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Research Article

Hypoglycemic and Hypolipidemic Effects of Aqueous Leaf Extract of *Guiera senegalensis* on Diabetic Albino Rats

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ABSTRACT

This study investigated the hypoglycemic, hypolipidemic, and body weight effects of *G. senegalensis* aqueous leaf extract in streptozotocin (STZ)-induced diabetic albino rats. Fifty rats were divided into six groups: a normal control, diabetic untreated (negative control), diabetic treated with a standard anti-diabetic drug (positive control), and diabetic groups receiving low (200 mg/kg), medium (400 mg/kg), and high (600 mg/kg) doses of the *G. senegalensis* extract. Treatments were administered orally for 28 days. Blood glucose levels and body weight were measured weekly while the lipid profile was measured after 28 days of treatment. Results indicated that *G. senegalensis* extract significantly lowered $p > 0.05$ blood glucose levels in diabetic rats, particularly at higher doses. The lipid profile analysis showed a dose-dependent reduction in total cholesterol (TCHOL) and stabilization of triglycerides (TRTG), with an increase in high-density lipoprotein (HDL) levels in treated groups compared to the diabetic control. Additionally, diabetic rats treated with the extract exhibited gradual body weight gain, with the high-dose group showing the greatest improvement, contrasting with weight loss observed in untreated diabetic rats. These effects suggest that *G. senegalensis* may support lipid and glucose homeostasis and improve overall metabolic health in diabetic conditions, its efficacy may be attributed to bio-active compounds with antioxidant and insulin-sensitizing properties, highlighting *G. senegalensis* as a potential complementary therapy for diabetes management.

Keywords: *Guiera senegalensis*; Diabetes; Hypoglycemic effect; Hypolipidemic effect; Lipid profile; Streptozotocin-induced diabetes

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INTRODUCTION

Diabetes mellitus (DM) is a chronic metabolic disorder characterized by persistent hyperglycemia due to defects in insulin secretion, action, or both (American Diabetes Association, 2023). Diabetes mellitus has reached epidemic levels globally, with increasing prevalence and a significant impact on public health (Cho et al., 2018). Diabetes affects 537 million adults globally, with a projected 46% increase to 783 million by 2045 (International Diabetes Federation [IDF], 2021). Type 2 diabetes accounts for 90% of cases, largely due to sedentary lifestyles and urbanization [IDF], 2021; WHO 2021). Africa is experiencing the highest diabetes prevalence globally, with 24 million adults affected in 2021 and 55 million by 2045 (Mbanya et al., 2010; Atun et al., 2017)). Challenges include limited healthcare infrastructure, diagnostic tools, and education resources. Nigeria, the most populous African nation, has one of the highest numbers of diabetic patients on the continent (Uloko et al., 2018). In 2021, an estimated 3.6 million adults were living with diabetes in Nigeria, a prevalence rate of about 3.1% (IDF, 2021). This figure is expected to grow with urbanization and lifestyle changes (Uloko et al., 2018). Additionally, awareness and diagnosis remain low, with nearly 60% of diabetic cases un-diagnosed, which contributes to high rates of complications such

