

Aqueous Root Extract of *Strophanthus hispidus* Demonstrates Antidiabetic Effect in Fructose-Streptozotocin-Induced Diabetic Rats

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ABSTRACT

Background and Purpose: This investigation evaluated the antidiabetic activity of the aqueous leaf extract of *Strophanthus hispidus* (SHP) in fructose/low-dose streptozotocin-induced type 2 diabetic rats due to the folkloric use of the root in traditional medicine for the treatment of both type 1 and type 2 diabetes mellitus.

Methods: Fructose/low-dose streptozotocin-induced diabetic rats were allotted into five groups of eight rats each and administered *S. hispidus* root extract at doses of 50, 100 and 200 mg/kg; glibenclamide 5 mg/kg; and normal saline 10 mL/kg respectively. A sixth group that consisted of non-diabetic rats were given distilled water (10 mL/kg). Treatment was by the oral route for 28 consecutive days. Fasting blood glucose (FBG) level was checked at intervals of 7 days. Blood samples were collected on day 28 an hour after the administration of the last dose, for the assay of serum levels of enzymes, lipids, insulin, haemoglobin (Hb), and glycosylated haemoglobin (HbA1c).

Results: The aqueous root extract of SHP demonstrated a significant ($P < 0.05$) reduction in FBG compared with diabetic non-treated control. The doses of 50, 100, 200 mg/kg of aqueous SHP and 5 mg/kg of glibenclamide elicited 82.07%, 88.83%, 88.03% and 78.01% reduction in FBG level respectively at day 28. The extract treated rats displayed significant ($P < 0.05$) decrease in urea, ALT, AST, ALP, LDL, TC, TG and HbA1c levels and significant ($P < 0.05$) increase in HDL and Hb levels. Significant ($P < 0.05$) dose-independent upsurge in serum insulin level was equally observed.

Conclusion: The aqueous root extract of SHP has blood glucose lowering potential and improves some of the imbalances that occur in diabetes.

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INTRODUCTION

Insulin resistance and decreased insulin secretion are the major features of Type 2 diabetes mellitus (DM) (Shoback and Gardner, 2011). Tissue unresponsiveness to insulin is anticipated to involve the insulin receptor (Shoback and Gardner, 2011). The most common type of DM is Type 2 (WHO, 2021). Reduction in insulin sensitivity is the principal anomaly experienced in the early stage of this condition. At this stage, various therapeutic interventions are employed to reverse this abnormality.

Predominant factors that predispose to development of Type 2 DM include lifestyle and genetics (Risérus *et al.*, 2019). Lifestyle aspects that are known to influence the development of Type 2 DM include obesity (BMI ≥ 30), inadequate physical activity, poor nutrition, stress, and urbanization (Williams, 2011). Overweight is associated with some cases in those of Asia, European and African origin (Shoback and Gardner, 2011).

Nutritional factors also contribute to the emergent of Type 2 DM. Excessive intake of carbohydrate is associated with an amplified risk (Malik *et al.*, 2010a; Malik *et al.*, 2010b; Hu *et al.*, 2012). The form of fats in the food contributes to the development of Type 2 DM (Risérus *et al.*, 2019). Dearth of exercise is alleged for 7% of the incidence (Lee *et al.*, 2012).

Medicinal plants have been proven to be beneficial in the management of hyperglycaemia with minimal side effects as against the conventional antidiabetic agents that present with severe debilitating adverse effects (Kamesawara *et al.*, 2001). Therefore, the use of medicinal plants has gained wide reputation not only in Ayurvedic medicine but also in African traditional medicine for the treatment of diabetes mellitus.

Strophanthus hispidus is vastly reputed in folklore African traditional medicine in the treatment of several inflammatory diseases and diabetes (Burkill, 2000; Odugbemi, 2008). Previous study has authenticated the use of *S. hispidus* in the management of alloxan-induced Type 1 diabetes (Fageyinbo *et al.*, 2019). Since the pathogenesis of Type 1 diabetes varies from that of Type 2, we undertook to study the antidiabetic activity of *S. hispidus* aqueous root extract in a rodent model of Type 2 DM.

