http://dx.doi.org/10.4314/jpb.v9i1.9
Vol. 9 no. 1, pp. 45-54 (March 2012)
http://ajol.info/index.php/jpb

Journal of
PHARMACY AND BIORESOURCES

Effects of the aqueous fruit extract of *Solanum macrocarpum* Linn. on hematological parameters of chronic triton-induced hyperlipidemic rats

Olufunke A. Sodipo[*], Fanna I. Abdulrahman[2] and Umar K. Sandabe[3]

[1]Department of Clinical Pharmacology and Therapeutics, College of Medical Sciences; [2]Department of Chemistry, Faculty of Science; [3]Department of Veterinary Physiology, Pharmacology and Biochemistry, Faculty of Veterinary Medicine, University of Maiduguri, P.M.B. 1069 Maiduguri. Nigeria.

Received 9th December 2011; Accepted 9th March 2012

Abstract
The dried and pulverized unripe fruit of *Solanum macrocarpum* (Solanaceae) was soxhlet-extracted with distilled water. Studies were then undertaken on the effect of the aqueous extract on haematological parameters and the leukocytic response on chronic triton-induced hyperlipdemic rats. Graded doses (25, 50, 100, 200mg/kg body weight) of the extract were administered intraperitoneally (i.p) to different groups of hyperlipidemic rats for 90 days. Significant dose dependent increases at 24 and 48hrs ($P<0.05$) in the levels of hemoglobin (Hb) erythrocyte count (RBC) mean cell volume (MCV) packed cell volume (PCV) and white blood cells (WBC) were observed. Also the decrease in mean cell volume (MCV) and mean cell hemoglobin (MCH) were statistically significant ($P<0.05$). The mean cell haemoglobin concentration (MCHC) increased significantly ($P<0.05$) at 24 and 48hrs. when compared to the negative control. The improved hematological parameters (Hb, RBC and PCV) probably imply a beneficial effect, suggesting that the plant could probably be used as an antianaemic agent.

Keywords: *Solanum macrocarpum*, hematological parameters, chronic hyperlipidemia, differential leukocyte count, triton.

INTRODUCTION

The use of medicinal plants in West Africa is probably as old as the duration of human settlement in the region (Abdulrahman *et al*., 2010, Sodipo *et al*., 2011a).

The genus *Solanum* is well known in traditional medicine (Burkhill, 2000; Grubben and Denton, 2004; Sodipo, 2009). Solanum species are about 1,500 in the world (Grubben and Denton, 2004; ANNON, 2007). In Africa and. adjacent islands, it is represented by at least 100 indigenous species; about 20 of these are recent introduction (Grubben and Denton, 2004). *Solanum macrocarpum* Linn. (Synonyms: *Solanum daysphyllum* and *Solanum macrocarpum* L.) has been reported to exhibit laxative and hypotensive properties (Sodipo *et al*., 2008b). The fruit is nontoxic as the intraperitoneal (i.p.) LD_{50} was 1280 mg/kg (Sodipo *et al*., 2009b), and heavy metals like lead (Pb), cadmium (Cd) and selenium (Se) were not detected in it (Sodipo *et al*., 2008a).

The plant, *Solanum macrocarpum* in

[*] Corresponding author. *E-mail*: sodipoolufunke@yahoo.com *Tel*: +234 (0)8034107098
ISSN 0189-8442

traditional medicine lowers hyperlipidemia (Burkhill, 2000, Grubben and Denton, 2004). Hyperlipidemia describes an increased concentration of lipids in the blood (Gun-Moore *et al*., 1997). The commonest and most important type of hyperlipidemia is hypercholesterolemia (Lawrence *et al*., 1997; Gun-Moore *et al.,* 1997). The aqueous fruit extract of the plant has been reported to exhibit lipid lowering activities (Sodipo *et al.,* 2009c, Sodipo *et al.,* 2011b) and at the same time has renal and hepatoproptective effects (Sodipo *et al.,* 2009a,b) in diet-induced hypercholesterolemic rats. The plant also improves hematological parameters in hypercholesterolemic and triton-induced hyperlipidemic rats (Sodipo *et al.,* 2009d, Sodipo *et al.,* 2011b). Association between anemia and hyperlipidemia in kittens has been demonstrated by Gun-Moore *et al.,* (1997). This may have been related to the lipid disorder or be due to iron deficiency. Supportive measures for the treatment of anemia by feeding on a low fat diet resulted in rapid resolutions of anemia and hyperlipidemia (Gun-Moore *et al.*, 1997). The degree of anemia in the kittens was positively correlated with severity of the hyperlipidemia. It was regenerative in nature and also had some features of iron deficiency anemia. It is therefore possible that hyperlipidemia and changes in lipid metabolism could result in erythrocyte fragility and haemolysis (Alleman, 1990). The mechanism of action of many hypolipidemic drugs is unknown; therefore, testing new plant products generally involves producing hyperlipidemia experimentally and observing the changes or measuring the effect on the serum blood levels of cholesterol (Williamson *et al.,* 1996, Sodipo *et al.,* 2011b). Atherosclerosis is induced with a high fat, high cholesterol diet over a period of 3 to 6 months after which serum analysis can be carried out. Hyperlipidemia occurs more rapidly and experiments take place over weeks rather than months. High sugar diets are sometimes used to induce atherosclerosis-especially if other metabolic disorders (e.g. diabetes mellitus) are under simultaneous investigation (Williamson *et al.,* 1996). The method described here is for measuring blood lipid-lowering effect of plants' extracts. Hyperlipidemia in rats may be induced by trixton-X-100 (polyoxyethylene octyl phenyl ether or octyl phenol ethoxylate) a non-ionic surfactant [$C_{14}H_{22}O$ ($C_2H_4O_6$)], which interferes with uptake of plasma lipids (Williamson *et al.,* 1996; Triton-X-100, 2008; ANNON 2008, Sodipo *et al.,* 2011b). It has been shown that intravenous injection of nonionic detergents such as triton WR-1339 (polymeric *p*-iso-octyl polyoxyethylene phenol) in experimental animals, results in a progressive increase in the concentration of lipids in the blood (Otway and Robinson, 1967). In the experiment that would be described, triton-X-100 was administered orally to the rats and not parenterally like triton-WR1339 because the pilot study revealed that 400mg/kg of the triton-X administered intraperitoneally (i.p.) to 30 rats in the first day killed all of them probably indicating high osmotic fragility and altered red blood cell (RBC) morphology as to cause icterus, leading to the death of the rats. Oral administration of the triton however did not cause death in the rats (Sodipo, 2009). In view of the reported uses of the fruit of this plant, especially in hypercholesterolemic and hyperlypidemic rats, the present study investigated the effect of the aqueous fruit extract of *S. macrocarpum* on hematological parameters in chronic triton-induced hyperlipidemic rats to find out if there is indeed an association between anemia and hyperlipidemia and if the reverse is also true, as only the effect of the extract on acute hyperlipidemic studies had been carried out (Sodipo *et al.*, 2011a).

