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Full Length Research Paper

Effects of the aqueous fruit extract of *Solanum macrocarpum* L., α-solanidine, nicotinic acid, cholestyramine and simvastatin on liver function of hyperlipidaemic rats administered triton-X orally for 7 days

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Studies were conducted on the effect of 50mg/kg each of the aqueous fruit extract of *Solanum macrocarpum*, α-solanidine, (a steroidal glycoalkaloid found in the Solanaceae), three antihyperlipidaemic drugs nicotinic acid, simvastatin and cholestyramine) on forty two (42) rats made hyperlipidaemic by treating them with 400 mg/kg triton-X for 7 days. The rats were divided into 7 groups of 6 rats each. At 24h, 48h and 72h respectively, the rats in each group were humanely sacrificed and blood samples collected for biochemical liver analysis. The liver function analyzed were total protein, albumin, total bilirubin and liver enzymes (ALP, ALT, and AST). The extract, α-solanidine and the three hypolipidaemic drugs all significantly increased (P<0.05 at 72h of study when compared to the positive control. There was no change (P>0.05) in albumin for the five substances tested. Bilirubin levels however decreased significantly (P<0.05) at 72h for both extract and cholestyramine and were lower than the values recorded for α-solanidine, simvastatin and nicotinic acid. The AST, ALT and ALP decreased significantly (P<0.05) at 72h for both the extract and cholestyramine while high levels of these serum enzymes were recorded for α-solanidine, nicotinic acid and simvastatin. The aqueous fruit extract of *S. macrocarpum* and cholestyramine probably had hepatoprotective effects on triton-induced hyperlipipidaemic rats when compared to α-solanidine, nicotinic acid and simvastatin under the condition of study.

Key words: *Solanum macrocarpum*, aqueous extract, liver function, hyperlipidaemic rats, α-solanidine, hypolipidaemic drugs.

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). As an alternative medicine, people derived therapeutic materials from thousands of plants (Agrawal and Sharma, 2012). Since reactive oxygen radicals play an important role in the genesis of numerous human disease processes, antioxidants derived from consumable fruits, vegetables, spices and beverages have received considerable attention. The antioxidants protect our body systems from free radicals mediated-damage at the cellular and molecular levels (Sharma et al., 2009; Mehta et al., 2010; Agrawal and Sharma, 2012). The pool of free radicals production in our body stems mainly from the mitochondrial activity, but environmental factors such as xenobiotics, pollutants and other stressors also contribute to it

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enormously. This phenomenon generates imbalance between the oxidants (free radical species, FRS) and the innate antioxidants; a condition referred to as oxidative stress. Oxidative stress leads to onset of numerous disease processes including cancer, heart, lung, brain and kidney associated diseases, cell death and aging (Agrawal and Sharma, 2012).

The aqueous extract of *Cynodon dactylon* was found to reduce oxidative stress parameters such as lipid peroxidation in carbofuran-induced oxidative stress in brain of Wistar rats. The observed changes in oxidative parameters in *C. dactylon* treated rats were comparable to that observed with vitamin C, one of the best known antioxidants (Rai et al., 2011). Thus, *C. dactylon* may be important in the context of development of an antioxidant.Extensive lipid peroxidation in biological membranes causes alteration in fluidity such as a decrease in its membrane potential and an increase in its permeability to different ions followed by an eventual rupture (Melita et al., 2010). The determination of malondialdehyde, MDA (a product of lipid peroxidation) level in erythrocytes gives an estimate of the rate of lipid peroxidation in cell membrane. Peroxidation of lipids occurs when pro-oxidant substances react with unsaturated fatty acids of biological membranes. The aqueous extract of *Emblica officinalis* seed (Euphorbiceae) had the potential to normalize the oxidative stress in severely diabetic rats. Also different parts of the plant have been used as hepatoprotective, anti-ulcer, antimutagenic and antiulcer agent (Mehta et al., 2010). Researchers over the years have produced convincing evidence towards application of natural antioxidants in place of synthetic molecules, as the latter have associated toxicities (Moure et al., 2001; Tseng and Lee 2006; Sharma et al., 2009). Among the natural antioxidants, polyphenolic compounds such as flavonoids, flavonols and terpenoids, etc. from plant origin have appeared as favoured choice. By virtue of being electron rich, these molecules can donate electrons to reactive oxygen species (ROS) and neutralize these chemical species (Sharma et al., 2009). The aqueous fruit extract of *Moringa oleifera* (drumstick), aqueous root extract of *Ficus bengalensis* and the aqueous seed extract of *Emblica officinalis* have been shown to contain high level of polyphenolics such as flavonoids, flavonols which are natural antioxidants that is free radical scavengers (Sharma et al., 2009).

