

*Full Length Research Paper*

# **Anti-hyperglycemic effects of *Stemonocoleus micranthus* (Fabaceae) stem bark on alloxan-induced hyperglycemic rats**

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This study evaluated the anti-hyperglycemic potential of *Stemonocoleus micranthus* Harms. (Fabaceae) stem bark. Three models used in this study were: normoglycemic animal model, oral glucose tolerance test (OGTT) and alloxan-induced hyperglycemic model for acute and prolonged administration. Five (5) groups of rats (n=5) were used for all models; group 1 served as the control (received 2 ml/kg of distilled water; p.o.), groups 2, 3, and 4 received *S. micranthus* extract (SME) 100, 200, and 400 mg/kg, respectively, while group 5 received glibenclamide (GLI 0.2 mg/kg) as a reference drug. In the normoglycemic study, the % reduction in blood glucose concentration (BGC) was 22.24, 29.97, 30.03 and 37.28% for SME (100, 200 and 400 mg/kg) and GLI, respectively. In the OGTT study, suppression in BGC was statistically significant ( $p < 0.05$ ) at 120 min for the 400 mg/kg SME group. The glycemic changes (%) observed in SME (100, 200 and 400 mg/kg) treated rats were 3.4, 0.86 and 0.45%, respectively at the 120 min relative to 0 min values. Also, oral administration of SME (100, 200, 400 mg/kg) and GLI significantly ( $p < 0.05$ ) reduced the BGC to varying degrees in alloxan-induced hyperglycemic rats. The SME at 400 mg/kg produced the highest percentage diminution in BGC of 23.26 and 67.66% for the acute and the prolonged anti-hyperglycemic study respectively, whereas the standard drug, GLI, exhibited 73.55 and 66.10%, respectively. Histopathological studies revealed protection from the harmful effect of alloxan on the kidney and liver by SME-treatment after 28 days as against GLI treated group where there was evidence of mild hepatitis. From the results, it can be deduced that *S. micranthus* stem bark possesses anti-hyperglycemic effects, thus scientifically corroborating with the folkloric use.

**Key words:** *Stemonocoleus micranthus*, alloxan, glibenclamide, normoglycemia, hyperglycemia.

## **INTRODUCTION**

The prevalence of diabetes is increasing worldwide, with the condition now recognized as one of the serious health

problems affecting both developed and developing countries in the 21<sup>st</sup> century. This is evidenced by a

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growing awareness of the complications arising from public health issues, which has led to the prediction of about 69% increase in the total number of adults likely to be diabetics in developing countries compared to 20% for developed countries by the year 2030 (WHO, 2002; Shaw et al., 2010; Ezuruike and Prieto, 2014). Despite the use of several therapeutic approaches (such as sulfonylureas, meglitinides, biguanides and  $\alpha$ -glucosidase inhibitors etc.) to slow the progression of this disorder, diabetes mellitus and its associated complications continue to pose a major health challenge to people (Ravi et al., 2005; Kavishankar et al., 2011). In view of this, alternative approaches are therefore urgently needed to manage it (Osigwe et al., 2015).

In recent years, there have been renewed interests in curbing the menace of diabetes using herbal medicine possibly, due to the wide acknowledged potency of many herbal preparations. Ethnobotanical reports indicate that over 80, 000 species of higher plants have been used for a medicinal purpose globally (Duke, 1992; Jantan et al., 2015). Many of these plants have been studied experimentally to validate their antidiabetic activity with several human clinical studies indicating the beneficial effects of herbal medicinal products in the prevention and control of diabetes (Ota and Ulrih, 2017; Onyeji et al., 2017; Salehi et al., 2019).

In African traditional medicine, *Stemonocoleus micranthus* is used to treat various ailments. Its morphological characteristics have been described (Lemmens, 2010); and its analgesic, narrow-spectrum antibacterial, central nervous system (CNS) depressant, local anaesthetic (Anaga et al., 2010), anti-ulcer (Ezea et al., 2014), antioxidant/hepatoprotective (Mbaoji et al., 2016), hypolipidemic (Mbaoji et al., 2017), antimicrobial (Tchimene et al., 2018) and antimalarial (Orabueze et al., 2019) properties have been documented. However, to the best of our knowledge, in spite of its folkloric use in the management of diabetes mellitus, there has been no report of anti-hyperglycemic activity for the plant. The present study, therefore, investigated the effect on blood glucose concentration in normoglycemic and hyperglycemic animal models in order to verify its folkloric use.

## MATERIALS AND METHODS

### Plant material and extraction procedure

Fresh *S. micranthus* stem barks were collected from Orba in Nsukka, Nigeria. Botanical identification was confirmed by Mr A.O. Ozioko, International Centre for Ethnomedicine and Drug Development (Inter-CEDD), Nsukka, Nigeria. After careful separation of the bark from the woody parts, they were dried in a shade for 7 days and pulverized into a coarse powder using a milling machine (Lab mill, serial no. 4745, Christy and Norris Ltd, England). About 2 kg of the powdered sample was extracted with about 10 L of a mixture of methanol-dichloromethane (1:1) using a Soxhlet apparatus. When extraction was completed, the resulting

filtrate was concentrated under reduced pressure at a temperature of 40°C to obtain a dry *S. micranthus* extract (SME, 106.28 g). This was put in a clean sample bottle, well labelled and kept in the refrigerator at 4°C until further use.

