Aqueous Extract of the Rhizomes of *Sansevieria senegambica* Baker (Agavaceae) moderated Plasma Biochemical and Haematological Indices in Salt-Loaded Rats

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ABSTRACT

The ability of an aqueous extract of the rhizomes of *Sansevieria senegambica* to moderate biochemical and haematological indices were investigated in normal and sub-chronic salt-loaded rats. The normal and treatment control groups received a diet consisting 100% of the commercial feed, while the test control, reference and test treatment groups received an 8% salt-loaded diet. The extract was orally administered daily at 100 and 200 mg/kg body weight; while the moduretics was administered at 1 mg/kg. The test control, reference and control groups received appropriate volumes of water by the same route. Compared to test control, the extract produced significantly (P<0.05) lower levels of plasma triglyceride, total- , VLDL-, LDL-, and non-HDL cholesterol, urea and sodium, atherogenic indices (cardiac risk ratio, atherogenic coefficient and atherogenic index of plasma), and activities of alanine and aspartate transaminases. It also produced significantly (P<0.05) higher levels of plasma HDL cholesterol, potassium and calcium, haematocrit, haemoglobin concentration, and red cell count. It produced a mixed effect on the total white cell, lymphocytes, monocytes and platelet counts of the test groups compared to the test control; without significantly altering the plasma total protein and albumin contents of the test groups. This result supports the use of the plant in traditional health care, for the management of hypertension, and highlights the cardio-protective potential of the rhizomes of, whilst suggesting that its antihypertensive activity may be mediated through alteration of plasma levels of sodium and potassium, or increases in muscle tone brought about by changes in plasma calcium levels.

(Keywords: haematological indices, lipid profile, plasma electrolytes, salt-loading, *Sansevieria senegambica*)

INTRODUCTION

Sansevieria senegambica (Family Agavaceae) belongs to the genus Sansevieria, whose common names include mother-in-laws tongue and snake plant. This genus consists of about sixty species of flowering plants, native to tropical and subtropical regions of the world (Evans, 2005). The leaves appear flattened toward the tip end with a slim point and a surface that is a matte-green with faint banding. It is grown as an ornamental plant (United States Department of Agriculture, 2008).

Analysis of the crude aqueous extract of the rhizome revealed the presence of β-sitosterol, tannic acid, and twenty nine known flavonoids consisting mainly of apigenin, quercetin, kaempferol, (-)-epicatechin, naringenin, biochanin, (+)-catechin (Ikewuchi and Ikewuchi, 2011, 2012). In Kain, northern Yatenga, Burkina Faso, the dried powder of *S. senegambica* is used in the preservation of grains (Jarvis *et al*., 2000).

In traditional health care practice, especially in Southern Nigeria, it is used for the management of bronchitis, inflammation, cough, boils and gonorrhea (Omobuwajo *et al*., 2008), arresting the effects of snake bites, as well as in compounding solutions used as hair tonic and in the management of diabetes mellitus, hypertension and liver problems. The ocular protective, hepatoprotective and anti-diabetic activities of the aqueous extract of the rhizomes

have been reported (Ikewuchi and Ikewuchi, 2011, 2012). However, the biochemical basis of the use of the rhizomes in the management of hypertension, as well as the biochemical impact of their administration to hypertensive patients is yet to be clearly understood. Thus, in the present study, the effects of an aqueous extract of the rhizomes of *S. senegambica* on biochemical and haematological indices of normal and salt-loaded Wistar rats were investigated.

MATERIALS AND METHODS

Preparation of plant extract

Samples of fresh whole *Sansevieria senegambica* plants were procured from a horticultural garden at the University of Port Harcourt's Abuja campus, Port Harcourt, Nigeria. They were duly identified by Dr. Michael C. Dike of Taxonomy Unit, Department of Forestry and Environmental Management, Michael Okpara University of Agriculture, Umudike, Abia State, Nigeria; and Mr. John Ibe, the Herbarium Manager of the Forestry Department, National Root Crops Research Institute (NRCRI), Umuahia, Nigeria.