EXPERIMENTAL

Plant collection and identification. The plant material *(Solanum macrocarpum* Linn.) used in this study was obtained from Alau in Konduga Local Government, Borno State, Nigeria, between October and November, 2007. The plant was identified and authenticated by Prof. S.S. Sanusi of the Department of Biological Sciences, University of Maiduguri, Maiduguri, Nigeria. Specimen voucher No. 548 was deposited at the Research Laboratory of the Department of Chemistry.

Extraction. The fruit of *S. macrocarpum* with the calyx removed was air dried and pulverized by grinding using pestle and mortar. The 2.2 kg of the ground fruit was subjected to exhaustive Soxhlet-extraction in distilled water at 100 °C to give the extract yield of 15.3 % ^{w}/W (Mittal *et al.,* 1981, Fernando *et al.,* 1991; Lin *et al.,* 1999). The resultant solution was concentrated *in vacuo* and it was stored in a specimen bottle and kept in a desiccator at room temperature until when required.

Animals. Thirty six (36) male albino rats of Wistar strain weighing 160-200 g were used in this study. The animals were obtained from the Animal House Unit of the Department of Veterinary Physiology and Pharmacology, University) of Maiduguri. The animals were housed under standard laboratory condition in plastic cages. They were fed commercial growers' mash feed (ECWA, Feeds, Jos, Nigeria) and water was provided *ad libitum*. All the animals were handled according to the international Guiding Principles for Biomedical Research Involving Animals (CIOMS, 1985) as certified by the Animal Ethics Committee of the Faculty of Veterinary Medicine, University of Maiduguri (Approved on October 15th, 2008 at its 12th Ethical Committee Meeting).

Administration of triton and extract. Thirty (30) albino rats were made hyperlipidemic by feeding them orally (p.o.) for 90 days with normal feed diet and triton-X (Sigma Chemical Co. St. Louis, MO., USA) at a dose of 400 mg/kg in saline suspension from the stock concentration of 535g/ml. The thirty six (36) rats for the experiment were divided into 6 groups of 6 animals each. After ninety (90) days, twenty five (25) of the rats were administered with graded doses of the fruit extract. Group I was the negative control and it was given normal feed and distilled water only. Group two was the positive control and it was given normal feed and triton-X with distilled water only. Groups 3, 4, 5, and 6 were administered with geometrical doses (25, 50, 100 and 200mg/kg) of the fruit extract intraperitoneally (i.p.) from a stock concentration of 200mg/ml. After 24, 48 and 72hrs, respectively of the effect of the extract on the hyperlipidemic rats, the hematological parameters were determined (Adapted from Williamson *et al.,* 1996). Weights were taken before being administered with triton-X administration and after thirty (30), sixty (60) and ninety (90) days of administration.

Hematological analysis. The estimation of the various hematological indices and leukocyte response tests were carried out after 24, 48 and 72 hrs respectively of the effect of the extract on the hyperlipidemic rats. At the end of the experimental period, blood samples were collected from the tail of each of the rats by making a cut right through at a region of 2.0 cm from the tip. The hematological parameters determined included red blood cell count (RBC), packed cell volume (PCV), hemoglobin (Hb) concentration and total white blood cell count (WBC). The Wintrobe indices: mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH) and mean corpuscular hemoglobin concentration (MCHC) were also determined. The hematological parameters were determined using standard procedures (Cole, 1974, Schalm *et al*., 1976; Brown, 1976; Dacie and Lewis, 1984).

