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Antidiabetic Potential of Methanolic Leaf Extract of Lagerstroemia parviflora Roxb. in Streptozotocin-Induced Diabetic Wistar Rats

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ABSTRACT:

Background: Diabetes mellitus is a chronic metabolic disorder characterized by persistent hyperglycemia resulting from impaired insulin secretion, insulin resistance, or both. Although several synthetic antidiabetic drugs are available, their long-term use may be associated with adverse effects, prompting the search for safer plant-based therapeutic alternatives.

Aim: The present investigation aimed to evaluate the antidiabetic efficacy of the methanolic leaf extract of Lagerstroemia parviflora Roxb. (MELP) in streptozotocin (STZ)-induced diabetic Wistar albino rats.

Materials and Methods: Diabetes was induced by intraperitoneal administration of streptozotocin (55 mg/kg). Experimental animals were allocated into normal, diabetic control, standard drug, and extract-treated groups. Methanolic extract of L. parviflora was administered orally at doses of 200 and 300 mg/kg body weight for 21 days. Biochemical investigations included fasting blood glucose, oral glucose tolerance, body weight, serum lipid profile, liver function markers (SGOT and SGPT), alkaline phosphatase, total protein, albumin, and other relevant biochemical parameters. Acute oral toxicity was evaluated according to OECD Guideline 423.

Results: Oral administration of MELP produced a significant reduction in fasting blood glucose levels compared with diabetic control animals. Treatment also improved body weight and corrected diabetes-associated dyslipidemia by lowering total cholesterol, triglycerides, and LDL cholesterol while increasing HDL cholesterol. Furthermore, serum SGOT and SGPT activities were significantly reduced, suggesting improvement in hepatic function. No mortality or treatment-related toxic effects were observed during acute toxicity assessment up to 3000 mg/kg.

Conclusion: The methanolic extract of Lagerstroemia parviflora leaves demonstrated significant antihyperglycemic and antihyperlipidemic activities in streptozotocin-induced diabetic rats. The extract also exhibited hepatoprotective properties and showed an acceptable safety profile. These findings support the traditional medicinal use of L. parviflora and indicate its potential as a natural therapeutic candidate for diabetes management. Further studies are required to isolate the active phytoconstituents and elucidate their mechanisms of action.

Keywords: Lagerstroemia parviflora, Diabetes mellitus, Streptozotocin, Antidiabetic activity, Herbal medicine, Hyperglycemia, Lipid profile, Hepatoprotection.

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INTRODUCTION:

Diabetes mellitus is one of the most prevalent endocrine disorders worldwide and represents a major public health challenge. The disease is characterized by chronic hyperglycemia resulting from defects in insulin secretion, insulin action, or both. Persistent elevation of blood glucose levels contributes to metabolic disturbances involving carbohydrate, lipid, and protein metabolism, ultimately leading to long-term complications affecting the cardiovascular system, kidneys, liver, nervous system, and retina.

Type 1 diabetes mellitus develops primarily because of autoimmune destruction of pancreatic β-cells, resulting in absolute insulin deficiency. In contrast, Type 2 diabetes mellitus is mainly associated with insulin resistance accompanied by progressive impairment of pancreatic β-cell function. The increasing prevalence of obesity, sedentary lifestyles, unhealthy dietary habits, and aging populations has contributed substantially to the global burden of Type 2 diabetes.

Although several oral hypoglycemic agents and insulin preparations are available, their prolonged administration may produce adverse effects such as hypoglycemia, gastrointestinal discomfort, hepatic dysfunction, weight gain, and reduced patient compliance. Consequently, medicinal plants have gained increasing attention as potential sources of safer and more effective antidiabetic agents.

Lagerstroemia parviflora Roxb., belonging to the family Lythraceae, has been traditionally employed in indigenous medicine for the treatment of various ailments. Previous phytochemical investigations have revealed the presence of bioactive constituents including flavonoids, tannins, phenolic compounds, glycosides, and triterpenoids, many of which possess antioxidant and antihyperglycemic properties. Nevertheless, scientific evidence supporting its antidiabetic activity remains limited.

Experimental diabetes induced by streptozotocin is a widely accepted animal model for evaluating potential antidiabetic agents because it closely resembles several biochemical and physiological abnormalities observed in human diabetes. Therefore, the present investigation was designed to evaluate the antihyperglycemic and hypolipidemic effects of the methanolic leaf extract of Lagerstroemia parviflora in streptozotocin-induced diabetic Wistar rats

AIM AND OBJECTIVES

To evaluate the antidiabetic activity of the methanolic leaf extract of Lagerstroemia parviflora Roxb. in streptozotocin-induced diabetic Wistar albino rats.

Objectives

To prepare the methanolic extract from the leaves of Lagerstroemia parviflora Roxb.