The rhizome was removed, cleaned of soil, oven dried at 55°C and ground into powder. The resultant powder was soaked in hot, boiled distilled water for 12 h., after which the resultant mixture was filtered and the filtrate was stored in the refrigerator for subsequent use. A known volume of this extract was evaporated to dryness, and the weight of the residue used to determine the concentration of the filtrate, which was in turn used to determine the dose of administration of the extract.

Experimental Design for the Study

Wistar albino rats (weighing 180-210 g at the start of the study) were collected from the animal house of the Department of Physiology, University of Nigeria, Enugu Campus. Studies were conducted in compliance with the applicable laws and regulations for handling experimental animals. The animals were housed in plastic cages. After a 1-week acclimatization period on guinea growers mash (Port Harcourt Flour Mills, Port Harcourt, Nigeria), they were weighed, and sorted into seven groups (Table 1) of five animals each, so that their average weights were approximately equal, before commencing the experiment. Hypertension was induced by giving 8% salt-loaded feed for six weeks, to the appropriate rats. The 8% salt-loaded regimen was adapted from Ikewuchi *et al*. (2011a, b, 2012). At the end of six weeks, they were again weighed, before commencing the administration of the extract.

The Moditen™ (amyloride hydrochloride-hydrochlorothiazide; product of Greenfield Pharmaceutical Co. Ltd, Jiang Su Province, China) and the extract were administered daily by intra-gastric gavages, for ten days. The dosages of administration of the extracts were adopted and modified from Ikewuchi and Ikewuchi (2011, 2012). The animals were allowed food and water *ad libitum*. At the end of the treatment period, the rats were weighed, fasted overnight and anaesthetized by exposure to chloroform. While under anesthesia, they were painlessly sacrificed and blood was collected from each rat into heparin and EDTA sample bottles. Then their hearts, kidneys, liver and lungs were removed and their sizes immediately determined. The heparin anti-coagulated blood samples were centrifuged at 1000 g for 10 min, after which their plasma was collected and stored for subsequent analysis, while the EDTA anti-coagulated blood samples were used for the haematological analysis.

Table 1: Experimental Design for the Anti-Hypertensive Screening.

S/N	ID	Treatment
1	Normal	Normal feed and water
2	Test control	8% salt-loaded feed and water
3	Reference treatment (Reference)	8% salt-loaded feed and moduretic (0.1 mg/Kg body weight)
4	Treatment 1	8% salt-loaded feed and extract (100 mg/Kg)
5	Treatment 2	8% salt-loaded feed and extract (200 mg/Kg)
6	Treatment Control 1	Normal feed and extract (100 mg/Kg)
7	Treatment Control 2	Normal feed and extract (200 mg/Kg)

Determination of Organ Sizes

This was carried out as earlier reported by Ikewuchi *et al*. (2011c). The carcasses of the rats were dissected and their lungs, kidney, heart and liver were collected and their sizes were

determined by water displacement method, using a eureka can.

Determination of the Plasma Biochemical Indices

Plasma total cholesterol (TC), HDL-cholesterol (HDLC) and triglyceride (TG) were assayed enzymatically with Randox test kits (Randox Laboratories, Crumlin, England, UK). Plasma LDL- and VLDL-cholesterol (LDLC and VLDLC) were calculated using the Friedewald equation (Friedewald *et al*., 1972) as follows:

$$\text{i.} \quad [\text{LDLC}]\ (\text{mmol/L}) = [\text{TC}] - [\text{HDLC}] - \frac{[\text{TG}]}{2.2}$$

$$ii. \quad [\text{VLDLC}]\ (\text{mmol/L}) = \frac{[\text{TG}]}{2.2}$$

While the plasma non-HDL cholesterol concentration was determined as reported by Brunzell *et al*. (2008):

[Non-HDL cholesterol] = [Total cholesterol] – [HDL cholesterol]