The total leucokyte count, also called the total white blood count (WBC) was determined using a hemocytometer (Schaim *et al*., 1976*;* Baker, *et al*., 1998). The differential leukocyte count (DLC) for lymphocytes, monocytes, eosinophil, neutrophil and basophil was determined using standard procedures (Cole, 1974; Schalm *et al*., 1976; Baker *et al*., 1998). The percentage (%) cell type was calculated as

Percentage cell type = Number of that cell type ÷ Total WBC count

Determination of total cholesterol. Two rats in each group were humanely sacrificed by cutting the throat with a sterile blade. Blood was collected from the vena cava into clean, labelled centrifuge tubes without anticoagulant after the extract had been allowed to act for 24, 48 and 72 hrs respectively. The blood was centrifuged at a rate of 12.000 rotations per minute (rpm) for 10 minutes. The clear, yellow serum was then separated from settled cellular elements. Cholesterol was assayed by Tindar's reaction (Evans and Stein, 1986; NIH, 1990) using commercial kits, from Fortress Diagnostic Ltd, Antrim.

Statistical analysis. Test of significance between control and treatment means were carried out by Analysis of Variance (ANOVA) using Graph Pad Software (1998).

RESULTS

Change in body weight. The effect of triton-X on mean body weight of albino rats fed orally with triton-X is shown in Table 1. The increase in body weight observed in the rats was statistically significant ($p < 0.05$) when compared to day zero in all the groups except in Group one. Group one was not administered with triton-X throughout the period of study. Also, there was a significant percentage weight gain ($p < 0.05$) in the hyperlipidemic rats (Groups two-six) when compared with Group one which received standard diet and water *ad libitum*.

Effect of extract on haematological parameters. The effect of aqueous fruit extract of *S. macrocarpum* on the haematological parameters of hyperlipidaemic rats are shown in Table 2. The dose-dependent increase in PCV was significant ($p < 0.05$) at 24 and 48 hrs of study. There was a significant increase in Hb ($p < 0.05$) with increase in extract dose at both 24 hrs and 48 hrs. The RBC values increased significantly ($p < 0.05$) throughout the period of study with increase in extract dose. The WBC dose-dependently increased on extract administration, only at 24 hrs ($p < 0.05$). The MCV decreased significantly ($p < 0.05$) throughout the period of study, whilst the MCH increased significantly ($p < 0.05$). The decrease in MCHC was significant at both 48 and 72 hrs ($p < 0.05$). The results of the differential leucocyte count (DLC) when graded doses of the extract were applied on hyperlipidaemic rats are shown in Table 3. There was no change in the DLC ($p > 0.05$) throughout the period of study i.e. there was no change in eosinophil, neutrophil, monocyte basophil and lymphocyte count.

Effect of extract on total cholesterol. The effect of the aqueous fruit extract of *Solanum macrocarpum* on total cholesterol of hyperlipidaemic rats administered orally with triton-X for 90days is shown in Table 4. There was a non-significant ($P>0.05$) increase in total cholesterol when compared to the positive control with increase in extract dose at 24, 48 and 72hrs respectively. The oral administration of triton-X resulted in a rise in serum cholesterol of rats in the positive control group (i.e. those administered only Triton-X).

DISCUSSION

The increase in mean body weight of the rats after triton-X administration for 90 days was significant ($p < 0.05$) (Groups two to six),

Table 2, whilst Group one fed with normal diet was not significant ($p > 0.05$). The percentage weight gain in the hyperlipidaemic rats (Groups two to six) was significantly high ($p < 0.05$) when compared to Group one. Excessive weight gain (obesity) has been implicated in hypertension and ischaemic heart disease (Nwanjo *et al*., 2006). It probably suggests that the triton-X had induced atherosclerosis as atherosclerosis takes three to six months to be induced in rats (Williamson *et al*., 1996). These significant ($P<0.05$) improved values of the RBC and Hb are indicative of haematinic and a blood enhancer for the fruit of *Solanum macrocarpum* (Sodipo *et al*., 2009d, 2011a). According to Brown (1976), antianaemic agents tend to stimulate production of RBC and improve the values of Hb. Furthermore, it was reported that *S. macrocarpum* contained moderately high iron content, 532.45±7.38 µg/g (Sodipo, *et al*., 2008a).

Table 1: Change in mean body weight of male albino rats after being administered orally with Triton-X (400 mg/kg) for 90 days

Group	Mean Body Weight ± S.D. (g)				% Increase in Mean Body Weight
	Days of Treatment				
	0	30	60	90	
One*	110.25 ± 10.50[a]	112.50 ± 20.45[a]	114.00 ± 12.51[a]	117.20 ± 15.07[a]	6.30 ± 4.57[a]
Two	100.20 ± 26.64[a]	135.80 ± 41.26[b]	203.44 ± 52.97[b]	214.20 ± 58.61[b]	113.78 ± 32.37[b]
Three	80.00 ± 17.25[a]	110.20 ± 27.52	163.64 ± 26.93[b]	174.20 ± 15.06[b]	117.75 ± 2.19[b]
Four	99.40 ± 29.19[a]	131.40 ± 41.58[b]	184.80 ± 37.58[b]	216.80 ± 41.05[b]	117.30 ± 11.86[b]
Five	116.60 ± 42.58[a]	129.00 ± 11.92[b]	172.78 ± 17.03[b]	194.80 ± 19.74[b]	67.07 ± 22.84[b]
Six	95.00 ± 20.96[a]	120.40 ± 36.65[b]	192.18 ± 34.03[b]	211.95 ± 33.74[b]	122.11 ± 12.78[b]