To assess the acute oral toxicity of the methanolic extract following OECD Guideline 423.

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To investigate the effect of the extract on fasting blood glucose levels in STZ-induced diabetic rats.

To evaluate changes in body weight following treatment.

To determine the effect of the extract on serum lipid parameters, including total cholesterol, triglycerides, HDL, and LDL cholesterol.

To evaluate liver function biomarkers such as SGOT, SGPT, and alkaline phosphatase.

To compare the therapeutic efficacy of the plant extract with the standard antidiabetic drug.

To establish the potential of Lagerstroemia parviflora as a natural antidiabetic agent for future pharmacological development

MATERIALS AND METHODS

Plant Material Collection and Authentication

Fresh leaves of Lagerstroemia parviflora Roxb. were collected from the Bhimbetka forest region, Bhojpur, Bhopal, Madhya Pradesh, India, during October 2019. The collected plant material was identified based on its morphological and organoleptic characteristics and authenticated by a qualified taxonomist at the Council of Scientific and Industrial Research (CSIR), New Delhi. A voucher specimen was deposited for future reference. The leaves were thoroughly washed to remove adhering impurities, shade-dried at room temperature, and pulverized into a coarse powder using a mechanical grinder. The powdered material was stored in airtight containers until extraction.

Preparation of Methanolic Extract

The dried leaf powder was extracted with methanol using a suitable extraction technique to obtain the methanolic extract of Lagerstroemia parviflora (MELP). The solvent was removed under reduced pressure to obtain a concentrated extract, which was stored in airtight containers at low temperature until further pharmacological evaluation.

Experimental Animals

Healthy adult Wistar albino rats of either sex weighing between 180 and 220 g were used in the study. The animals were procured from a registered animal facility and housed under standard laboratory conditions with controlled temperature (25 ± 2°C), relative humidity, and a 12-hour light/dark cycle. Standard laboratory pellet diet and clean drinking water were provided ad libitum. The animals were acclimatized for one week before the initiation of the experiment.

All experimental procedures were conducted following institutional animal ethics guidelines and were approved by the Institutional Animal Ethics Committee (IAEC) in accordance with CPCSEA regulations.

Acute Oral Toxicity Study

The acute oral toxicity study was performed according to OECD Guideline 423. Different doses of the methanolic extract were administered orally to experimental animals to evaluate its safety profile. The animals were observed continuously during the first few hours and

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periodically for 14 days for any signs of toxicity, behavioral abnormalities, morbidity, or mortality.

No treatment-related toxic effects or mortality were observed up to an oral dose of 3000 mg/kg body weight, indicating that the extract possesses a wide margin of safety.

Induction of Experimental Diabetes

Experimental diabetes was induced by a single intraperitoneal injection of streptozotocin (STZ) at a dose of 55 mg/kg body weight dissolved in freshly prepared 0.1 M sodium citrate buffer (pH 4.5). To prevent initial hypoglycemia, animals received 5% glucose solution overnight following STZ administration.

After 72 hours, fasting blood glucose levels were measured. Animals exhibiting fasting blood glucose concentrations greater than 250 mg/dL were considered diabetic and selected for the study.

Experimental Design

Thirty Wistar albino rats were randomly divided into five groups, each consisting of six animals.

Group I: Normal control receiving vehicle only.

Group II: Diabetic control receiving STZ without treatment.

Group III: Diabetic rats treated with Glibenclamide (500 µg/kg body weight, orally).

Group IV: Diabetic rats treated with methanolic extract of Lagerstroemia parviflora (200 mg/kg body weight, orally).

Group V: Diabetic rats treated with methanolic extract of Lagerstroemia parviflora (300 mg/kg body weight, orally).

All treatments were administered once daily for 21 consecutive days.

Assessment of Body Weight and Blood Glucose

Body weight was recorded before induction of diabetes and at the completion of the treatment period. Fasting blood glucose levels were measured on Day 0, Day 8, and Day 21 using standard biochemical methods to evaluate the antihyperglycemic effect of the extract.

Biochemical Analysis

At the end of the treatment period, animals were euthanized under ethical laboratory procedures. Blood samples were collected, allowed to clot, and centrifuged to obtain serum. Biochemical parameters were analyzed using an automated clinical chemistry analyzer.

The following biochemical markers were evaluated:

- Fasting blood glucose
- Oral glucose tolerance
- Total cholesterol
- Triglycerides
- High-density lipoprotein (HDL) cholesterol
- Low-density lipoprotein (LDL) cholesterol
- Very low-density lipoprotein (VLDL)
- Total protein
- Albumin
- Alkaline phosphatase (ALP)

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- Acid phosphatase (ACP)
- Serum glutamate oxaloacetate transaminase (SGOT/AST)
- Serum glutamate pyruvate transaminase (SGPT/ALT)

Commercial diagnostic reagent kits were used according to the manufacturers' instructions.