### Animals

Male Wistar albino rats (100-180 g; 8-12 weeks old) obtained from the Department of Pharmacology and Toxicology, University of Nigeria, Nsukka were used in this study. They were provided with standard laboratory pellets (Guinea Feeds Nigeria Limited) and water *ad libitum*. All animal experiments were conducted according to the institutional principles on the use of laboratory animals and, in compliance with the international guidelines for care and use of laboratory animals (Pub. No. 85 -23, revised 1985).

### Normoglycemic animal study

Twenty-five adult Wistar albino rats fasted for 18 h were grouped into 5 ( $n = 5$ ) and treated as follows: Group 1 (control group) received 2 ml/kg of distilled water, Group 2 received the standard drug, 0.2 mg/kg glibenclamide (GLI) while Groups 3, 4 and 5 received 100, 200 and 400 mg/kg of SME respectively by gastric gavage. These treatments were done once as a single dose and blood samples collected from each of the rats through tail snipping at 0, 0.5, 1, 2 and 4 h. The blood glucose concentration (BGC) was measured using a One Touch Ultra® glucometer (Lifescan; Johnson & Johnson, Milpitas, CA, USA). Glycemic change (%) was calculated relative to 0 h values.

### Oral glucose tolerance test (OGTT)

As previously described by Akunne et al. (2017), twenty-five Wistar albino rats were divided into five (5) groups ( $n = 5$ ) and fasted for 18 h. The procedure, dosage of extract/standard drug/animal groupings were as described above. Furthermore, the rats were fed with glucose load (2 g/kg) and the BGC of each blood sample from the rats was measured immediately at time 0 (prior to glucose dosing) and at 30, 60, 90 and 120 min afterwards as described above. Glycemic change (%) was calculated relative to 0 min values.

### Evaluation of anti-hyperglycemic activity

#### Induction of hyperglycemia

Hyperglycemia was induced using alloxan monohydrate (Sigma-Aldrich Co., St. Louis, MO, USA). Alloxan monohydrate was freshly prepared in ice-cold normal saline and administered at 130 mg/kg, *i.p.* The rats were weighed and fasted for 12 h before alloxanization, with free access to clean drinking water. After 5 days of stabilization, hyperglycemia was confirmed by determining the fasting blood glucose concentration (BGC) as described above. Animals having fasting BGC  $\geq 200$  mg/dL (11.1 mmol/L) were considered hyperglycemic and used for the study.

#### Acute anti-hyperglycemic study

In the experiment, twenty-five (25) alloxan-induced diabetic rats were grouped into five (5) ( $n = 5$ ) as follows: Group 1 (diabetic control, DC) received only vehicle (2 ml/kg of distilled water; *p.o.*), Groups 2, 3, 4, and 5 received GLI (0.2 mg/kg), 100, 200 and 400

**Table 1.** Effect of SME on BGC in normoglycemic rats.

Treatment	Dose (mg/kg)	Blood glucose conc. (mg/dl)				
		0 h	0.5 h	1 h	2 h	4 h
Control	-	84.6±8.14	83.0±8.84	81.8±8.56	86.0±7.84	82.0±7.78
GLI	0.2	82.6±5.28	79.0±3.90	78.6±8.80	69.8±13.81 <sup>c,d</sup>	51.8±8.68 <sup>c,d</sup>
SME	100	103.4±7.70	93.8±8.74	88.0±10.48 <sup>d</sup>	81.4±10.98 <sup>d</sup>	80.4±10.32 <sup>d</sup>
	200	97.4±4.73	92.0±6.75	89.8±4.28	76.6±4.63 <sup>d</sup>	68.2±6.30 <sup>d</sup>
	400	105.2±9.74	88.4±11.31 <sup>d</sup>	86.8±10.32 <sup>d</sup>	77.8±9.12 <sup>d</sup>	73.6±10.84 <sup>d</sup>

Values are expressed as the mean ± SEM. n =5; <sup>c, d</sup> p<0.05) significant when compared with the control and 0 h values respectively (One-way ANOVA; Dunnett's post hoc); GLI = glibenclamide; SME = *S. micranthus* extract.

mg/kg of SME, respectively. The BGC was monitored at 0.5, 1, 2, 4 and 8 h respectively after administration of a single dose of the extract per oral.

### Prolonged anti-hyperglycemic study

A total of twenty-five (25) fresh batches of animals were used for the study. The procedure, dosage of extract/standard drug/animal groupings were as described above. Treatment was administered by oral gavage once daily over a period of 28 days (4 weeks). The fasting BGC was monitored at weeks 1, 2, 3 and 4 respectively as described above. The percentage reductions in BGC were calculated relative to pre-treatment values using the formula:

$$PBGC = (BGC_0 - BGC_T / BGC_0) \times 100$$

Where: PBGC = Percentage blood glucose concentration; BGC<sub>0</sub> = blood glucose conc. at 0 h/days; BGC<sub>T</sub> = blood glucose level at a particular hour or day.

### Histopathological analysis

Histological studies were carried out on the kidney and liver of SME-treated diabetic as per the procedures described by Okoli et al. (2010) with minor modifications. Briefly, one animal from each group was sacrificed after twenty-eight days (four weeks) of extract administration and the kidneys and liver were sectioned in hematoxylin (H) and eosin (E) dyes for histological examination.

