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Effects of ethanol leaf fractions of *Sida acuta* and *Ficus exasperata*, alone and in combination, on lipid profile in alloxan-induced diabetic Wistar rats

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Abstract

Diabetes mellitus is associated with dyslipidemia, a metabolic disturbance that increases cardiovascular risk. This study evaluated the effects of ethanol leaf fractions of *Sida acuta* and *Ficus exasperata*, administered singly and in combination, on lipid profile parameters in alloxan-induced diabetic Wistar rats. Sixty-three female Wistar rats were divided into nine groups of seven rats each. Diabetes was induced using alloxan, and diabetic rats were treated orally for 28 days with glibenclamide, ethanol fraction of *Sida acuta*, ethanol fraction of *Ficus exasperata*, and combined ethanol fractions of both plants. Blood samples were collected by cardiac puncture into plain bottles, allowed to clot at room temperature and centrifuged at 3000 rpm for 10 minutes to obtain serum. Total cholesterol, triglycerides and high-density lipoprotein cholesterol were determined using commercially prepared Randox diagnostic test kits according to the manufacturer's instructions. Low-density lipoprotein cholesterol and very-low-density lipoprotein cholesterol were calculated. The diabetic untreated group showed dyslipidemia, characterized by increased total cholesterol, triglycerides, low-density lipoprotein cholesterol and very-low-density lipoprotein cholesterol, with reduced high-density lipoprotein cholesterol compared with the normal control. Treatment with the plant fractions produced varying improvements in lipid profile, especially in total cholesterol and low-density lipoprotein cholesterol. The 200 mg/kg combined fraction produced the most favourable lipid-modulating effect, with several lipid parameters approaching normal control values. These findings suggest that ethanol leaf fractions of *Sida acuta* and *Ficus exasperata* may possess hypolipidemic potential in alloxan-induced diabetic Wistar rats, particularly at selected doses and in combination.

Keywords: *Sida acuta*; *Ficus exasperata*; Alloxan-induced diabetes; Lipid profile; Dyslipidemia; Hypolipidemic activity

1. Introduction

Diabetes mellitus is a global metabolic disorder characterized by persistent hyperglycaemia resulting from impaired insulin production and/or utilization. Its global burden continues to rise, with recent estimates from the International Diabetes Federation showing that diabetes remains a major public health challenge with increasing prevalence and projected growth by 2050 [1]. In addition to hyperglycaemia, diabetes mellitus is commonly associated with disturbances in lipid metabolism, which contribute significantly to the development of cardiovascular complications. Current diabetes care recommendations emphasize cardiovascular risk reduction as a major component of diabetes management, including the monitoring and control of lipid abnormalities [2]. Diabetic dyslipidaemia is commonly characterized by elevated triglycerides, reduced high-density lipoprotein cholesterol and abnormal low-density lipoprotein cholesterol patterns, including atherogenic small dense LDL particles [3,4]. These lipid abnormalities may arise from insulin deficiency or insulin resistance, which alters hepatic lipid synthesis, lipoprotein metabolism, fatty acid utilization and clearance of circulating triglyceride-rich particles [5]. Increased LDL-C and VLDL-C promote atherogenic changes, while reduced HDL-C limits reverse cholesterol transport, thereby increasing the risk of vascular injury and cardiovascular disease. Lipid profile assessment remains an important biochemical tool in evaluating

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metabolic complications associated with diabetes. Alloxan-induced diabetes is a widely used experimental model for studying antidiabetic and lipid-modulating agents. Alloxan selectively damages pancreatic β-cells mainly through oxidative stress-mediated mechanisms, resulting in impaired insulin secretion and persistent hyperglycaemia [6,7]. The resulting insulin deficiency can further disrupt carbohydrate and lipid metabolism, making the model useful for assessing both antihyperglycaemic and hypolipidaemic effects of natural products. In experimental diabetes, changes in serum total cholesterol, triglycerides, HDL-C, LDL-C and VLDL-C provide useful indicators of the extent of diabetic dyslipidaemia and the possible protective effects of therapeutic interventions. Medicinal plants are important sources of bioactive compounds for the management of metabolic diseases, especially in regions where traditional medicine is widely practiced. Plant-based secondary metabolites such as flavonoids, tannins, alkaloids, saponins and phenolic compounds have been reported to exhibit antioxidant, anti-inflammatory, antihyperglycaemic and lipid-modulating activities [8,9]. These phytochemicals may improve lipid metabolism through mechanisms such as inhibition of lipid peroxidation, enhancement of antioxidant defence, modulation of cholesterol biosynthesis, improvement of insulin sensitivity and increased clearance of circulating lipids.

