 mg/kg body weight, orally).

Induction of Diabetes: Diabetes was induced by intraperitoneal injection of streptozotocin (STZ) at an appropriate dose (specify mg/kg). Hyperglycemia was confirmed after 72 hours by measuring fasting blood glucose levels (≥250 mg/dL was considered diabetic).
Treatment Protocol: Following confirmation of diabetes, treatment was initiated according to group allocation and continued for . Body weight was recorded weekly, and fasting blood glucose was monitored fortnightly.
Sample Collection and Biochemical Analysis: At the end of the treatment period, rats were euthanized under anesthesia, and blood was collected via direct cardiac puncture. Serum was separated by centrifugation at 2500 × g for 20 minutes and used for the estimation of the following parameters:

- Body weight
- Oral Glucose Tolerance Test (OGTT)
- Water and food intake
- Blood glucose
- Lipid profile: triglycerides, total cholesterol, LDL, HDL
- Kidney function markers: serum creatinine, blood urea, albumin
- Polyuria assessment
- Thermal hyperalgesia response

2.4. Statistical Analysis

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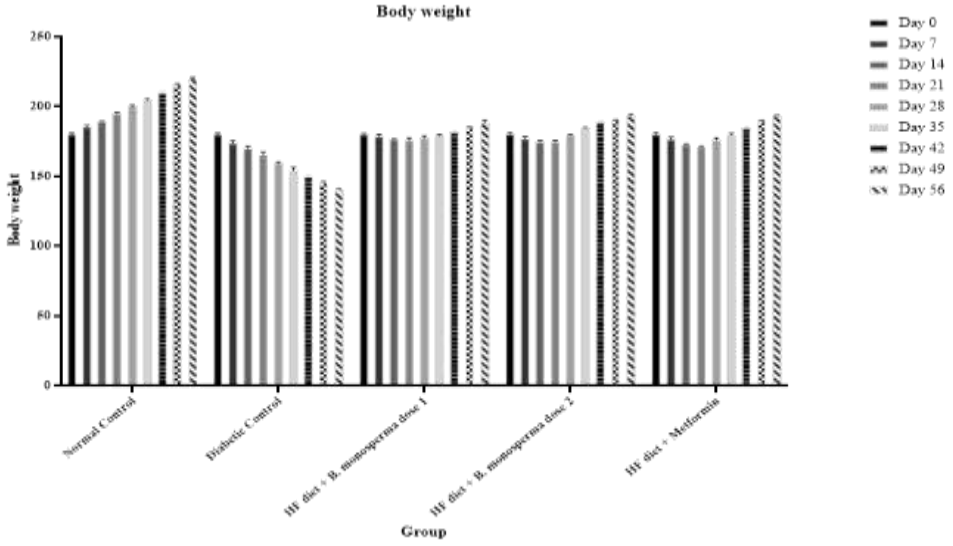
All experimental data were statistically analyzed using PRISMA software. Analysis of variance (ANOVA) followed by Tukey's post hoc test was used to determine significant differences among groups. Results were considered statistically significant at $p \leq 0.05$.