Within rows, means with different superscripts are statistically significant ($p < 0.05$) when compared to day zero (0) using one way analysis of variance (ANOVA). 0 day = before triton-X administration n = 6 rats
Group One* = Rats fed with normal diet and had free access to water for 90 days but were not administered triton-X

Table 2: Effect of the aqueous fruit extract of *S. macrocarpum* on haematological parameters of hyperlipidaemic rats administered orally with triton-X for 90 days

Hours post admin	Group	Extract dose (mg/kg)	PCV (%)	Hb (g/100 ml)	RBC × 10^6 (mm^3)	WBC (g/100 ml)	MCV (ϕ^3)	MCH (pg)	MCHC (g/dl)
			Mean ± S.D.						
24	One	-ve control	43.00±1.41[a]	16.80±0.00[a]	5.11 ±0.13[a]	9,150.00±148.49[a]	8.00±0.23[a]	2.19±0.29[a]	0.41±0.01[a]
	Two	+ve control	40.00±0.00[b]	11.30±0.14[b]	5.00 ±0.14[b]	8,650.00±777.82[b]	8.14±0.35[b]	1.65±0.06[b]	0.42±0.00[a]
	Three	25.00	45.00±5.66[b]	17.15±0.64[b]	6.70 ±0.15[b]	11,000.00±113.14[b]	6.86±0.70[b]	2.22±0.09[b]	0.39±0.01[a]
	Four	50.00	46.00±5.66[b]	17.95±1.63[b]	7.50±1.17[b]	12,900.00±424.28[b]	6.78±0.98[b]	2.24±0.30[b]	0.39±0.01[a]
	Five	100.00	46.50±1.41[b]	18.25±0.35[b]	8.58±1.52[b]	13,300.00±141.41[b]	5.43±0.54[b]	2.56±0.04[b]	0.36±0.04[a]
	Six	200.00	58.50±0.71[b]	22.00±0.02[b]	13.63±0.69[b]	29,150.00±148.49[b]	4.33±0.27[b]	3.36±0.10[b]	0.26±0.01[a]
48	One	-ve control	48.00±1.41[a]	17.85±0.28[a]	7.65±1.41[a]	10,450.00±122.33[a]	6.08±0.07[a]	2.06±0.21[b]	0.39±0.01[a]
	Two	+ve control	43.50±0.79[b]	11.50±0.42[b]	5.16±0.09[b]	8.300.00±141.42[a]	8.43±0.28[b]	1.63±0.09[b]	0.36±0.01[b]
	Three	25.00	50.50±0.71[b]	18.35±0.35[b]	7.90±0.14[b]	14,500.00±424.26[a]	5.84±0.15[b]	2.08±0.28[b]	0.38±0.04[b]
	Four	50.00	50.50±2.12[b]	18.80±1.13[b]	8.75±0.21[b]	15,900.00±191.42[a]	5.78±0.38[b]	2.15±0.08[b]	0.38±0.01[b]
	Five	100.00	55.00±1.41[b]	20.40±0.85[b]	9.80±0.28[b]	21,300.00±989.50[a]	5.62±0.02[b]	2.16±0.01[b]	0.36±0.01[b]
	Six	200.00	56.50±0.71[b]	22.00±0.00[b]	13.5±0.70[b]	26,562.50±795.50[a]	4.27±0.29[b]	2.33±0.01[b]	0.27±0.01[b]
72	One	-ve control	47.50±1.41[a]	17.00±1.41[a]	7.88±0.18[a]	15,300.00±495.68[a]	6.22±0.40[a]	1.94±0.09[a]	0.38±0.03[a]
	Two	+ve control	46.00±1.41[a]	11.40±0.28[a]	5.18±0.80[b]	9,250.00±212.13[a]	8.88±0.13[b]	1.61±0.06[b]	0.40±0.02[b]
	Three	25.00	51.00±1.41[a]	18.65±0.78[a]	8.76±0.37[b]	15,450.00±212.13[a]	5.83±0.60[b]	1.94±0.09[b]	0.36±0.06[b]
	Four	50.00	52.00±1.41[a]	18.75±2.40[a]	9.50±0.42[b]	17,100.00±141.42[a]	5.82±0.08[b]	1.97±0.16[b]	0.36±0.02[b]
	Five	100.00	54.50±0.71[a]	19.20±1.13[a]	9.90±0.57[b]	25,100.00±141.42[a]	5.48±0.41[b]	2.20±0.01[b]	0.34±0.02[b]
	Six	200.00	56.00±0.00[a]	22.75±1.77[a]	12.60±0.59[b]	26,400.00±565.69[a]	4.53±0.09[b]	2.37±0.16[b]	0.25±0.00[b]

Within columns, means with different superscripts are statistically significant ($p < 0.05$) when compared to Group I (-ve control) -ve control = Rats fed with normal feed diet and had free access to water
+ve control = Rats fed with normal feed diet and given triton-X

Table 3: Effect of the aqueous fruit extract of *S. macrocarpum* on differential leucocyte count (DLC) of hyperlipidaemic rats administered orally with triton-X for 90 days