MATERIALS AND METHODS

Plant material and extraction

The fresh roots of *Strophanthus hispidus* (SHP) were collected from Ile-Oluji village, Oke-Igbo local government, Ondo State, South-West, Nigeria. The plant was identified and authenticated in the Department of Botany, University of Lagos, Lagos, Nigeria where a

voucher specimen (LUH 2618) was deposited. The roots were chopped into smaller pieces, air-dried in the laboratory at room temperature and pulverized using Christy and Norris 8 Lab Milling Machine (serial No. 50158, Ipswich, United Kingdom). A quantity (250 g) of the pulverized roots was macerated with 1.5 L of distilled water and refrigerated for 72 h. The extract was filtered using Whatman No. 1 paper. The filtrate was evaporated to dryness in an oven (Gallenkamp®, Leicestershire, UK) at 40°C (Fageyinbo *et al.*, 2019).

Drugs, chemicals and reagents

Glibenclamide (Diatab®) was manufactured by May and Baker Nigeria Plc; D-fructose was manufactured by Surechem Ltd, Needham, United Kingdom; glucose D was manufactured by Havit Remedies Private, Ltd, Chhatrai, India; Streptozotocin (STZ) and Drabkin reagent were manufactured by Sigma-Aldrich Schnelldorf, Germany.

Experimental animals

Sprague-Dawley rats of both sexes weighing between 100 – 120 g were used. The rats were purchased from the Animal Centre, College of Medicine, University of Lagos, Nigeria. The experimental protocols were approved by the Health Research Ethics Committee of the College of Medicine, University of Lagos with reference number: CMUL/HREC/11/17/283.

Induction of diabetes

The Sprague-Dawley rats were given 20% fructose solution as drinking fluid for 14 days excluding those in the non-diabetic control group. Streptozotocin (STZ; 40 mg/kg in 0.1 M sodium citrate buffer, pH=4.5) was administered after the 14 days. Fasting blood glucose (FBG) level was measured after 72 h by placing 2 drops of venous blood obtained by pinching the tail of each rat on glucose test strips which were introduced into a glucometer (Accu-chek®). Rats with glucose level ≥ 200 mg/dL were considered diabetic and were used in the study (Srinivasan *et al.*, 2005; Aslan *et al.*, 2007; Fageyinbo *et al.*, 2019).

Treatment protocols

Diabetic rats were assigned to five groups (n=8) comprising diabetic control (10 mL/kg normal saline), glibenclamide (5 mg/kg), and aqueous root extract of SHP (50, 100 and 200 mg/kg). A sixth group of rats (n=8) served as the non-diabetic and was given distilled water (10 mL/kg). All treatments were given orally once daily for 28 days (Fageyinbo *et al.*, 2019).

FBG level and body weight of each rat were determined on days 7, 14, 21 and 28. On day 28, blood was collected from each rat through the retro-orbital plexus. Blood serum for the biochemical analysis was obtained by coagulation and centrifugation of the blood sample in the non-heparinized centrifuge tubes. Blood samples collected in EDTA were used for hematological assays (Hb and HbA1c). The

animals were thereafter sacrificed by cervical dislocation and the livers were harvested for glycogen assays (Srinivasan *et al.*, 2005; Aslan *et al.*, 2007; Fageyinbo *et al.*, 2019).

Biochemical assays

Blood serum for the biochemical analysis obtained by coagulation and centrifugation of the blood sample in the non-heparinized centrifuge tubes were analysed for alkaline phosphatase (ALP), aspartate transaminase (AST), alanine transaminase (ALT), albumin (ALB), total bilirubin (TB), lipids (triglycerides (TG), total cholesterol (TC), high-density lipoprotein (HDL)), total protein (TP), urea, and creatinine (CREA) using standard diagnostic test kits (Randox Laboratories Ltd, UK) on automated Clinical System (Beckman Coulter Inc. Galway, Ireland) (Oyetunji and Musbau, 2014; Fageyinbo *et al.*, 2019).

Haemoglobin (Hb) and glycosylated haemoglobin (HbA1c) estimation

Drabkin and Austin (1932) and Nayak and Pattabiraman (1981) methods were adopted for the estimation of haemoglobin (Hb) and glycosylated haemoglobin (HbA1c) levels respectively.

Statistical analysis

The results were analysed using One-way ANOVA followed by Tukey's multiple comparison test using Graph-Pad Prism 6 (Graph-Pad Software Inc., CA, USA). Comparisons were considered significant at $P < 0.05$. Data are presented as mean $\pm$ S.E.M.