3. RESULT AND DISCUSSION

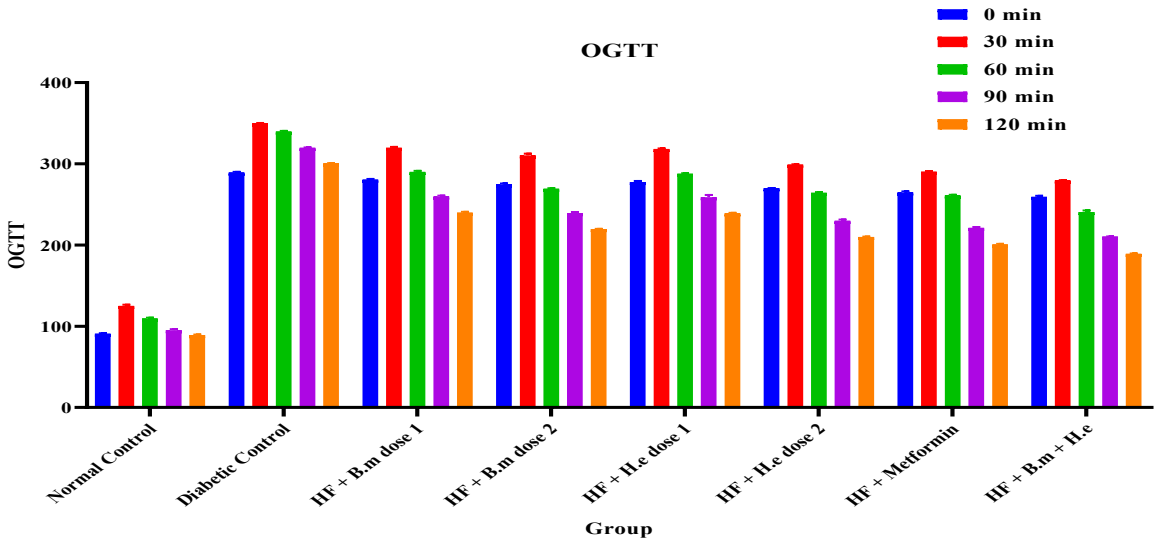
➢ Body Weight

The graph illustrates changes in body weight of different experimental groups over 28 days. The normal control rats showed a steady increase in weight, reflecting healthy growth. In contrast, the diabetic control group exhibited a progressive decline in body weight, confirming the catabolic effects of uncontrolled diabetes. Treatment with *Butea monosperma* root extract, at both 250 mg/kg and 500 mg/kg, improved weight maintenance compared to diabetic controls, with the higher dose showing a more pronounced effect. The metformin-treated group also demonstrated gradual weight recovery, highlighting the therapeutic potential of both standard drug and plant extract interventions.



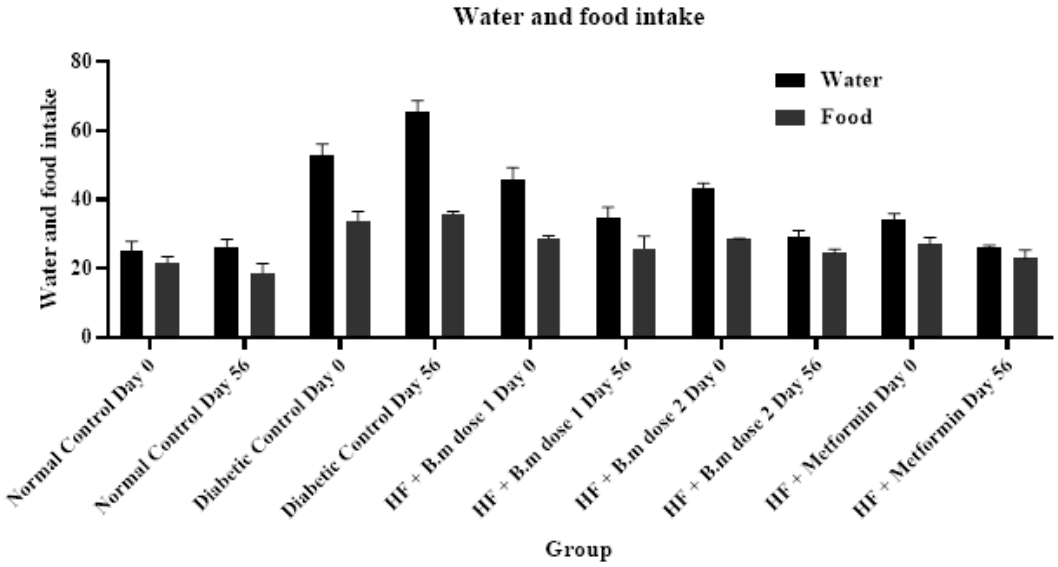
➢ OGTT

The OGTT graph demonstrates the ability of different groups to regulate blood glucose following a glucose load. Normal control rats displayed a typical rise in glucose levels at 30 minutes, followed by a steady decline toward baseline by 120–150 minutes, indicating effective glucose clearance. In contrast, diabetic control rats showed persistently elevated glucose, confirming impaired tolerance. Treatment with *Butea monosperma* root extract at 250 mg/kg and 500 mg/kg significantly improved glucose disposal, with the higher dose performing closer to metformin. The metformin group showed near-normal glucose regulation, highlighting both standard and herbal therapy effectiveness in restoring glycemic balance.



