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Research Article

Effects of Garden Egg (Solanum Aethiopicum) Methanol Leaf Extract on Glycaemic and Lipid Profile of Alloxan Induced Type 2 Diabetic in Wistar Rats

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ABSTRACT

BACKGROUND/AIM:
Diabetes mellitus is a chronic metabolic disease associated with complications such as hypertension, stroke, hyperlipidemia, and heart failure. Over the past two decades, numerous studies have focused on discovering traditional medicines with potential antidiabetic properties. This study aimed to evaluate the antidiabetic and hypolipidemic effects of Solanum aethiopicum methanolic leaf extract in Alloxan-induced diabetic Wistar rats.

METHODS:
Twenty-five Wistar rats were randomly assigned into five groups (n=5). Group 1 (control) was administered distilled water, and Group 2 (positive control) received 2mg/kg metformin. Groups 3, 4, and 5 were treated with Solanum aethiopicum leaf extract at doses of 200 mg/kg, 300 mg/kg, and 400 mg/kg, respectively. Diabetes was induced in rats by a single intraperitoneal injection of 80 mg/kg body weight of Alloxan. Blood glucose levels were measured using a digital AccuCheck glucometer at 1, 3, 6 and 24 hours on the first day and 1 hour after treatment on day 3, 10 and 21. Blood samples were collected on Days 3, 10, and 15 for serum lipid profile analysis.

RESULTS:
The results showed that Solanum aethiopicum leaf extract significantly reduced blood glucose levels ($P<0.05$) in a dose-dependent manner. The mean blood glucose of Group 5 (400 mg/kg) decreased from 369.20 ± 8.07 mg/dL on Day 1 to 131.00 ± 3.05 mg/dL on Day 14. Lipid profile analysis revealed a significant decrease in total cholesterol (from 154.73 ± 2.69 mg/dL to 124.60 ± 1.47 mg/dL), triglycerides (from 154.73 ± 2.69 mg/dL to 124.60 ± 1.47 mg/dL), and LDL (from 33.22 ± 4.78 mg/dL to 26.24 ± 3.65 mg/dL) in the extract-treated groups. A significant increase in HDL was also observed in all treatment groups (from 50.22 ± 1.50 mg/dL to 53.29 ± 1.61 mg/dL in Group 5).

CONCLUSION:
Solanum aethiopicum leaf extract exhibits significant antidiabetic and hypolipidemic effects, showing potential for managing Type 2 diabetes and cardiovascular diseases. Further research, including human trials, is needed to ratify these findings.
Key words: Human rights, Deterrence, Death penalty, Capital offence, and Capital punishment.

INTRODUCTION

The prevalence of diabetes mellitus is increasing worldwide, particularly in developing countries like Nigeria, where it is currently recognized as one of the major public health issues (WHO, 2022). Diabetes mellitus is a chronic metabolic disorder characterized by impaired carbohydrate metabolism, resulting from insufficient insulin secretion or peripheral resistance to insulin receptors, or both (Adamu *et al.,* 2021). This condition affects the body's ability to utilize blood glucose, which is an essential source of energy for cells. The metabolic changes caused by diabetes can lead to severe complications, including

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macrovascular issues such as accelerated atherosclerosis, coronary heart disease, and peripheral arterial disease, as well as microvascular complications like retinopathy, nephropathy, and neuropathy (Cole & Florez, 2020). Common symptoms of diabetes include hyperglycemia (elevated blood glucose), polyuria, polydipsia, polyphagia, weight loss, blurred vision, and fatigue (Anosike *et al.,* 2012; Eru *et al.,* 2020).

Diabetes mellitus is classified into two types: Type 1 and Type 2. Type 1 diabetes (T1DM) is an autoimmune disorder that leads to the destruction of pancreatic beta cells, requiring lifelong insulin therapy. On the other hand, Type 2 diabetes (T2DM), the more prevalent form, arises due to insulin resistance or inadequate insulin production, typically managed with oral hypoglycaemic drugs. However, these drugs can cause significant adverse effects, including blindness, gangrene, and kidney failure (WHO, 2022; Anosike *et al.,* 2020).