The atherogenic indices were calculated as earlier reported by Ikewuchi *et al*. (2011d) using the following formulae:

$$\text{i.} \quad \text{Cardiac Risk Ratio} = \frac{[\text{Total cholesterol}]}{[\text{HDL cholesterol}]}$$

$$\text{ii.} \quad \text{Atherogenic Coefficient} = \frac{[\text{Total cholesterol}] - [\text{HDL cholesterol}]}{[\text{HDL cholesterol}]}$$

$$\text{iii.} \quad \text{Atherogenic Index of Plasma} = \log\frac{[\text{Triglyceride}]}{[\text{HDL cholesterol}]}$$

The plasma activities of alanine and aspartate transaminases were determined using Randox test kits (Randox Laboratories, Crumlin, England, UK). The activities of alanine and aspartate transaminases were respectively measured by monitoring at 546 nm, the concentrations of pyruvate and oxaloacetate hydrazones formed with 2,4-dinitrophenylhydrazine.

Plasma urea, creatinine, total protein and albumin concentrations were determined using Randox test kits (Randox Laboratories, Crumlin, England, UK). The wavelength for the determination of urea was 546 nm and that of creatinine was 482 nm. Plasma total protein was determined by the Biuret method, whilst plasma albumin was determined using the bromocresol green dye binding method. Total protein and albumin were determined at 560 nm and 630 nm, respectively.

Plasma sodium and potassium concentration were determined by colorimetric method using Atlas Medical test kits (ATLAS Medical, William James House, Cowley Road, Cambridge, UK). Plasma bicarbonate and chloride concentrations were determined by the titrimetric methods (Cheesbrough, 2004). Plasma calcium concentration was determined by the cresol phthalein complexone method, using Randox test kits (Randox Laboratories, Crumlin, England, UK), and the concentration of the resultant complex was measured at 575 nm. The plasma albumin 'corrected' calcium levels were calculated according to the method of Crook (2006) as follows:

$$\text{Corrected calcium (mg/dL)} = 4\{\text{measured calcium (g/L)} + 0.02[40 - \text{albumin (g/L)}]\}$$

Determination of the Haematological Indices

Haematological indices were determined using Medonic M16 Hematological Analyzer (Nelson Biomedical Limited, UK).

Statistical Analysis of Data

All values are reported as the mean ± S.E.M. (standard error mean). The values of the variables were analyzed for statistically significant differences using the Student's t-test, with the help of SPSS Statistics 17.0 package (SPSS Inc., Chicago Ill). $P<0.05$ was assumed to be significant.

RESULTS

Table 2 shows the effect of aqueous extract of the rhizomes of *Sansevieria senegambica* on the organ sizes of normal and salt-loaded rats. There were no significant differences in the mean daily weight gains and organ sizes of all the groups.

The effect of aqueous extract of the rhizomes of *Sansevieria senegambica* on the plasma lipid profiles of normal and salt-loaded rats is shown in Table 3. The plasma triglyceride, total- , VLDL-, LDL- and non-HDL cholesterol levels of the test control group were significantly (P<0.05) higher than those of the other groups, while the plasma HDL cholesterol level of the test control group was significantly (P<0.05) lower than those of the other groups.

The effect of aqueous extract of the rhizomes of *Sansevieria senegambica* on the atherogenic indices of normal and salt-loaded rats is presented in Table 4. The atherogenic indices (cardiac risk ratio, atherogenic coefficient and atherogenic index of plasma) of the test control group were significantly (P<0.05) higher than those of the other groups.

Table 5 shows the effect of aqueous extract of the rhizomes of *Sansevieria senegambica* on the plasma markers of liver and kidney functions in normal and salt-loaded rats. The plasma urea levels and alanine and aspartate transaminases activities of the test control group was significantly (P<0.05) higher than those of the other groups. There were no significant differences in the plasma total protein and albumin contents of the test control and test groups.