Over the past two decades, an expanding body of evidence from epidemiological and laboratory studies have demonstrated that some edible plants as a whole, or their identified ingredients with antioxidant properties have substantial protective effects on human carcinogenesis, cardiovascular, hepatic and renal disorder (Dixit and Ali, 2010).

Inspite of tremendous advances in modern medicine, no effective drugs are available, which stimulate liver function and offer protection to the liver from damage of help to regenerate hepatic cells (Repetto and Llesuy, 2002). In the absence of reliable liver-proctective drugs in modern medicine, a large number of medicinal preparations are recommended for treatment of liver disorders and quite often claimed to offer significant relief (Dixit and Ali, 2010). Attempts are being made globally to get scientific evidences for these traditionally reported herbal drugs.

In 2002, at the international Aloe Science Council (IASC) Annual Conference, Vinson Joe presented evidence from a human chemical study, that the bioavailability of antioxidant supplement vitamin C and E was increased by over 200 percent when taking Aloe Vera gel. The *Aloe barbadensis* leaf extract may act by either directly scavenging the reactive oxygen metabolites, due to the presence of various antioxidant molecules (Nwanjo, 2006; Dixit and Ali, 2010). *Solanum macrocarpum* (“Gorongo” in Kanuri) is one of the plants used for folkloric medicinal purposes. Although the unripe fruit of the plant is used by traditional healers for the treatment of various ailments (Grubben and Denton, 2004), information on the hepatotoxicity of the extract in man and animals is not readily available except that by Sodipo et al., (2009; 2011; 2012) that investigated the effect of the aqueous fruit extract of the plant on the liver function of diet-induced hypercholesterolaemic rats, acute and chronic triton-induced hyperlipidaemic rats, respectively. The present study investigated the effect of the aqueous fruit extract of *S. macrocarpum*, α-solanidine [a glycoalkaloid found in Solanaceae and said to lower hyperlipidaemia, (Olaniyi, 1998; ANONa, 2007)] and three atihyperlipidaemic drugs namely simvastatin, nicotinic acid and cholestyramine (Hardaman and Limbird, 2001) in an attempt to find an alternative hypolipidaemic agent that is both therapeutically and cost effective but with fewer side effects (especially hepatic effects) than the existing ones which are expensive and at the same time have numerous side effects (Hardman and Limbird, 2001).

MATERIALS AND METHODS

Plant collection and identification

The plant material (*Solanum macrocapum* 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.

Table1. Change in body weight of male albino rats after being administered orally with triton-X (400 mg/kg) for 7 days.

Group	Body Weight (g) Days of Treatment	
	0	7
	Mean ± S. D.	
One *	148.00±009.38[a]	170.80±10.59[b]
Two	117.80±26.68[a]	128.00±23.93[a]
Three	148.80±5.26[a]	166.00±4.58[a]
Four	117.80±26.6[a]	128.00±23.93[a]
Five	165.40±41.71[a]	173.00±42.57[a]
Six	164.80±38.75[a]	181.80±40.02[a]
Seven	86.60±16.10[a]	100.00±18.56[a]

Within rows, means with different superscripts are statistically significant ($p < 0.05$) when compared to day zero (0) using student t-test
0 day = Before triton-X administration
n = 6 rats per group
Group One* = Rats fed with normal diet and had free access to water, but were not administered triton-X

Extraction

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

Animals and treatment

Forty two (42) Wistar strain male albino rats weighing 160-200g 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 grower's 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).

A total of forty two (42) male albino rats weighing between 160 and 200g were used for the work. They were randomly distributed into seven groups of 6 rats per group.

After administration of the extract, α-solanidine and the three hypolipidaemic drugs to the rats in groups three-seven respectively, every 24hrs for 3 consecutive days, 2 rats from each group (Groups one-seven) were humanely sacrificed and blood samples were collected for biochemical liver analysis. (Adapted from Williamson et al., 1996).