### Statistical analysis

Data were analysed using One Way Analysis of Variance (ANOVA) (SPSS version 20) and the results presented as mean ± SEM. Differences between mean values were considered significant at p<0.05 (Dunnett's Post Hoc test).

## RESULTS

SME at all doses tested did not exert any significant (p<0.05) reduction in BGC of normoglycemic rats relative to the control group. Similar result was also observed with the standard (GLI, 0.2 mg/kg) at 0.5 h and 1 h, respectively (Table 1). However, at 2 and 4 h, administration of GLI produced significant (p<0.05) reduction in BGC relative to the control group. Relative to

the baseline (0 h) values, the percentage reductions for SME (100, 200 400 mg/kg) were respectively 22.24, 29.97 and 30.03 % while GLI reduced the BGC by 37.28% (Figure 1) at 4 h.

Significant (p<0.05) increase in BGC of the rats was observed at 30 min of glucose load relative to 0 min values (Table 2). Administration of SME (100, 200 and 400 mg/kg) suppressed the postprandial rise in BGC throughout the experimental period. At 120 min, significant (p<0.05) reduction in BGC was observed in the 400 mg/kg treated group. The standard, GLI significantly reduced the BGC at 60, 90 and 120 min relative to the control. The glycemic changes (%) observed in SME-treated (100, 200 and 400 mg/kg) treated rats were 3.4, 0.86 and 0.45% respectively while the standard agent, GLI (0.2 mg/kg) produced the highest glycemic change of 42.11% relative to 0 min values at 120 min (Figure 2).

The result shows that the BGC of the DC (Group 1) increased from 446.21±72.45 at 0 h to 512.4±48.72 at 8 h, representing about a 15% increase. At the 8h, SME (100 and 200 mg/kg) exhibited significant (p<0.05) reduction in BGC while the group treated with 400 mg/kg exhibited significant (p<0.05) reduction in the BGC of the rats from 0.5-8 h relative to the DC group. Similarly, GLI (0.2 mg/kg) significantly (p<0.05) reduced the BGC throughout the period of the study relative to the DC group and 0 h values (Table 3). The reduction (%) of blood glucose at 8h was 5.62%, 20.06% and 23.26% for 100, 200 and 400 mg/kg, respectively (Figure 3).

The effects of repeated-dose administration of SME (100, 200, 400 mg/kg) and GLI (0.2 mg/kg) (Table 4) show a non-dose dependent reduction in BGC over the 28-day administration period, with all the values being lower than the basal (day 0) diabetic fasting BGC. The reduction in BGC was statistically significant (p<0.05) for the group treated with SME (100 and 200 mg/kg) and GLI (0.2 mg/kg) relative to the diabetic control (DC), and was sustained throughout the duration of the experiment. Similarly, for the group that received 400 mg/kg, the BGC was significantly (p<0.05) reduced at week 3 and week 4 respectively, relative to the control. With a value of 67.66% at week 4, the 400 mg/kg SME group exhibited the highest percentage reduction in BGC, a value which

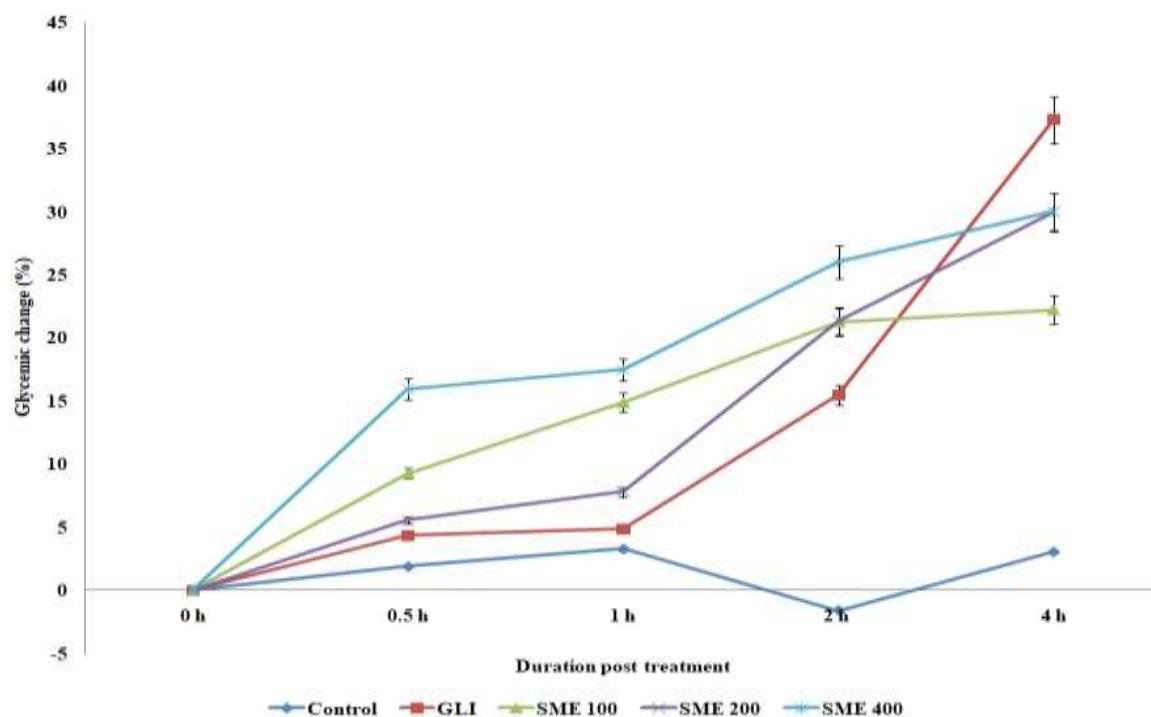


Figure 1. Glycemic change (%) by SME in normoglycemic rats.