The effect of aqueous extract of the rhizomes of *Sansevieria senegambica* on the plasma electrolyte levels of normal and salt-loaded rats is shown in Table 6. The plasma concentrations of potassium and calcium in the test control group were significantly (P<0.05) lower than those of the other groups. The plasma sodium level of the test control group was significantly (P<0.05) higher than those of the other groups.

Table 7 shows the effect of aqueous extract of the rhizomes of *Sansevieria senegambica* on the haematological indices of normal and salt-loaded rats. The haematocrit, haemoglobin concentration, and red cell count of the test control group were significantly (P<0.05) lower than those of the other groups. The total white cell counts of the test control group was significantly (P<0.05) lower than those of the reference treatment group, significantly (P<0.05) higher than that of treatment 1, but not significantly different from those of the other groups. The lymphocytes count of the test control group was significantly (P<0.05) lower than those of the other groups, except treatment 1. The monocytes counts of the test control group was significantly (P<0.05) higher than those of the other groups. The mean cell haemoglobin and mean cell haemoglobin concentration of the test control group were not significantly different from the other groups, except from treatment 2 whose values was significantly (P<0.05) lower. The platelet counts of the test control group was significantly (P<0.05) lower than those of control, treatment 1, and treatment controls 1 and 2, but not significantly different from those of the reference treatment and treatment 2.

DISCUSSION

A high plasma triglyceride level is both an independent and synergistic risk factor for cardiovascular diseases (Dobiásová, 2004; Martirosyan *et al*., 2007; McBride, 2007); and is often associated with hypertension (Lopes *et al*., 1997; Zicha *et al*., 1999), abnormal lipoprotein metabolism, obesity, insulin resistance and diabetes mellitus (Franz *et al*., 2002; McBride, 2007; Shen, 2007). The treatment significantly reduced plasma levels of triglycerides. This effect may have been mediated by the flavonoid (Ikewuchi and Ikewuchi, 2011) and tannic acid (Ikewuchi and Ikewuchi, 2012) contents of the rhizomes extract. Flavonoids (Middleton et al., 2000) and tannic acid (Park *et al*., 2002) decreases plasma triglycerides levels. Anyone or a combination of the above mentioned components could have been responsible for the hypotriglyceridemic effect of the extract, observed in this study.

The extract produced low plasma total cholesterol levels in the treated rats. This may be cardioprotective, since elevated plasma total cholesterol level is a recognized and well established risk factor for developing atherosclerosis and other cardiovascular diseases (Ademuyiwa *et al*., 2005).

High plasma levels of VLDL cholesterol is a risk factor for cardiovascular disease (Ademuyiwa *et al*., 2005; Lichtennstein *et al*., 2006a,b) and often accompanies hypertension (Lopes *et al*., 1997; Zicha *et al*., 1999), diabetes mellitus (Rang et al., 2005; Shen, 2007; Brunzell *et al*., 2008) and obesity (Krauss *et al*., 2006). In this study, the extract significantly lowered plasma VLDL cholesterol levels in the treated animals.

Table 2: Effect of Aqueous Extract of the Rhizomes of *Sansevieria senegambica* on the Organ Sizes of Normal and Salt-Loaded Rats.

Treatment group	Mean daily weight gain (g/day)		Size (cm^3)			
	Before treatment	After treatment	Liver size	Kidney size	Heart size	Lung size
Normal	1.04±0.29[a]	1.84±0.82[a]	7.20±0.26[a]	1.60±0.25[a,b]	1.00±0.00[a]	2.82±0.26[a]
Test control	0.71±0.12[a]	0.78±2.07[a]	4.90±0.03[c]	1.50±0.16[a]	1.05±0.02[b]	3.20±0.25[a,b]
Reference	0.48±0.22[a]	2.50±0.63[a,*]	5.00±0.00[d]	1.00±0.00[b]	1.00±0.00[a]	3.67±0.18[b]
Treatment 1	0.83±0.36[a]	-0.63±2.50[a]	6.33±0.18[a]	1.00±0.00[b]	1.00±0.00[a]	3.07±0.04[a]
Treatment 2	0.48±0.40[a]	2.34±1.16[a]	4.60±0.39[c,d,e]	1.10±0.06[a,b]	1.00±0.00[a]	3.33±0.37[a,b]
Treatment Control 1	0.69±0.07[a]	2.66±1.05[a]	5.70±0.16[b,e]	0.97±0.02[b]	0.97±0.02[a]	2.60±0.22[a]
Treatment Control 2	1.07±0.22[a]	2.50±1.82[a]	6.00±0.32[a,b]	1.00±0.00[b]	1.00±0.00[a]	4.00±0.32[b]