RESULTS

Effect of aqueous extract of *S. hispidus* on blood glucose level

Significant ($P < 0.05$) reduction in blood glucose level was produced by aqueous root extract of SHP and glibenclamide compared with the diabetic control. The extract compared effectively with the reference drug and provided prompt reduction in blood glucose level. Percentage reduction in glucose level was day-dependent but dose-independent and it peaked at the 28th day. The oral doses of 50, 100 and 200 mg/kg elicited 82.07%, 88.83% and 88.03% reduction in glucose level respectively; and glibenclamide elicited 78.01% reduction in glucose level at 28th day (Table 1). The glucose level of extract-treated diabetic rats returned to basal values or below.

Effect of *S. hispidus* aqueous extract on body weight

Significant ($P < 0.05$) increase in body weight was observed after 2 weeks of fructose administration compared with the non-diabetic control. There was minor decline in body

weight at day 7 and significant ($P < 0.05$) fall in body weight of glibenclamide (5 mg/kg), extract-treated diabetic rats (50 and 100 mg/kg) groups when compared to the non-diabetic control group at day 14. Similarly, at days 21 and 28, significant ($P < 0.05$) increase in body weight was observed in extract-treated and glibenclamide-treated groups when compared with the diabetic control group. The diabetic control group showed continuous reduction in body weight from day 7 till day 28 (Table 2).

Effect of *S. hispidus* aqueous extract on some biochemical indices

Diabetic un-treated control rats had significant ($P < 0.05$) increase in urea, creatinine, ALT, AST and ALP levels compared to the non-diabetic ones. The aqueous extract of *S. hispidus* and glibenclamide-treated diabetic rats had substantial ($P < 0.05$) decrease in urea, ALT, AST, and ALP levels. Reduction in creatinine, bilirubin, albumin and an increase in TP levels were obtained but not significant in extract-treated diabetic rats in comparison to diabetic ones (Table 3). Extract and glibenclamide-treated groups also had significant ($P < 0.05$) reduction in LDL, TC and TG but a significant ($P < 0.05$) increase in HDL was observed.

Effect of *S. hispidus* aqueous extract on serum insulin level

Diabetic rats treated with 100 and 200 mg/kg doses of the extract or 5 mg/kg glibenclamide had a significant ($P < 0.05$) dose-independent increase in serum insulin in comparison to the diabetic control (Figure 1). This effect was prominent at the dose of 100 mg/kg of the extract and was comparable with that of the reference drug (glibenclamide).

Effect of *S. hispidus* aqueous extract on hepatic glycogen level

Significant reduction ($P < 0.05$) of glycogen in the liver of untreated diabetic rats compared to the non-diabetic rats was observed (Figure 2). However, an increase was observed in extract and glibenclamide-treated groups when compared to their diabetic counterparts. Maximum hepatic glycogen level was produced by the extract at a dose of 100 mg/kg.

Effect of *S. hispidus* aqueous extract on Hb and HbA1c levels

Haemoglobin (Hb) levels were significantly ($P < 0.05$) decreased in diabetic rats (Figure 3) whereas HbA1c levels (Figure 4) were significantly ($P < 0.05$) increased when compared with non-diabetic control ones. Nevertheless, Hb and HbA1c levels were significantly ($P < 0.05$) increased and decreased respectively in SHP and glibenclamide treated groups (Figure 3 and Figure 4). This activity was dose-independent.

Table 1: Effect of aqueous extract of *S. hispidus* on glucose level of fructose/low dose STZ-induced Type 2 diabetes