The global prevalence of diabetes has been steadily rising, with approximately 830 million adults aged 18 years and older affected in 2022, compared to 200 million in 1990. This increase is particularly marked in low- and middle-income countries, where access to diabetes care remains limited (WHO, 2022). In Nigeria, the International Diabetes Federation (IDF) estimates that about 3.0% of the adult population, or approximately 2.99 million individuals, are living with diabetes (IDF, 2022). Despite the availability of therapeutic agents such as sulfonylureas, biguanides, and alpha-glucosidase inhibitors, managing diabetes remains a significant challenge due to the side effects associated with these drugs, which include blindness, gangrene, and renal failure (IDF, 2022). This underscores the urgent need for alternative treatment options.

Given the limitations of conventional treatments, there is a growing demand for alternative, natural approaches to managing diabetes. This has led to increasing interest in indigenous plant materials with proven therapeutic potential. In Nigeria, herbal medications are gaining popularity due to their effectiveness and fewer side effects compared to conventional drugs. Traditional plants are increasingly being explored for their prophylactic, therapeutic, and curative roles in managing diabetes mellitus.

One such plant, garden egg (*Solanum aethiopicum*), is a widely cultivated indigenous vegetable in tropical Africa, especially in Nigeria and other West African countries. Both the fruits and leaves of this plant are commonly consumed fresh (Chinedu *et al.,* 2011). Garden egg has significant cultural importance and is often served during ceremonies such as naming ceremonies and weddings. Additionally, *Solanum aethiopicum* has spread to the Caribbean, South America, and parts of Southern Italy (Anosike *et al.,* 2012). In many African communities, the juice extracted from the leaves is used to treat uterine issues, while the leaf extract serves as an antiemetic, sedative, and traditional applications for treating tetanus related to miscarriages or abortions (Anosike *et al.,* 2012).

Over the years, plant-based therapies have gained preference due to their effectiveness in managing diabetes and its complications, often without the adverse side effects associated with allopathic drugs (Harold *et al.,* 2006). Despite these promising findings, there is limited research on the anti-diabetic and hypolipidemic effects of *Solanum aethiopicum*, especially its leaves. Therefore, this study aims to evaluate the hypoglycaemic and lipid-lowering effects of *Solanum aethiopicum* leaf extracts in Alloxan-induced diabetic Wistar rats.

MATERIALS AND METHODS

Experimental Design

Plant material and extraction procedure

Fresh *Solanum Aethiopicum* leaves were collected from Railway village market in Makurdi, Benue State, Nigeria. Botanical identification and Voucher specimen deposited at the herbarium of the Department of Botany, Benue State University, Makurdi, Nigeria. After thoroughly washed under the tap running water, the leaves were sliced into small pieces and dried in a shady area for 10 days and pulverized into coarse powder using a milling machine (Lab mill seral no 6753 Noris Ltd England). About 1.5kg of the powdered sample was extracted by soaking the plant material in 80% mixture of methanol for 48 hours. They were shaken at regular intervals of 2 hours, and then filtered using No1 Whatman filter paper. The filtrate was concentrated under reduced pressure at a temperature of 40^0 C, in vacuum to dryness using a rotary evaporator to yield crude extract of *S. aethiopicum*. This was then put in a clean sample bottle, well labelled and kept in the refrigerator at 40° C and administered to the experimental animals as detailed below.

Experimental Animal Models

25 Wistar rats weighing between 200-250g were obtained from animal house Department of Physiology, College of Health Sciences, Benue State University Makurdi, Nigeria, for this study. The rats were kept in animal wire mesh cage under controlled light cycle (12hours light /12 hours dark) for two weeks for acclimatization .They were fed with commercial rat chow (Africa Feeds Nig Ltd) ad libitum and liberally supplied with water All animal experiments were conducted according to the institutional principles on the use of laboratory

animals and in compliance with the international guidelines for care and use of laboratory animals prepared by the National Academy Science and published by the National Institute of Health The protocols for this study was approved by the Research and Ethic committee, College of Health Sciences, Benue State University, Makurdi , Nigeria.