All the rats in the 7 groups were weighed at day zero (i.e. before administration of triton-X) and 1 week after before they were sacrificed. (See Appendix I)

Biochemical Liver Function tests

The liver function parameters estimated from the serum were protein, albumin total bilirubin and liver enzymes which included aspartate amino transferase (AST), alanine amino transferase (ALT) and alkaline phosphatase (ALT). AST and ALT were assayed using commercial Randox kits (UK) and by Quinica Clinical Applicanda, JA kits (Moss et al., 1986). The total protein in the serum was estimated using direct Biuret method (Peters et al., 1982; Afonja, 1997). Serum albumin and bilirubin were determined by the dye bromocresol-green method by Dounmas *et al.,* (1971); Spencer and Price (1977); Teitz (1994).

Determination of total Cholesterol

Two rats in each group were humanly sacrificed by cutting the throat with a sterile blade. Blood was collected from the vena cava into clean, labelled centrifuge rubes without anticoagulant after the extract had been allowed to act for 24, 48 and 72hrs respectively. The blood was centrifuged at a rate of 12,000 revolution per minute (rpm) for 10 minutes. The clear, yellow serum was then separated from settled cellular elements. Cholesterol was assayed by Tindar's

Table 2. Effect of Aqueous Fruit Extract of *S. macrocarpum*, α-solanidine, nicotinic acid, cholestyramine and simvastatin on protein, albumin and total bilirubin of Hyperlipidaemic rats administered Triton-X for 7 days.

Hours after extract/drug administration	Dosage mg/kg	Extract/Dug	Protein (g/L)	Albumin (g/L)	Total bilirubin (µmol/L)
				Mean ±S.D.	
	50	+ve control	89.00 ± 1.41[a]	48.00 ± 0.00[a]	59.50±0.71[a]
	50	-ve control	66.50 ± 2.12[a]	32.00 ± 0.00[a]	5.50 ± 2.12[a]
	50	Aqueous extract	78.00 ± 4.24[a]	40.00 ± 1.41[a]	2.50 ± 1.71[a]
24	50	α-solanidine	66.50 ± 0.71[a]	36.00 ± 2.83[a]	3.00 ± 0.00[a]
	50	Nicotinic acid	70.50 ± 0.71[a]	39.50 ± 0.71[a]	3.00 ± 0.00[a]
	50	Cholestyramine	76.00 ± 4.24[a]	41.50 ± 2.12[a]	4.50 ± 1.41[a]
	50	Simvastatin	70.50± 4.95[a]	38.50± 0.71[a]	4.00± 0.00[a]
	50	+ve control	88.50 ± 0.71[a]	49.00 ± 1.41[a]	3.50 ± 1.71[a]
	50	-ve control	61.00 ± 14.14[a]	32.00 ± 4.95[a]	5.00 ± 4.49[a]
	50	Aqueous extract	73.50 ± 2.12[a]	41.50 ± 1.41[a]	2.50 ± 1.71[a]
48	50	α-solanidine	65.00 ± 5.66[a]	37.00 ± 1.41[a]	4.00 ± 1.41[a]
	50	Nicotinic acid	66.50 ± 4.95[a]	38.50 ± 0.71[a]	3.50 ± 1.41[a]
	50	Cholestyramine	73.00 ± 7.07[a]	41.00 ± 4.24[a]	2.50 ± 1.41[a]
	50	Simvastatin	71.50 ± 10.61[a]	44.50 ± 6.36[a]	4.00 ± 2.83[a]
	50	+ve control	82.00 ± 1.41[a]	48.50 ± 0.71[a]	3.50 ± 0.71[a]
	50	-ve control	58.50 ± 3.54[b]	32.00 ± 0.71[a]	4.80 ± 0.71[a]
	50	Aqueous extract	70.50 ± 3.54[b]	40.50 ± 0.71[a]	2.50 ± 0.71[a]
72	50	α-solanidine	60.00 ± 1.41[b]	37.50 ± 0.71[a]	3.50 ± 0.71[a]
	50	Nicotinic acid	69.00 ± 1.41[b]	38.50 ± 0.71[a]	2.50 ± 0.71[a]
	50	Cholestyramine	70.00 ± 2.83[b]	38.50 ± 0.71[a]	2.50 ± 0.71[a]
	50	Simvastatin	69.00 ± 1.41[b]	38.50 ± 0.71[a]	4.50 ± 0.71[a]

-ve control = Rats fed with normal feed diet and had free access to water
+ve control = Rats fed with normal feed diet and triton-X
Within columns, means with different superscripts are statistically significant (P<0.05)
reaction (Evans and Stein, 1986; NIH, 1990) using commercial
kits, from Fortress Diagnostic Ltd, Antrim.