Treatment	Glucose Level (mg/dL)						
	Basal	Day 0	Day 1	Day 7	Day 14	Day 21	Day 28
Distilled Water (10 mL/kg)	66.4 ± 4.0	68.4 ± 3.5	65.4 ± 2.6*	59.4 ± 3.5*	68.8 ± 3.5*	67.6 ± 1.9*	72.6 ± 1.7*
<i>S. hispidus</i> (50 mg/kg)	73.8 ± 6.5	411.8 ± 16.7	394.0 ± 8.9* (4.3)	309.4 ± 8.9* (24.8)	113.4 ± 9.2* (72.4)	81.2 ± 4.4* (80.2)	73.8 ± 4.5* (82.0)
<i>S. hispidus</i> (100 mg/kg)	61.8 ± 2.8	431.8 ± 18.0	393.0 ± 16.5* (8.9)	257.2 ± 16.7* (40.4)	114.8 ± 3.7* (73.4)	59.8 ± 4.7* (86.1)	48.2 ± 2.4* (88.8)
<i>S. hispidus</i> (200 mg/kg)	79.0 ± 7.4	483.2 ± 43.3	382.8 ± 17.5* (20.7)	291.2 ± 7.09* (39.7)	143.6 ± 9.6* (70.2)	66.0 ± 5.4* (86.3)	57.8 ± 4.5* (88.0)
Glibenclamide (5 mg/kg)	79.0 ± 4.3	391.2 ± 21.4	413.6 ± 13.99* (-5.7)	337.2 ± 20.6* (13.8)	215.0 ± 15.0* (45.0)	120.2 ± 18.7* (69.2)	86.0 ± 3.9* (78.0)
Diabetic Control	89.4 ± 7.6	453.6 ± 39.8	485.6 ± 30.1	467.8 ± 22.8	434.0 ± 35.6	385.8 ± 33.2	379.2 ± 29.2

* $P < 0.05$ versus diabetic control. Data are mean ± S.E.M., n=8. Values in parenthesis indicate percentage reduction in blood glucose level. Diabetic control received normal saline 10 mL/kg. Basal = pre-induction; Day 0 = 1 h post-treatment; Day1= 24 h post-treatment.

Table 2: Effect of aqueous extract of *S. hispidus* on body weight of fructose/low dose STZ-induced Type 2 diabetic rats

Treatment	Body Weight (Kg)						
	Initial	Basal	Day 1	Day 7	Day 14	Day 21	Day 28
Distilled Water (10 mL/kg)	0.116 ± 0.004	0.121 ± 0.006	0.123 ± 0.005	0.126 ± 0.006	0.124 ± 0.005	0.125 ± 0.003*	0.130 ± 0.004*
<i>S. hispidus</i> (50 mg/kg)	0.112 ± 0.003	0.133 ± 0.007 ^{a,b}	0.133 ± 0.007 ^{a,b}	0.128 ± 0.006 ^b (3.75↓)	0.117 ± 0.005 ^a (12.03↓)	0.120 ± 0.005* (9.77↓)	125.0 ± 0.004* (6.01↓)
<i>S. hispidus</i> (100 mg/kg)	0.115 ± 0.004	0.136 ± 0.001 ^{a,b}	0.136 ± 0.004 ^{a,b}	0.129 ± 0.006 ^b (5.14↓)	0.117 ± 0.004 ^a (13.97↓)	0.123 ± 0.001* (9.55↓)	0.127 ± 0.001* (6.61↓)
<i>S. hispidus</i> (200 mg/kg)	0.103 ± 0.002	0.128 ± 0.006 ^{a,b}	0.128 ± 0.005 ^{a,b}	0.125 ± 0.004 ^b (2.34↓)	0.121 ± 0.003 (5.46↓)	0.124 ± 0.004* (3.12↓)	0.126 ± 0.003* (1.56↓)
Glibenclamide (5 mg/kg)	0.116 ± 0.003	0.32 ± 0.007 ^{a,b}	0.132 ± 0.008 ^{a,b}	0.127 ± 0.007 ^b (3.78↓)	0.114 ± 0.008 ^a (13.63↓)	0.123 ± 0.007* (6.81↓)	0.129 ± 0.007* (2.27↓)
Diabetic Control	0.118 ± 0.004	0.133 ± 0.002 ^{a,b}	0.133 ± 0.001 ^{a,b}	0.130 ± 0.001 ^b (2.25↓)	0.120 ± 0.001 (9.77↓)	0.112 ± 0.002 (15.78↓)	0.101 ± 0.001 ^a (24.06↓)

* $P < 0.05$ versus diabetic control; ^a $P < 0.05$ versus distilled water; ^b $P < 0.05$ versus initial body weight. Data are mean ± S. E. M, n=8. Diabetic control received normal saline 10 mL/kg. The values in parenthesis indicate percentage loss (↓) in body weight of the rats. Initial = before fructose consumption; Basal = after fructose consumption.