Values are mean ± S.E.M., n=5, per group.
[a,b,c]Values in the same column with different superscripts are significantly different at $P<0.05$.
*$P<0.05$ compared to the corresponding values before treatment.

Table 3: Effect of Aqueous Extract of the Rhizomes of *Sansevieria senegambica* on the Plasma Lipid Profile of Normal and Salt-Loaded Rats.

Treatment group	Concentration (mmol/L)					
	Triglyceride	Total cholesterol	HDL cholesterol	VLDL cholesterol	LDL cholesterol	Non-HDL cholesterol
Normal	0.34±0.01[a]	1.45±0.033[a]	0.73±0.04[a]	0.15±0.01[a]	0.56±0.04[a,d]	0.71±0.05[a]
Test control	2.13±0.00[c]	3.26±0.033[c]	0.32±0.00[c]	0.97±0.00[c]	1.97±0.03[c]	2.94±0.03[c]
Reference	0.94±0.02[d]	1.90±0.05[d]	1.00±0.04[d]	0.43±0.01[d]	0.47±0.02[d]	0.90±0.02[d]
Treatment 1	0.57±0.02[e]	2.37±0.03[e]	0.72±0.01[a]	0.26±0.01[e]	1.39±0.03[e]	1.65±0.03[e]
Treatment 2	0.69±0.02[f]	1.30±0.02[b]	0.41±0.00[b]	0.32±0.01[f]	0.58±0.02[a]	0.89±0.02[a,d]
Treatment Control 1	0.74±0.02[f]	1.86±0.03[d]	0.71±0.03[a]	0.34±0.01[f]	0.81±0.04[f]	1.15±0.04[b]
Treatment Control 2	0.33±0.01[a]	1.76±0.03[d]	0.59±0.01[e]	0.15±0.01[a]	1.02±0.03[b]	1.17±0.03[b]

Values are mean ± S.E.M., n=5, per group.
[a,b,c]Values in the same column with different superscripts are significantly different at $P<0.05$.

Table 4: Effect of Aqueous Extract of the Rhizomes of *Sansevieria senegambica* on the Atherogenic Indices of Normal and Salt-Loaded Rats.

Treatment group	Cardiac risk ratio	Atherogenic coefficient	Atherogenic index of plasma
Normal	1.99±0.09[a]	0.99±0.09[a]	-0.34±0.03[a]
Test control	10.12±0.06[c]	9.12±0.06[c]	0.82±0.00[c]
Reference	1.90±0.04[a]	0.90±0.04[a]	-0.03±0.02[d,e]
Treatment 1	3.30±0.06[d]	2.30±0.06[d]	-0.10±0.02[e]
Treatment 2	3.19±0.06[b,d]	2.19±0.06[b,d]	0.23±0.01[f]
Treatment Control 1	2.62±0.10[e]	1.62±0.10[e]	0.02±0.02[d]
Treatment Control 2	2.99±0.04[b]	1.99±0.04[b]	-0.25±0.02[b]

Values are mean ± S.E.M., n=5, per group.
[a,b,c]Values in the same column with different superscripts are significantly different at $P<0.05$.

Table 5: Effect of Aqueous Extract of the Rhizomes of *Sansevieria senegambica* on the Plasma Markers of Liver and Kidney Functions in Normal and Salt-Loaded Rats.

