

## Effect of Aqueous *Solanum macrocarpon* Leaves Extract on Hyperglycemia, Liver Enzymes, and Liver and Pancreas Histology in Alloxan-Induced Diabetes

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### ABSTRACT

*Solanum macrocarpon* (SM) is frequently used for both medicinal and dietary purposes. It has been documented to have hypoglycemic properties in diabetes management. This research delved into the effect of aqueous *Solanum macrocarpon* leaves extract on blood glucose levels, liver enzymes, antioxidant enzymes, and histology of the liver and pancreas in alloxan-induced diabetic rats. A total of thirty male Wistar rats, with weights ranging from 150 to 200 g, were randomly divided into six groups, each containing five rats. The normal (A) and diabetic control (B) groups received distilled water. The diabetic treated groups (C, D, E, and F) were administered 5 mg of glibenclamide, 250 mg/kg, 500 mg/kg, and 750 mg/kg of *Solanum macrocarpon* extract orally for a period of 14 days. Significant reversal of the altered levels of liver enzymes was noted in the results. Positive alterations in blood glucose concentration and antioxidant enzyme activity were also observed. The histological examination showed damage to the hepatic and pancreatic cells of the diabetic untreated rat group, which was mitigated in diabetic rats treated with the aqueous extract. The findings indicate that the aqueous *Solanum macrocarpon* leaves extract serves as a valuable source of natural antioxidants, promoting both liver function and blood glucose regulation.

**Keywords:** Antioxidant enzymes, diabetes mellitus, histology, liver enzymes, pancreas, *Solanum macrocarpon*.

### Introduction

Diabetes mellitus is a chronic, endocrine abnormality in which a person has a elevated blood glucose level, stemming from insufficient insulin production by the body or an inadequate response of body cells to insulin (Silva *et al.*, 2018). Insulin, a hormone produced by the pancreas, plays a crucial role in facilitating the absorption of glucose by body cells and its conversion into energy. When this absorption falters, glucose accumulates in the

bloodstream, leading to hyperglycemia and other associated complications involving the vascular system, nerves, and other organs (Rother, 2007). Research indicates that diabetes mellitus has affected over 200 million individuals worldwide, with its prevalence projected to surpass 300 million by 2035 (Saeedi *et al.*, 2019).

Traditional diabetes treatments are often linked to side effects, e.g. glyburide, glimepiride and

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glipizide have an increased risk of gastrointestinal problems and vitamin B12 deficiency (Rother, 2007; Silva *et al.*, 2018). Some antidiabetic agents are also contraindicated in pregnancy, making insulin the preferred but costlier choice for the average population (Abdollahi *et al.*, 2011). Consequently, there has been a notable surge in the use of natural plant-based remedies for managing this condition (Chang *et al.*, 2007).

Unlike chemotherapeutic agents, medicinal plants have garnered attention for their non-toxic nature, wide availability, affordability, and fewer adverse effects (Chang *et al.*, 2005). Among such plants recognized for their potential in treating diabetes mellitus is *Solanum macrocarpon*, commonly called African eggplant. This perennial plant exhibits medicinal promise in its roots, leaves, and fruit (Oboh *et al.*, 2005; Chang *et al.*, 2007). *Solanum macrocarpon* use in indigenous medicine ranges from weight reduction to treat several illnesses, including asthma, allergic rhinitis, nasal catarrh, skin infections, rheumatic disease, constipation, and dyspepsia (Bello *et al.*, 2005). These pharmacological properties have been attributed to certain chemical substances in the plants, such as polyphenols (Sánchez-Mata *et al.*, 2010). Examination of its leaves has revealed a substantial presence of these phenolic compounds, especially flavonoids, which could contribute to its robust antioxidant properties (Komlaga *et al.*, 2014).

*Solanum macrocarpon* has been reported to lower blood glucose levels, although its potential for treating diabetes is not explicitly addressed in existing literature, despite its long-standing traditional use. This study aims to assess the effectiveness of using the aqueous leaf extract of *Solanum macrocarpon* in comparison to glibenclamide in male Wistar rats. The study evaluates its impact on blood glucose levels, the histology of the liver and pancreas, as well as its influence on antioxidant levels and liver enzymes.

