

**EVALUATION OF ANTIDYSLIPIDEMIC AND ANTIOXIDANT POTENTIAL OF  
*HIBISCUS SABDARIFFA*, *MORINGA OLEIFERA*, *ZINGIBER OFFICINALE*, AND  
*AZADIRACHTA INDICA* HERBAL TEAS IN ALLOXAN- INDUCED DIABETES IN  
MALE WISTAR RATS**

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### ABSTRACT

Several studies have suggested a significant negative correlation between antioxidant activities and lipid profile parameters in diabetic patients. However, this study explores the therapeutic potential of herbal teas made from *Hibiscus sabdariffa*, *Moringa oleifera*, *Zingiber officinale*, and *Azadirachta indica*. Diabetes was induced in seven groups of six animals each through a one-time intra-peritoneal injection. These groups were then treated orally for 28 days with various combinations of alloxan and the herbal teas: alloxan + Zobo (100+400 mg/kg), alloxan + moringa (100+200 mg/kg), alloxan + ginger (100+500 mg/kg), alloxan + 'Dogoyaro' (100+250 mg/kg), and alloxan + glibenclamide (100+5 mg/kg). Dyslipidemia and oxidative stress markers were measured, revealing significant reductions in total cholesterol (TC), LDL-C, and triglycerides (TG), and an increase in HDL-C in the herbal tea-treated groups compared to alloxan alone. Hepatic antioxidant enzymes (GSH-px, SOD, and CAT) decreased by alloxan were reversed by the herbal teas. Additionally, the teas reduced malondialdehyde (MDA) levels in liver tissue elevated by alloxan.

**KEYWORDS:** Antidyslipidemic, Antioxidant, diabetes, cardiovascular, alloxan.

### 1.0 INTRODUCTION

Diabetes mellitus is a persistent metabolic disorder characterized by elevated blood glucose levels due to inadequate insulin secretion or resistance to insulin action, leading to complications in carbohydrate, lipid, and protein metabolism (Rajendiran et al., 2018). With the number of diabetics expected to rise from 382 million in 2013 to 592 million by 2035 (Guariguata et al., 2014), it poses a global health concern. Cardiovascular disease (CVD) is the leading cause of morbidity and mortality among type 2 diabetes patients. According to the American Heart Association, at least 68% of diabetics aged 65 or older die of heart disease, and 16% die of stroke. Diabetic dyslipidemia, marked by elevated triglycerides, low HDL-C, and elevated LDL-C, significantly increases cardiovascular risk in diabetic patients (Liya et al., 2014). While antioxidants have been shown to mitigate diabetic complications and improve insulin sensitivity, the high cost and side effects of

traditional antidiabetic drugs highlight the need for affordable, effective alternative treatments.

### 2. MATERIALS AND METHODS

#### 2.1 Chemicals

The experiment utilized hydrochloric acid, Ellman's reagent, hydrogen peroxide, various salts and buffers, and other chemicals of the highest analytical grades. Key reagents and test kits were sourced from Randox Laboratories, UK.

#### 2.2 Plant Materials

Dried calyces of *Hibiscus sabdariffa*, fresh leaves of *Moringa oleifera*, ginger roots, and *Azadirachta indica* leaves were procured from Mile Three Market in Port Harcourt, Nigeria, and identified at the Department of Botany, Rivers State University.

### 2.3 Animals and Experimental Design

Forty-two male Wistar rats (100-150g) were housed in plastic enclosures with a 12-hour light/dark cycle and fed rat pellets and water. After a week of acclimatization, the rats were divided into seven groups and treated for 28 days as follows:

- Group 1: Control
- Group 2: Alloxan (100 mg/kg)
- Group 3: Alloxan + Hibiscus sabdariffa (400 mg/kg)
- Group 4: Alloxan + Moringa oleifera (200 mg/kg)
- Group 5: Alloxan + Zingiber officinale (500 mg/kg)
- Group 6: Alloxan + Azadirachta indica (250 mg/kg)
- Group 7: Alloxan + Glibenclamide (5 mg/kg)

### 2.4 Tissue Preparation

After treatment, The experimental animals were sacrificed, and blood and organs (liver, kidney, pancreas) were collected for biochemical, inflammatory, and histological analyses.