Hours post admin	Group	Extract dose (mg/kg)	DLC (%)				
			Lymphocyte	Neutrophil	Eosinophil	Monocyte	Basophil
			Mean ± S.D.				
24	One	-ve control	52.50±0.71[a]	27.00±2.83[a]	4.50±0.00[a]	1.00±0.00[a]	2.00±0.00[a]
	Two	+ve control	63.00±4.24[a]	54.50±0.71[a]	10.50±0.71[a]	2.50±0.00[a]	4.50±0.71[a]
	Three	25.00	52.50±0.71[a]	32.50±0.71[a]	5.50±0.71[a]	1.00±0.00[a]	2.50±0.71[a]
	Four	50.00	52.50±0.71[a]	37.50±0.71[a]	5.50±0.71[a]	1.50±0.71[a]	2.50±0.71[a]
	Five	100.00	52.50±0.71[a]	39.00±0.00[a]	6.00±0.00[a]	2.00±0.00[a]	3.00±0.00[a]
	Six	200.00	57.00±1.41[a]	39.50±0.71[a]	6.00±0.00[a]	2.50±0.71[a]	3.00±0.00[a]
48	One	-ve control	28.50±0.71[a]	27.00±4.24[a]	5.00±0.00[a]	1.00±1.00[a]	1.50±0.71[a]
	Two	+ve control	65.00±4.24[a]	52.00±0.70[a]	11.00±1.41[a]	2.50±0.71[a]	5.50±0.71[a]
	Three	25.00	54.00±1.41[a]	35.00±1.41[a]	5.00±1.41[a]	1.50±0.71[a]	2.00±0.00[a]
	Four	50.00	55.00±1.41[a]	36.50±0.70[a]	5.50±0.71[a]	1.50±0.71[a]	2.50±0.71[a]
	Five	100.00	56.50±2.12[a]	40.50±2.12[a]	5.60±0.71[a]	2.50±0.71[a]	3.50±0.71[a]
	Six	200.00	59.00±1.41[a]	52.50±0.71[a]	6.50±0.71[a]	3.00±0.41[a]	4.00±1.41[a]
72	One	-ve control	29.00±1.41[a]	23.00±1.41[a]	2.50±0.71[a]	0.00±0.00[a]	1.00±0.00[a]
	Two	+ve control	75.50±1.41[a]	51.00±1.41[a]	11.50±2.12[a]	2.50±0.71[a]	4.50±0.71[a]
	Three	25.00	52.50±0.71[a]	33.50±2.12[a]	5.50±0.71[a]	0.50±0.71[a]	1.50±0.71[a]
	Four	50.00	54.00±1.41[a]	35.00±2.12[a]	6.00±1.41[a]	0.50±0.71[a]	2.00±0.00[a]
	Five	100.00	55.00±1.41[a]	35.00±1.41[a]	6.00±2.83[a]	1.00±0.00[a]	2.00±1.41[a]
	Six	200.00	58.50±0.71[a]	38.50±1.41[a]	7.50±0.71[a]	1.50±0.71[a]	3.50±0.71[a]

Within columns, means with different superscripts are statistically significant ($p < 0.05$) when compared to Group I (-ve control). -ve control = Rats fed with normal feed diet and had free access to water
+ve control = Rats fed with normal feed diet and given triton-X

Table 4: Effect of the aqueous fruit extract *S. macrocarpum* on total cholesterol of hyperlipidemic rats administered orally with Triton-Z for 90 days

Hours post admin	Group	Extract dose (mg/kg)	Total Cholesterol (mmol/L) Mean ± S.D.
24	One	-ve control	1.70±0.28[a]
	Two	+ve control	2.40±0.29[a]
	Three	25.00	2.15±0.64[a]
	Four	50.00	2.10±0.57[a]
	Five	100.00	2.35±0.07[a]
	Six	200.00	1.35±0.07[a]
48	One	-ve control	1.70±0.14[a]
	Two	+ve control	2.55±0.07[a]
	Three	25.00	2.50±0.14[a]
	Four	50.00	1.50±0.07[a]
	Five	100.00	1.45±0.07[a]
	Six	200.00	1.25±0.35[a]
72	One	-ve control	1.90±0.14[a]
	Two	+ve control	2.40±0.50[a]
	Three	25.00	2.20±0.28[a]
	Four	50.00	2.20±0.42[a]
	Five	100.00	1.70±0.14[a]
	Six	200.00	2.35±0.07[a]

Within columns, mean with the same superscripts are not statistically significant ($P>0.05$) when compared to Group I (-ve control), -ve control = Rats fed with normal feed diet and had free access to water.
+ve control = Rats fed with normal feed diet and given triton-X