Statistical Analysis

Data were expressed as the mean ± S.D. The results obtained were subjected to Analysis of Variance (ANOVA) and Student t-test using Graph Pad Software (1998).

RESULTS

Change in Mean Body Weight of Male Albino Rats (Wistar strain) after being administered orally with Triton-X for 7 Days

The effect of triton-X on mean body weight of albino rats feds orally with triton-X is show in Table 1. There was increase in body weight of the rats in groups one, two and five (P<0.05) when compared to day zero (i.e. when no triton-X was administered).

Effect on Liver Enzymes

The effect of the aqueous fruit extract of *S. macrocarpum*, α-solanidine, nicotinic acid, cholestyramine and simvastatin on some liver enzymes are shown in Table 3. The changes in AST values were significant (p <0.05) throughout the study whilst that of ALT and ALP were significant at 72h. At 24h, the AST value for α-solanidine was very high, 89.00 ± 0.00 U/L, even higher than that of the positive control, 82.50 ± 9.19 U/L. The AST value for simvastatin was also high, 80.50 ± 12.02 U/L. The AST value for the aqueous extract and cholestyramine were the same, 46.50 ± 7.78 U/L. The AST value recorded for nicotinic acid was 59.00 ± 0.00 U/L. At 48h, the AST value for the aqueous extract was 45.00 ± 0.00 U/L, that of α-solanidine, though still high had reduced a bit to 71.50 ± 6.36 U/L. The AST value for cholestyramine was low, 42.00 ± 0.00 U/L, but those for nicotinic acid and simvastatin still remained high, 63.00 + 5.66 U/L and 78.00 ± 15.56 U/L respectively. At 72h, the AST values for the aqueous extract still remained low, and the value was 40.50 ± 0.71 U/L. The ALT values and ALP values followed a similar pattern for the aqueous extract, α-solanidine and the three hypolipidaemic drugs at 72 hrs (p < 0.05). The values for the negative values were

Table 3. Effect of aqueous fruit extract of *S. macrocarpum*, α-solanidine, nicotinic acid, cholestyramine and simvastatin on serum enzymes of Hyperlipidaemic rats administered Triton-X for 7 days.

Hours after extract/drug administration	Dosage mg/kg	Extract/Dug	Serum enzymes (U/L)		
			AST	ALT	ALP
			Mean ±S.D.		
	50	+ve control	59.50 ± 10.61[a]	25.00 ± 12.02[a]	171.50±41.72[a]
	50	-ve control	82.50 ± 9.19[a]	35.00 ± 12.73[a]	221.00 ± 14.14[a]
	50	Aqueous extract	46.50 ± 7.78[a]	25.50 ± 1.66[a]	198.00 ± 0.00[a]
24	50	α-solanidine	89.00 ± 0.00[a]	29.50 ± 5.36[a]	200.50 ± 17.68[a]
	50	Nicotinic acid	59.00 ± 0.00[a]	27.00 ± 6.83[a]	165.00 ± 35.36[a]
	50	Cholestyramine	46.50 ± 7.78[a]	19.00 ± 2.83[a]	141.00 ± 1.41[a]
	50	Simvastatin	80.50± 12.02[a]	23.00± 8.49[a]	179.00± 5.66[a]
	50	+ve control	41.00 ± 0.00[a]	19.00 ± 2.83[a]	203.50 ± 4.95[a]
	50	-ve control	82.50 ± 9.19[a]	35.00 ± 0.71[a]	232.00 ± 2.88[a]
	50	Aqueous extract	45.00 ± 0.00[a]	19.00 ± 2.83[a]	187.50 ± 12.83[a]
48	50	α-solanidine	71.50 ± 6.36[a]	29.50 ± 6.36[a]	202.00 ± 14.14[a]
	50	Nicotinic acid	63.00 ± 5.66[a]	25.00 ± 5.66[a]	175.50 ± 13.44[a]
	50	Cholestyramine	42.00 ± 0.00[a]	29.00 ± 0.00[a]	169.00 ± 43.84[a]
	50	Simvastatin	78.00 ± 15.56[a]	27.50 ± 9.19[a]	199.00 ± 1.41[a]
	50	+ve control	41.00 ± 1.41[a]	22.00 ± 1.41[a]	209.00 ±1.41[a]
	50	-ve control	84.50 ± 7.07[b]	35.50 ± 2.12[a]	225.00 ± 7.07[a]
	50	Aqueous extract	40.50 ± 0.71[b]	18.00 ± 1.41[a]	196.50 ± 0.71[a]
72	50	α-solanidine	65.00 ± 2.83[b]	28.00 ± 1.41[a]	200.00 ± 1.41[a]
	50	Nicotinic acid	65.00 ± 2.12[b]	20.50 ± 0.71[a]	179.00 ± 1.41[a]
	50	Cholestyramine	40.50 ± 0.71[b]	17.50 ± 0.71[a]	142.50 ± 3.54[a]
	50	Simvastatin	68.00 ± 1.41[b]	20.50 ± 0.71[a]	191.00 ± 1.41[a]