Table 2. Effect of SME on BGC in glucose-loaded rats (OGTT).

Treatment	Dose (mg/kg)	Blood glucose conc. (mg/dl)				
		0 min	30 min	60 min	90 min	120 min
Control	-	92.4±14.07	150.6±8.70 <sup>d</sup>	129.6±11.90 <sup>d</sup>	114.4±13.05 <sup>d</sup>	105.8±16.83 <sup>d</sup>
GLI	0.2	104.0±10.90	140.4± 8.00 <sup>d</sup>	90.6± 6.80 <sup>c</sup>	69.4±3.87 <sup>c, d</sup>	60.2±3.61 <sup>c, d</sup>
SME	100	100.0±6.85	150.8±10.55 <sup>d</sup>	113.4±9.17	104.8±4.29	96.6±2.99
	200	92.4±4.61	150.8±3.72 <sup>d</sup>	118.0±5.51 <sup>d</sup>	97.4±3.44	91.6±3.79
	400	88.0±4.91	138.6±9.13 <sup>d</sup>	126.0±6.52 <sup>d</sup>	102.4±4.08 <sup>d</sup>	87.6±5.16 <sup>c</sup>

Values are expressed as the mean ± SEM. n = 5; <sup>c, d</sup>p < 0.05 when compared with the control and 0 min values respectively (One-way ANOVA; Dunnett's post hoc); GLI = glibenclamide; SME = *S. micranthus* extract.

was higher than the standard, GLI (66.10%) (Figure 4).

Histopathological studies revealed severe cellular proliferation of the kidney and epithelium of the bile duct in the diabetic control group. Rats treated with SME at different doses (100, 200 and 400 mg/kg) showed unaltered renal tubules of the kidney with normal glomerulus and apparently normal plates of the hepatocytes. However, a mild hepatitis (degeneration of hepatocytes) was observed in the standard control group (GLI; 0.2 mg/kg) (Figures 5 and 6).

## DISCUSSION

The unprecedented increase in diabetes continues to attract wider interest in the quest for more efficient

management of diabetes mellitus (Jebur et al., 2016). This study investigated the anti-hyperglycemic potential of *S. micranthus* Harms. (Fabaceae) stem bark using normoglycemic, oral glucose - loaded and alloxan-induced hyperglycemic rat models.

In the normoglycemic model, normal healthy animals were used in testing *S. micranthus* extract (SME) as a potential oral hypoglycemic agent. As a valid screening method, it tests the effect of drugs in animals with an intact pancreatic activity (Williamson et al., 2016). Since the SME at all doses tested did not exert any significant blood glucose reduction relative to the control group, it implies that SME, unlike the insulinotropic agent, glibenclamide used in this study does not precipitate hypoglycemia in non-diabetic animals. The oral glucose tolerance test (OGTT) is a research model used to verify

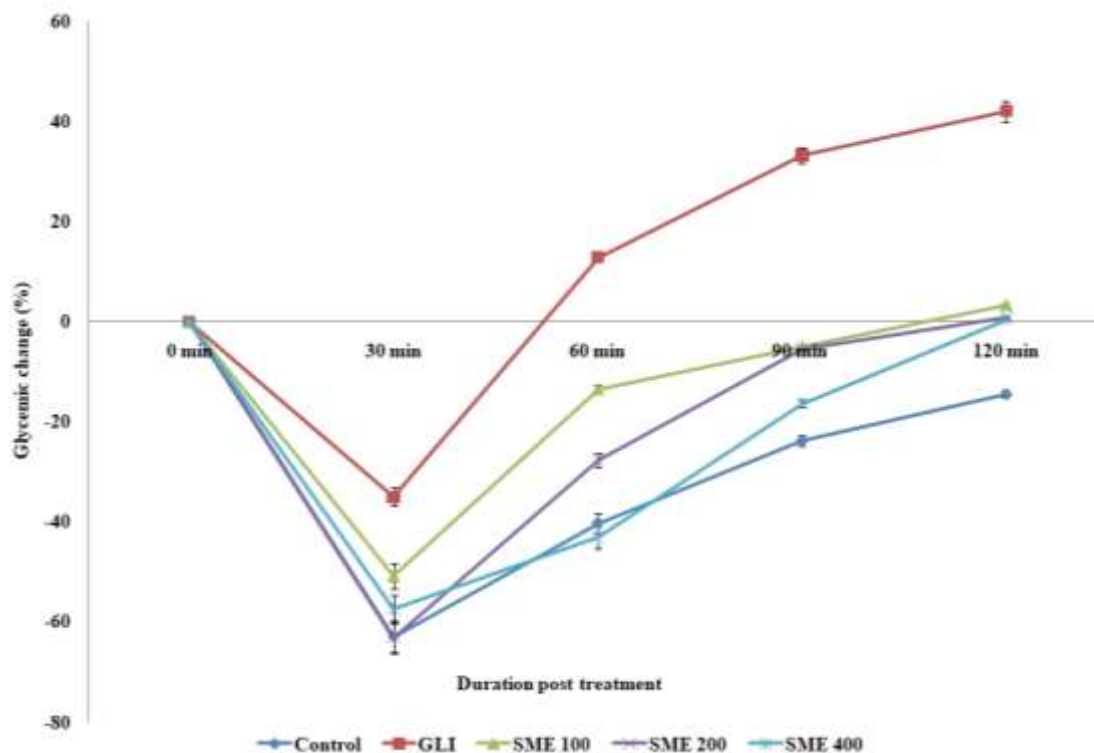


Figure 2. Glycemic change (%) by SME in glucose-loaded rats.