Table 3: Some biochemical parameters and lipid profile in fructose/low dose STZ-induced Type 2 diabetic rats treated with the aqueous extract of *S. hispidus*

Treatment	CREA ($\mu\text{mol/L}$)	UREA (mmol/L)	BIL ($\mu\text{mol/L}$)	ALT (IU/L)	AST (IU/L)	ALB (g/dL)	ALP (IU/L)	TP (mg/dL)	TC (mmol/L)	TG (mmol/L)	HDL (mg/dL)	LDL (mg/dL)
Distilled Water (10 mL/kg)	1.7 ± 0.1	22.6 ± 0.3^a	0.4 ± 0.0	3.9 ± 0.1^a	16.1 ± 0.2^a	3.2 ± 0.1	165.7 ± 1.8^a	6.9 ± 0.0	92.3 ± 0.5^a	60.6 ± 0.1^a	70.8 ± 2.7^a	18.8 ± 0.3^a
<i>S. hispidus</i> (50 mg/kg)	2.2 ± 0.1	72.3 ± 2.1^a	0.4 ± 0.0	2.8 ± 0.0^a	21.6 ± 0.1^a	2.3 ± 0.0	250.9 ± 12.5^a	9.8 ± 0.2	102.7 ± 1.5^a	73.7 ± 1.0^a	52.3 ± 3.3^a	24.1 ± 1.5^a
<i>S. hispidus</i> (100 mg/kg)	2.1 ± 0.1	63.3 ± 2.2^a	0.3 ± 0.0	2.5 ± 0.5^a	33.1 ± 1.0^a	2.1 ± 0.1	239.4 ± 9.3^a	8.3 ± 0.1	79.9 ± 0.3^a	67.9 ± 0.7^a	77.3 ± 2.7^a	18.6 ± 2.0^a
<i>S. hispidus</i> (200 mg/kg)	1.4 ± 0.0	66.6 ± 0.8^a	0.3 ± 0.0	3.9 ± 0.5^a	34.3 ± 0.7^a	2.9 ± 0.0	263.3 ± 8.8^a	7.6 ± 0.1	93.2 ± 0.9^a	77.8 ± 0.7^a	80.8 ± 3.6^a	10.2 ± 0.4^a
Glibenclamide (5 mg/kg)	2.1 ± 0.0	61.9 ± 2.4^a	0.3 ± 0.0	3.4 ± 0.4^a	21.9 ± 0.1^a	2.8 ± 0.0	233.0 ± 6.7^a	7.3 ± 0.1	93.4 ± 1.3^a	95.5 ± 1.2^a	63.2 ± 2.8^a	22.4 ± 1.6^a
Diabetic Control	3.2 ± 0.2	$86.1 \pm 4.8^*$	1.0 ± 0.1	$60.9 \pm 2.9^*$	$68.3 \pm 0.9^*$	2.9 ± 0.1	$338.8 \pm 5.4^*$	5.9 ± 0.2	$130.1 \pm 1.1^*$	$98.3 \pm 5.0^*$	$35.6 \pm 4.5^*$	$78.8 \pm 4.6^*$

* $P < 0.05$ versus distilled water; $^aP < 0.05$ versus diabetic control. Data are mean $\pm$ S. E. M., $n=8$. Diabetic control received normal saline 10 mL/kg. CREA: creatinine; ALT: alanine aminotransferase; BIL: bilirubin; AST: aspartate aminotransferase; ALB: albumin; TP: total protein, TC: total cholesterol; TG: triglyceride; ALP: alkaline phosphatase, HDL: high density lipoprotein, LDL: low density lipoprotein.

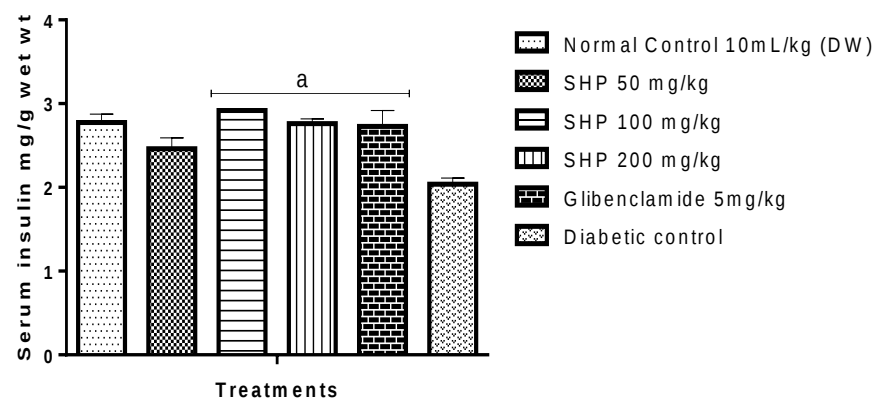


Figure 1: Serum insulin level in fructose/low dose streptozocin-induced diabetic rats treated with the aqueous extract of *S. hispidus* (SHP). $^aP < 0.05$ versus diabetic control. Data are mean $\pm$ S.E.M., $n=8$. DW: Distilled water.