The presence of iron therefore could have contributed to the observed improvement of hematological parameters. Also the anemia in kittens which was positively correlated with the severity of hyperlipidemia was reduced by administration of iron and low fat diet (Gun-Moore *et al.*, 1997). The increase in the hematological parameters in this study was also due to the activities of the chemical constituents of the plant. Saponins, found in the extract (Sodipo *et al.*, 2008a) are known to hydrolyse and produce saponins which may be steroid or triterpene (Eghianruwa, 2002). Shapiro and Greenfield (1987) reported the stimulatory effect of steroid on bone marrow resulting in increased erythropoiesis. Initial phytochemical studies revealed the presence of the steroidal nucleus and saponins in the aqueous fruit extract of *S. macrocarpum* (Sodipo *et al.*, 2008a). Of interest however, is the fact that when serum was analysed at 24 and 48 hrs (that the aqueous fruit extract was in the rats), the Hb and RBC were all significantly increased when compared with the negative control (Table 2). The increase in RBC was corroborated by the pattern of PCV which also increased significantly at 24 and 48hrs, since these parameters are in direct relationship (Nwafor, 1998; Sodipo *et al.*, 2009d, 2011a). This is probably an indication that the maximal haematinic effect was attained at 48hrs. The RBC values in the positive control group (i.e. the rats that received only Triton-X but no extract) were the least throughout the period of study when compared to those that were administered graded doses of the extract. This implies that the Triton had probably altered the morphology of the RBCs and also increased their osmotic fragility which in turn may lead to icterus. The result of this study agrees with that of Hall *et al*., (2000) who observed increased RBC osmotic fragility and altered RBC morphology in cats that received 250 mg/kg Triton WR 1339 in which one of them developed icterus and died 5 days later. The degree of anemia in kittens was positively correlated with the severity of the hyperlipidemia (Gun-Moore *et al*., 1997). It was regenerative in nature and also had some features of iron deficiency anemia. It is possible that hyperlipidemia and changes in lipid metabolism could result in erythrocyte fragility and hemolysis (Alleman, 1990). Also, increased levels of cholesterol lead to coronary artery disease and haemolytic jaundice (Mukherjee, 1988; Odutola, 1992).

These results of the Wintrobe indices buttressed the fact that the aqueous fruit extract of *Solanum macrocarpum* has antianaemic effect on the atherosclerotic rats. The MCV and MCH values decreased significantly ($P<0.05$) with increase in extract dose in the atherosclerotic rats throughout the period of study. This does not confirm that there was anaemia because red cell indices cannot bake the place of direct observation of RBC which increased significantly ($P<0.05$) throughout the period of study. The MCHC also increased significantly at 48 and 72hrs relative to the negative control ($P<0.05$). These results buttressed the fact that the aqueous fruit extracts of *Solanum macrocarpum* has antianaemic effect on atherosclerotic rats. The administration of graded doses of *S. macrocarpum* extract significantly stimulated increased production of WBC ($p<0.05$) on chronically induced hyperlipidemic rats. This could be a possible stimulation of the immune defence system (Kashinath, 1990; Abdulrahman, 2004 as occurred in the hypercholesterolemic rats (Sodipo *et al.*, 2009d) and acute triton-induced hyperlipidemic rats (*Sodipo et al.*, 2011a).

Furthermore, reports have shown that persistent antigen load in the body results in lymphocytosis (Schalm *et al.*, 1976: Biu, 2007; Abdulrahman *et al.*, 2010, Sodipo *et al.*, 2010d; 2011a). The antigenicity of the

extract may in part be due to the presence of tannins (Evans, 2002) which are found in the plant (Sodipo *et al*., 2008a).

The changes in differential leukocyte count (DLC) – the lymphocyte, neutrophil, eosinophil, monocyte and basophil did not show change (P>0.05) when compared to the control in the atherosclerotic rats with increase in extract dose, probably implying non-stimulation of the immune system.

Cholesterol is the main lipid found in blood, bile and brain tissue (Sood, 2006). Increased levels of cholesterol are associated with coronary heart disease (CHD), hyperprothrombinemia, diabetes, cirrhosis and various liver diseases (Odutola, 1992; Iweala and Okeke, 2005; Sodipo *et al.*, 2009d). In the present study, the decrease in serum total cholesterol, though not significant, is in agreement with the hypocholesterolemia recorded with the aqueous stem bark of *Paustinystalia yohimbe* (K. Schum) and *P. macroceras* (Perre ex Bielle) in male Wistar rats (Jacks, 2004) and as reported with the fruit of *S. melongena* L., *S. gilo* Radii and *S. macrocarpum* which were fed with diet-rich food (1 % cholesterol plus groundnut oil) (Odutola *et al.*, 2004; Sodipo *et al.*, 2009c) and acute triton-induced hyperlipidemic rats (Sodipo *et al.*, 2011a). The aqueous fruit extract of *S. macrocarpum* could probably ameliorate the occurrence of coronary heart disease by lowering cholesterol level in the rats administered triton-X to make them hyperlipidemic. The phytochemistry revealed that the fruit of *S. macrocarpum* contains alkaloids (Sodipo *et al.*, 2008a). Reports have shown the *Solanum* alkaloids to be solanidine and solasodine (Sodipo *et al.*, 2009d). The steroidal alkaloids are said to be responsible for lowering hyperlipidemia (Sodipo *et al.*, 2008a, 2009c). Furthermore; saponins as found in this plant (Sodipo *et al.*, 2008a) are cholesterol-lowering agents (Cheeke, 1971). Thus the fruit of *S. macrocarpum* may probably be used in the treatment of hyperlipidemia as claimed in traditional medicine.

CONCLUSION

It can be concluded that the improved hematological prameters (Hb, RBC, and PCV) observed in the chronically induced herlipidemic rats after administration of the aqueous fruit extract of *Solanum macrocarpum* probably suggests a beneficial effect, suggesting that the plant could probably be used as an antianaemic agent.