## Materials and Methods

### *Preparation of aqueous Solanum macrocarpon leaves extract*

Fresh *Solanum macrocarpon* leaves were procured from the Obafemi Awolowo market in Sagamu, Ogun state, and was authenticated by the Department of Botany, Olabisi Onabanjo University, Ago-Iwoye. The leaves were air-dried at room temperature and subsequently oven-dried at 45°C until the complete moisture content was removed. The dried leaves were grounded into powdered form and weighed. An adaptation of the method outlined by Oben *et al.* (2006) was employed for the aqueous extraction process. Specifically, 25 g of the ground leaf sample were immersed in 400 mL of distilled water for 24-hour period, and the resulting mixture was later strained through a filter cloth. The filtrate was subsequently refrigerated.

### *Alloxan monohydrate administration*

Alloxan solution was prepared at 1 g/15 mL in distilled water and was administered to 12 hours fasted Wistar rats by a single intraperitoneal injection of freshly prepared alloxan monohydrate solution (150 mg/kg body weight) (Vijayvargia *et al.*, 2000). Since alloxan can lead to fatal hypoglycemia as a result of massive pancreatic insulin release, the rats were treated with 20% glucose solution orally after 72 hours of induction (Fluttert *et al.*, 2000). Rats with blood glucose levels >140 mg/dL were selected to participate in the experiment.

### *Glibenclamide preparation*

The antidiabetic drug glibenclamide was purchased from a reputable pharmacy in Sagamu, Nigeria. About twenty (20) mg of the drug was dissolved in 10 mL of distilled water and was administered to the specified rat group at a daily dose of 5 mg.

### **Laboratory animals**

Thirty (30) male Wistar rats of weight 150 g – 200 g were used in this experiment, and they were all procured from a reputable animal house in Ibadan, Oyo State, Nigeria. The animals were housed in hygienic and well-ventilated plastic cages and provided with pelletized food and water on a daily basis throughout the duration of the research.

### **Ethical clearance**

The Ethical Committee for Research of the Department of Physiology, Faculty of Basic Medical Science (FBMS), Olabisi Onabanjo University, Sagamu, Nigeria, ensured ethical considerations in compliance with the guiding principles and regulations of approval for the use and care of animals.

### **Grouping of animals**

The rats were randomly divided into six groups, with each group consisting of 5 rats. Group A was designated as the negative control, while Group B served as the positive control, representing diabetic rats left untreated. Group C received the standard drug, glibenclamide, at a dose of 5 mg/kg body weight. Groups D to F were the diabetic test groups, receiving doses of the aqueous extract at 250 mg, 500 mg, and 750 mg/kg body weight. The aqueous extract was administered orally twice daily using a cannula for a duration of 14 days. Adequate food and water were provided to all the rat groups.

### **Fasting blood glucose determination**

The blood glucose level was assessed using a glucometer (Accu-Chek Active Test Meter). Blood was obtained by cutting the tail vein of the rats (Fluttert *et al.*, 2000).

### **Collection of blood and organ samples**

At the end of the treatment period, blood samples were collected from the optical sinus of the animals into EDTA and lithium-heparinized bottles for biochemical analysis. the experimental

animals were humanely euthanized using cervical dislocation, and essential organs such as the liver and pancreas were preserved for further examination related to antioxidants and histological evaluations.

### **Determination of superoxide dismutase (SOD) activity**

The level of SOD activity was determined using Randox Laboratories kit manufacturer's instructions. First, 2 mL of the sample was pipette into a clean test tube, and 2.5 mL of 0.05 M carbonate buffer (pH 10.2) was added to equilibrate in the spectrophotometer. Then, the reaction was started by adding 0.3 mL of freshly prepared 0.3 mM epinephrine to the mixture, quickly mixed by inversion. The increase in absorbance at 480 nm was monitored every 60 seconds for 180 seconds. One unit of SOD activity was given as the amount of SOD necessary to cause 50% inhibition of the oxidation of adrenaline to adrenochrome during 1 minute.