### 2.5 Biomarkers for Lipid Profile Test

Lipid concentrations (cholesterol, LDL, HDL, VLDL, triglycerides) were measured using Randox kits and absorbance readings at specific wavelengths.

### 2.6 Antioxidant Assays

Antioxidant enzyme activities (SOD, catalase, and glutathione peroxidase) and malondialdehyde (MDA) levels were assessed using established biochemical methods.

### 2.7 Statistical Analysis

Data were analyzed using Graph Pad Prism, with results expressed as mean  $\pm$  standard deviation. Statistical significance was determined using one-way ANOVA and post hoc testing ( $p < 0.05$ ).

## 3. RESULTS

### 3.1 Effects of Selected Herbal Teas on Body Weight

Diabetes induction caused a significant reduction in body weight. Herbal teas and the standard drug led to slight weight increases by the end of the study. Specifically, *Moringa* and the standard drug resulted in an increase, while Zobo, ginger, and 'Dogoyaro' showed insignificant increases compared to the diabetic-untreated control.

**Table 3.1: Effect of Different Herbal Teas on Body Weight of Treated Rats Over 4 Weeks (28 Days).**

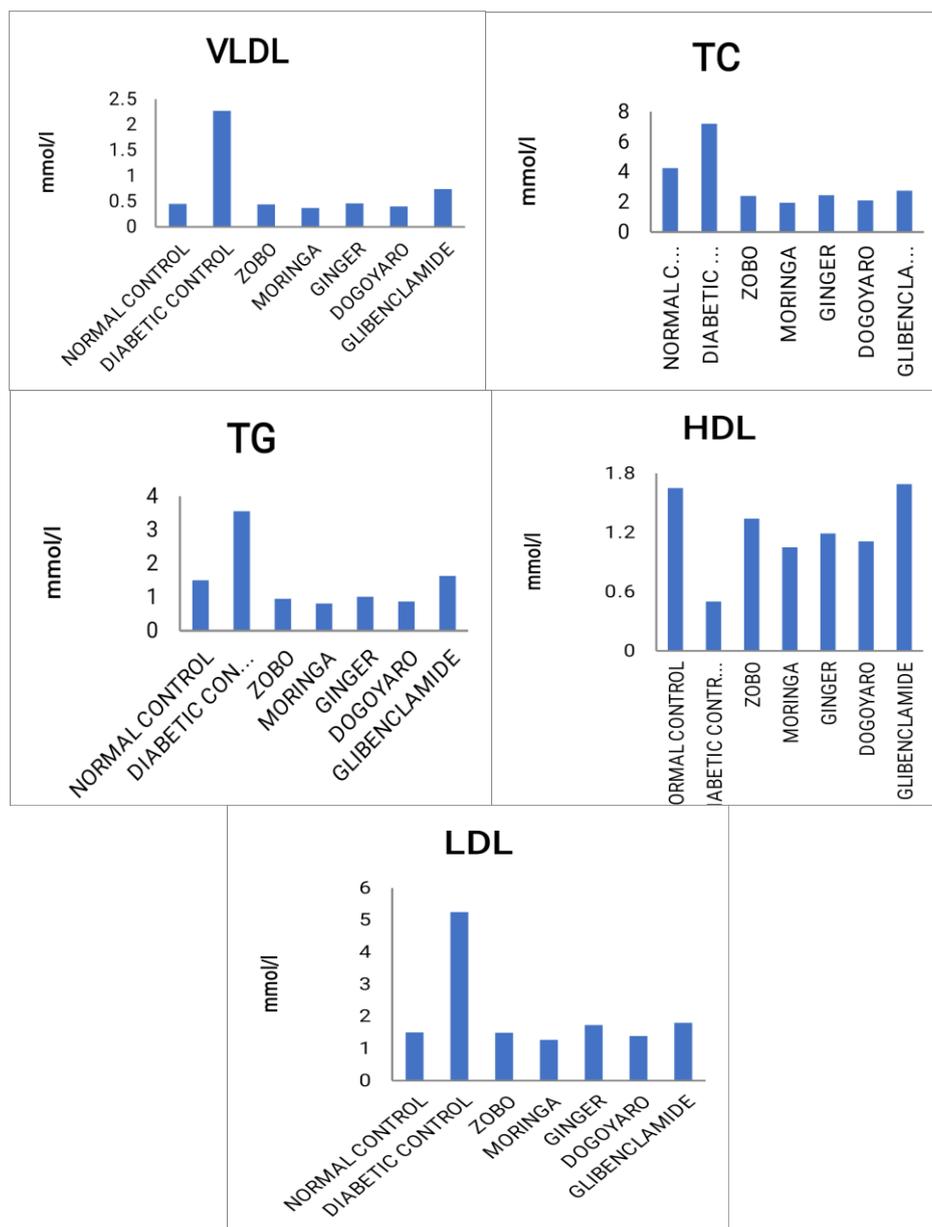
GROUPS	INITIAL (g)	WEEK 1	WEEK 2	WEEK 3	WEEK 4