Table 3. Effect of SME on BGC in the acute hyperglycemic study.

Treatment	Dose (mg/kg)	Blood Glucose Conc. (mg/dl)					
		0 h	0.5 h	1 h	2 h	4 h	8 h
DC	-	446.2±72.45	449.4±71.42	457.4±66.31	461.6±64.75	478.8±60.82	512.4±48.72 <sup>d</sup>
GLI	0.2	490.8±50.06	369.4±31.55 <sup>c, d</sup>	351.8±43.98 <sup>c, d</sup>	258.2±28.05 <sup>c, d</sup>	160.6±5.81 <sup>c, d</sup>	129.8±4.33 <sup>c, d</sup>
SME	100	422.8±75.16	447.8±57.70	447.2±50.24	446.6±55.03	438.8±56.88	399.0±62.10 <sup>c, d</sup>
	200	446.6±77.16	527.8±59.35 <sup>d</sup>	510.0±40.08 <sup>d</sup>	494.2±49.16	415.4±69.44	357.0±74.57 <sup>c, d</sup>
	400	377.4±63.56	395.8±76.58 <sup>c</sup>	391.0±83.43 <sup>c</sup>	385.8±76.42 <sup>c</sup>	345.8±81.52 <sup>c</sup>	289.6±72.81 <sup>c, d</sup>

Values are expressed as the mean ± SEM. n = 5; <sup>c, d</sup> p < 0.05 when compared with the diabetic control and 0 h values respectively (One-way ANOVA; Dunnett's post hoc); DC=diabetic control; GLI = glibenclamide; SME = *S. micranthus* extract.

the anti-hyperglycemic actions of medicinal drugs (Ernsberger and Koletsky, 2015). As SME suppressed the rise in BGC following a glucose load, it suggests that the extract may be effective in controlling the overt postprandial rise in blood glucose that increases the risk of chronic hyperglycemia in diabetes. This may be as a result of the reduced rate at which glucose is absorbed from the intestine; increased peripheral glucose utilization through a variety of metabolic pathways (Patel et al., 2011); or a possible incretin mimetic effect. Thus, postprandial hyperglycemia control in diabetes is considered beneficial in reducing the risk of micro and macrovascular complications (Balkau, 2000; Ceriello, 2000). Alloxan-induced hyperglycemia is widely accepted as a screening method for the study of antidiabetic

agents (Etuk, 2010; Okoye et al., 2012). Alloxan monohydrate induces diabetes by selectively destroying the  $\beta$ -cells of the islets of Langerhans due to its selective accumulation through the glucose transporter 2 (GLUT2) and hence, minimizes the release of insulin and glucose uptake by peripheral tissues (Tafesse et al., 2017). It has been reported that insulin deficiency in animals, leads to the development of various metabolic aberrations (Gupta and Sharma, 2017). The observed increase in BGC corroborates with previous reports documenting elevated BGC in alloxan-induced hyperglycemic rats (Omonije et al., 2019). Treatment with SME even at the lowest dose of 100 mg/kg caused a marked reduction of BGC in the acute and prolonged study, an indication of higher potency and a possible non-pancreatic mechanism of

