	Original Research Article

Hepatoprotective and Renoprotective Potential of Selected Varieties of *Solanum lycopersicum* in Albino Rats Fed with High-Fat Diet

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Abstract

Worldwide, the prevalence of overweight and obesity due to lifestyle is on the rise. Numerous health problems, including metabolic disorders, diabetes mellitus, and cardiovascular diseases, are significantly correlated with it. This study evaluated the protective effects of selected varieties of *Solanum lycopersicum* on liver and kidney markers in albino rats fed with a high-fat diet (HFD). A total of twenty-five healthy male albino rats weighing between (150–180 g) were fed high fat diet for the first four (4) weeks, and rats weighing above 300g were randomly divided into five groups of five rats each for another four (4) weeks. Group 1 served as the normal control group, Group 2 served as the negative control (rats fed a high-fat diet only), Group 3 was administered the standard drug (5mg/kg Lovastatin), Groups 4 and 5 animals were administered 200mg/kg body weight of two different varieties of *Solanum lycopersicum*. After 4 weeks of administration, rats were euthanized, blood sample was collected and centrifuged for analysis. The serum levels of alanine aminotransferase (ALT), aspartate aminotransferase (AST), alkaline phosphatase (ALP), Total bilirubin (TB), Conjugated bilirubin (CB), total protein (TP), albumin, (ALB) creatinine, urea, uric acid, and electrolytes were measured. The results showed a significant ($p < 0.05$) elevation of liver enzymes and kidney markers in HFD-fed rats. At the same time, the *Solanum lycopersicum*-treated groups exhibited a marked improvement in both liver and kidney parameters compared to the HFD control. The study concludes that *Solanum lycopersicum* possesses hepatoprotective and renoprotective potential, suggesting its nutritional importance in preventing diet-induced metabolic disorders.
Keywords: *Solanum lycopersicum*, liver markers, kidney function, high-fat diet, albino rats.

INTRODUCTION

The prevalence of obesity has increased significantly during the past 50 years, approaching epidemic levels. It is a serious public health concern since it substantially raises the risk of type 2 diabetic melliatus. Conditions that reduce the life expectancy and quality of life, such as diabetes, myocardial infarction, stroke, and many malignancies (Blüher and M, 2019). The prevalence of obesity has increased almost threefold worldwide, tripling between 1975 and 2020 (WHO, 2021). Furthermore, by 2020, 39% of adults worldwide, more than 2 billion people, will be overweight. (Othman *et al.,* 2022).

Excessive consumption of high-fat diets (HFD) is a leading factor in the development of obesity, hyperlipidemia, and metabolic disorders, which are often associated with liver and kidney dysfunction (Sun *et al.,* 2021). The liver plays a central role in lipid metabolism, and prolonged HFD feeding induces hepatocellular damage, reflected in elevated serum liver enzymes such as alanine aminotransferase (ALT) and aspartate aminotransferase (AST) (Li *et al.,* 2020). Similarly, HFD negatively affects renal function, leading to increased urea, creatinine, and electrolyte imbalance (Rahman *et al.,* 2017).

Solanum lycopersicum is rich in carotenoids, flavonoids, vitamins, and phenolic compounds, with

lycopene being the most abundant bioactive molecule. Lycopene has been documented to exhibit antioxidant, anti-inflammatory, and lipid-lowering properties (Story *et al.,* 2010). Previous studies suggest that tomato supplementation may improve lipid profile and reduce oxidative stress in experimental models of hyperlipidemia (Shi *et al.,* 2015). However, limited research exists on the protective role of *Solanum lycopersicum* on both liver and kidney function in the context of HFD-induced metabolic disorders.