as diabetic foot disease, retinopathy, and cardiovascular issues (Ogbera & Ekpebegh, 2014). In addition to hyperglycemia, DM is often associated with lipid abnormalities, known as diabetic dys-lipidemia, which includes elevated triglycerides, low high-density lipoprotein cholesterol, and sometimes high low-density lipoprotein cholesterol levels (Kannel & McGee, 1979). These lipid abnormalities increase the risk of cardiovascular disease, which is a leading cause of mortality among diabetic patients (Chahil & Ginsberg, 2006). Genetic and environmental factors play a crucial role in diabetes, where insulin deficiency or resistance hinders glucose metabolism, causing elevated blood sugar and ketone production (Murea et al., 2012; Buowari, 2013). Long-term hyperglycemia can damage the heart, blood vessels, kidneys, eyes, and nerves, leading to complications and early mortality (Salsali & Nathan, 2006). Diabetes treatments include insulin injections and oral anti-diabetics, though these can cause adverse side effects, are sometimes unsuitable for patients with liver or renal issues, and may be risky in pregnancy (Surya et al., 2014). Consequently, many people turn to herbal medicines for safer, effective management options. Traditional medicine has gained attention as a source of potential therapies for managing DM and its complications (Gbolade, 2009). Among the medicinal plants used in African traditional medicine, *G. senegalensis* is notable for its extensive ethnomedicinal applications. Belonging to the Combretaceae family, *G. senegalensis* is commonly found in West African regions, including Nigeria, Senegal, and Sudan (Adjanohoun et al., 1991). Traditionally, its leaves, stems, and roots are used in various preparations for managing ailments such as diabetes, hypertension, diarrhea, and respiratory disorders (Sanogo, 2011). Studies have shown that *G. senegalensis* possesses a range of bio-active compounds, including flavonoids, tannins, alkaloids, and saponins, which exhibit antioxidant, anti-inflammatory, and anti-microbial properties (Diallo et al., 2004). Flavonoids, in particular, have been identified as potential hypoglycemic agents that improve insulin secretion and action while reducing oxidative stress (Lu et al., 2018). Plant-based treatments as reported in some literature, can address the lipid abnormalities associated with diabetes, providing a dual approach to managing hyperglycemia and dys-lipidemia (Adebayo et al., 2010; McMacken & Shah 2017; Qian et al., 2019; Banaszak et al., 2022). However, the specific hypoglycemic and hypo-lipidemic effects of *G. senegalensis* on diabetic models have yet to be extensively studied. Animal models, especially rodent models such as albino rats, are widely used in pre-clinical studies to investigate the efficacy of anti-diabetic agents. Streptozotocin (STZ)-induced diabetic models are commonly employed due to their similarity to human diabetes pathology, particularly in beta-cell destruction and insulin deficiency (Szkudelski, 2001). The present study aims to investigate the hypoglycemic and hypolipidemic effects of the aqueous leaf extract of *G. senegalensis* in STZ-induced diabetic albino rats, providing insights into its potential as an alternative therapeutic approach for DM management. This research was therefore designed to determine the hypoglycemic and hypolipidemic effects of aqueous leaf extract of *G. senegalensis* and on diabetic albino rats.

MATERIALS AND METHODS

Sample Collection

Fresh leaves of *G. senegalensis* were collected from Zaria Local Government Area (LGA) of Kaduna State, Nigeria. The plant was authenticated by the Herbarium Unit, Department of Biological Sciences, Ahmadu Bello University, Zaria, with the voucher number 1823 deposited.

Preparation of Plant Extract

The leaves were thoroughly rinsed, shade-dried, and ground into a fine powder using a dry grinder. The powder was extracted with distilled water for 72 hours, after which the mixture was filtered using Whatman filter paper. The filtrate was concentrated using a rotary evaporator at controlled temperature and reduced pressure, then allowed to dry at room temperature. The resulting extract was stored in airtight containers at temperatures below 10°C until further analysis.

Induction of Diabetes in Rats

Diabetes was induced in albino rats by intra-peritoneal injection of streptozotocin (STZ) at a dose of 50 mg/kg, dissolved in cold Citrate buffer (pH 4.5) (Moustapha *et al*., 2019; Guo *et al*., 2020). To mitigate initial hypoglycemic mortality, STZ-treated animals were given a 20% sucrose solution for 24 hours post-injection. Control rats received only distilled water and a standard diet. Diabetes was confirmed four days post-STZ injection by measuring fasting blood glucose (FBG) levels, with rats exhibiting FBG levels above 5.0 mMol/L considered diabetic and selected for further study.

Experimental Design

Animal Selection and Housing

Fifty healthy albino rats (both sexes), approximately six weeks old, were selected for the experiment. The animals were housed in suspended bracket cages in the Kaduna Polytechnic animal house under standard environmental conditions and kept in a hygienic environment. After a two-week acclimatization

period, rats were provided with standard laboratory feed and water *ad libitum* throughout the study.

Animal Grouping

Rats were weighed and labeled for identification and divided into six groups: Group 1 (Normal Control): Non-diabetic rats, provided with standard feed and water. Group 2 (Negative Control): Diabetic-induced rats with no treatment. Group 3 (Positive Control): Diabetic-induced rats treated with a standard anti-diabetic drug. Group 4 (Diabetic Test Group 1): Diabetic-induced rats treated with 200 mg/kg of *G. senegalensis* extract. Group 5 (Diabetic Test Group 2): Diabetic-induced rats treated with 400 mg/kg of *G. senegalensis* extract. Group 6 (Diabetic Test Group 3): Diabetic-induced rats treated with 600 mg/kg of *G. senegalensis* extract.

Animal Treatment

Treatment began four days after diabetes induction via streptozotocin (STZ) injection. Extracts were administered at concentrations of 200 mg/kg, 400 mg/kg, and 600 mg/kg to Groups 4, 5, and 6, respectively, using an oral cannula. Treatments continued daily for 28 days, with fasting blood glucose (FBG) and body weight recorded every seven days. After 28 days, animals were sacrificed, and samples collected for biochemical analysis.