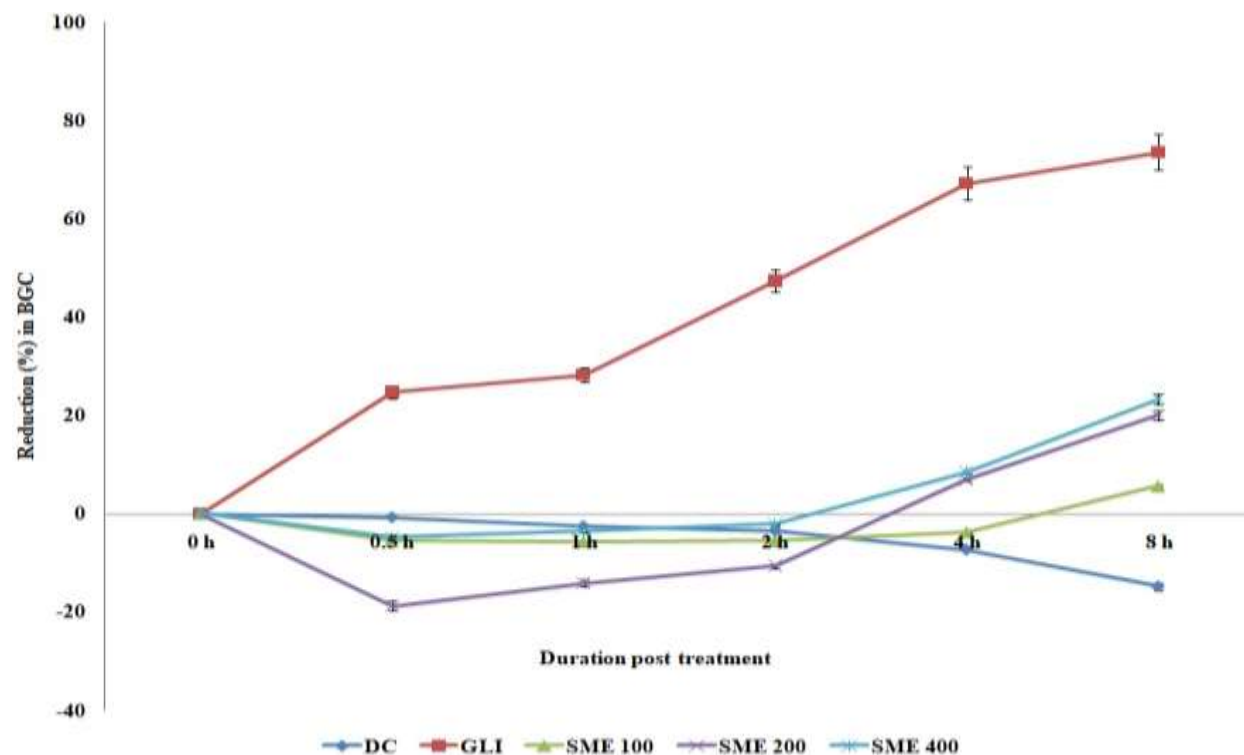


Figure 3. Reduction (%) in BGC by SME in acute hyperglycemic study.

Table 4. Effect of SME on BGC in the prolonged hyperglycemic study.

Treatment	Dose (mg/kg)	Blood Glucose Conc. (mg/dl)				
		Day 0	Week 1	Week 2	Week 3	Week 4
DC	-	278.00±26.53	331.00±22.68	335.00±16.32	317.20±21.02	305.60±12.06
GLI	0.2	295.00±67.99	192.00±42.79 <sup>c, d</sup>	201.00±120.5 <sup>c, d</sup>	111.33±6.39 <sup>c, d</sup>	100.00±6.11 <sup>c, d</sup>
SME	100	295.00±67.99	286.50±20.71 <sup>c, d</sup>	163.75±30.91 <sup>c, d</sup>	143.00±54.27 <sup>c, d</sup>	143.50±12.58 <sup>c, d</sup>
	200	289.50±41.19	275.75±29.26 <sup>c</sup>	133.00±11.79 <sup>c, d</sup>	152.00±19.87 <sup>c, d</sup>	121.50±7.03 <sup>c, d</sup>
	400	494.75±42.05	362.67±89.68 <sup>d</sup>	326.50±93.81 <sup>d</sup>	245.00±70.06 <sup>c, d</sup>	160.00±17.76 <sup>c, d</sup>

Values are expressed as the mean ± SEM. n = 5; <sup>c, d</sup>p < 0.05 significant when compared with the diabetic control and 0 h values respectively (One-way ANOVA; Dunnett's post hoc); DC=diabetic control; GLI = glibenclamide; SME = *S. micranthus* extract.

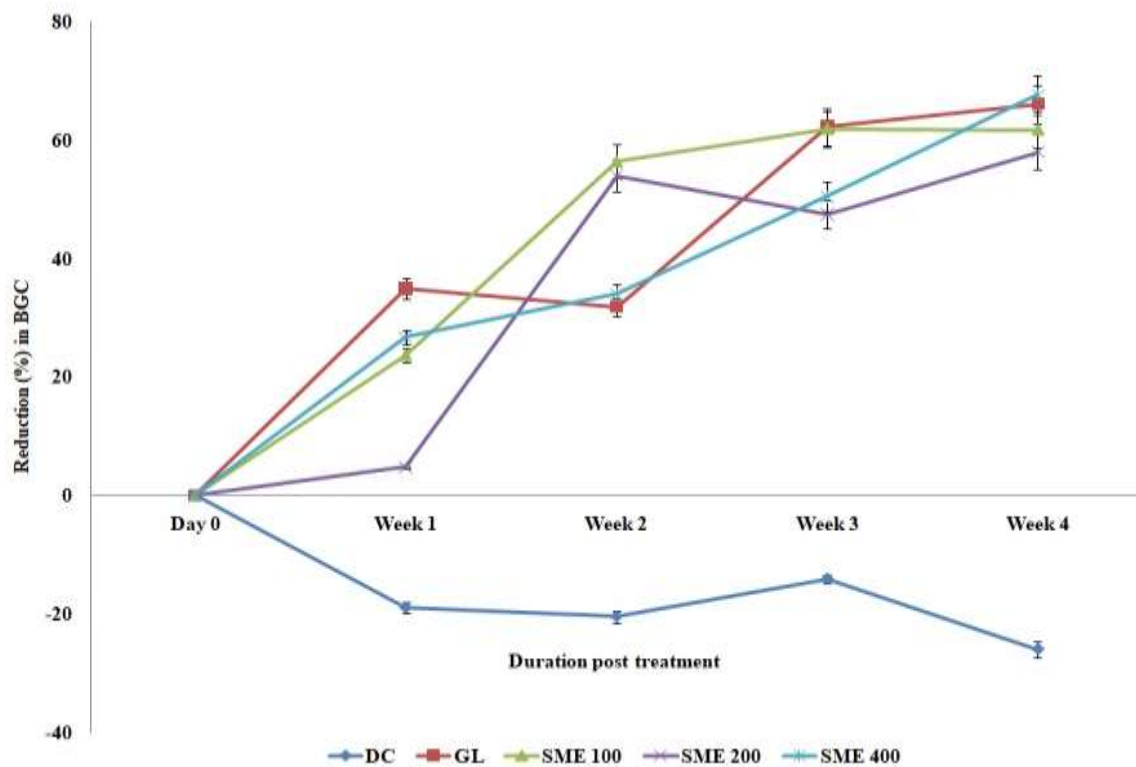
anti-hyperglycemic action (Patel et al., 2011; Saxena and Aargal, 2018).