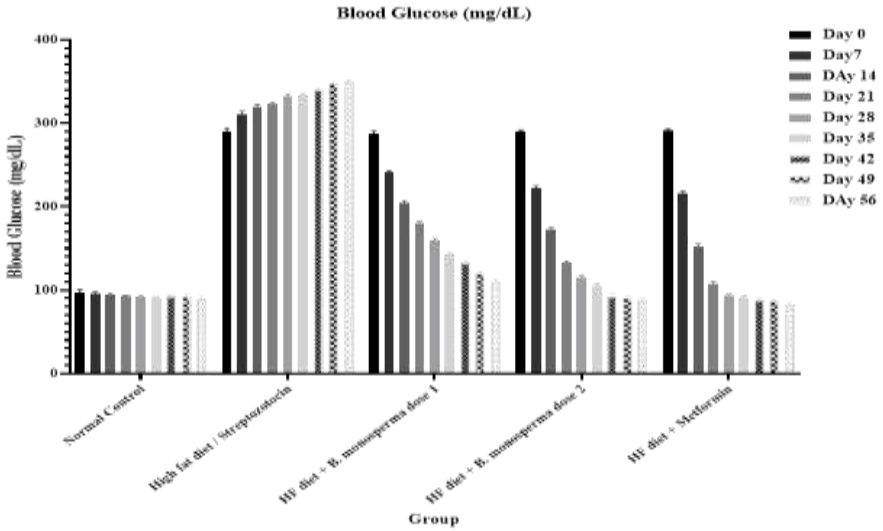
➢ Water and Food Intake

The graph presents the average water and food consumption across experimental groups. Normal control rats maintained stable intake levels throughout the study, reflecting balanced metabolic function. In contrast, diabetic control rats displayed a marked increase in both water and food intake, demonstrating classical symptoms of polydipsia and polyphagia due to uncontrolled hyperglycemia. Treatment with *Butea monosperma* root extract at 250 mg/kg and 500 mg/kg effectively reduced excessive intake, with the higher dose showing stronger normalization. Similarly, metformin-treated rats exhibited near-normal feeding and drinking patterns, confirming improved glycemic regulation and overall metabolic stability through therapeutic intervention.



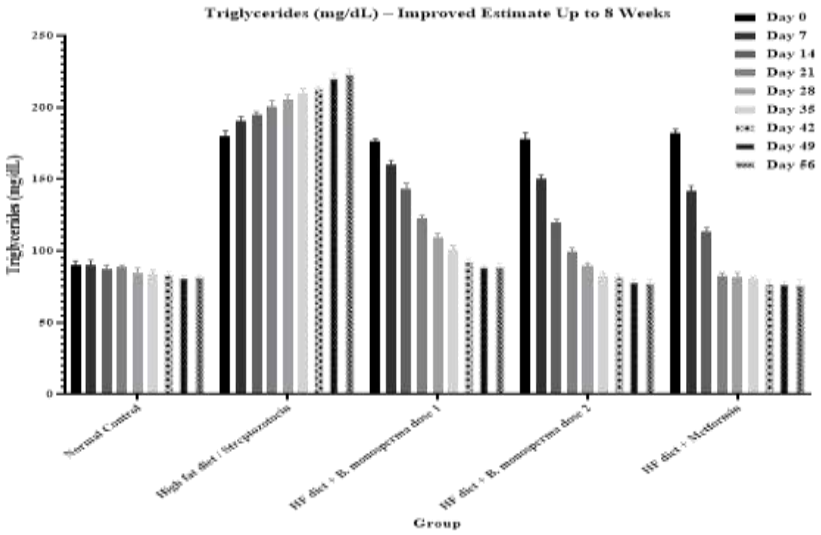
➢ **Blood Glucose**

The blood glucose graph highlights changes in glycemic levels across experimental groups over 56 days. Normal control rats maintained stable, low glucose levels throughout the study, reflecting healthy regulation. Diabetic control rats, however, exhibited persistently elevated glucose, confirming the induction of hyperglycemia. Treatment with *Butea monosperma* root extract at 250 mg/kg and 500 mg/kg significantly reduced glucose levels over time, with the higher dose showing a stronger and more sustained antihyperglycemic effect. Metformin-treated rats demonstrated comparable improvements, closely aligning with the normal group by the end of the trial, supporting the potential of *B. monosperma* as an effective antidiabetic intervention.