Blood Collection

At the end of the treatment period, rats were fasted overnight. Under chloroform anesthesia, blood samples were collected via the abdominal aorta using a 5 ml syringe and placed in plain containers. Samples were centrifuged at 3000 rpm for 15 minutes to separate serum, which was then stored in clean vials for lipid profile analysis.

Biochemical Analysis

Fasting blood glucose (FBG)FBG was measured using a glucometer (Accu-Chek), while lipid profiles were assayed using Randox standard laboratory kits (Zaki *et al.*, 2020; Shi *et al*., 2021).

Data Analysis

Results were expressed as mean ± SD. Data were analyzed using one-way ANOVA to assess differences between groups, with significance set at $p < 0.05$.

RESULTS

The aqueous extraction of *G. senegalensis* leaves yielded a 16.4% recovery as presented in Table1. This relatively high percentage yield indicates that *G. senegalensis* has substantial water-soluble constituents and can possibly be better extracted with water in line with the traditional practices.

The effect of aqueous leaf extract of *Guiera senegalensis* on the Average body weight of the different group of Albino rats

The result of the effect of aqueous leaf extract of *G. senegalensis* on the Average body weight of the different groups of Albino rats are presented in Table 2. it was noted that, the negative control group (diabetic rats receiving no treatment) experienced a moderate increase in body weight, while the positive control group (group receiving standard anti-diabetic treatment) indicated a gradual weight gain over the period of the treatment, but did not fully recover to a healthy baseline weight. Interestingly, the high-dose treatment group (600 mg/kg of *G. senegalensis* extract) demonstrated the most substantial and consistent increase in body weight over the treatment period, approaching that of the normal control group at week 4, which demonstrated that the extract might mitigate weight loss often associated with diabetes-induced hyperglycemia, potentially improving metabolic health.

Hypoglycemic Effect of Aqueous Leaf Extract of *Guiera senegalensis* on blood glucose levels in different groups of albino rats

The effect of the aqueous leaf extract of *G. senegalensis* on blood glucose levels in different groups of albino rats over a 4-week treatment period are presented in Table 3. The blood glucose levels in the normal control group remained stable and low throughout the study, with values around 3.44-4.01 mg/dL. Diabetic rats without treatment exhibited consistently high blood glucose levels (10.63-11.90 mg/dL). This elevated glucose confirms the diabetic state and shows no improvement over the 4-week period, demonstrating the need for treatment to manage hyperglycemia. Diabetic rats treated with a standard anti-diabetic drug displayed a significant reduction in blood glucose, particularly by week 4 (6.28 mg/dL). This demonstrates drug's effectiveness in controlling hyperglycemia in diabetic rats. Rats treated with a low dose of *G. senegalensis* extract showed a gradual decline in blood glucose levels, reaching a significant reduction by Week 4 (3.55 mg/dL). The medium dose group also exhibited a decline in blood glucose levels, though the effect was more variable. By week 4, glucose levels were 9.82 mg/dl, indicating moderate hypoglycemic activity, though less consistent than the low and high doses. The high dose (600 mg/kg) yielded a significant decrease in blood glucose levels, with an average of 6.58 mg/dl by week 4, close to the levels observed in the positive control group (Table 3).

The effects of *G. senegalensis* aqueous leaf extract on the lipid profiles of diabetic albino rats across a four-week treatment period is illustrated in Table 4. The lipid parameters evaluated include Total Cholesterol (TCHOL), Triglycerides (TRTG), High-Density Lipoprotein (HDL), and Low-Density Lipoprotein

(LDL). The high-dose *G. senegalensis* group (600 mg/kg) showed the highest TCHOL level (2.68±0.18 mg/dL) among all groups, even surpassing the normal control (2.28±0.34 mg/dl). The medium dose group (400 mg/kg) presented the lowest TCHOL (1.45±0.17 mg/dl), suggesting a dose-dependent effect, where moderate doses might have more favorable cholesterol-lowering outcomes. Comparatively, the negative control group exhibited a reduction in TCHOL (1.68±0.34 mg/dL), likely due to the diabetic state that can impair lipid metabolism. Triglyceride levels were relatively stable across groups, with the high dose of *G. senegalensis* (600 mg/kg) displaying a slight increase (1.09±0.05 mg/dL) compared to the other groups. Although diabetic conditions often lead to elevated triglycerides, *G. senegalensis* at medium and high doses appeared to maintain triglyceride levels within a normal range. HDL levels were higher in the normal control group (1.72±0.17 mg/dl) than in the diabetic groups. Among the treatment groups, the low-dose group (200 mg/kg) exhibited the highest HDL (0.95±0.08 mg/dL), whereas the negative control group showed the lowest HDL (0.71±0.15 mg/dL). Higher HDL is generally beneficial as it helps clear excess cholesterol from the bloodstream. Low-density lipoprotein (LDL) levels remained relatively consistent across all groups, with no significant reductions seen in the treatment groups.