### **Determination of reduced glutathione (GSH) level**

The total sulfhydryl groups, protein-bound sulfhydryl groups, and free sulfhydryl groups like glutathione (GSH) in biological samples can be determined using Ellman's reagent, 5, 5' – dithiobis-2-nitrobenzoic acid (DTNB). First, 0.7 mL of the sample was pipetted in a clean test tube, and 1.5 mL of Ellman's reagent was added to the sample. The yellow color's absorbance formed upon the addition of Ellman's reagent was read within 5 minutes at 412 nm using a spectrophotometer.

### **Determination of catalase (CAT) activity**

Catalase activity was determined according to the method of Sinha (1971). Subsequent heating for 10 minutes in a boiling water bath changed the color of the solution to stable green due to the formation of chronic acetate. After cooling at room temperature, the volume of the reaction mixture was made to 3 mL with distilled water, and the

absorbance was measured with a spectrophotometer at 570 nm.

#### **Estimation of aspartate aminotransferase (AST) activity**

It was determined by a quantitative in-vitro method using a spectrophotometer. The assay was performed using the principle of Reitman and Frankel (1957). AST was measured by monitoring the concentration of oxaloacetate hydrazone formed with 2,4-dinitrophenylhydrazine at 546 nm absorbance for 5 minutes.

#### **Estimation of alanine phosphatase (ALP) activity**

It was determined by the colorimetric endpoint method. First, 0.5 mL of Alkaline Phosphatase substrate was dispensed into labeled test tubes and equilibrated for three minutes for each sample. Then, 0.05 mL of each standard control was added at timed intervals and sampled to its respective test tube—the wavelength of the spectrophotometer at 590 nm.

#### **Estimation of alanine aminotransferase (ALT) activity**

It was determined by a quantitative in-vitro method using a spectrophotometer. The assay was performed using the principle of Reitman and Frankel (1957). ALT was measured by monitoring the concentration of pyruvate hydrazone formed with 2,4-dinitrophenylhydrazine at 546 nm absorbance.

#### **Determination of total and conjugated bilirubin (TB, CB), albumin (ALB), and total protein (TP) levels**

Randox assay kit was used to determine these parameters, following the manufacturer's instruction. Total and conjugated bilirubin was measured at an absorbance of 610 nm, while albumin and total protein were read at 540 nm after 5 minutes using a spectrophotometer.

#### **Histological studies**

The liver and pancreas were harvested from the animals and placed in formal saline for routine histopathology analysis. A histopathology examination was carried out at the Department of Histopathology, Olabisi Onabanjo University Teaching Hospital (OOUTH), Ogun state.

#### **Statistical analysis**

The data obtained was expressed as mean  $\pm$  standard error of the mean. The statistical significance was evaluated by one-way analysis of variance (ANOVA) using the Microsoft Excel 2013 software version. A value of  $p < 0.05$  was considered statistically significant.

#### **Result**

Table 1 shows the blood glucose level in alloxan-induced diabetic rats across the groups treated with aqueous extract of *Solanum macrocarpon* and glibenclamide. Before administering Alloxan, there was euglycemia in all the groups A-F. After induction of diabetes, Alloxan resulted in a significant increase in blood sugar levels in groups B-F. Blood glucose levels in groups D ( $70.6 \pm 4.89$ ), E ( $72 \pm 4.54$ ), and F ( $79 \pm 6.54$ ) significantly reduced with treatment when compared to group C ( $82 \pm 4.89$ ) and the untreated group B ( $236 \pm 6.77$ ).

Table 2 shows liver protein values in alloxan-induced diabetic rats treated with aqueous extract of *Solanum macrocarpon* and glibenclamide. There was no significant increase in TP level in groups D ( $5.8 \pm 0.13$ ), E ( $6.52 \pm 0.54$ ), and F ( $6.14 \pm 0.13$ ) when compared to group B ( $5.1 \pm 0.11$ ). Albumin concentration showed increases in groups D ( $3.24 \pm 0.19$ ), E ( $3.02 \pm 0.20$ ), and F ( $3.02 \pm 0.04$ ), with groups B ( $2.6 \pm 0.16$ ) and C ( $2.74 \pm 0.09$ ), but only the increases in groups D and F was significant. Total and conjugated bilirubin levels showed a non-significant increase across all treated groups compared to group B ( $0.18 \pm 0.04$ ), but only in group C ( $0.32 \pm 0.04$ ).