Solanum lycopersicum can be eaten as whole fruits, juice, soup, and bastes and are an important part of a balanced diet (Collins *et al.,* 2022). Numerous health benefits of tomatoes have been shown in the past few decades, including their effects on skin, kidney, hepatic, and cardiovascular problems, as well as cancer, diabetes mellitus, hypertension, and infertility (Collins *et al.,* 2022). Because tomatoes contain a variety of phenolic compounds and flavonoids, including lycopene, vitamins C, E, and B12, ferulic acid, hydroxycinnamic acid, homovanillic acid, α-tomatine, tomtidine, caffeic acid, resveratrol, kaempferol, quercetin, delphinidin, phytofluene, and nucleoside, these effects have been linked to the fruits' hypolipidemic, antioxidant, and anti-inflammatory properties (Collins *et al.,* 2022). Of these, tomatine, glycoalkaloid saponins, and esculeoside A have drawn the most attention (Arroyave *et al.,* 2021).

MATERIALS AND METHODS

Area of Study

The research was conducted at Sa'adu Zungur State University, Gadau, located in Itas/Gadau Local Government Area, Bauchi State, Nigeria.

Sample Collection and Preparation

The varieties of *Solanum lycopersicum* (*Roba* E1 and *Siriya* E2) were purchased from Gadau Market, in Itas/Gadau Local Government Area of Bauchi State. The plant varieties were identified and authenticated at the Department of Biological Sciences, Sa'adu Zungur State University, Bauchi and were given voucher numbers of (*Roba*: SAZU00210) and (*Siriya*: SAZU00198). The samples were washed thoroughly with distilled water, blended, and homogenized. The homogenates were freeze-dried using an MRC Mini Freeze-Dryer. The freeze-dried materials were ground into fine powder using pistle and mortar and stored in airtight containers at 20°C until further analysis.

The volume of extracts to be administered was calculated according to dose and weight of the experimental animal using the relation below (Alhassan *et al.,* 2016).

Volume of extract (ml) to be administered
$$= \frac{\text{Weight of animal (kg) x dose (mg/kg)}}{\text{Concentration of extract (mg/ml)}}$$

Experimental Animals

The twenty-five healthy adult male albino rats (150–180g) were obtained from the National Veterinary Research Institute (NVRI), Vom, Plateau State, Nigeria. Rats were housed under standard laboratory conditions (12hr light/dark cycle, 25 ± 2 °C) with free access to food and water. All experimental procedures were approved by the Institutional Animal Ethics Committee (Ref. No. BASUG/FBMS/REC/VOL. 08/01058).

Experimental Diets

The control group received standard rat chow. Hyperlipidaemia was induced based on a modified method described by Vesselinvitch *et al*. (1980). A high-fat diet was prepared by mixing pure cholesterol, palm oil, and grower mash in a ratio of 2:20:78 by mass. Fully grown rats were exposed to the diet for six (4) weeks, and their body weight was recorded weekly to monitor changes.

Experimental Design

Rats were randomly divided into five groups (n = 5 per group):

- **Group 1:** (Normal Control) standard rat chow only
- **Group 2:** (Negative control) High-fat diet only
- **Group 3:** High-fat diet treated with levostatin (Standard drug) 5mg/kg body weight.
- **Group 4:** High-fat diet treated with 200 mg/kg body weight of *Solanum lycopersicum* (E_1)
- **Group 5:** High-fat diet treated with 200 mg/kg body weight *Solanum lycopersicum* (E_2)

Treatments were administered via oral gavage daily for four (4) weeks, after which rats were anesthetized with diethyl ether and sacrificed. Blood samples were collected into plain tubes. The blood was centrifuged at 1500 g for 15 minutes, and the serum was stored at -20°C until further biochemical analysis (Silvia *et al.,* 2018).

Statistical Analysis

All data were expressed as mean ± standard deviation. Statistical differences between groups were analyzed by one-way analysis of variance (ANOVA) followed by Tukey's test after investigating the data for normality using Shapiro-Wilk test and for variances homogeneity to be sure that the data are normally distributed and variances would be homogenous using GraphPad Instat3 Software version 3.05 Differences of P < 0.05 were considered to be significant (GraphPad, 2000).