GROUP 1	133.0 $\pm$ 6.25 <sup>bc</sup>	137.4 $\pm$ 7.29 <sup>bc</sup>	113.0 $\pm$ 29.00	138.2 $\pm$ 7.08 <sup>b</sup>	138.6 $\pm$ 6.04
GROUP 2	129.0 $\pm$ 5.19 <sup>b</sup>	124.6 $\pm$ 6.22 <sup>ab</sup>	97.2 $\pm$ 25.08	68.6 $\pm$ 28.37 <sup>ab</sup>	67.8 $\pm$ 27.97
GROUP 3	117.0 $\pm$ 2.41 <sup>a</sup>	119.4 $\pm$ 2.40 <sup>a</sup>	104.2 $\pm$ 2.69	61.0 $\pm$ 24.94 <sup>a</sup>	62.2 $\pm$ 25.43
GROUP 4	112.2 $\pm$ 3.64 <sup>a</sup>	114.4 $\pm$ 3.71 <sup>a</sup>	87.0 $\pm$ 21.90	74.8 $\pm$ 18.79 <sup>ab</sup>	75.6 $\pm$ 18.96
GROUP 5	115.4 $\pm$ 2.94 <sup>a</sup>	117.6 $\pm$ 2.77 <sup>a</sup>	100.0 $\pm$ 4.51	60.4 $\pm$ 24.74 <sup>a</sup>	62.8 $\pm$ 25.68
GROUP 6	116.2 $\pm$ 3.26 <sup>a</sup>	119.0 $\pm$ 3.03 <sup>a</sup>	104.6 $\pm$ 2.44	59.8 $\pm$ 24.42 <sup>a</sup>	60.2 $\pm$ 24.59
GROUP 7	141.6 $\pm$ 3.37 <sup>c</sup>	138.8 $\pm$ 3.15 <sup>c</sup>	110.6 $\pm$ 27.81	72.0 $\pm$ 29.94 <sup>ab</sup>	71.2 $\pm$ 29.52

- Group 1: Normal Control
- Group 2: Diabetes Control
- Group 3: Zobo Extract
- Group 4: Moringa Extract
- Group 5: Ginger Extract
- Group 6: 'Dogoyaro' Extract
- Group 7: Glibenclamide

Values are expressed as mean  $\pm$  standard deviation (n=8),  $p < 0.05$  versus control. Statistical analysis was carried out using one-way analysis of variance (ANOVA) and Duncan's post hoc test.