Treatment group	Magnitude						
	Alanine transaminase activity (U/L)	Aspartate transaminase activity (U/L)	Total protein content (g/dL)	Albumin content (g/dL)	Creatinine content (µmol/L)	Urea content (mmol/L)	Blood urea nitrogen (mg/dL)
Normal	67.02±2.08^{a}	7.71±0.21^{a}	9.53±0.08^{a}	6.12±0.37^{a}	15.25±0.62^{a}	21.54±0.50^{a}	60.46±1.41^{a}
Test control	98.98±1.58^{c}	117.95±3.94^{b}	8.04±0.44^{c}	5.16±0.36^{a,b}	19.06±0.61^{b}	106.84±0.92^{c}	299.85±2.59^{c}
Reference	63.80±0.83^{a}	10.88±0.55^{c}	7.86±0.40^{b,c}	5.96±0.31^{a,b}	41.29±1.54^{c}	24.24±0.90^{a,d}	68.03±2.54^{a,d}
Treatment 1	25.37±1.24^{d}	18.13±0.93^{d}	7.71±0.47^{b,c}	5.49±0.25^{a,b}	25.41±1.39^{d}	27.12±0.62^{d}	76.11±1.75^{d}
Treatment 2	27.80±1.08^{b}	39.16±1.43^{e}	7.75±0.39^{b,c}	5.17±0.19^{a,b}	7.94±0.26^{e}	16.10±0.60^{e}	45.19±1.68^{e}
Treatment Control 1	20.89±1.06^{d}	26.13±1.48^{f}	7.52±0.44^{b,c}	5.89±0.28^{a}	61.94±3.87^{f}	38.91±0.47^{f}	109.19±1.33^{f}
Treatment Control 2	22.95±0.77^{d}	31.70±1.37^{f}	6.44±0.31^{b}	4.62±0.27^{b}	25.41±1.90^{d}	43.41±0.74^{b}	121.83±2.09^{b}

Values are mean ± S.E.M., n=5, per group.
^{a,b,c}Values in the same column with different superscripts are significantly different at $P<0.05$.

Table 6: Effect of Aqueous Extract of the Rhizomes of Sansevieria senegambica on the Plasma Electrolyte Profiles of Normal and Salt-Loaded Rats.

Treatment group	Concentration					
	Potassium (mEq/L)	Sodium (mEq/L)	Calcium (mg/dL)	Albumin corrected calcium (mg/dL)	Chloride (mEq/L)	Bicarbonate (mmol/L)
Normal	4.49±0.33^{a,b,d}	155.05±4.11^{a}	8.56±0.10^{a,c}	3.49±0.01^{a}	102.80±1.54^{a}	16.00±0.82^{a}
Test control	3.72±0.29^{a,d}	203.71±3.55^{c}	8.34±0.02^{c}	3.49±0.00^{a}	99.53±0.53^{a,c}	20.67±0.71^{c}
Reference	5.71±0.24^{c}	166.88±3.45^{d}	8.87±0.02^{b,e}	3.51±0.00^{a}	99.07±1.43^{c}	11.83±0.87^{d}
Treatment 1	4.35±0.20^{d}	147.49±4.97^{a}	9.35±0.08^{d}	3.53±0.00^{b}	100.53±1.80^{a,c}	18.60±0.51^{c}
Treatment 2	5.87±0.40^{b,c}	175.41±2.80^{b}	8.77±0.12^{a,e}	3.51±0.01^{a}	117.43±1.60^{d}	25.17±1.17^{b}
Treatment Control 1	4.42±0.22^{d}	172.71±4.75^{b,d}	8.83±0.18^{a,b,c,d}	3.51±0.01^{a,c}	129.32±1.65^{b}	25.38±0.89^{b}
Treatment Control 2	3.73±0.12^{a}	159.40±3.57^{a,d}	9.10±0.08^{b,d}	3.53±0.01^{b,c}	98.58±2.99^{a,c}	20.63±0.80^{c}

Values are mean ± S.E.M., n=5, per group.
^{a,b,c}Values in the same column with different superscripts are significantly different at $P<0.05$.