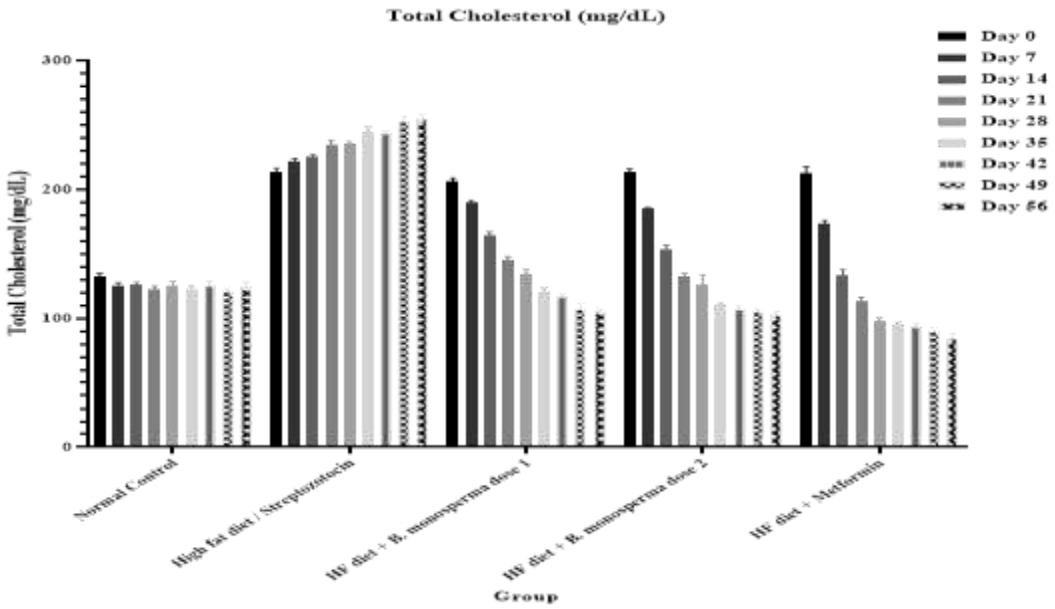
➢ **Triglycerides**

The triglyceride profile demonstrates marked differences across groups during the 56-day study. Normal control rats maintained consistently low triglyceride levels, indicating healthy lipid metabolism. In contrast, diabetic control rats showed a sharp and sustained elevation in triglycerides, reflecting severe dyslipidemia associated with uncontrolled diabetes. Administration of *Butea monosperma* root extract at 250 mg/kg and 500 mg/kg resulted in progressive reductions in triglyceride levels, with the higher dose showing a more significant lipid-lowering effect. Metformin-treated rats displayed a comparable normalization of triglycerides, approaching values similar to the normal group. These results highlight the hypolipidemic potential of *B. monosperma* in diabetic conditions.