ACKNOWLEDGMENTS

The authors gratefully acknowledge the technical assistance of Messers Fine Akawo of Chemistry Department and Bitrus Wampana of Veterinary Physiology Pharmacology and Biochemistry. The award of a fellowship to the first author by the University of Maiduguri, Maiduguri is also appreciated.

REFERENCES

Abdulrahman FI (2004). Studies on the chemical contents and pharmacological activities of the root-bark extract on *Vitex doniana* (Black Plum). Ph.D. Thesis, University of Maiduguri, Maiduguri, Nigeria. 166pp.

Abdulrahman H, Akan JC, Sodipo OA and Onyeyili PA (2010). Effect of aqueous root-bark extract of *Vitex domina* sweet on hematological parameters in rats. *J. Am. Sci*. **6**: 8-12.

Alleman AR (1990). The effects of hemolysis and lipaemia on serum biochemical constituents. *Vet. Med*. **85**:1272-1284.

ANNON (2007). Nightshade. http://www.library.viu.edu/vex/toxic/rightsha/ nightsh.htm. Access Date: 26/5/2007

ANNON (2008). Sigma Aldrich. http://www.sigmaldrich.com/sigma/product 1% 20 information.% 20 sheetlt853pis. Pdf. Access Date: 19/12/2008.

Baker FI, Silverton RE, Pallister CJ (1998). *Baker and Silvertons Introduction to Medical Laboratory Technology*, 7th ed. Bounty Press Ltd, Nigeria. pp. 339-373.

Biu AA (2007). The efficacy and toxicity of Neem (*Azadirachta indica A. Juss*) Leaf aqueous extract against coccidiosis in chickens (*Gallus gallus domesticus*) and as a feeding deterrent to quela (*Queleo quelea*) birds, in Borno State, Nigeria Ph.D. Thesis, University of Maiduguri, Maiduguri, Nigeria. 255pp.

Brown BA (1976). *Hematology Principles and Procedures*. 2 ed. Lea and Feibiger, Philadelphia, USA pp. 65-81.

Burkill HM. (2000). *The Useful Plants of West Tropical Africa* (Vol. 5) families S-Z. 2nd ed. Royal Botanic Gardener, Ken, London, U.K. pp. 119. 124-125, 130.

Cheeke PR (1971). Nutritional and physiological implications of saponins. A review. *Can. J. Animal Sci*. **51**:621-632.

CIOMS (1985). Council for International Organizations of Medical Sessions. International Guiding Principles for Biomedical Research Involving Animal %WHO 1211. Geneva, Switzerland. 27.

Cole EH. (1974). *Veterinary Clinical Pathology*. W.B. Saunders Co. Philadelphia. 2nd ed. pp. 110-116.

Dacie JV, Lewis SM (1984). P*ractical Haematology* 6th ed. Churchill Livingstone, Edinburgh, UK. pp. 24-36.

Eghianruwa KI (2002). *A Dictionary of Pharmacology and Toxicology*. 1st ed. Striling-Horden Publishers, Ibadan, Nigeria, 28Opp.

Evans A, Stein MD (1986). Lipids lipoproteins and apolipoprotiens, In. Textbook of *Clinical Chemistry* (Tietz, N.W. ed). W.H. Saunders Co. Philadelphia, USA. pp 844-887.

Evans WC (2002). *Trease and Evans Pharmacognosy*, 15th ed. Harcout Publishers Ltd, China, 585.pp.

Fernando MR, Wickramansingbe SMD, Nalinle I, Thabrew Ml, Ariyanando PL and Karunanayake EH (1991). Effects of Artocarpus heterophyllus and "*Asteracanthus longifolia* glucose on tolerance in normal human subjects and in maturity-onset diabetic patients. *J. Ethnopharmacol*. **31**:277-283.

Graph Pad Software (1998). Graph Pad Software, Inc., San Diego, California, USA www.graphpad.com.

Grubben GJH and Denton OA (2004). PROTA 2. *Plant Resources of Tropical Africa 2. Vegetables*. Ponen and Looijen hv, Wagening en, Netherlands. ppA84-487.

Gun-Moore DA, Watson TDG, Dodkin SJ, Blaxter AC, Crispin SM and GruffyddJones TJ (1997). Transient hyperlipidemia and anemia in kittens. *Vet Record* **140**:355-359.

Hall JA, Gradin JL, Andreason CB and Wonder RC (2000). Use of non-toxic detergent (Triton WR 1339) in healthy cats to assess hepatic secretion of triglyceride. *Am. J. Vet. Sci. Res.* **61**:941-950.

Iweala EEJ and Okeke CU (2000). Comparative study of the hypoglycaemic and biochemical effect of *Catharanthus roseus* Linn. Family Apocynaceae (Madagascar periwinkle) and chlorpropamide (diabenese) on afloxaninduced diabetic rats. Biokemistri **17**:149-156.

Jacks TW (2004). Acute and chronic effect of oral administration of aqueous stem bark extract on *Pausinystalia yohimbe* (K. Schum Pierre) and *Pausinystalia macroceras* (Pierre ex Bielle) on the histopathology of the Testes of albino Wistar rats. A probable remedy for male infertility. Ph.D. Thesis, University of Maiduguri, Maiduguri, Nigeria. 421pp.