Sida acuta Burm. f. is a medicinal plant traditionally used for several ailments and has been reported to possess antioxidant, anti-inflammatory, hypoglycaemic and other pharmacological properties [8]. Its biological activities have been linked to the presence of phytochemicals such as flavonoids, alkaloids, tannins, saponins and phenolic compounds, which may contribute to its potential usefulness in metabolic disorders. *Ficus exasperata* Vahl, commonly known as sandpaper leaf, is widely used in traditional medicine for the management of diabetes and metabolic disorders. Recent studies have reported that Ficus species contain diverse phytochemicals with antioxidant and pharmacological activities, while F. exasperata has demonstrated cardioprotective effects in diabetic Wistar rats [9,10]. A previous study also showed that ethanol extracts of *Ficus exasperata* and Sida acuta leaves produced protective effects against diabetes-induced hepatic and renal dysfunction when administered singly or in combination [11]. Although both Sida acuta and *Ficus exasperata* have been individually studied for medicinal properties, there is still a need to further evaluate their lipid-modulating effects, particularly when administered singly and in combination in diabetes-associated dyslipidaemia. Combination therapy using medicinal plants may produce additive or synergistic effects, but it may also produce non-uniform responses depending on dose, phytochemical interaction and metabolic pathway affected.

Therefore, this study was designed to evaluate the effects of ethanol leaf fractions of Sida acuta and *Ficus exasperata*, administered singly and in combination, on lipid profile parameters in alloxan-induced diabetic Wistar rats. The findings may provide further scientific evidence on the hypolipidaemic potential of these plants and their possible relevance in the management of diabetes-associated lipid abnormalities.

2. Materials and Methods

2.1. Study design

This was an experimental animal study designed to evaluate the effects of ethanol leaf fractions of Sida acuta and *Ficus exasperata* on lipid profile parameters in alloxan-induced diabetic Wistar rats. The study involved induction of diabetes using alloxan, followed by treatment with ethanol leaf fractions of Sida acuta and *Ficus exasperata*, administered singly and in combination. The lipid profile parameters evaluated were total cholesterol, triglycerides, high-density lipoprotein cholesterol, low-density lipoprotein cholesterol and very-low-density lipoprotein cholesterol. The study consisted of nine experimental groups, including the normal control, diabetic untreated control, standard drug-treated group and extract-treated groups. Each group contained seven rats.

2.2. Collection and authentication of plant materials

Fresh leaves of *Ficus exasperata* Vahl were obtained from a *Ficus exasperata* tree located at the workshop site of Safety-way Driving School, Aroma, Awka, Anambra State, Nigeria, between 3:00 and 4:00 p.m. Fresh leaves of Sida acuta Burm. f. were collected within the premises of Paul University, Awka, Anambra State, Nigeria, between 10:00 a.m. and 2:00 p.m. during the dry season. The plant samples were identified and authenticated by late Dr. (Mrs.) B. O. Aziagba of the Department of Botany, Nnamdi Azikiwe University, Awka, Nigeria. Voucher specimens were deposited at the Herbarium of the Department of Botany, Nnamdi Azikiwe University, Awka. The voucher number for *Ficus exasperata* was N.A.U.H. No. 28A, while that of Sida acuta was N.A.U.H. No. 75A.

2.3. Preparation of ethanol leaf fractions

The collected leaves of *Ficus exasperata* and Sida acuta were thoroughly rinsed with clean running tap water to remove dirt and other surface contaminants. The leaves were air-dried at ambient room temperature of approximately 27- 30 °C until completely dried. The dried leaf samples were separately ground into powder using a Buchymix electric blender,

Turbocrush BM2016JS. Successive solvent extraction of the powdered leaves was carried out using solvents of increasing polarity, namely n-hexane, petroleum ether, ethanol and water. One thousand grams of each powdered leaf sample was weighed separately and soaked in 5 L of n-hexane for 24 hours. After 24 hours, the mixture was sieved through muslin cloth and filtered using Whatman No. 1 filter paper, 125 mm diameter. The filtrate was concentrated using an Electric Thermostatic Water Bath Boiler, Model No. KJ420, at 40 °C. The residue obtained after n-hexane extraction was air-dried, weighed and successively extracted with petroleum ether, ethanol and water using the same procedure sequentially. The petroleum ether fraction was concentrated at 40 °C, the ethanol fraction at 50 °C and the aqueous fraction at 65 °C. Each fraction was evaporated to dryness using a temperature-regulated water bath and stored in a refrigerator at approximately -4 °C until required for administration. For reconstitution, n-hexane and petroleum ether fractions were dissolved using Tween-80, while ethanol and aqueous leaf fractions were dissolved in water. The ethanol fractions of *Ficus exasperata* and Sida acuta were used for the antidiabetic treatment study and lipid profile evaluation.