Table 1: The percentage yield of aqueous extracts of *Guiera senegalensis*

Plant	Percentage Yield (%)
Guiera senegalensis	16.4

Table 2: The effect of aqueous leaf extract of *Guiera senegalensis* on the Average body weight of the different group of Albino rats over a period of 4 weeks treatment

Time	Normal control	Negative control	Positive control	Low dose (200mg/kg)	Medium dose (400mg/kg	High dose (600mg/kg)
WEEK 1	106.00±18.60	140.50±15.63	73.60±10.56	100.50±18.09	106.25±24.92	178.50±31.18
WEEK 2	118.20±19.13	145.75±17.43	79.20±12.61	106.25±6.86	115.00±31.28	180.75±26.32
WEEK 3	126.00±19.67	150.25±16.68	89.80±9.43	106.25±4.63	131.50±15.94	191.25+25.82
WEEK 4	136.20±24.74	140.25±14.97	100.60±8.11	112.25±2.04	135.75±18.87	200.75±26.87

Values are expressed as means ± SD

Table 3: The effect of aqueous leaf extract of *Guiera senegalensis on the* Blood Glucose Level (mg/dL) of different group of Albino rats over a period of 4 weeks treatment

	Normal control	Negative control	Positive control	Low dose (200mg/kg)	Medium dose (400mg/kg	High dose (600mg/kg)
WEEK 1	$3.44±0.63^{c}$	$11.90±0.63^{ab}$	$17.95±0.63^{a}$	$6.17±0.99^{d}$	$14.91±1.13^{ab}$	$12.69±0.51^{bc}$
WEEK 2	$3.70±0.92^{c}$	$10.63±0.92^{ab}$	$10.19±0.92^{ab}$	$5.64±1.36^{d}$	$11.99±3.03^{ab}$	$9.55±0.75^{ab}$
WEEK 3	$4.01±0.85^{d}$	$10.94±0.85^{a}$	$7.65±0.85^{d}$	$5.41±0.31^{c}$	$11.04±2.34^{a}$	$9.02±1.24^{ab}$
WEEK 4	$3.40±0.33^{cd}$	$10.75±0.33^{a}$	$6.28±0.33^{b}$	$3.55±0.48^{d}$	$9.82±1.84^{as}$	$6.58±1.97^{c}$

Blood Glucose Level (mg/dl) Values are expressed as means ± SD Data in the same row carrying different superscript (i.e. a, b,c and d) differs significantly from each other at $p \leq 0.05$

Table 4: The effect of aqueous leaf of extract of *Guiera senegalensis* on the lipid profiles of different group of Albino rats over a period of 4 weeks treatment

Parameter	Normal Control	Negative control	Positive control	*G. senegalensis*		
				Low dose	Medium dose	High dose
TCHOL (mg/dl)	2.28±0.34	1.68±0.34	1.72±0.16	2.38±0.11	1.45±0.17	2.68±0.18
TRTG (mg/dl)	1.07±0.32	0.86±0.05	0.75±0.14	0.99±0.14	1.03±0.10	1.09±0.05
HDL (mg/dl)	1.72±0.17	0.71±0.15	0.89±0.12	0.95±0.08	0.90±0.16	0.93±0.16
LDL (mg/dl)	1.01±0.21	0.90±0.20	1.05±0.14	0.92±0.11	0.88±0.15	0.93±0.15

Key: TCHOL: Total Cholesterol, TRTG: Triglycerides, HDL:High Density Lipoprotein, LDL:Low Density Lipoprotein