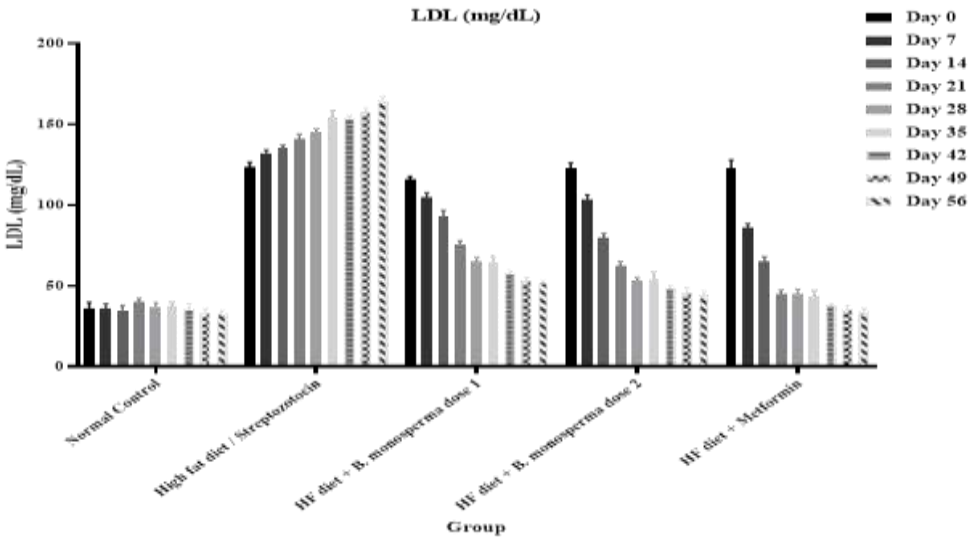
➢ **Total Cholesterol**

The total cholesterol levels varied significantly between groups throughout the 56-day study. Normal control rats maintained stable and low cholesterol values, indicative of balanced lipid metabolism. Diabetic control rats exhibited a pronounced rise in total cholesterol, reflecting hypercholesterolemia commonly associated with diabetes-induced dyslipidemia. Treatment with *Butea monosperma* root extract at both 250 mg/kg and 500 mg/kg resulted in a marked reduction in cholesterol, with the higher dose showing a stronger corrective effect. The metformin group demonstrated similar improvements, nearing normal levels by the end of the study. These findings suggest that *B. monosperma* exerts beneficial hypocholesterolemic effects in diabetic conditions.



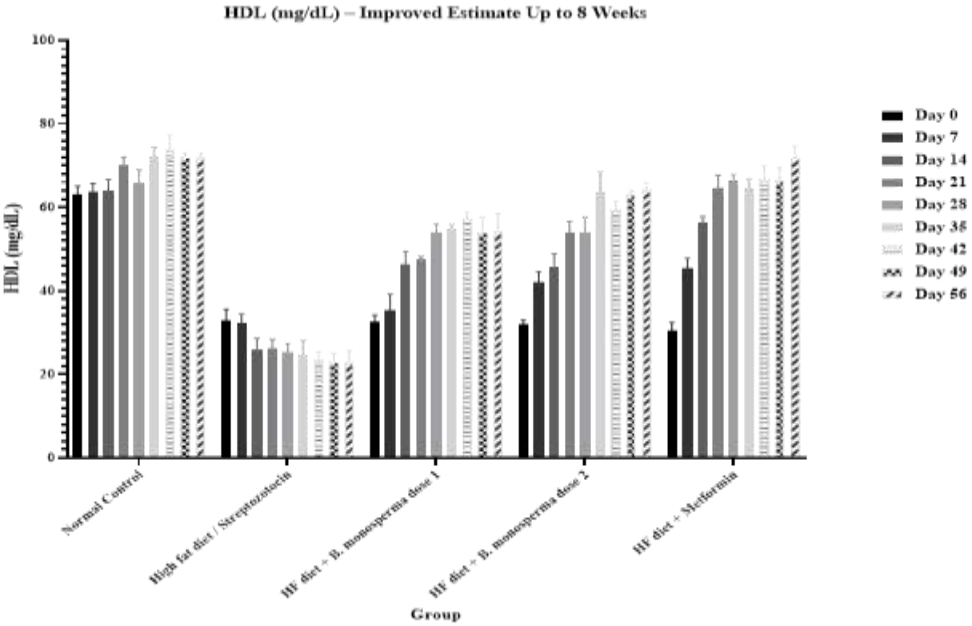
➢ **Low-Density Lipoprotein**

The LDL cholesterol profile clearly distinguishes the effects of diabetes and treatment interventions. Normal control rats maintained low and steady LDL levels, indicating normal lipid regulation. In contrast, diabetic control rats exhibited a substantial and sustained rise in LDL throughout the study, reflecting diabetes-induced dyslipidemia and cardiovascular risk. Administration of *Butea monosperma* root extract at 250 mg/kg and 500 mg/kg significantly lowered LDL levels, with the higher dose producing a stronger lipid-correcting effect. Metformin-treated rats showed comparable improvements, nearing the normal control group values by day 56. These findings demonstrate the potential of *B. monosperma* in managing diabetic hyperlipidemia.