The liver enzymes activities in alloxan-induced diabetic rats treated with glibenclamide and aqueous extract of *Solanum macrocarpon* leaves are also shown in Table 2. A decrease in AST level was observed in groups D ( $10.8 \pm 0.49$ ), E ( $8.6 \pm 1.12$ ), and F ( $12.6 \pm 2.11$ ) when compared to group C ( $13.2 \pm 0.37$ ), which was significant only in groups D and E. The decrease in group E was also significant compared to group B ( $12.4 \pm 0.98$ ).

There was also a significant decrease in ALT activity in groups D ( $15.8 \pm 0.73$ ), E ( $17.6 \pm 1.47$ ), and F ( $20 \pm 2.74$ ) when compared to groups B ( $26.6 \pm 0.98$ ) and C ( $26.8 \pm 0.49$ ). ALP levels also showed a decrease in groups D ( $19.52 \pm 1.16$ ), E ( $23.5 \pm 5.14$ ), and F ( $23.8 \pm 1.28$ ) with group B ( $26.8 \pm 0.49$ ), which was significant only in group D.

**Table 1:** Blood glucose level in alloxan-induced diabetic rats treated with aqueous *Solanum macrocarpon* extract and glibenclamide

Parameters (mg/dL)	Groups					
	A	B	C	D	E	F
Pre- Treatment	$62.6 \pm 4.80$	$60 \pm 6.36$	$56.4 \pm 4.00$	$68.2 \pm 2.93$	$71.8 \pm 5.26$	$54 \pm 5.91$
After Induction	$66.2 \pm 3.2$	$389 \pm 1.22$	$312.8 \pm 3.35$	$159.4 \pm 14.10$	$376.8 \pm 30.46$	$392.6 \pm 33.01$
Post-Treatment	$67.2 \pm 5.46$	$236 \pm 6.77$	$82 \pm 4.89$	$70.6 \pm 4.89$	$72 \pm 4.54$	$79 \pm 6.54$

**Table 2:** Liver protein changes and liver enzymes activity in alloxan-induced diabetic rats treated with aqueous *Solanum macrocarpon* extract and glibenclamide

Parameters (mg/dL)	Groups					
	A	B	C	D	E	F
TP	$6.26 \pm 0.11$	$5.1 \pm 0.11^a$	$5.7 \pm 0.26$	$5.8 \pm 0.13^{ab}$	$6.52 \pm 0.54^b$	$6.14 \pm 0.13^b$
ALB	$2.96 \pm 0.09$	$2.6 \pm 0.16$	$2.74 \pm 0.09$	$3.24 \pm 0.19^{bc}$	$3.02 \pm 0.20$	$3.02 \pm 0.04^{bc}$
TB	$0.32 \pm 0.02$	$0.18 \pm 0.04^a$	$0.32 \pm 0.04^b$	$0.18 \pm 0.04^{ac}$	$0.26 \pm 0.02$	$0.22 \pm 0.02^{ac}$
CB	$0.18 \pm 0.02$	$0.13 \pm 0.03$	$0.12 \pm 0.02$	$0.09 \pm 0.01^a$	$0.1 \pm 0^a$	$0.12 \pm 0.02$
AST	$11.2 \pm 0.49$	$12.4 \pm 0.98$	$13.2 \pm 0.37^a$	$10.8 \pm 0.49^c$	$8.6 \pm 1.12^{bc}$	$12.6 \pm 2.11$
ALT	$25.4 \pm 0.24$	$26.6 \pm 0.98$	$26.8 \pm 0.49^a$	$15.8 \pm 0.73^{abc}$	$17.6 \pm 1.47^{abc}$	$20 \pm 2.74^c$
ALP	$16.2 \pm 0.49$	$26.8 \pm 0.49^a$	$20.6 \pm 1.47^{ab}$	$19.52 \pm 1.16^{ab}$	$23.5 \pm 5.14$	$23.8 \pm 1.28^a$

<sup>a</sup> - Values were significant when compared to group A; <sup>b</sup> - Values were significant when compared to group B; <sup>c</sup> - Values were significant when compared to group C; <sup>d</sup> - Values were significant when compared to group D; <sup>e</sup> - Values were significant when compared to group E; <sup>f</sup> - Values were significant when compared to group F.