Statistical Analysis

Experimental data were expressed as mean ± standard error of the mean (SEM). Statistical analysis was performed using one-way analysis of variance (ANOVA), followed by an appropriate post hoc multiple comparison test. Differences were considered statistically significant at $P < 0.05$

RESULTS

Acute Oral Toxicity

The methanolic extract of Lagerstroemia parviflora (MELP) exhibited a favorable safety profile in the acute oral toxicity study conducted according to OECD Guideline 423. No mortality, behavioral abnormalities, neurological symptoms, or treatment-related toxic manifestations were observed in animals receiving oral doses up to 3000 mg/kg body weight throughout the 14-day observation period. These findings indicate that the extract is relatively safe for pharmacological investigations.

Effect on Body Weight

Administration of streptozotocin caused a marked reduction in body weight in diabetic control animals, reflecting impaired carbohydrate metabolism and enhanced protein catabolism associated with diabetes mellitus. Treatment with MELP at doses of 200 mg/kg and 300 mg/kg significantly minimized body weight loss when compared with untreated diabetic rats. The higher dose demonstrated greater improvement and produced results comparable to those observed with the standard antidiabetic drug, indicating restoration of normal metabolic function.

Effect on Fasting Blood Glucose

Diabetic control animals exhibited persistently elevated fasting blood glucose levels throughout the study period. Oral administration of MELP resulted in a progressive and statistically significant reduction in blood glucose concentrations from Day 8 onward. The antihyperglycemic effect became more pronounced by Day 21.

Among the treatment groups, the 300 mg/kg dose produced a greater reduction in fasting blood glucose than the 200 mg/kg dose. The glucose-lowering activity of the higher dose approached that of the standard drug, demonstrating dose-dependent antidiabetic efficacy.

Effect on Serum Lipid Profile

Experimental diabetes produced significant disturbances in lipid metabolism, characterized by elevated serum total cholesterol, triglycerides, LDL cholesterol, and VLDL cholesterol together with reduced HDL cholesterol.

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Treatment with MELP effectively corrected these abnormalities. Both treatment doses significantly decreased serum total cholesterol, triglycerides, LDL cholesterol, and VLDL cholesterol while simultaneously increasing HDL cholesterol compared with diabetic control animals. Improvement was more pronounced in rats receiving 300 mg/kg of the extract, indicating beneficial effects on diabetes-associated dyslipidemia.

Effect on Liver Function Biomarkers

Diabetic rats exhibited significantly elevated serum SGOT, SGPT, and alkaline phosphatase activities, suggesting hepatic injury associated with persistent hyperglycemia.

Administration of MELP significantly reduced the levels of these hepatic enzymes in comparison with diabetic control animals. The reduction was dose-dependent, with the 300 mg/kg treatment group showing greater improvement. These findings indicate that the extract not only improves glycemic control but also protects hepatic tissue against diabetes-induced damage.

Effect on Serum Protein and Albumin

Diabetes caused a decline in serum total protein and albumin concentrations, reflecting altered protein metabolism and impaired liver function. Treatment with MELP restored both parameters toward normal values, indicating improvement in protein synthesis and overall metabolic status.

DISCUSSION

Diabetes mellitus is a multifactorial metabolic disorder characterized by chronic hyperglycemia resulting from impaired insulin secretion, insulin resistance, or both. Persistent hyperglycemia contributes to disturbances in carbohydrate, lipid, and protein metabolism, eventually leading to complications involving the liver, kidneys, cardiovascular system, and nervous system. Therefore, identifying plant-derived therapeutic agents with multiple pharmacological benefits remains an important area of diabetes research.

In the present investigation, streptozotocin (STZ) administration successfully induced experimental diabetes in Wistar albino rats, as evidenced by persistent hyperglycemia, loss of body weight, altered lipid metabolism, and elevated hepatic enzyme levels. These pathological changes closely resemble the metabolic abnormalities observed in human diabetes, validating the suitability of the experimental model.

Treatment with the methanolic extract of Lagerstroemia parviflora significantly reduced fasting blood glucose levels throughout the experimental period. The antihyperglycemic effect was dose-dependent, with the 300 mg/kg dose producing greater glucose reduction than the 200 mg/kg dose. Although the standard drug exhibited the highest glucose-lowering activity, the extract demonstrated substantial therapeutic efficacy, suggesting the presence of bioactive

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phytoconstituents capable of improving glucose homeostasis.