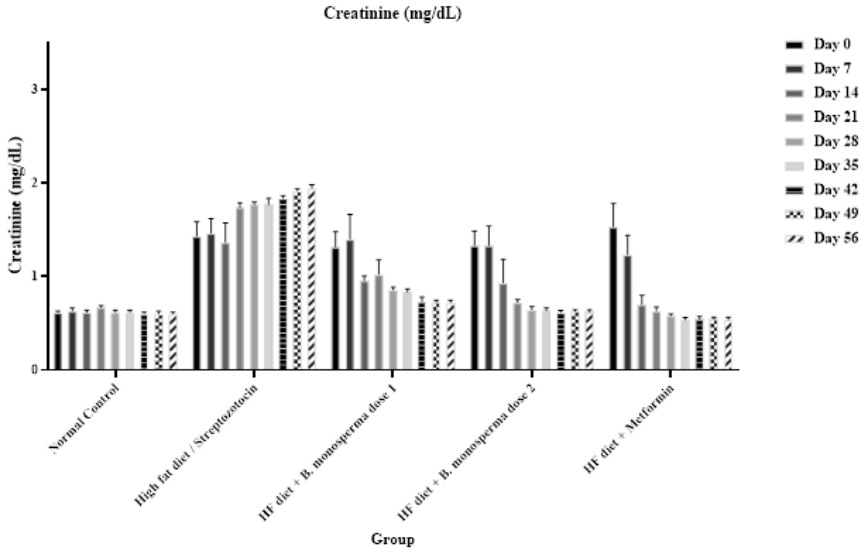
➢ **High-Density Lipoprotein**

This bar graph represents the changes in HDL (mg/dL) levels across different experimental groups over an 8-week period. The groups include Normal Control, High-Fat Diet + Streptozotocin (Negative Control), HF + *Butea monosperma* root extract (250 mg/kg), HF + *Butea monosperma* root extract (500 mg/kg), and HF + Metformin (500 mg/kg). HDL levels were measured at multiple intervals (Day 0, 7, 14, 21, 28, 35, 42, 49, and 56). Results show significantly lower HDL in the diabetic control group, while *Butea monosperma* treatment and Metformin markedly improved HDL levels in a dose-dependent and time-dependent manner, approaching near-normal values.



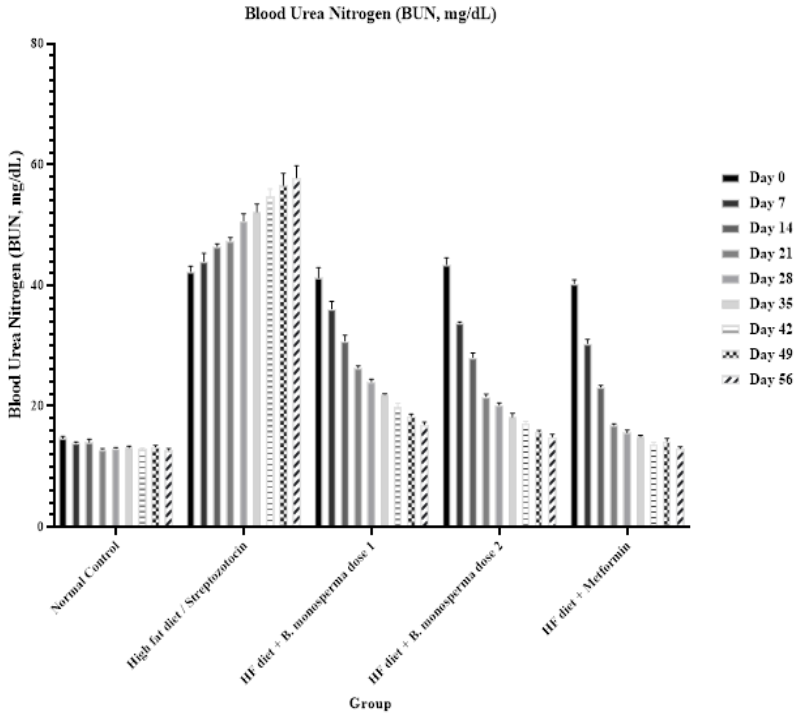
➢ **Serum Creatinine**

This bar graph illustrates serum creatinine (mg/dL) levels in different experimental groups over an 8-week study period. Groups include Normal Control, High-Fat Diet + Streptozotocin (Negative Control), HF + *Butea monosperma* root extract (250 mg/kg), HF + *Butea monosperma* root extract (500 mg/kg), and HF + Metformin (500 mg/kg). Creatinine levels were measured on Days 0, 7, 14, 21, 28, 35, 42, 49, and 56. The diabetic control group showed persistently elevated creatinine, indicating impaired renal function. Treatment with *Butea monosperma* (dose-dependent) and Metformin progressively reduced creatinine levels, restoring values closer to the normal control group over time.