2.4. Experimental animals

A total of sixty-three female Wistar albino rats weighing between 170 and 200 g were used for the one-month antidiabetic treatment study. The animals were obtained from Chris Experimental Animal Farm and Research Laboratory, Awka, Anambra State, Nigeria. The animals were housed in standard cages under suitable laboratory conditions and allowed to acclimatize to the experimental environment for one week before the commencement of the study. During the acclimatization and experimental periods, the rats were fed with Vital Growers Mash pellets purchased from a Vital Feed distributor in Awka, Anambra State, Nigeria. Clean drinking water was provided ad libitum throughout the study. Before the commencement of the experiment, the animals were weighed, randomly assigned to their respective experimental groups and properly labelled for identification. The sixty-three rats were divided into nine groups of seven rats each.

2.5. Ethical approval

Ethical approval for the study was obtained from the Nnamdi Azikiwe University Animal Research Ethics Committee, Nnamdi Azikiwe University, Awka, Nigeria, with approval number NAU/AREC/2023/00027. The animals were handled according to accepted laboratory animal care guidelines throughout the study.

2.6. Induction of diabetes

Alloxan was purchased from recognized manufacturers and their accredited vendors. Before the induction of diabetes, the animals were fasted overnight prior to the measurement of fasting blood glucose levels, but were allowed free access to water. Fasting blood glucose levels were measured using a One Touch Glucometer and compatible test strips. Diabetes was induced by a single intraperitoneal injection of alloxan at a dose of 150 mg/kg body weight according to the method described by Radenković et al. [7]. Two hours after alloxan administration, each rat was orally given 5 mL of 5% glucose solution to prevent hypoglycaemia. Thereafter, the animals were allowed free access to food and clean drinking water. Forty-eight hours after alloxan administration, blood samples were collected through the orbital route and glucose concentrations were determined using a One Touch Glucometer and compatible test strips. Diabetes was considered successfully induced when fasting blood glucose levels increased above the normal range of 60 -120 mg/dL to values above 200 mg/dL. Other observable signs used as supporting evidence of diabetic induction included excessive urination, weakness associated with excessive hunger and loss of body weight.

2.7. Experimental grouping and treatment

Following confirmation of diabetes, the animals were treated orally with the standard drug, ethanol leaf fraction of Sida acuta, ethanol leaf fraction of *Ficus exasperata* or combined ethanol fractions of both plants for twenty-eight days. Glibenclamide was purchased from recognized manufacturers and their accredited vendors. The ethanol fractions used for treatment were dissolved in water before oral administration.

The animals were divided into nine groups of seven rats each as follows:

- Group A: Normal control
- Group B: Diabetic untreated control
- Group C: Diabetic rats treated with glibenclamide at 0.29 mg/kg body weight
- Group D: Diabetic rats treated with 200 mg/kg ethanol fraction of Sida acuta
- Group E: Diabetic rats treated with 400 mg/kg ethanol fraction of Sida acuta
- Group F: Diabetic rats treated with 200 mg/kg ethanol fraction of *Ficus exasperata*

- Group G: Diabetic rats treated with 400 mg/kg ethanol fraction of *Ficus exasperata*
- Group H: Diabetic rats treated with 200 mg/kg combined ethanol fractions of Sida acuta and *Ficus exasperata*
- Group I: Diabetic rats treated with 400 mg/kg combined ethanol fractions of Sida acuta and *Ficus exasperata*. The treatment lasted for twenty-eight days.

2.8. Collection of blood samples

At the end of the twenty-eight-day treatment period, the animals were anaesthetized by chloroform inhalation. Blood samples were collected by cardiac puncture into clean, dry plain bottles without anticoagulant. The blood samples were allowed to clot at room temperature, after which they were centrifuged at 3000 rpm for 10 minutes. The clear serum obtained was carefully separated and used for lipid profile analysis.

2.9. Determination of lipid profile

The lipid profile of the experimental animals was determined using commercially prepared Randox diagnostic test kits. The lipid parameters analysed included total cholesterol, triglycerides, high-density lipoprotein cholesterol, low-density lipoprotein cholesterol and very-low-density lipoprotein cholesterol. Total cholesterol, triglycerides and high-density lipoprotein cholesterol were determined using Randox test kits according to the manufacturer's instructions provided in the reagent manual. The biochemical principles of the assays were based on standard enzymatic colorimetric methods as described by Trinder [13] and Tietz et al. [14]. Very-low-density lipoprotein cholesterol was calculated as triglycerides divided by five. Low-density lipoprotein cholesterol was calculated using the Friedewald equation as follows:

$$\text{LDL-C} = \text{Total cholesterol} - (\text{HDL-C} + \text{VLDL-C})$$

The lipid profile results were expressed in mg/dL.