RESULTS

Table 1 presents the liver function indices (AST, ALT, ALP, CB, TB, TP, and ALB) of rats fed with high fat diet administered with two different varieties of *Solanum lycopersicum.* A significant (p<0.05) increase in mean serum levels of all the parameters was observed in the negative control group (rats fed high fat diet only).

On the other hand, a significant (p<0.05) decrease in mean serum levels of ALT, AST, ALP, TB, CB, and TP was observed in the extracts administered groups compared to the negative control.

Table 1: The effect of administration of two varieties of *Solanum lycopersicum* on Liver enzymes in rats fed with high fat diet

Gps	AST (U/L)	ALP (U/L)	ALT (U/L)	TB (mg/dL)	CB (mg/dL)	TP (g/dL)	Alb (g/dL)
NC	84.00 ± 2.28 a	211.00 ± 3.08 a	46.20 ± 2.86 a	2.60 ± 0.16 a	2.64 ± 0.11 a	6.68 ± 0.13 a	3.60 ± 0.16 a
HFD	320.60 ± 4.28 a,b,c,d	420.60 ± 4.28 a,b,c,d	73.60 ± 4.28 a,b,c,d	3.70 ± 1.09 a,b,c,d	3.40 ± 1.09 a,b,c,d	7.90 ± 1.09 a,b,c,d	2.80 ± 1.09 a,b,c,d
HFD-TS	93.60 ± 4.28 b	228.60 ± 4.28 b	47.60 ± 4.28 b	2.90 ± 1.09 b	2.63 ± 1.09 b	6.10 ± 1.09 b	4.00 ± 1.09 b
HFD-E1	103.60 ± 4.28 c	256.60 ± 4.28 c	57.60 ± 4.28 c	3.00 ± 1.09 c	2.70 ± 1.09 c	6.80 ± 1.09 c	3.60 ± 1.09 c
HFD-E2	118.60 ± 4.28 d	287.60 ± 4.28 d	52.60 ± 4.28 d	3.10 ± 1.09 d	2.80 ± 1.09 d	6.30 ± 1.09 d	4.10 ± 1.09 d

Results are expressed as mean ± SD (n=5). Values in the same column bearing similar superscripts are significantly different at P<0.05. Key: GPS: Groups, NC: Normal control, HFD: High fat diet fed rats only, HFD-TS: High fat diet fed rats treated with standard drugs (5mg/kg b.w of Lovastatin), HFD-E1: High fat diet fed rats treated with 200mg/kg body weight of extract 1. HFD-E1: High fat diet fed rats treated with 200mg/kg body weight of extract 2. ALT-Alanine aminotransferase, AST- Aspartate aminotransferase, ALP- Alkaline phosphatase, TP-Total Protein, ALB- Albumin, CB- Conjugated Bilirubin, T.B- Total Bilirubin.

Table 2 presents the kidney function indices (creatinine, Urea, Na, Cl, K and HCO$_3$) of rats fed with high fat diet administered with two different varieties of *Solanum lycopersicum.* A significant (p<0.05) increase in mean serum levels of all the parameters was observed in the negative control group (rats fed high fat diet only). On the other hand, a significant (p<0.05) decrease in mean serum levels of creatinine, urea, and electrolytes was observed in the extracts administered groups compared to the negative control.

Table 2: The effect of administration of two varieties of *Solanum lycopersicum* on Kidney parameters in rats fed with a high-fat diet