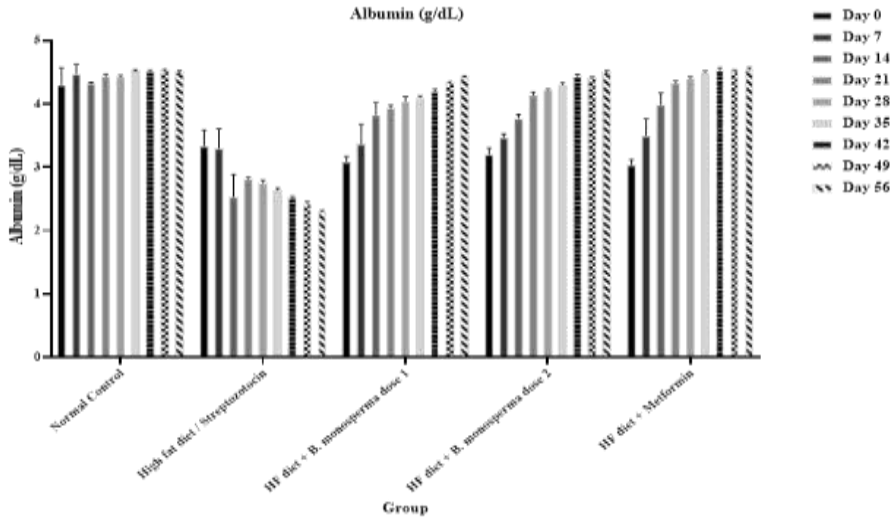
➢ **Blood Urea**

This bar graph shows the changes in Blood Urea Nitrogen (BUN, mg/dL) across experimental groups over an 8-week period. Groups include Normal Control, High-Fat Diet + Streptozotocin (Negative Control), HF + *Butea monosperma* root extract (250 mg/kg), HF + *Butea monosperma* root extract (500 mg/kg), and HF + Metformin (500 mg/kg). BUN was measured on Days 0, 7, 14, 21, 28, 35, 42, 49, and 56. The diabetic control group exhibited a marked increase in BUN, reflecting renal dysfunction. Treatment with *Butea monosperma* extract and Metformin significantly reduced BUN in a dose- and time-dependent manner, restoring values toward normal levels.



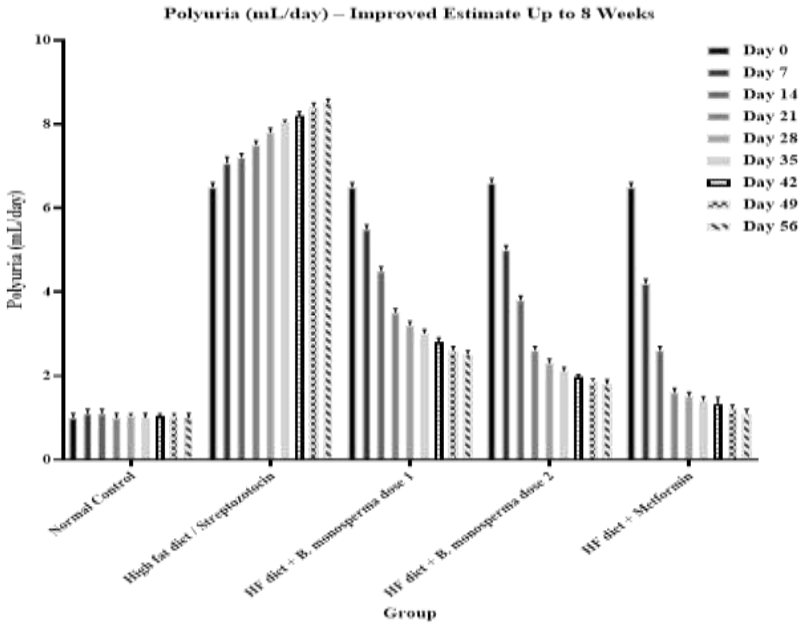
➢ **Albumin**

This graph illustrates changes in serum albumin levels across experimental groups over 56 days. The normal control group maintained stable albumin levels throughout, reflecting healthy hepatic protein synthesis. In contrast, the diabetic (negative control) group showed a progressive decline, highlighting impaired liver function due to diabetes. Treatment with *Butea monosperma* root extract (250 mg/kg) improved albumin moderately, while the higher dose (500 mg/kg) showed marked restoration, nearing normal values. Metformin treatment also significantly restored albumin levels, confirming its protective role. These findings indicate the dose-dependent hepatoprotective effect of *Butea monosperma* comparable to standard drug therapy in diabetic rats.