2.10. Statistical analysis

Data obtained from the experiment were analysed using the Statistical Package for Social Sciences software for Windows, version 23.0, SPSS Inc., Chicago, Illinois, USA. Results were expressed as mean ± standard error of mean. Statistical comparison among the experimental groups was carried out using one-way analysis of variance. The one-way analysis of variance was used to determine whether statistically significant differences existed among the mean values of the control and treated groups. The level of statistical significance was set at $p < 0.05$. Differences between group means were considered statistically significant when the probability value was less than 0.05, while values greater than 0.05 were regarded as not statistically significant.

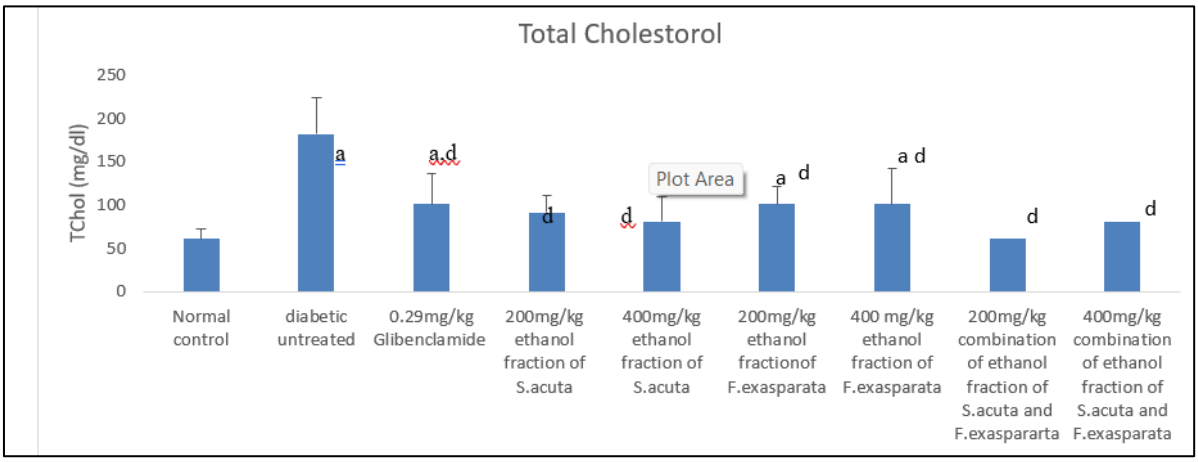
3. Results

The effect of ethanol leaf fractions of Sida acuta and *Ficus exasperata*, administered singly and in combination, on the lipid profile of alloxan-induced diabetic Wistar rats is presented in Table 1. The diabetic untreated group showed marked alteration in lipid profile when compared with the normal control group. Total cholesterol increased significantly ($p < 0.05$) in the diabetic untreated group, from 60.79 ± 11.70 mg/dL in the normal control to 182.39 ± 42.18 mg/dL. The diabetic untreated group also showed higher triglycerides, LDL-C and VLDL-C values, while HDL-C was reduced when compared with the normal control group. Treatment with glibenclamide produced a significant ($p < 0.05$) reduction in total cholesterol compared with the diabetic untreated group. Glibenclamide also significantly ($p < 0.05$) increased HDL-C from 38.79 ± 4.07 mg/dL in the diabetic untreated group to 47.68 ± 0.96 mg/dL. Treatment with ethanol fraction of Sida acuta at 200 mg/kg reduced total cholesterol from 182.39 ± 42.18 mg/dL in the diabetic untreated group to 91.19 ± 19.40 mg/dL, while the 400 mg/kg dose significantly ($p < 0.05$) reduced total cholesterol to 81.06 ± 28.66 mg/dL. The 400 mg/kg dose of Sida acuta produced a greater reduction in total cholesterol and LDL-C than the 200 mg/kg dose.

Treatment with ethanol fraction of *Ficus exasperata* at 200 mg/kg reduced total cholesterol from 182.39 ± 42.18 mg/dL in the diabetic untreated group to 101.33 ± 20.26 mg/dL. The 400 mg/kg dose also reduced total cholesterol to 101.33 ± 20.26 mg/dL. Both doses produced improvements in HDL-C, triglycerides, LDL-C and VLDL-C when compared with the diabetic untreated group.