The observed antihyperglycemic activity may be attributed to several possible mechanisms. Phytochemicals such as flavonoids, phenolic compounds, tannins, and triterpenoids present in Lagerstroemia parviflora are known to possess antioxidant and antidiabetic properties. These compounds may enhance peripheral glucose utilization, improve insulin sensitivity, suppress hepatic glucose production, reduce oxidative stress, and preserve pancreatic β-cell function. However, further mechanistic and molecular investigations are required to confirm these pathways.

A characteristic feature of uncontrolled diabetes is progressive body weight loss resulting from increased protein degradation and impaired glucose utilization. In this study, diabetic control animals showed significant weight reduction, whereas treatment with the methanolic extract effectively prevented excessive weight loss. Restoration of body weight suggests improved metabolic efficiency and enhanced utilization of glucose and nutrients following treatment.

Diabetes-induced dyslipidemia is recognized as a major risk factor for cardiovascular complications. Persistent insulin deficiency promotes excessive mobilization of free fatty acids from adipose tissue, resulting in elevated serum cholesterol, triglycerides, LDL cholesterol, and VLDL cholesterol together with reduced HDL cholesterol. Administration of Lagerstroemia parviflora markedly improved these lipid abnormalities. The reduction in atherogenic lipoproteins and the elevation of HDL cholesterol indicate that the extract possesses significant antihyperlipidemic activity, which may contribute to lowering cardiovascular risk in diabetic conditions.

Liver dysfunction is another important complication associated with chronic diabetes. Elevated serum SGOT, SGPT, and alkaline phosphatase activities observed in diabetic control animals indicate hepatocellular injury resulting from oxidative stress and metabolic disturbances. Treatment with the methanolic extract significantly normalized these biochemical markers, suggesting a protective effect on hepatic tissue. The hepatoprotective activity may be associated with the antioxidant properties of the phytoconstituents, which reduce oxidative damage and stabilize hepatocyte membranes.

The acute oral toxicity study further demonstrated that the extract was well tolerated up to 3000 mg/kg body weight without mortality or observable toxic manifestations. This finding indicates a wide therapeutic margin and supports the potential safety of the extract for future pharmacological investigations.

Overall, the present findings demonstrate that the methanolic leaf extract of Lagerstroemia parviflora exerts significant antihyperglycemic, antihyperlipidemic, and hepatoprotective effects

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in streptozotocin-induced diabetic rats. The beneficial effects are likely mediated through the combined action of multiple phytochemicals that improve glucose metabolism, regulate lipid homeostasis, and protect hepatic function. Nevertheless, additional studies involving phytochemical isolation, molecular targets, pharmacokinetics, chronic toxicity, and clinical evaluation are necessary before the extract can be considered for therapeutic application in humans.

CONCLUSION

The present investigation demonstrated that the methanolic leaf extract of Lagerstroemia parviflora Roxb. possesses significant antidiabetic activity in streptozotocin-induced diabetic Wistar albino rats. Oral administration of the extract at doses of 200 and 300 mg/kg significantly reduced fasting blood glucose levels, improved body weight, corrected diabetes-associated dyslipidemia, and restored altered liver enzyme activities. The extract also showed a favorable safety profile in the acute oral toxicity study, with no observable toxic effects up to 3000 mg/kg body weight.

The observed pharmacological effects may be attributed to the presence of biologically active phytoconstituents such as flavonoids, phenolic compounds, tannins, and triterpenoids, which are known to possess antioxidant and antihyperglycemic properties. Overall, the findings support the traditional medicinal use of Lagerstroemia parviflora and indicate its potential as a promising natural therapeutic agent for the management of diabetes mellitus. However, further phytochemical characterization, mechanistic studies, chronic toxicity evaluation, and well-designed clinical trials are necessary to confirm its efficacy and safety in humans.

Study Limitations

- The study was limited to an experimental animal model and therefore cannot be directly extrapolated to humans.
- Active phytochemical constituents responsible for the observed antidiabetic activity were not isolated or characterized.
- Histopathological evaluation of pancreatic tissue was not included.
- Molecular mechanisms underlying the antihyperglycemic activity were not investigated.
- Long-term toxicity and pharmacokinetic studies were beyond the scope of the present work.

Future Scope

Future investigations should focus on:

- Isolation and characterization of bioactive phytoconstituents.
- Elucidation of molecular mechanisms involved in glucose regulation.
- Histopathological and immunohistochemical studies of pancreatic tissue.
- Long-term safety and pharmacokinetic evaluation.

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- Clinical trials to establish therapeutic efficacy and safety in diabetic patients.
- Development of standardized herbal formulations based on Lagerstroemia parviflora.

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Conflict of Interest

The authors declare that there are no conflicts of interest regarding the publication of this manuscript.

Ethical Approval

All experimental procedures involving animals were conducted following the guidelines of the Committee for the Purpose of Control and Supervision of Experiments on Animals (CPCSEA) and were approved by the Institutional Animal Ethics Committee (IAEC).

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