Table 7: Effect of aqueous extract of the rhizomes of *Sansevieria senegambica* on the haematological indices of normal and salt-loaded rats

Parameter	Magnitude						
	Normal	Test control	Reference	Treatment 1	Treatment 2	Treatment Control 1	Treatment Control 2
Haematocrit (%)	28.05±1.21^{a}	25.27±0.76^{c}	36.64±1.19^{b}	33.70±1.19^{b}	33.20±1.43^{b}	33.65±1.57^{a,b}	36.64±1.69^{b}
Haemoglobin concentration (g/dL)	9.95±0.42^{a}	9.10±0.24^{c}	12.70±0.68^{b}	11.50±0.63^{b}	11.30±0.53^{b}	11.90±0.69^{a,b}	12.70±0.37^{b}
Red cell count (x10^{9} cells/L)	3.25±0.22^{a}	2.84±0.12^{c}	4.67±0.80^{a,b,c}	3.96±0.35^{a,b}	4.00±0.25^{b}	4.10±0.29^{a,b}	4.75±0.13^{b}
Total white cell count (x10^{9} cells/L)	5.40±1.09^{a,b,c}	5.10±0.31^{a,d}	7.06±0.44^{c}	3.92±0.29^{b}	4.33±0.18^{b,d}	6.03±0.30^{a}	4.82±0.39^{a,d}
Neutrophils count (%)	5.90±1.32^{a,b,c}	8.47±0.64^{a}	4.66±0.52^{c}	9.66±0.43^{a}	5.07±0.32^{c}	6.23±0.41^{b}	5.76±0.34^{b,c}
Lymphocytes count (%)	78.85±1.74^{a,d}	70.97±1.68^{c}	85.84±2.44^{b}	74.28±1.99^{c,d}	83.50±0.98^{a,b}	82.03±1.80^{a,b}	84.28±0.76^{a,b}
Monocytes count (%)	15.25±0.68^{a}	20.60±1.07^{c}	9.50±0.64^{d}	16.06±0.79^{a}	11.43±0.67^{b,d}	11.75±0.44^{b}	9.96±0.46^{b,d}
Eosinophils count (%)	0.00±0.00^{a}	0.00±0.00^{a}	0.00±0.00^{a}	0.00±0.00^{a}	0.00±0.00^{a}	0.00±0.00^{a}	0.00±0.00^{a}
Basophils count (%)	0.00±0.00^{a}	0.00±0.00^{a}	0.00±0.00^{a}	0.00±0.00^{a}	0.00±0.00^{a}	0.00±0.00^{a}	0.00±0.00^{a}
Mean cell volume (fL)	87.10±2.46^{a}	89.65±2.88^{a}	86.83±13.24^{a,b}	87.07±5.80^{a,b}	84.72±3.46^{a}	83.15±2.30^{a,b}	77.06±1.45^{b}
Mean cell haemoglobin concentration (g/dL)	35.48±0.18^{a,b}	36.06±0.34^{a}	34.58±0.83^{a,b}	34.06±0.93^{a,b}	34.06±0.51^{b}	35.29±0.51^{a,b}	34.76±0.58^{a,b}
Mean cell haemoglobin (pg/cell)	3.09±0.09^{a}	3.23±0.08^{c}	2.97±0.39^{a,b,c,d}	2.94±0.11^{a,b,c,d}	2.88±0.08^{b}	2.93±0.07^{a,b,c}	2.68±0.02^{d}
Platelet count (x10^{4} cells/mm^{3})	267.38±4.66^{a}	171.00±5.35^{c}	161.70±5.07^{c}	308.00±4.74^{b}	164.83±3.11^{c}	235.50±5.04^{d}	276.30±5.74^{a}

Values are mean ± S.E.M., n=5, per group.
^{a,b,c}Values in the same row with different superscripts are significantly different at $P<0.05$.