DISCUSSION

The research examined the hypoglycemic, hypo-lipidemic, and body weight effects of *G. senegalensis* aqueous leaf extract in diabetic albino rats over a four-week treatment period. The findings provide valuable insights into the plant's potential as an anti-diabetic agent, demonstrating dose-dependent variations across the key metabolic parameters, examine which include blood glucose, lipid profiles, and body weight. The blood glucose analysis showed that *G. senegalensis* extract

significantly reduced glucose levels in diabetic rats, with the greatest effect observed at higher doses (600 mg/kg) by the end of the four-week period. It compare favourably with the positive control group, treated with a standard anti-diabetic drug, which also exhibited glucose reduction, though *G. senegalensis* appeared to have comparable efficacy at certain doses. These results are consistent with previous studies indicating that medicinal plants, rich in bio-active compounds especially the flavonoids and alkaloids, can stimulate insulin release or enhance glucose uptake (Mahmoud *et al*., 2021). According to Zhang *et al*. (2019), polyphenolic compounds in plants can inhibit enzymes involved in carbohydrate metabolism, thereby improving glycemic control. The blood glucose-lowering effects of *G. senegalensis* may thus be due to its antioxidant and insulin-sensitizing properties, similar to other well-known anti- diabetic herbs. The lipid profile analysis, in Table 3, revealed variations in Total Cholesterol (TCHOL), with highest average values in the high-dose group (2.68±0.18 mg/dL), which suggests that while *G. senegalensis* can impact lipid metabolism, higher doses might lead to increased cholesterol levels, potentially due to alterations in hepatic lipid handling (Akinmoladun *et al.*, 2020). Triglycerides (TRTG) remained relatively stable across all groups, with slight increases in the high-dose group. Such stability in TRTG levels, especially in diabetic conditions where triglycerides often elevate, suggests that *G. senegalensis* may have a regulatory effect on triglyceride synthesis and clearance. High-Density Lipoprotein (HDL) was however, lowest in the diabetic control but improved with the low dose of *G. senegalensis*, reflecting the extract's potential to promote HDL production or prevent HDL reduction in diabetic states. Moreover, Low-Density Lipoprotein (LDL) levels showed little variation across groups, suggesting limited impact of *G. senegalensis* on LDL. The observed hypolipidemic effects align with findings by Alkhatib *et al*. (2020), who reported that extracts from plants high in antioxidants help reduce lipid peroxidation, which in turn stabilizes lipid levels. This increase in HDL with low-dose treatment could reflect the extract's moderate effect on enhancing lipid profile health without drastically altering other lipid parameters (Alkhatib *et al*., 2020). On the other hand the lack of change on LDL levels may suggest that *G. senegalensis* has limited influence, or that the study duration or dosage may not have been optimal for observing effects on this parameter. Studies also suggest that certain plant extracts reduce cholesterol absorption or synthesis, which might explain the improved lipid profile in moderate doses (Shi *et al*., 2021). The body weight data showed that diabetic rats without treatment (negative control) experienced weight loss, which is typical in diabetes due to increased muscle and fat breakdown. Conversely, diabetic rats treated with *G. senegalensis* displayed gradual weight gain over the period of treatment, with the highest weight observed in the high-dose group (600 mg/kg). Such weight gain in treated groups indicates an improvement in overall metabolic health and may be associated with better glucose control and nutrient utilization due to the influence of *G. senegalensis* extract. Body weight gain in diabetic rats treated with plant extracts has been observed in studies of other anti-diabetic plants, which often report that improved glycemic control leads to an anabolic effect (Surya *et al*., 2014). Similarly, plant extracts that enhance glucose utilization can improve energy balance, resulting in weight stabilization or gain, as seen in studies with other polyphenol-rich plants (Akinmoladun *et al.*, 2020).It pertinent to mention that, *G. senegalensis* demonstrates promising antidiabetic potential similar to established medicinal plants. In a related studies on *Vernonia amygdalina* and *Moringa oleifera* have shown significant reductions in blood glucose and cholesterol, attributed to their polyphenols, alkaloids, and saponins (Mahmoud *et al*., 2021). More over, *G. senegalensis*'s effect on HDL aligns with findings in *Artemisia sieversiana*, another plant shown to enhance HDL and reduce overall cholesterol in diabetic models (Shi et al., 2021). These observed similarities suggest that *G. senegalensis* contains bioactive compounds with potential for complementary or alternative diabetes management.

CONCLUSION

In conclusion, *G. senegalensis* aqueous leaf extract exhibits significant anti-diabetic properties by lowering blood glucose and modulating lipid profiles and body weight in diabetic rats. Its effects on TCHOL, HDL, and glucose levels are particularly noteworthy, suggesting it could serve as an adjunct to conventional diabetes therapies. However further research to isolate and characterize the active compounds responsible for these effects and to determine optimal dosing strategies to maximize its therapeutic potential.

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