The reduction in BGC correlates with that of the normoglycemic model, which showed that SME does not precipitate hypoglycemia in diabetic animals, an indication of its anti-hyperglycemic actions. The anti-hyperglycemic action of medicinal plants has been attributed to involving increase in peripheral glucose utilization; increase hepatic glycogen synthesis or decrease in glycogenolysis and gluconeogenesis; intestinal inhibition of glucose absorption and attenuation of glycemic response to carbohydrates (Andrade-Cetto and Wiedenfeld, 2004; Bnouham et al., 2006). In this context, SME may have acted via these mechanisms in maintaining glucose homeostasis. Several studies on medicinal plants have also reported similar anti-

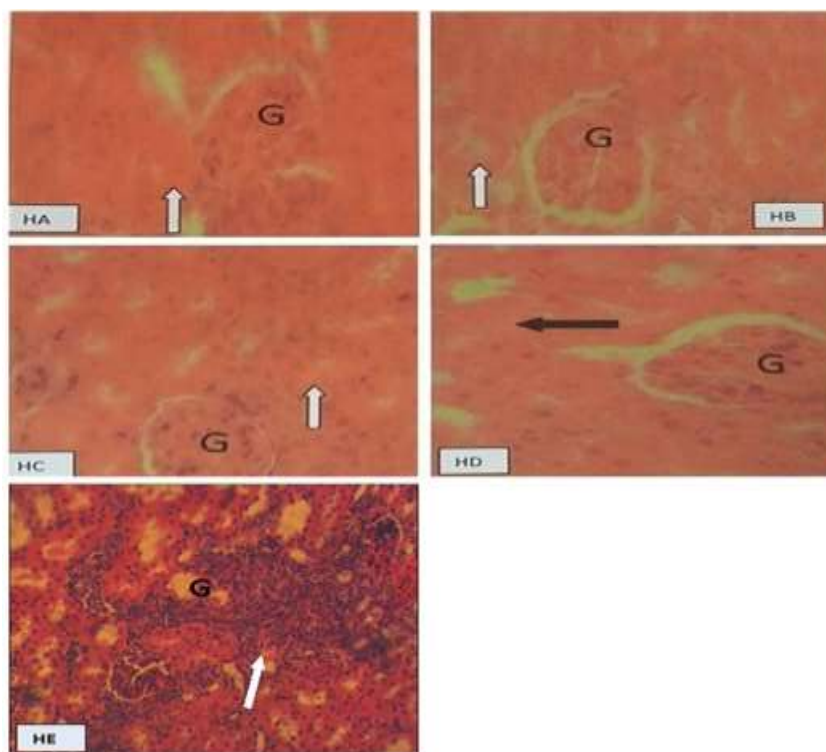
hyperglycemic mechanisms (Nyunai et al., 2015; Ramu et al., 2016; Kumbhare and Sivakumar, 2019).

Data from scientific reports show that medicinal plants contain a large variety of bioactive constituents such as glycosides, alkaloids, terpenoids, flavonoids, carotenoids, etc., that are frequently implicated as having anti-hyperglycemic activity (Osadebe et al., 2014). *S. micranthus* Harms. (Fabaceae) stem bark extract has been reported to contain flavonoids, tannins, saponins and alkaloids (Ezea et al., 2014; Mbaaji et al., 2016). It has been reported that alkaloids have antidiabetic activity on alloxan-induced diabetic mice (Sharma et al., 2009). Flavonoids are known for their antidiabetic activity and hence they help to suppress glucose levels; decrease plasma cholesterol and triglyceride significantly, and increase hepatic glucokinase activity probably by