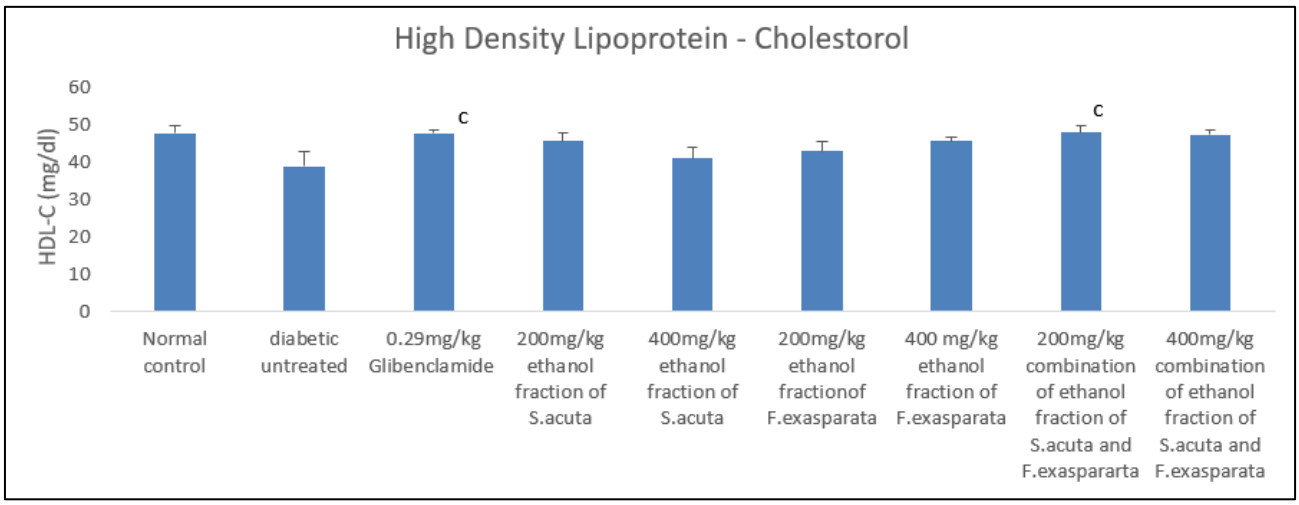
The combined ethanol fractions of Sida acuta and *Ficus exasperata* also produced notable changes in lipid profile. The 200 mg/kg combined fraction showed the most favourable lipid profile among the extract-treated groups, with total cholesterol, HDL-C, triglycerides and VLDL-C values approaching those of the normal control group. This group showed

a significant ($p < 0.05$) reduction in total cholesterol to 60.79 ± 20.26 mg/dL and a significant increase in HDL-C to 47.98 ± 1.69 mg/dL when compared with the diabetic untreated group. However, the 400 mg/kg combined fraction produced a significant ($p < 0.05$) reduction in total cholesterol from 182.39 ± 42.18 mg/dL to 81.06 ± 40.53 mg/dL but did not show uniform improvement across all lipid parameters. In particular, LDL-C increased from 106.10 ± 40.30 mg/dL in the diabetic untreated group to 132.04 ± 63.37 mg/dL in the 400 mg/kg combined fraction group.



[a] Significant increase compared with normal control; [b] significant decrease compared with normal control; [c] significant increase compared with diabetic untreated group; [d] significant decrease compared with diabetic untreated group.

Figure 1 Effect of Effect of ethanol leaf fractions of Sida acuta and *Ficus exasperata* on Total cholesterol



. [a] Significant increase compared with normal control; [b] significant decrease compared with normal control; [c] significant increase compared with diabetic untreated group; [d] significant decrease compared with diabetic untreated group.

Figure 2 Effect of Effect of ethanol leaf fractions of Sida acuta and *Ficus exasperata* on High Density Lipoprotein Cholesterol