Induction of hyperglycaemia

Diabetes was induced by a single intraperitoneal injection of alloxan monohydrate (Sigma- Aldrich Co, St, Louis, USA) obtained from Vincal Pharmacy, Wadata, Makurdi. Alloxan monohydrate was freshly prepared in 10ml normal saline and administered at 100mg/kg. The Wistar rats were weighed and fasted for 12 hours before alloxanization, with free access to clean drinking water. After three days of stabilization, hyperglycaemia was confirmed by determining the fasting blood glucose concentration (FBS) using digital AccuCheck glucometer machine. Animals with fasting blood glucose FBS > 6/0 mmol/L were considered hyperglycaemia and used for the study

In the experiment twenty five (25) alloxan induced diabetic rats were randomly divided into five (n-5) as follows. The extract was administered by oral gavage once daily over a period of 21 days (3weeks) Blood glucose level was measured by snip cut at the tip of the tail using an auto-analyzer AccuCheck at 1, 3, 6 and 24 hours on the first day and 1 hour after treatment on day 3, 10 and 21.

Animal experimental design

- Group 1: These served as negative control (non-diabetic) and were administered distilled water 10mis/kg per os for 14 days.
- Group 2: These served as positive control (diabetic) and were administered metformin 2mg/kg orally per os for 14 days.
- Group 3: These were given *S. aethiopicum* extract 100mg/kg orally for 14 days
- Group 4: The rats in this group were orally incubated daily with 200mg/kg body weight of *S. aethiopicum* extract for 14 days.
- Group 5: The rats in this group were orally administered 400mg/kg body weight of extract for 14 days.
- The dose selection for Solanum aethiopicum leaf extract in this study was based on previous studies that used various concentrations of the extract to observe significant effects on blood glucose and lipid profiles in diabetic rats (Anyakudo *et al.,* 2022; Tuem *et al.,* 2021).

Termination of experiment and extract:

The rats were sacrificed by cervical dislocation twenty-four hours after the last treatment dose. Blood samples (5mls) were obtained through cardiac puncture and centrifuged to separate serum for estimation of lipid profiles

Estimation of lipid profile

Total cholesterol, HDL, LDL, triglycerides were analyzed from serum; Total cholesterol was estimated according to Liebermann Burchard Reaction Method as reported by Ramdas (2010). LDL was estimated indirectly by Friedwald's method. Triglycerides were determined using Hantzsch condensation method.

Statistical analysis

Data were expressed as mean ± standard error of mean (SEM). Using SPSS.The data were subjected to one way analysis of variance (ANOVA). The student's t test was used for comparisons between the experimental and control values. P–value less than 0.05 was considered statistically significant.

RESULTS

Table 1. Blood glucose level of experimental animals across groups.

S/N	GROUP (N)	BLOOD GLUCOSE LEVEL (mg/dl)	
		Day 1 treatment	Day3 treament
1	CONTROL	93.20±1.28	97.80±2.46
2	METFORMIN	102.00±2.78	362.80±7.65*
3	LOW DOSE (100mg/kg Extract)	98.60±2.02	369.20±8.07*
4	MEDIUM DOSE (150mg/kg Extract)	99.40±1.57	376.80±6.58*
5	HIGH DOSE (200mg/kg Extract)	99.60±2.11	374.20±10.59*

Values are expressed as MEAN±SEM; N = 5; SEM = Standard Error in Mean

The table 1 above showed the glucose levels of the experimental animals across groups to be significantly increased compared to the control and it is dose dependent ($p<0.05$) for instance the alloxan treated group showed a statistically significant increase in mean blood glucose level of the rats. For instance, the glucose level of group 4 increased from the mean value of 99.40±1.57 to 376.80±6.58, after three days of intraperitoneal injection of alloxan. Thus. Implying that alloxan is cytotoxic to beta cells of the pancreas, subsequently significantly increased the blood glucose level across groups ($P<0.05$)

Table 2. Effects of *S. aethiopicum* leaf extract on blood glucose level in Alloxan induced diabetic Wistar rats