**Table 3:** Antioxidant enzyme activity and lipid peroxidation in alloxan-induced diabetic rats treated with aqueous extract of *Solanum macrocarpon* and glibenclamide.

Parameters (µmol/mL)	Groups					
	A	B	C	D	E	F
GSH	16.60 ± 2.70	7.06 ± 1.09 <sup>a</sup>	12.51 ± 0.26 <sup>b</sup>	10.90 ± 2.20	3.49 ± 0.32 <sup>abc</sup>	11.57 ± 0.75 <sup>b</sup>
SOD	1.02 ± 0.21	1.40 ± 0.11	1.29 ± 0.01	1.57 ± 0.10 <sup>a</sup>	1.79 ± 0.09 <sup>abc</sup>	0.93 ± 0.00 <sup>bc</sup>
CAT	10.90 ± 1.66	12.79 ± 1.40	0.86 ± 1.56	14.17 ± 0.99	13.65 ± 0.69 <sup>c</sup>	13.66 ± 1.08 <sup>c</sup>
MDA	2.79 ± 0.60	2.44 ± 0.47	2.87 ± 0.27	0.85 ± 0.48 <sup>a</sup>	4.8 ± 1.10	3.59 ± 0.74

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The antioxidant enzymes activity and lipid peroxidation in alloxan-induced diabetic rats treated with glibenclamide and aqueous extract of *Solanum macrocarpon* leaves is shown in Table 3. GSH levels decreased significantly in group B (7.06 ± 1.09) compared with group A (16.60 ± 2.70). There were also increases in groups C (12.51 ± 0.26), D (10.90 ± 2.20) and F (11.57 ± 0.75) when compared to group B (12.51 ± 0.26). In addition, it was significant in groups C and F. SOD activity showed a significant increase in groups D (1.57 ± 0.10) and E (1.79 ± 0.09) when compared to groups A (1.02 ± 0.21) and B (1.40 ± 0.11) respectively. There was also an increase in CAT levels across groups D (14.17 ± 0.99), E (13.65 ± 0.69), and F(13.66 ± 1.08) when compared to groups B (12.79 ± 1.40) and C (0.86 ± 1.56). MDA levels showed a significant decrease in group D (0.85 ± 0.48) when compared to groups A (2.79 ± 0.60) and B (2.44 ± 0.47).

***Histological changes of the liver in diabetic rats treated with aqueous extract of Solanum macrocarpon leaves and glibenclamide.***

The photomicrographs of the liver histology of Wistar rats (×400) stained with H&E across all the groups are displayed in Figures 1-6. Figure 1 depicts the liver section of normal rats, showing the typical cellular structures of the hepatocytes

(black arrow), which are arranged in trabeculae running radiantly from the central vein and are separated by sinusoids (yellow arrow). They are regular and contain a sizeable spherical nucleus with a distinctly marked nucleolus. Figure 2 shows degenerated hepatocytes embedded in connective tissue (black arrow). Hepatocytes (yellow arrow) are disarranged from the central vein with damaged sinusoids (red arrow). The portal triad has also been destroyed in group B. The slowly regenerating structures of the hepatic lobule (red arrow) can be seen in Figure 3 for group C. The trabeculae arrangement is still absent with an indistinct nucleolus. Figure 4 represents diabetic rats + 250 mg/kg *Solanum macrocarpon* extract (group D), and it shows cellular rearrangement of the liver architecture, portal vein(red arrow), bile ducts (yellow arrow) and hepatic artery (green arrow). Observations from Figures 5 and 6, for groups E & F, show recovering structures of the hepatocytes and associated liver structures.