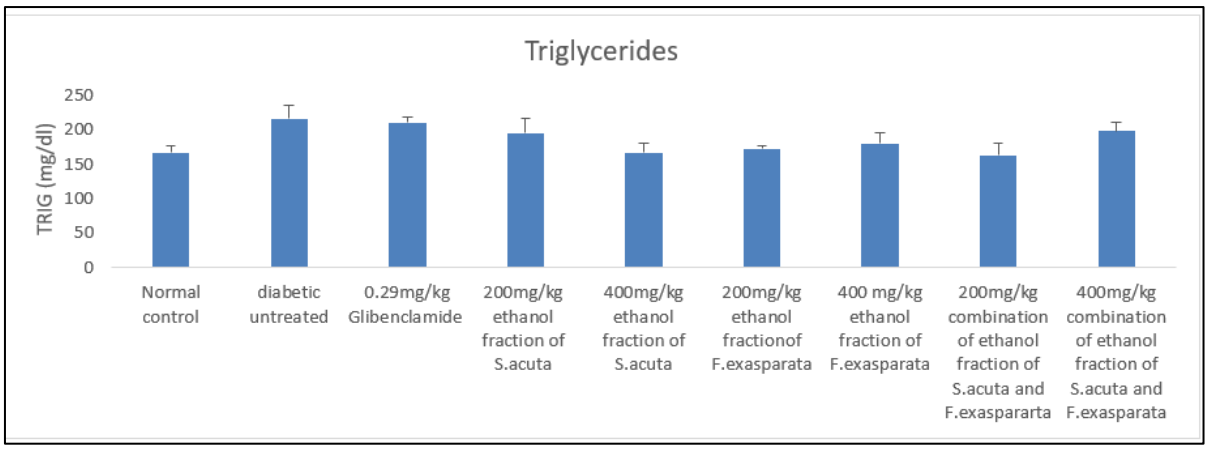


Figure 3 Effect of Effect of ethanol leaf fractions of Sida acuta and *Ficus exasperata* on Triglyceride

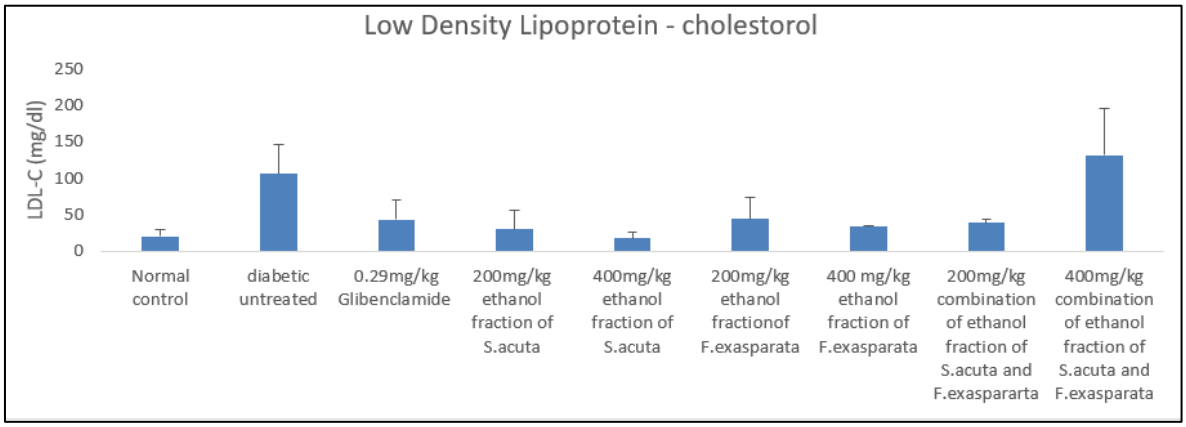


Figure 4 Effect of Effect of ethanol leaf fractions of Sida acuta and *Ficus exasperata* on Low Density Lipoprotein Cholesterol

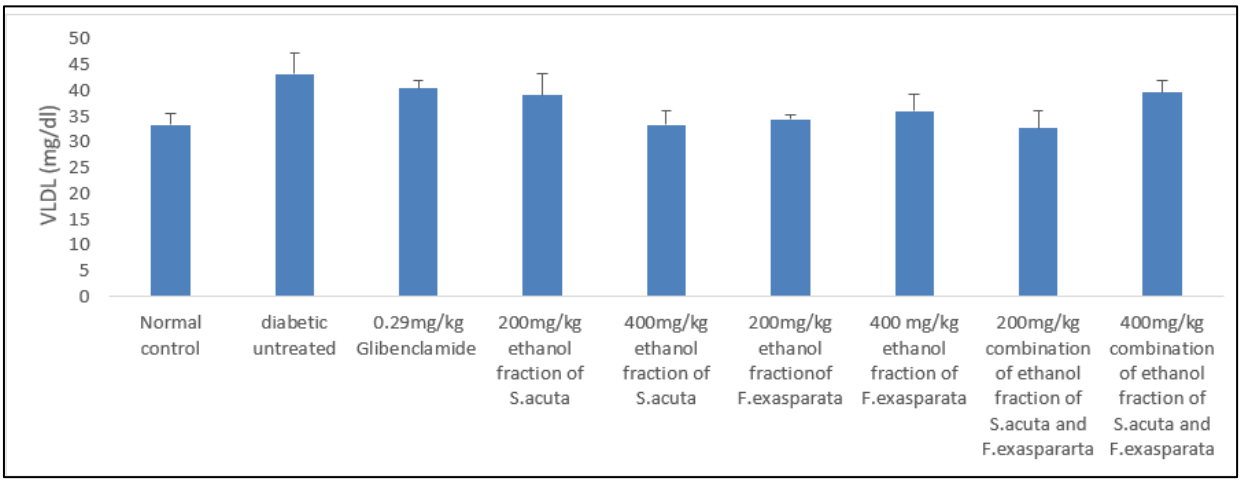


Figure 5 Effect of Effect of ethanol leaf fractions of Sida acuta and *Ficus exasperata* on Very Low Density Lipoprotein