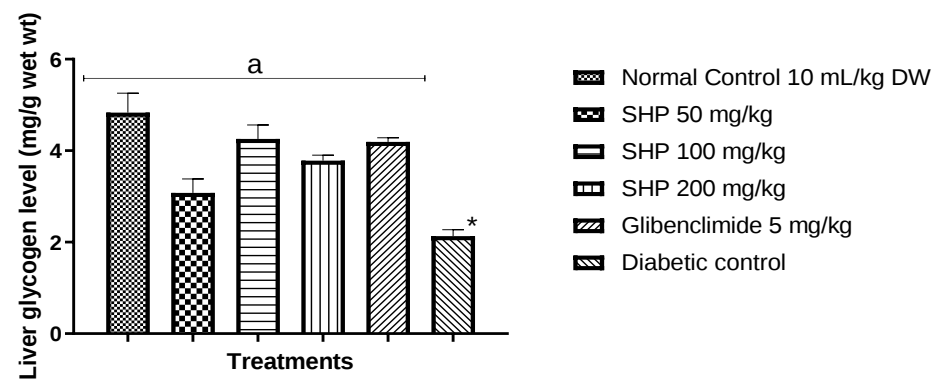


Figure 2: Hepatic glycogen level in fructose/low dose streptozocin-induced diabetic rats treated with the aqueous extract of *S. hispidus* (SHP). $^aP < 0.05$ versus diabetic control. Data are mean $\pm$ S.E.M., $n=8$. DW: Distilled water.

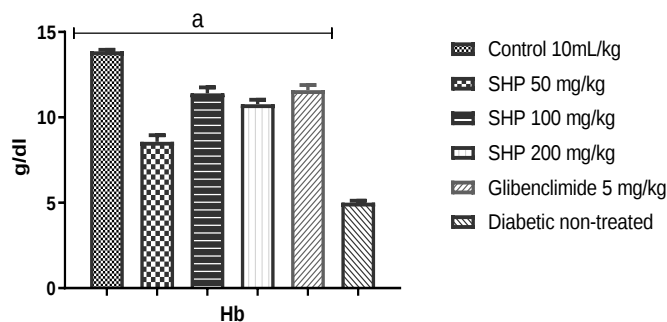


Figure 3: Haemoglobin (Hb) concentration in fructose/low dose streptozotocin-induced diabetic rats treated with the aqueous extract of *S. hispidus* (SHP). ^a $P < 0.05$ versus diabetic control group, Data are mean $\pm$ S.E.M, n=8.

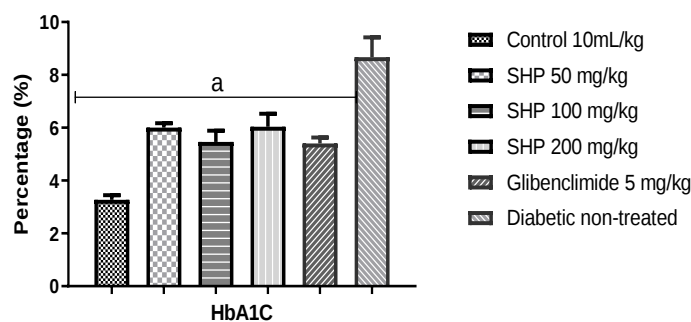


Figure 4: Glycosylated haemoglobin (HbA1c) in fructose/low dose streptozotocin-induced diabetic rats treated with the aqueous extract of *S. hispidus* (SHP). ^a $P < 0.05$ versus diabetic control group, Data are mean $\pm$ S.E.M, n=8.

DISCUSSION

In this study, the rats had access to 20% fructose solution for two weeks as the only source of drinking fluid to induce insulin resistance followed by injection with STZ (40 mg/kg) to induce partial pancreatic beta cell dysfunction. This model has been shown to mimic several features that are parallel to the human pathogenesis of Type 2 DM (Chen and Wang, 2005). Insulin resistance and reduced plasma insulin concentrations leading to hyperglycaemia were established in the rats (Chen and Wang 2005).