***Histological changes of the pancreas in diabetic rats treated with aqueous extract of Solanum macrocarpon leaves and glibenclamide.***

Slides of the pancreas histology of Wistar rats (×400) stained with H&E across all the groups are depicted in Figures 7-11. Figure 7 represent the kidney of normal group, showing the typical



exocrine component forms of the pancreas closely packed by acinar cells (red arrow) and are arranged into small lobules. Pancreatic lobules separated by intact intralobular and interlobular connective tissue septa intact (yellow arrow). Figure 8 shows degenerated exocrine component forms of the pancreas closely packed by acinar cells (red arrow) and the absence of lobules. Pancreatic lobules are also damaged (yellow arrow) in this group B. The exocrine component of the pancreas showing gradual recovery (yellow arrow) but still disarranged can be seen in Figure 9 for group C. The endocrine part, known as the islet of Langerhans (blue arrow), is seen sufficiently interspersed between the acinar cells. Figure 10 represents diabetic rats + 250 mg/kg *Solanum macrocarpon* extract (group D), and it shows cellular improvement in the arrangement of lobules with organized cells (red and yellow arrows). Observations from Figure 11, groups E & F, show recovering structures of the pancreatic lobules separated by intact intralobular and interlobular. However, connective tissue septa (green arrow) are still infiltrated by degenerated cells. The Islet of Langerhans (blue arrow) is not sufficiently interspersed between the acinar.

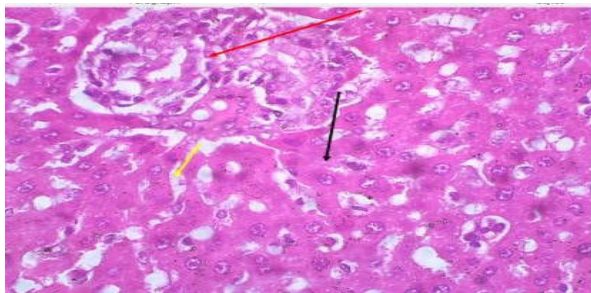


Figure 1: Liver section for Group A.

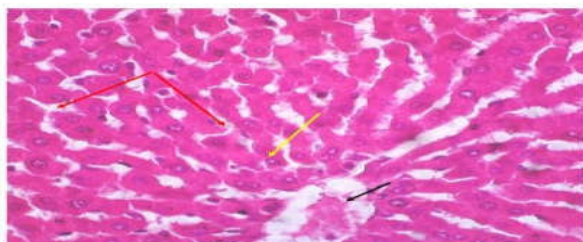


Figure 2: Liver section of Group B.

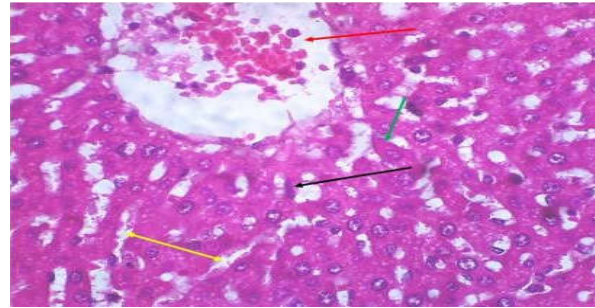


Figure 3: Liver section for Group C.

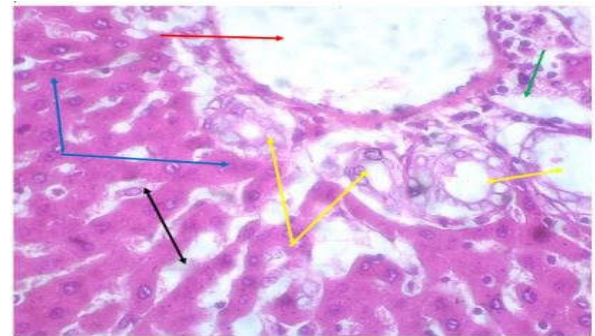


Figure 4: Liver section for Group D.

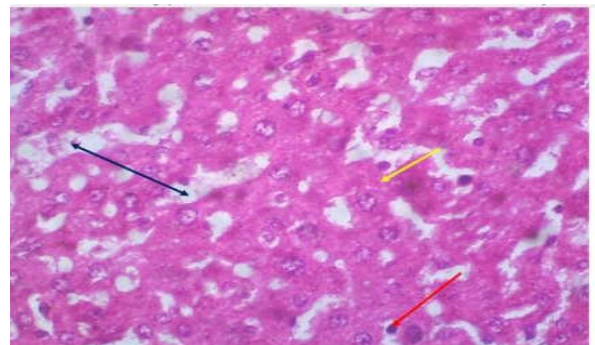


Figure 5: Liver section for Group E.