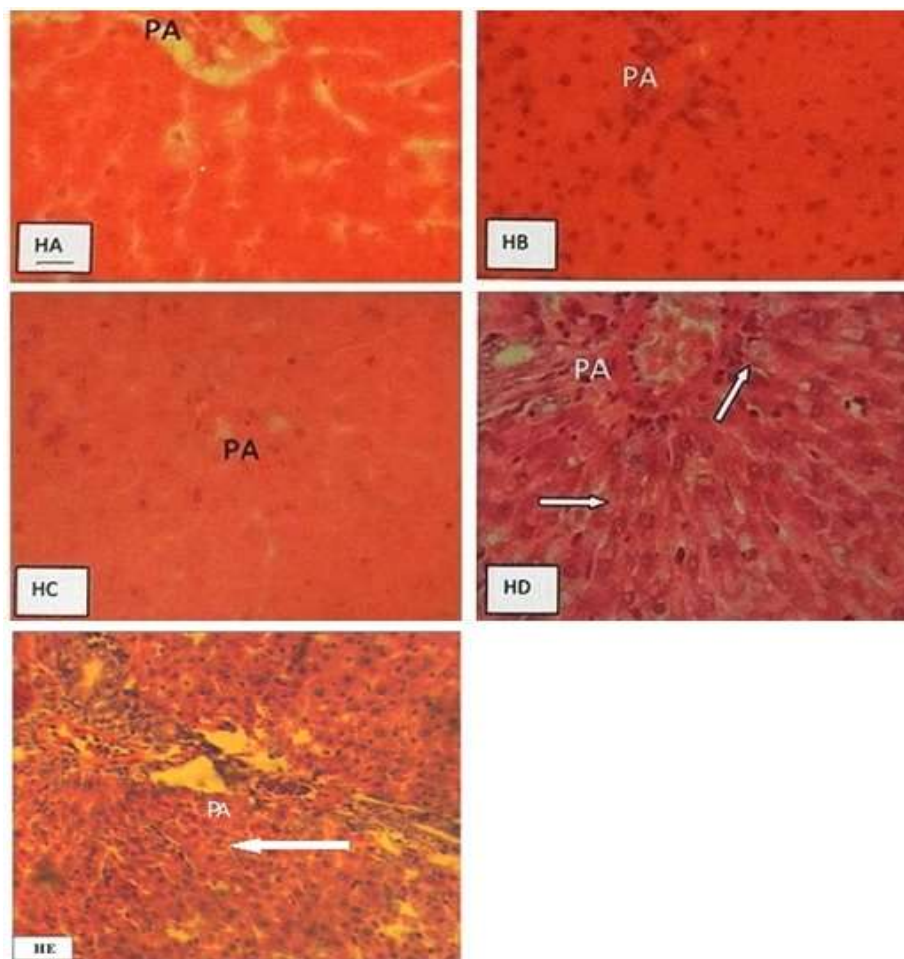




**Figure 4.** Reduction (%) in BGC by SME in prolonged hyperglycemic study.



**Figure 5.** Histologic section of a kidney from diabetic rats HA, HB, HC and HD showing the glomerulus (G) and the renal tubules (arrows) with no observable changes and severe cellular proliferation of the kidney (arrow) in HE. HA = 100 mg/kg, HB = 200 mg/kg, HC = 400 mg/kg, HD = GLI, HE = diabetic control (DC).



**Figure 6.** Histologic section of liver from diabetic rats HA, HB, HC and HD showing the portal area (PA), mild hepatosis (degeneration of hepatocytes - arrows) in HD and proliferation of the epithelium of bile duct (arrow) in HE. HA = 100 mg/kg, HB = 200 mg/kg, HC = 400 mg/kg, HD = GLI, HE = diabetic control (DC).

stimulating release of insulin from pancreatic islets (Hossain et al., 2016; AL-Ishaq et al., 2019). Tannins are a very large group of plant-derived polyphenolic compounds that are known to exhibit antidiabetic effects mainly by inhibiting the activation of  $\alpha$ -amylase and  $\alpha$ -glycosidase activities (Kunyanga et al., 2011). Saponins have been shown to modulate insulin secretion and decrease glucose levels in alloxanized rats (Elekofehinti et al., 2013). It is suggested that these chemical constituents may be responsible for the anti-hyperglycemic activity either alone or in synergy with one another. This is in agreement with previous studies on other plants (Birru et al., 2015; Tomar et al., 2016; Akunne et al., 2017).

The severe cellular proliferation of the kidney and epithelium of the bile duct in the diabetic control rats reflects the pathological changes associated with chronic effects of alloxan-induced hyperglycemia (Lucchesi et al., 2015). The mild hepatosis (degeneration of hepatocytes) of the liver observed in the standard group may probably

be due to post-mortem degeneration as studies have shown that glibenclamide can prevent the liver damage caused by severe hyperglycemia (Jelizaveta et al., 2012). Therefore, this damage could not have been as a result of the drug (glibenclamide). However, diabetic rats treated with SME (100, 200 and 400 mg/kg) showed unaltered renal tubules of the kidney with normal glomerulus and apparently normal plates of the hepatocytes. Previous study has reported no significant morphological or pathological changes in the kidney and liver tissues of rats treated with various doses of SME compared with the control group (Mbaoji et al., 2017). The organs had normal cellular architecture even in animals that received higher doses of the extract. This suggests that SME is not active or harmful and as such may have equally protected the liver and kidneys of the animals from the toxicity of alloxan which is known to cause organ damage by oxidative radical generation (Jebur et al., 2016). Consequent upon this histopathological investigation, the SME is considered



safe and this, however, suggests that the active principles in the extract could be nephro or hepatoprotective in function. This is in tandem with the previous work on the antioxidant/hepatoprotective effects of SME as well as the LD<sub>50</sub> which was estimated to be greater than 5000 mg/kg body weight (Mbaoji et al., 2016).

Based on the above investigation, *S. micranthus* stem bark extract had a pronounced effect in controlling hyperglycemic conditions without causing overt hypoglycemia, thus exhibiting anti-hyperglycemic activity. It may as well provide additional protection against hyperglycemic-related complications. This gives scientific evidence to the folkloric claims of the plant in the management of diabetes. Further research on the isolation and characterization of the active phytoconstituents is ongoing.

## CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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