In the present investigation, treatment with aqueous extract of *S. hispidus* displayed significant day-dependent anti-hyperglycaemic activity. Lowered blood glucose level was observed in the group that received 100 mg/kg of the extract and there was a more favorable antidiabetic effect than the reference standard drug. Elevated blood glucose level returned to basal level at the 21st day of treatment with the extract after which the rats experienced hypoglycaemic effect. The effective reduction in blood glucose level displayed may be because aqueous *S. hispidus* extract has the ability to stimulate insulin release and sensitize the insulin receptor and ultimately may enhance peripheral glucose uptake (Pottathil et al., 2020).

The body weight of the rats significantly increased after two weeks of fructose administration compared with the initial body weight. Drop in body weight was witnessed after STZ administration, and further reduction was observed till 14 days. Significant increase in body weight was observed at 21st and 28th day, which may be as a result of control over muscle wasting and this indicates appropriate glycaemic control (Fageyinbo et al., 2019; Pottathil et al., 2020). Reduction in body mass witnessed in diabetic untreated rats in comparison to non-diabetic rats may suggest uncontrolled breakdown of tissue proteins (Fageyinbo et al., 2019; Pottathil et al., 2020).

Daily administration of *S. hispidus* aqueous extract for 28 days to fructose/low dose STZ diabetic rats was hepatoprotective as seen in the reduction in the serum AST, ALT and ALP levels. Heart and liver diseases have been associated with increase in serum levels of AST and ALT enzymes (Lanjhiyana et al., 2011). The quantity of any of these enzymes in the serum is proportional to the leakage or damage of cells of the organs in which they are primarily found. These organs include the liver, pancreas, heart, kidney, skeletal muscle and to a lesser level, the red blood cells (Lanjhiyana et al., 2011). These enzymes are found in enormous magnitudes in the serum when any one of these organs is damaged such as occurs in heart attacks or liver damage (Lanjhiyana et al., 2011).

It is well acknowledged that ALT is principally located in the liver, the increased spillage of this enzyme into the bloodstream is a consequence of liver abnormality (Lanjhiyana et al., 2011). ALT therefore, serves as a precise pointer of liver status and an upsurge its serum levels indicates liver damage. Higher than normal amounts of ALP indicate disease of the liver or bile tract blockage as well as abnormalities in bone metabolism (Lanjhiyana et al., 2011). The reduction in the serum ALP levels by the extract indicates its protective effect on the function of the liver. Creatinine, bilirubin and urea levels which were also significant reduced by the extract point out protective effect of the extract on the kidney and may mitigate diabetic-induced nephropathy (Fageyinbo et al., 2019).

The extract also increased the levels of HDL, a cardio-protective lipid, in diabetic rats. Increase in HDL is linked with a decline in coronary menace (Harrison et al., 2003; Pottathil et al., 2020). This cardio-protective effect of *S. hispidus* supports an earlier report (Gundamaraju et al., 2014). Elevated TC and more notably, LDL levels, are keys to development of coronary diseases (Harrison et al., 2003; Pottathil et al., 2020). In this present study, aqueous extract

of *S. hispidus* attenuated the raised TC and LDL levels in the diabetic rats.

Increase HbA1C levels corresponds to the various problems such retinopathy, nephropathy, and neuropathy associated with diabetes (Prabhu et al., 2007; Pottathil et al., 2020). Therefore, the outcomes of the current investigation disclosed that treatment of fructose/STZ-induced Type 2 diabetic rats with the aqueous extract of *S. hispidus* significantly decreased the elevated HbA1C, but increased Hb, hepatic glycogen and insulin levels. These effects displayed by the extract may prevent retinopathy, nephropathy, and neuropathy associated with diabetes.

CONCLUSION

The lowered blood glucose level, favourable lipid profile, improved serum insulin and hepatic glycogen levels in fructose/low-dose STZ-induced Type 2 diabetic rats by the aqueous extract of *Strophanthus hispidus* indicates that it offers benefits in the management of the disease. The active constituents in the extract that may be responsible for the antidiabetic effect need to be isolated and characterized.

CONFLICT OF INTEREST

This study was not supported by grant from any funding agency.

AUTHORS CONTRIBUTIONS

MSF: conceptualization, data curation, writing of original draft, writing of revisions and editing. **AJA and EOA:** supervision, revision and editing. **JF:** Writing of revisions and editing.

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