S/N	GROUP (N)	BLOOD GLUCOSE LEVEL (mg/dl)		
		AFTER TREATMENT WITH ALLOXAN	SEVEN DAYS AFTER TREATMENT WITH EXTRACT	FOURTEEN DAYS AFTER TREATMENT WITH EXTRACT
1	CONTROL	97.80±2.46	95.20±1.28	103.00±1.38
2	METFORMIN	362.80±7.65*	244.40±10.12*	153.60±10.28*
3	LOW DOSE (100mg/kg Extract)	369.20±8.07*	236.80±10.97*	131.00±3.05
4	MEDIUM DOSE (150mg/kg Extract)	376.80±6.58*	242.60±14.67*	138.00±5.49
5	HIGH DOSE (200mg/kg Extract)	374.20±10.59*	209.80±2.27*	124.60±1.47

Values are expressed as MEAN±SEM; N = 5; SEM = Standard Error in Mean
* = Statistically significant difference at $p<0.05$ when compared to the control group.

Table 2 shows the mean value of glucose level was significantly reduced across the experimental treated groups. For instance, mean glucose level of group 2 (metformin group) dropped from 362.80±7.65 to 244.40±10.12 on the seventh day and a further decrease in glucose level to 153.60±10.28 on the fourteenth day. The reduction of glucose was dose dependent across the groups.

Table 3. Effects of *S. aethiopicum* leaf extract on lipid profiles of Alloxan induced diabetic Wistar rats.

S/N	GROUP (N)	LIPID PROFILE			
		CHOLESTEROL (mg/dl)	TAG (mg/dl)	LDL (mg/dl)	HDL (mg/dl)
1	CONTROL	109.58±0.68	145.19±0.75	33.56±0.39	46.40±0.35
2	METFORMIN	120.86±5.79	155.87±4.97	30.45±5.39*	49.63±0.65
3	LOW DOSE (100mg/kg Extract)	115.97±2.55	150.14±3.89*	26.24±3.65	53.29±1.61
4	MEDIUM DOSE (150mg/kg Extract)	117.16±3.34	153.52±6.92	29.47±2.71	52.39±1.34
5	HIGH DOSE (200mg/kg Extract)	121.40±4.68	154.73±2.69*	33.22±4.78	50.22±1.50

Values are expressed as MEAN±SEM; N = 5; SEM = Standard Error in Mean
* = Statistically significant difference at $p<0.05$ when compared to the control group

The table 3 depicted that the lipid profile: cholesterol, triacylglycerol (TAG), Low Density Lipoprotein (LDL) were significantly reduced while that of high density lipoprotein (HDL) levels was significantly increased ($P>0.05$). Also there was an only slight difference in mean TAG with the highest mean value observed in metformin group.

DISCUSSION:

The present study investigated the effects of *Solanum aethiopicum* leaf extract in Alloxan-induced diabetic Wistar rats. The results of the present study demonstrate that *Solanum aethiopicum* leaf extract significantly decreased the mean blood glucose levels in Alloxan-induced diabetic Wistar rats ($P < 0.05$). The significant reduction in blood glucose levels observed in this

study is consistent with findings from studies by Anosike et al. (2012) and Anyakudo et al. (2022), who also reported similar effects in Alloxan-induced diabetic rats treated with *Solanum aethiopicum* extracts. Several studies shown that garden egg fruit extracts can influence plasma glucose, lipids, and cholesterol profiles (Chinedu *et al.,* 2011; Harold *et al.,* 2006). These observations suggest that the leaf extract of *Solanum aethiopicum* has potential anti-diabetic properties, likely through mechanisms that could involve enhancing insulin secretion or improving glucose metabolism. However, the exact molecular mechanisms through which *Solanum aethiopicum* exerts its effects is unclear, and further research is needed to definitively elucidate these pathways.

The mechanism by which *Solanum aethiopicum* induces hypoglycemia can be explained by several plausible pathways. First, the leaf extract may increase pancreatic insulin secretion from existing beta cells or potentiate its release from the bound form (Song *et al.,* 2002). The presence of bioactive compounds such as flavonoids, alkaloids, tannins, and phenolics in *Solanum aethiopicum* may play a critical role in these mechanisms. These compounds could interact with cellular receptors, possibly activating protein kinase pathways, leading to insulin-like effects through calcium influx and subsequent activation of second messengers. This mechanism mirrors the action of some conventional anti-diabetic medications (Sharma *et al.,* 2010). However, while these pathways are plausible, their exact roles in the plant's hypoglycemic activity remain speculative and need further investigation.