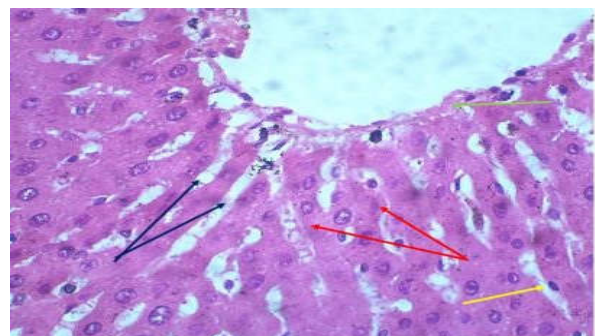


Figure 6: Liver section for Group F.



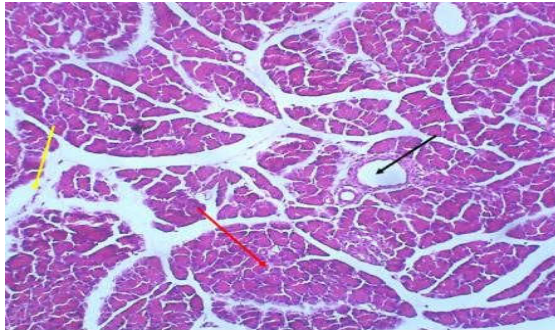


Figure 7: Pancreas section for Group A.



Figure 8: Pancreas section for Group B.

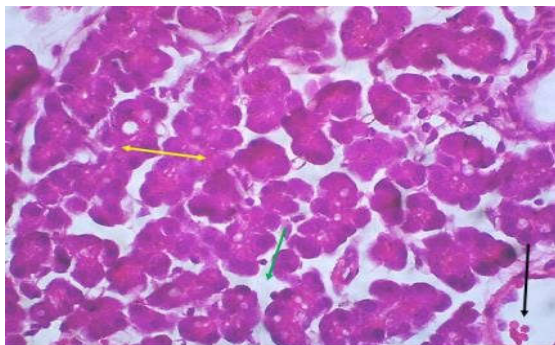


Figure 9: Pancreas section for Group C.

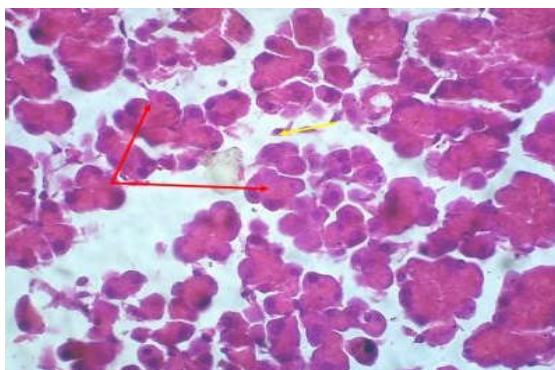


Figure 10: Pancreas section for Group D.

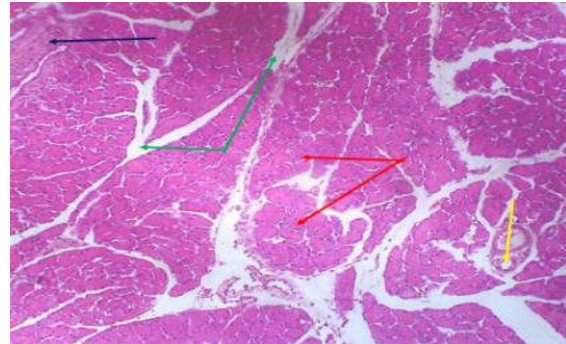


Figure 11: Pancreas section for Group E and F.

### Discussion

This study was carried out to determine the effect of aqueous leaf extract of *Solanum macrocarpon* and an antidiabetic drug (glibenclamide) on blood glucose level, histology of liver and pancreas, antioxidant and liver enzymes in alloxan-induced diabetic male Wistar rats.

These results showed that aqueous *Solanum macrocarpon* leaves extract significantly restored the elevated blood glucose levels to average values compared to glibenclamide. This outcome aligns with prior studies on hypoglycemic activities reported by Tende *et al.* (2011) along with other research articles (Jaiswal *et al.*, 2009; Tende *et al.*, 2011; Yassa and Tohamy, 2014). Blood glucose levels in fasting animals reflect both circulating insulin levels and the sensitivity of peripheral tissues to insulin action. Typically, the average blood glucose level in Wistar rats falls between 50-135 mg/dL, and levels exceeding 150 mg/dL are generally considered hyperglycemic (Jaiswal *et al.*, 2009).