Kashinath KT (1990). Hypolipidemic effect of disulphide in rats fed high lipids diet and! or ethanol. Ph.D. Thesis, University of Bangalore, pp. 221-225.

Lawrence DR, Bennet PN and Brown MJ (1997). Hyperlipidemias. Clinical Pharmacology, 8th ed. Churchill Livingstone, New York, U.S.A. pp. 478-483.

Lin H, Opuku AR, Geheeb-Keler M, Hutchings AD, Terbalanche SE, Jagher AK and Van-Standen J (1999). Preliminary screening of some traditional Zulu medicinal plants for anti-inflammatory and antibacterial activities. *J. Ethnopharmacol*. 68:267-274.

Mittal GC, Aguwa CN, Ezeinu BU and Akubue PI (1981). Preliminary pharmacological studies on antivenom action of Diodia scandens leaves. *Nig. J. Pharm*. **12**:432-436.

Mukherjee KL (1988). *Medicinal Laboratory Technology*. A procedure manual for routine diagnosis tests. Vol III. Tata McGraw Hill Pub. Co. Ltd. New Delhi. 1, 282 pp.

NIH (1990). National Institute of Health Recommendations for Improving Cholesterol Measurement. *A Report from the Lab. Standardisaton Panel of the National Cholesterol Education Programme*. NIH Publication No. 90-2564.

Nwafor PA (1998): Anticonceptive and other pharmacological effects of *Asparagus pubescens* bark root and *Cassia nigricans* leaves. Ph.D. Thesis, University of Jos, Jos, Nigeria. 263pp.

Nwanjo HV, Oze G, Okafor MC, Nwosu D and Nwankpa P (2006). Antihyperlipidaemic and heart rate lowering effects of aqueous leaf extract of *Viscum album* (Mistletoe) in hypercholesterolaemic rats. *J. Med. Lab. Sci.* **15**(2): 11-15.

Odutola AA (1992). *Rapid Interpretation of Routine Clinical Laboratory Tests*. S. Asekome and Company, Zaria, p. 112.

Otway S and Robinoon DS(1967). The use of non-ionic detergent (Triton-WR1339) to determine rates of triglyceride entry into the circulation of the rat under different physiological condition. *J. Physiol.* **190**:321-333.

Schalm OW, Jam NC and Carol EJ (1976). *Veterinary Hematology*, 31d ed. Lea and Feibiger, Philadelphia, USA. pp. 20-280.

Shapiro ME and Greenfield 5 (1987). The complete blood count and leucocyte differential count. An approach to their application. *Ann. Intern*. M. 106:65-74.

Sodipo OA (2009). Studies on chemical components and some pharmacological activities of *Solanum macrocarpum* Linn. fruit (Garden egg). Ph.D. Thesis, University of Maiduguri, Maiduguri. 387pp.

Sodipo OA, Abdulrahman Fl, Sandabe UK and Akinniyi JA (2009a). Effects of urea, serum creatinine and some electrolytes on aqueous extracts of *Solanum macrocarpum* Linn, in rats pre-fed 1% cholesterol and groundnut oil. *Sahel J. Vet. Sci.* **8** (1):19-23.

Sodipo OA, Abdulrahman FI, Sandabe UK and Akinniyi FI (2009b). Effect of *Solanum macrocarpum* Linn. on biochemical liver function in diet-induced hypercholesterolaemic rats. *Nig. Vet. J.* **30** (1):1-8.

Sodipo OA, Abdulrahman Fl, Sandabe UK and Akinniyi JA (2009c). Total lipid profile with aqueous fruit extract of *Solanum macrocarpum* Linn. in hypercholesterolaemic albino rats. *J. Pharm. Biores*.**6** (1):10-15.

Sodipo OA, Abdulrahman Fl, Sandabe UK and Akinniyi JA (2009d). Effects of aqueous fruit extract on *Solanum macrocarpum* Linn, on some haematological indices in albino rats fed with cholesterol-rich diet. *Sahel J. Vet. Sci*. **8** (2):5-12.

Sodipo OA, Abdulrahman FI, Sandabe UK and Akinniyi JA (2011a). Effects of the aqueous fruit extract of *Solanum macrocarpum* Linn. on haematological parameters of triton-induced hyperlipidemic rats. *AJPP*. **5** (5): 632-639.

Sodipo OA, Abdulrahman FI, Sandabe UK and Akinniyi JA (2011b). Total lipid profile and faecal cholesterol with aqueous fruit extract of *Solanum macrocarpum* in triton-induced hyperlipidemic albino rats. *JMPR*. **5** (16): 3833-3838.

Sood R (2006). *Textbook of Medical Laboratory Technology*. 1st ed Jaypee Brothers Medical Publishers (p) New Delhi, India, pp. 609-672.

Triton-X-100 (2008): Sigma Chemical Company, U.S.A. http://en. wikipedia.org./wiki/triton-x-100. Access Date: 19/12/2008.

Williamson EM, Okpako DT and Evans FJ (1996). *Pharmacological Methods in Phytotherapy Research Vol. 1. Selection, Preparation and Pharmacological Evaluation of Plant Material*. Wiley and Sons, England. 228p.