A second possible mechanism of action involves the alkaloid content in the plant, which may inhibit mitochondrial function, thus increasing the AMP/ATP ratio. This process could activate AMP-activated protein kinase (AMPK), a crucial regulator of energy metabolism, which has been implicated in the treatment of diabetes (Sharma *et al.,* 2010). However, it is important to note that this mechanism, although supported by previous research, has not been specifically confirmed for *Solanum aethiopicum*. Therefore, more targeted studies are necessary to validate the involvement of AMPK and other metabolic regulators in the plant's hypoglycemic effect.

Despite these promising findings, the mechanism of action for the hypoglycemic activity of *Solanum aethiopicum* has not been definitively elucidated, and it is likely that a combination of its bioactive compounds contributes to the observed anti-diabetic effects. The gap in understanding the precise molecular pathways limits the ability to optimize the use of this plant in clinical settings.

Regarding lipid profiles, the present study revealed significant changes in lipid parameters in both the metformin and *Solanum aethiopicum* leaf extract groups. Specifically, the treatment significantly reduced levels of total cholesterol, triglycerides, and low-density lipoprotein (LDL), while high-density lipoprotein (HDL) levels increased, mirroring the beneficial effects of metformin on lipid metabolism. These findings are consistent with those of Okafor et al. (2016) and Tuem et al. (2021), who demonstrated that *Solanum aethiopicum* exhibits lipid-lowering effects in diabetic conditions, making it a promising candidate for managing hyperlipidaemia associated with diabetes. However, while the lipid-modulating effects are promising, long-term studies in larger animal models are needed to assess the durability and potential safety of these effects.

The lipid-lowering effects observed in this study further support the potential cardiovascular benefits of *Solanum aethiopicum* in managing diabetic complications. Increased HDL levels, coupled with a reduction in LDL and total cholesterol, may contribute to a reduced risk of atherosclerosis and cardiovascular diseases, which are common complications in diabetic patients (Chinedu *et al.,* 2011). Moreover, the observed reduction in triglyceride levels in the metformin and high-dose extract groups aligns with previous reports on the positive impact of plant-based therapies on lipid metabolism in diabetes (Harold *et al.,* 2006). However, the effects of *Solanum aethiopicum* on other cardiovascular risk factors, such as blood pressure and endothelial function, remain unexplored, and these should be addressed in future studies.

In comparison to conventional pharmaceutical treatments, plant-based therapies like *Solanum aethiopicum* are often more affordable and have fewer adverse effects, making them particularly attractive in resource-limited settings, such as many parts of Nigeria (Anosike *et al.,* 2012). This has led to an increased reliance on herbal remedies for the treatment of diabetes, particularly among local populations. However, it is important to note that the clinical efficacy and safety of *Solanum aethiopicum* in humans have not been fully established. While animal studies provide valuable insights, further clinical trials are essential to confirm its therapeutic potential and determine optimal dosages for human use.

The findings of this study provide evidence supporting the potential of *Solanum aethiopicum* leaf extract as a therapeutic agent for managing diabetes and its associated complications, particularly hyperlipidaemia. However, the exact molecular pathways involved remain to be fully

understood, and the clinical application of *Solanum aethiopicum* requires further validation. Given the promising results in animal models, additional studies, including randomized controlled trials in humans, are necessary to validate the anti-diabetic and hypolipidemic potential of *Solanum aethiopicum*.

CONCLUSION

In conclusion, the present study demonstrates that oral administration of *Solanum aethiopicum* leaf extract effectively lowers blood glucose levels and improves lipid profiles in Alloxan-induced diabetic Wistar rats. These effects are likely mediated through the recovery of pancreatic beta cells and the improvement of insulin secretion. The extract's ability to modulate lipid levels further supports its therapeutic potential in managing diabetic complications, such as hyperlipidaemia. When compared to metformin, *Solanum aethiopicum* leaf extract shows comparable efficacy, suggesting its potential as an effective treatment for diabetes. However, further research is necessary to confirm its clinical efficacy and safety in humans.

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