4. Discussion

The present study evaluated the effects of ethanol leaf fractions of Sida acuta and *Ficus exasperata*, administered singly and in combination, on lipid profile parameters in alloxan-induced diabetic Wistar rats. The result showed that alloxan-

induced diabetes produced dyslipidaemia, as demonstrated by increased total cholesterol, triglycerides, LDL-C and VLDL-C, together with reduced HDL-C in the diabetic untreated group when compared with the normal control group. This pattern agrees with the established biochemical features of diabetic dyslipidaemia, which is commonly characterized by elevated triglycerides, increased atherogenic lipoproteins and reduced HDL-C [3,15]. The observed alteration in lipid profile confirms that alloxan-induced diabetes did not only affect glucose metabolism but also disrupted lipid homeostasis. The increase in total cholesterol, triglycerides, LDL-C and VLDL-C observed in the diabetic untreated rats may be attributed to insulin deficiency caused by alloxan-mediated pancreatic β-cell damage. Insulin plays an important role in regulating lipid metabolism by suppressing lipolysis in adipose tissue, reducing hepatic VLDL production and promoting the clearance of triglyceride-rich lipoproteins through lipoprotein lipase activity [5]. In insulin-deficient states, increased mobilization of free fatty acids from adipose tissue to the liver enhances hepatic triglyceride synthesis and VLDL secretion. This may explain the elevated triglycerides and VLDL-C observed in the diabetic untreated group. Increased LDL-C may result from altered lipoprotein metabolism and reduced clearance of circulating lipids. These changes are clinically important because diabetic dyslipidaemia is strongly associated with increased cardiovascular risk [2,15]. Treatment with glibenclamide produced improvement in lipid profile, particularly by reducing total cholesterol and increasing HDL-C compared with the diabetic untreated group. This observation supports the role of improved glycaemic control in correcting diabetes-associated lipid abnormalities. Glibenclamide, a sulfonylurea antidiabetic drug, stimulates insulin release from pancreatic β-cells, and the resulting improvement in insulin availability may enhance glucose utilization and regulate lipid metabolism. Similar improvement in lipid profile following treatment with standard antidiabetic agents and herbal formulations has been reported in alloxan-induced diabetic rats [16]. The ethanol fraction of Sida acuta produced improvement in lipid profile, especially in total cholesterol and LDL-C. At 200 mg/kg and 400 mg/kg, Sida acuta reduced total cholesterol when compared with the diabetic untreated group, while the 400 mg/kg dose produced a stronger reduction in LDL-C. This suggests that the ethanol fraction of Sida acuta may possess lipid-modulating activity in diabetic conditions. The effect may be linked to the phytochemical constituents of Sida acuta, including alkaloids, flavonoids, saponins, tannins and phenolic compounds, which have been associated with antioxidant and pharmacological activities [8,17,18]. Flavonoids and phenolic compounds may reduce oxidative stress and lipid peroxidation, while saponins may contribute to cholesterol reduction by binding bile acids and interfering with intestinal cholesterol absorption. The improvement observed in this study supports earlier reports that Sida acuta possesses pharmacological properties that may be beneficial in metabolic disorders [8,17].