The cholesterol lowering effect of the extract may be due to the presence of flavonoids (Ikewuchi and Ikewuchi, 2012), β-sitosterol and tannic acid (Ikewuchi and Ikewuchi, 2011). These are known cholesterol lowering and atheroprotective agents (Lee *et al*., 1999; Dillard and German, 2000; Piironen *et al*., 2000; Berger *et al*., 2004; Chu *et al*., 2004; Basu *et al*., 2007; Lau, 2008). Thus, anyone or a combination of some or all of the above mentioned components could have been responsible for the hypocholesterolemic effect of the extract, observed in this study.

In this study, the increased plasma HDL cholesterol levels produced by the administration of the extract, portends ability to reduce cardiovascular risk. According to clinical data, increases in plasma HDL cholesterol concentration reduce cardiovascular risk (Assmann and Gotto, 2004; Rang *et al*., 2005).

Several studies have shown that non-high density lipoprotein cholesterol is a better predictor of cardiovascular disease risk than is low density lipoprotein cholesterol (Shen, 2007; Liu *et al*., 2005; Pischon *et al*., 2005). Therefore, the significantly lower plasma non high density lipoprotein cholesterol levels observed in the test groups indicate the ability of the extract, to reduce cardiovascular risk. This cholesterol lowering effect of the extract may be due to its content of β-sitosterol and tannic acid (Ikewuchi and Ikewuchi, 2011), which are known to have cholesterol lowering and atheroprotective activity (Dillard and German, 2000; Piironen *et al*., 2000; Berger *et al*., 2004; Basu *et al*.,2007).

The extract dose dependently lowered atherogenic indices of the treated animals. Low atherogenic indices are protective against coronary heart disease (Usoro *et al*., 2006). Atherogenic indices are powerful indicators of the risk of heart disease: the higher the value, the higher the risk of developing cardiovascular disease and vice versa (Brehm *et al*., 2004; Dobiásová, 2004; Usoro *et al*., 2006; Martirosyan *et al*., 2007).

The extract had no deleterious effects on liver and kidney functions in the test animals, at least at the dose at which it was administered in this study. It countered the salt-loading induced lowering of plasma calcium levels. The extract may have evoked the present effect by altering parathyroid hormone secretion whose role is, increase the renal tubular reabsorption of calcium, promote intestinal calcium absorption by stimulating the renal production of 1,25-dihydroxyvitamin D, and, if necessary, resorb bone (Brown and Hebert, 1997; Crook, 2006). The improved plasma calcium may impart greatly on arterial muscles tones, since cardiac muscles rely on extracellular Ca^{2+} for contraction (Murray, 2003). Thus, the mechanism of the anti-hypertensive action of the extract may be via moderation of muscle tone, brought about by increases in plasma calcium concentration, which in turn may have been produced by reducing calcium entry into the cells or increasing its removal from the cells into the extracellular space.

Reduction in plasma sodium and chloride concentrations is one of the mechanisms of action of anti-hypertensive drugs, especially the diuretics (Rang *et al*., 2005; Crook, 2006). Amongst them are the potassium-sparing diuretics, which inhibit either aldosterone directly, or the Na^+/K^+ exchange mechanisms in the distal tubules and collecting ducts (Rang *et al*., 2005; Crook, 2006). The net result is the loss of sodium in the urine and the retention of potassium in the blood, culminating in lowered plasma sodium and increased plasma potassium levels. In this study, the extract produced low plasma sodium and increased plasma potassium levels.

CONCLUSION

This study showed that the extract positively affected the haemopoietic system; and integrity and function (dose dependently) of the liver and kidney of the rats, and improved the lipid profile, at least at the doses at which it was administered in this study. All of these highlight the cardio-protective potential of the rhizomes of *Sansevieria senegambica* and support its use in traditional health care practices for the management of hypertension, whilst suggesting that its antihypertensive activity may be mediated through alteration of plasma sodium and potassium levels, or increases in muscle tone brought about by changes in plasma calcium levels.

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