In the histological analysis of the pancreas, the islet of Langerhans from the extract-treated rats appeared less shrunken and more increased than those in the untreated group and group C. This histopathological improvement in the extract-treated rats resembled the outcomes seen in diabetic rats administered glibenclamide, consistent with Koshy *et al.* (2012), who reported a reduction in pancreatic damage in diabetic rats treated with the aqueous leaf extract. Moreover,



islet cells in diabetic rats treated with the *Solanum macrocarpon* extract were observed to regenerate considerably. The precise mechanism remains unclear, but it has been documented that the flavonoid fraction of this plant extract reduces blood glucose levels by increasing the number of beta cells. It was also reported that the phenolic content may have stopped further destruction of the remaining beta cells in the islet by mopping up the circulating reactive oxygen species generated by the alloxan to destroy the beta cells and then allowing other phytochemicals of the plant to induce regenerative processes (Eliakim-Ikechukwu and Obri, 2009).

In the liver, the extract-treated rats demonstrated normalization of the liver histology with regenerating architecture and decreased hemorrhages with little to no infiltration by cells. Similar outcomes have been observed in other studies with different extracts. For example, the fruit extract of *Momordica charantia* exhibited a therapeutic effect on alloxan-induced hepatic damage (Abdollahi *et al.*, 2011). Diabetes-induced liver injury was associated with an increased amount of lipid peroxidation and decreased antioxidant enzyme activity, indicating oxidative stress in the liver of rats. There were also excessive amounts of deposition in the liver section; all of these abnormalities were ameliorated by aqueous extract treatment (Abdollahi *et al.*, 2011).

The significant decrease ( $p < 0.05$ ) in the liver enzyme activity in diabetic rats after the 14 days treatment period with the extract when compared to the diabetic untreated group and group C is also reported by many other studies (Zhang *et al.*, 1995). Additionally, significant increases ( $p < 0.05$ ) were observed in total protein (TP) and albumin levels. Liver enzymes are glycoprotein enzymes bound to cell membranes, with the highest concentration found in the sinusoids and the epithelium of central veins. Leibovitch *et al.* (1991) observed increased levels of Alanine Phosphatase (ALP), Aspartate Transaminase

(AST), and Alanine Transaminase (ALT) in a pathological condition involving the liver. This result corroborates findings from this study. A decrease in the levels of total bilirubin (TB) and Conjugated Bilirubin (CB) was also reported by Ramesh and Pugalendi (2006).

Also, the result showed a significant increase ( $p < 0.05$ ) in the activities of SOD, CAT, GSH and MDA in the liver and a significant decrease ( $p < 0.05$ ) in that of the pancreas of the diabetic treated rats compared with those of the diabetic untreated group and glibenclamide treated group. This suggests that the administration of the aqueous extract helps safeguard beta cells and hepatic cells from oxidative stress-induced damage.

### Conclusion

The research findings suggest that the oral administration of aqueous *Solanum macrocarpon* leaf extract results in a significant decrease in fasting blood glucose levels of diabetic rats, suggesting hypoglycemic properties. It also showed that treatment of diabetic rats with this extract improved serum Alanine Phosphatase (ALP), Aspartate Transaminase (AST), Alanine Transaminase (ALT), Total Bilirubin (TB) and Conjugated Bilirubin (CB) as well as Total Protein (TP) and Albumin (ALB) significantly in comparison to the standard antidiabetic drug, promoting liver function. Furthermore, treatment with the aqueous extract demonstrated a strong antioxidant effect and proliferation of the pancreatic and hepatic histoarchitecture in rat models induced with diabetes. Further investigations should be conducted to ascertain the exact physiological mechanism through which the aqueous *Solanum macrocarpon* leaf extract protects the liver and pancreatic cells from inflammation and necrosis associated with hyperglycemia and hepatic dysfunction. It is recommended that more analysis be performed to corroborate these findings.

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