Gps	Cre (mg/dL)	Urea (mg/dL)	Na$^+$ (mmol/L)	Cl$^-$ (mmol/L)	K$^+$ (mmol/L)	HCO3$^-$ (mmol/L)
NC	55.80 ± 1.92 [a]	5.58 ± 0.19 [a]	140.00 ± 4.12 [a]	107.20 ± 2.77 [a]	4.36 ± 0.24 [a]	18.40 ± 2.30 [a]
HFD	72.60 ± 4.28 [a,b,c,d]	7.10 ± 1.09 [a,b,c,d]	168.60 ± 4.28 [a,b,c,d]	97.60 ± 4.28 [a,b,c,d]	5.70 ± 1.09 [a,b,c,d]	28.60 ± 4.28 [a,b,c,d]
HFD-TS	58.60 ± 4.28 [b]	5.70 ± 1.09 [b]	135.60 ± 4.28 [b]	106.60 ± 4.28 [b]	4.90 ± 1.09 [b]	16.60 ± 4.28 [b]
HFD-E1	60.60 ± 4.28 [c]	5.80 ± 1.09 [c]	134.60 ± 4.28 [c]	104.60 ± 4.28 [c]	4.90 ± 1.09 [c]	19.60 ± 4.28 [c]
HFD-E2	62.60 ± 4.28 [d]	5.90 ± 1.09 [d]	141.60 ± 4.28 [d]	107.60 ± 4.28 [d]	4.20 ± 1.09 [d]	13.60 ± 4.28 [d]

Results are expressed as mean ± SD (n=5). Values in the same column bearing similar superscripts are significantly different at P<0.05. Key: GPS: Groups, NC: Normal control, HFD: High fat diet fed rats only, HFD-TS: High fat diet fed rats treated with standard drugs (5mg/kg b.w of Lovastatin), HFD-E1: High fat diet fed rats treated with 200mg/kg body weight of extract 1. HFD-E1: High fat diet fed rats treated with 200mg/kg body weight of extract 2. Cre-Creatinine.

DISCUSSION

High-fat diets (HFDs) are widely recognized as one of the primary contributors to the development of obesity and metabolic disorders. The consumption of excess dietary fats, especially those high in saturated and trans fats, leads to an imbalance in lipid metabolism and results in the accumulation of excess adipose tissue, particularly in the abdominal region (Tan and Norhaizan, 2024). This increased adiposity promotes insulin resistance, which is a key feature of metabolic syndrome and a precursor to the development of T2DM (Hasnani *et al.,* 2024). The pathological effects of high-fat diets extend beyond obesity to affect several key organs involved in metabolism. One of the primary organs affected by HFDs is the liver, which plays a central role in glucose and lipid homeostasis. Chronic consumption of HFDs can lead to non-alcoholic fatty liver disease (NAFLD), a condition characterized by the accumulation of fat in the liver, which impairs hepatic function and contributes to insulin resistance (Zargar *et al.,* 2025). This research showed that both varieties of *Solanum lycopersicum* decreased hepatic dysfunction induced by high-fat diet feeding. The result showed a significant (p<0.05) increase in mean serum of ALT, AST, ALP, conjugated bilirubin, total bilirubin and total protein in the group fed high fat diet when compared with the normal control group. This could be due to an imbalance in lipid metabolism which results in the accumulation of excess adipose tissue. However, treatment with both varieties of *Solanum lycopersicum* significantly decreases the liver marker enzymes as observed. The study aligns with the findings of Albrahim and Robert, (2022), which showed the effects of lycopene on

Metabolic Syndrome and Kidney Injury in Rats Fed a high-fat diet.

Kidneys are the major organs in metabolizing toxic compounds besides the liver. It receives about 1200ml of blood per minute containing a lot of chemical compounds. Studies have shown that HFDs can induce kidney dysfunction by promoting oxidative stress, inflammation, and glomerular injury (Maiwall *et al.,* 2023). The result showed a significant ($p<0.05$) increase in mean serum levels of urea, creatinine, Na^+, K^+ and HCO_3^- in the group fed high fat diet when compared with the normal control group. Administration of both varieties of *Solanum lycopersicum* significantly decreases levels of urea, creatinine, Na^+, K^+ and HCO_3^- when compared with the group fed with high fat diet.

CONCLUSION

In conclusion, the selected varieties of *Solanum lycopersicum* show significant hepatoprotective and renoprotective effects in high-fat diet-fed albino rats with *Raba* E_1 showing slightly better efficacy than *Siriya* E_2. The observed benefits are likely due to bioactive compounds such as lycopene, flavonoids, and phenolic acids. Incorporation of *Solanum lycopersicum* into daily diet may serve as a preventive measure against metabolic disorders and related complications.

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