The ethanol fraction of *Ficus exasperata* also improved selected lipid profile parameters in the diabetic rats. Both 200 mg/kg and 400 mg/kg doses reduced total cholesterol and LDL-C compared with the diabetic untreated group, while HDL-C values improved. This finding supports previous reports on the medicinal and pharmacological relevance of Ficus species. Hasnat et al. [9] reported that Ficus species contain diverse bioactive constituents with antioxidant, anti-inflammatory and metabolic regulatory properties. In addition, Adeyomoye et al. [10] reported that methanol extract of *Ficus exasperata* influenced oxidative stress markers, antioxidant defence, inflammatory mediators and cardiovascular-related molecular pathways in diabetic Wistar rats. These findings support the possibility that *Ficus exasperata* may protect against diabetes-related metabolic and cardiovascular disturbances. The improvement in lipid profile observed in the *Ficus exasperata*-treated groups may be due to the ability of its bioactive constituents to reduce oxidative stress, improve antioxidant defence and modulate lipid metabolism. Oxidative stress plays an important role in diabetes-induced β-cell dysfunction and diabetic complications [20]. Plant fractions with antioxidant activity may indirectly improve lipid metabolism by reducing oxidative damage and improving metabolic regulation. Previous studies on *Ficus exasperata* have also reported beneficial effects on diabetes-related complications, including neurochemical alterations and oxidative stress, supporting its traditional use in the management of diabetes-related disorders [21]. The combined ethanol fraction of Sida acuta and *Ficus exasperata* at 200 mg/kg produced the most favourable lipid profile response among the extract-treated groups. This group showed total cholesterol, HDL-C, triglycerides and VLDL-C values that were close to those of the normal control group. The reduction in total cholesterol and improvement in HDL-C suggest that the 200 mg/kg combination may have produced a beneficial interaction between the bioactive constituents of both plants. Combination therapy using medicinal plants may produce additive or synergistic effects due to the presence of multiple phytochemicals that may act through different biochemical pathways, including antioxidant protection, modulation of insulin activity, inhibition of lipid peroxidation and regulation of hepatic lipid metabolism [16,22]. However, the 400 mg/kg combined fraction did not show uniform improvement across all lipid parameters, despite reducing total cholesterol. In particular, LDL-C was higher in this group compared with the diabetic untreated group. This non-uniform response suggests that the lipid-modulating activity of the combined fractions may not be strictly dose-dependent. It may also indicate possible phytochemical interaction at the higher combined dose, differences in absorption or metabolism of the active constituents, or physiological variation in the response of diabetic animals. This observation is important because it shows that a higher dose of combined plant fractions may not necessarily produce a better lipid profile outcome. Therefore, the 200 mg/kg combined fraction appears to be more effective than the 400 mg/kg combined fraction in this study. The reduction in

total cholesterol and LDL-C observed in several treated groups is particularly important because LDL-C is a major atherogenic lipoprotein. Increased LDL-C promotes lipid deposition in blood vessels and contributes to the development of cardiovascular complications, while HDL-C is protective because it participates in reverse cholesterol transport. Therefore, the ability of the plant fractions, especially the 200 mg/kg combined fraction, to improve HDL-C and reduce atherogenic lipid parameters suggests possible cardioprotective relevance in diabetic conditions. Current diabetes care and lipid-disorder management literature emphasizes the importance of lipid control in reducing cardiovascular risk in diabetes [2,15]. The findings of this study are consistent with previous experimental reports showing that alloxan-induced diabetes causes lipid profile derangement, while treatment with medicinal plant extracts can reduce total cholesterol, triglycerides, LDL-C and VLDL-C and improve HDL-C [16,22]. Studies on antidiabetic natural products have also shown that phytochemical-rich products may exert beneficial metabolic effects through antioxidant and anti-inflammatory activity, improved insulin action, reduced insulin resistance and regulation of glucose- and lipid-related metabolic pathways [22,23]. This supports the present finding that ethanol leaf fractions of Sida acuta and *Ficus exasperata* may possess hypolipidaemic potential in alloxan-induced diabetic rats. The findings of this result suggests that ethanol leaf fractions of Sida acuta and *Ficus exasperata* improved selected lipid profile parameters in alloxan-induced diabetic Wistar rats, with the 200 mg/kg combined treatment showing the most potent effect. The observed hypolipidaemic activity may be associated with the phytochemical constituents of the plants and their possible antioxidant, insulin-modulating and lipid-regulatory effects. The non-uniform response observed at the higher combined dose indicates the need for further studies to establish the active compounds, clarify the mechanisms of action, evaluate dose-response relationships and assess long-term safety.

5. Conclusion

The findings of this study showed that alloxan-induced diabetes caused dyslipidemia in Wistar rats, as evidenced by increased total cholesterol, triglycerides, LDL-C and VLDL-C, with a reduction in HDL-C in the diabetic untreated group. Treatment with ethanol leaf fractions of Sida acuta and *Ficus exasperata*, administered singly and in combination, produced varying degrees of improvement in the lipid profile of the diabetic rats. The 200 mg/kg combined ethanol fraction of Sida acuta and *Ficus exasperata* produced the most potent lipid-modulating effect among the extract-treated groups, while the 400 mg/kg combined fraction did not produce uniform improvement across all lipid parameters. These findings suggest that ethanol leaf fractions of Sida acuta and *Ficus exasperata*, especially at selected doses and in combination, may possess hypolipidemic potential in alloxan-induced diabetic Wistar rats. However, further studies are recommended to isolate and characterize the active bioactive compounds, determine the exact mechanism of action, establish the optimal therapeutic dose and evaluate long-term safety.

Compliance with ethical standards

Acknowledgments

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Disclosure of conflict of interest

No, we have no conflict.

Statement of ethical approval

Ethical approval for this animal study was obtained from the Nnamdi Azikiwe University Animal Research Ethics Committee, Nnamdi Azikiwe University, Awka, Nigeria, with approval number NAU/AREC/2023/00027.

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