### 3.2 Lipid Profile Assays

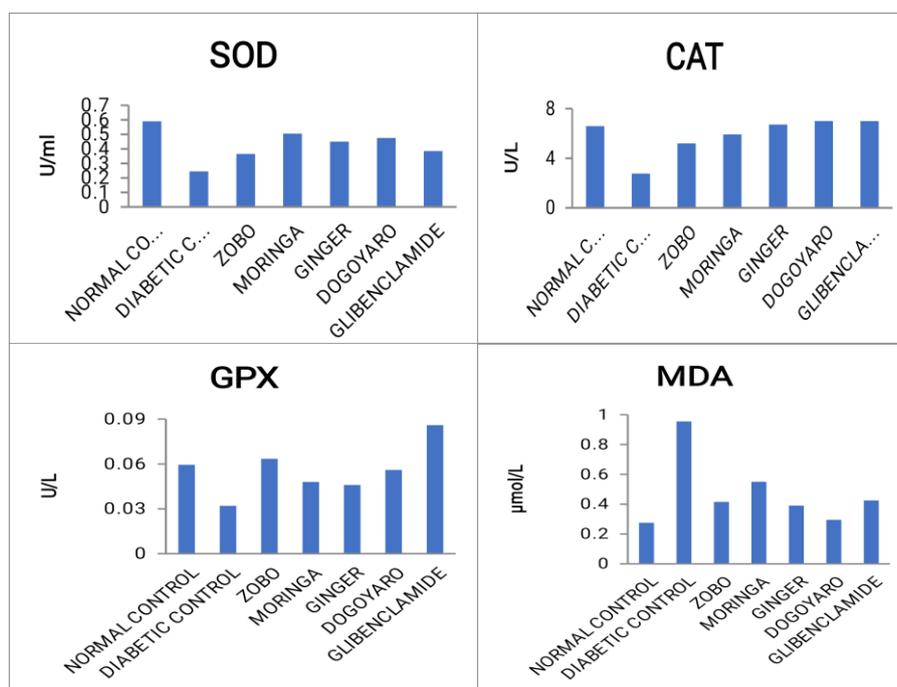
Rats with induced diabetes exhibited higher levels of TC, TG, LDL, and VLDL, and lower HDL levels compared to the normal control rats. The study further revealed that diabetic rats treated with the selected herbal teas had significantly lower TC, TG, LDL, and VLDL levels, and a significant ( $p < 0.05$ ) increase in HDL levels compared to the diabetes control group, as shown in Figure 1.



**Figure 1: Effect of Different Herbal Teas on Liver Function Test in Treated Rats. Values are expressed as mean  $\pm$  standard deviation (n=8),  $p < 0.05$  versus control. Statistical analysis was performed using one-way analysis of variance (ANOVA) and Duncan's post hoc test.**

### 3.3 Antioxidant Assays

In alloxan-induced diabetic rats, there was a decrease in the activity levels of SOD, CAT, and GPx, along with a significant ( $p < 0.05$ ) increase in MDA compared to normal controls. However, treatment with herbal teas resulted in increased activities of hepatic SOD, CAT, and GPx, and a significant ( $p < 0.05$ ) decrease in hepatic MDA levels in rats treated with the herbal teas compared to the alloxan-induced diabetic rats.



**Figure 2: Effect of Different Herbal Teas on Antioxidant Biomarkers in the Liver of Treated Rats. Values are expressed as mean  $\pm$  standard deviation (n=8),  $p < 0.05$  versus control. Statistical analysis was conducted using one-way analysis of variance (ANOVA) and Duncan's post hoc test.**

#### 4.0 DISCUSSION

Diabetes is a persistent metabolic disorder marked by irregular carbohydrate metabolism resulting from insufficient insulin production or improper insulin utilization by the body. Managing diabetes involves dietary modifications, physical activity, insulin replacement therapy, and oral hypoglycemic drugs (Aba *et al.*, 2018). However, conventional medications often have toxic effects on patients and can cause long-term complications in organs like the liver and kidneys (Kumari *et al.*, 2021). Additionally, many individuals in developing countries like Nigeria cannot afford these medications and resort to using plants to treat diabetes. This study aimed to assess the effects of 'Zobo' tea (*Hibiscus sabdariffa*), ginger tea (*Zingiber officinale*), *Moringa* tea, and 'Dogoyaro' tea on alloxan-induced diabetic rats.