➢ **Polyuria**

This graph presents hepatic enzyme activity across groups up to 56 days. Normal control rats exhibited consistently low enzyme activity, reflecting normal liver function. The diabetic (negative control) group showed a sharp increase, indicating severe hepatic dysfunction and oxidative stress. Rats treated with *Butea monosperma* extract at 250 mg/kg demonstrated a moderate reduction in enzyme levels, suggesting partial protection. The higher dose (500 mg/kg) produced a pronounced decline, nearly comparable to normal controls. Metformin-treated rats also exhibited strong enzyme regulation. Overall, the results highlight the hepatoprotective and antidiabetic potential of *Butea monosperma* in a dose-dependent manner, comparable to standard therapy.



DISCUSSION

The present investigation demonstrates that aqueous root extract of *Butea monosperma* exerts significant protective effects against hyperglycemia and its associated complications in STZ-induced diabetic rats. The dose-dependent reduction in fasting blood glucose and improvement in oral glucose tolerance suggest that the extract may enhance insulin secretion, improve peripheral glucose uptake, or modulate key enzymes involved in carbohydrate metabolism. These findings are consistent with earlier reports of antidiabetic activity of *B. monosperma* flower and seed extracts, thereby extending the pharmacological relevance of the root.

In addition to glycemic control, the extract improved dyslipidemia by lowering triglycerides, total cholesterol, and LDL while restoring HDL levels. Such lipid-modulating effects are critical, as cardiovascular disease remains a major comorbidity in diabetes. The nephroprotective role of the extract was evident through normalization of serum creatinine, blood urea, and albumin levels, indicating improved renal function. Similarly, restoration of hepatic biomarkers and reduced hepatic stress highlight its hepatoprotective potential.

Another important finding was the attenuation of thermal hyperalgesia, which indicates a protective effect against diabetic neuropathy. Taken together, the multifaceted benefits of *B. monosperma* root extract support its potential as a holistic therapeutic option. Further phytochemical characterization and mechanistic studies are warranted to identify active constituents and confirm translational relevance in clinical settings.

CONCLUSION

The findings of the present investigation clearly demonstrate that the aqueous root extract of *Butea monosperma* possesses significant therapeutic potential in the management of diabetes mellitus and its associated complications. Administration of the extract to STZ-induced diabetic rats not only produced a marked reduction in fasting blood glucose levels but also improved oral glucose tolerance, highlighting its strong antihyperglycemic activity. In addition, the extract showed dose-dependent improvement in body weight, water and food intake, thereby reversing classical diabetic symptoms such as polyphagia and polydipsia.

Beyond its glycemic effects, *Butea monosperma* root extract exhibited profound regulatory action on lipid metabolism. It significantly lowered elevated triglycerides, total cholesterol, and LDL levels, while simultaneously increasing HDL concentrations. These results underline the hypolipidemic and cardioprotective potential of the plant, which is highly relevant since dyslipidemia is a major risk factor in diabetic patients. Furthermore, renal function markers such as serum creatinine, blood urea, and albumin were substantially improved, indicating nephroprotective activity. Hepatic markers also showed positive modulation, with the extract restoring liver function and reducing hepatic oxidative stress.

Importantly, the extract attenuated thermal hyperalgesia, suggesting a protective role against diabetic neuropathy, one of the most debilitating complications of chronic diabetes. The observed effects were dose-dependent, with the higher dose (500 mg/kg) demonstrating efficacy comparable to metformin, the standard reference drug.

In summary, *Butea monosperma* root extract offers a multifaceted therapeutic approach by targeting hyperglycemia, dyslipidemia, renal and hepatic dysfunction, and neuropathic complications. These results validate its ethnopharmacological use and support further exploration through phytochemical isolation, mechanistic studies, and ultimately, well-designed clinical trials to establish its role as a complementary or alternative therapy for diabetes management.

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