Alloxan-induced diabetic rats typically exhibit weight loss and other diabetic symptoms such as hyperglycemia (Ime *et al.*, 2022). Despite having the same diet, all induced animals showed significant weight loss after diabetes induction, likely due to structural protein degradation and muscle wasting (Ezeigwe *et al.*, 2020). Interestingly, the results showed that, there is no significant improvement in body weights of the experimental animals, whether treated with plant extracts or the standard drug. However, rats given 'moringa tea' and the standard drug showed a slight improvement in body weight compared to those treated with Zobo, ginger, and Dogoyaro tea extracts. These findings align with previous studies by Ime *et al.* (2022) and Ezeigwe *et al.* (2020), where it was reported, there was a sort of

weight recovery after treatment with *Hibiscus sabdariffa*, *Zingiber officinale*, *Moringa*, and *Azadirachta indica*.

In this study, untreated diabetic rats exhibited significantly higher levels of total cholesterol, low-density lipoprotein cholesterol (LDL-C), triglycerides, and very low-density lipoprotein cholesterol (VLDL-C) along with a significant reduction in high-density lipoprotein (HDL-C) compared to the control group (Figure 1). Oral administration of teas extracted from *Hibiscus sabdariffa*, *Zingiber officinale*, *Moringa*, and *Azadirachta indica* led to significant ( $p < 0.05$ ) reductions in serum levels of triglycerides, total cholesterol, LDL-C, and VLDL-C, and a significant increase in HDL-C compared to untreated diabetic rats, indicating the hypolipidemic properties of these plants. However, the changes in triglycerides, total cholesterol, LDL-C, and VLDL-C levels and the increase in HDL-C after tea administration were not significant compared to the control group. The reductions in serum cholesterol levels after tea administration could be attributed to the presence of flavonoids, alkaloids, tannins, and saponins, which are known to be present in these plants (Villarruel-López *et al.*, 2018; Tsado *et al.*, 2019). The observed increases and decreases in serum HDL-C and LDL-C levels, respectively, compared with untreated diabetic rats, indicate a reduced risk of developing atherosclerosis after drinking these teas.

Oxidative stress increases the production of reactive oxygen species (ROS), leading to cellular lipid peroxidation, which plays a major role in the pathogenesis of diabetic condition. Antioxidant supplementation and medicinal plants with antioxidant

properties have been reported to mitigate this effect (Rajendiran *et al.*, 2018). Antioxidant enzymes like SOD, CAT, and GPx help maintain physiological oxygen and hydrogen peroxide levels by balancing oxygen radicals and removing peroxides. In this study, alloxan-induced diabetic rats showed decreased activity levels of SOD, CAT, and GPx, and increased MDA, indicating oxidative stress induced by alloxan.

Alloxan induces oxidative stress and beta-cell damage through ROS formation, leading to lipid peroxidation, protein denaturation, DNA damage, decreased insulin production, and ultimately diabetes. However, treatment with herbal teas for 4 weeks increased hepatic SOD, CAT, and GPx activities, and decreased hepatic MDA levels compared to alloxan-treated rats. These findings support previous studies (Ayobami *et al.*, 2020; Ime *et al.*, 2022) that report the antioxidant properties of *Hibiscus sabdariffa*, *Zingiber officinale*, *Moringa*, and *Azadirachta indica*. The phytochemicals such as flavonoids, glycosides, tannins, saponins, and ascorbic acid in these extracts must have played a major role to neutralize free radicals and toxic factors, leading to increased antioxidant marker activity and decreased lipid peroxidation.

## 5.0 CONCLUSION

This study demonstrated that organic teas obtained from *Hibiscus sabdariffa*, *Moringa oleifera*, *Zingiber officinale*, and *Azadirachta indica* significantly reduced markers of dyslipidemia and increased antioxidant activity in a model of alloxan-induced diabetes in male Wistar rats. These findings highlight the potential of traditional medicine and medicinal plants as complementary approaches to conventional diabetes therapies.

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## Contribution of Authors

EAS and NE contributed to the conceptualization and design of the work. EAS, NE, MIS, and OKA conducted the laboratory experiments. EAS, OKA, FOR, NE, and SVD interpreted the data. EAS, MIS, NE, OKA, SVD, and FOR drafted the manuscript.

## Disclosure Statement

The authors declare no conflict of interest.

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