-ve control = Rats fed with normal feed diet and had free access to water

+ve control = Rats fed with normal feed diet and triton-X

Within columns, means with different superscripts are not statistically significant (P<0.05)

lower than those of the positive control. α-solanidine recorded the highest level of ALT among the substances tested, 29.00 ± 6.36 U/L at 24 his. The ALP values for α-solanidine were the highest throughout the period of study when compared to the other compounds. At 24h, the value recorded for ALP with α-solanidine was 200.50 ± 17.68 U/L whilst cholestyramine had the least, 141.00 ± 1.41 U/L.

Effect on Protein, Albumin and Total Bilirubin

The effect of the aqueous fruit extract of *S. macrocalpum*, α-solanidine, and the three hypolipidaemic drugs are shown in Table 2. The protein values were significantly higher ($p < 0.05$) than those of the positive control at 72h. However, they were not as high as those of the negative controls. At 24h of study, the protein value for the negative control was 89.00g/l.

Effect of the Aqueous Fruit Extract of *S. macrocarpum* α-solanidine, nicotinic acid, cholestyramine and simvastatin on total cholesterol of hyperlipidaemic rats administered triton-X orally for 7 days

The effect of the aqueous fruit extract of S. macrocarpum, α-solanidine and the three hypolipidemic drugs on total cholesterol of hyperlipidaemic rats are shown in Table 4. There was a non-significant (P>0.05) decrease in total cholesterol when compared to the negative control that was administered triton-X at 24, 48, and 72h respectively.

DISCUSSION

The increase in mean body weight of rats after Triton-X administration for 7 days (Table 1) was statistically

Table 4. Effect of Aqueous fruit extract of *S. macrocarpum*, α-solanidine, nicotinic acid, cholestyramine and simvastatin on total cholesterol of hyperlipidaemic rats administered Triton-X for 7 days.

Hours after extract/drug administration	Dosage mg/kg	Extract/Dug	Total cholesterol Mean ±S.D. (mmol/L)
	50	+ve control	2.75 ± 0.07[a]
	50	-ve control	3.50 ± 0.28[a]
	50	Aqueous extract	2.95 ± 0.07[a]
24	50	α-solanidine	2.80 ± 0.28[a]
	50	Nicotinic acid	2.75 ± 0.07[a]
	50	Cholestyramine	3.00 ± 0.00[a]
	50	Simvastatin	2.80 ± 0.00[a]
	50	+ve control	2.70± 0.14[a]
	50	-ve control	4.10 ± 0.14[a]
	50	Aqueous extract	2.85 ± 0.21[a]
48	50	α-solanidine	2.50 ± 0.14[a]
	50	Nicotinic acid	2.70 ± 0.00[a]
	50	Cholestyramine	2.80 ± 0.14[a]
	50	Simvastatin	2.60 ± 0.57[a]
	50	+ve control	2.65 ± 0.07[a]
	50	-ve control	3.50 ± 0.07[a]
	50	Aqueous extract	2.65 ± 0.07[a]
72	50	α-solanidine	2.55 ± 0.07[a]
	50	Nicotinic acid	2.95 ± 0.07[a]
	50	Cholestyramine	2.90 ± 0.00[a]
	50	Simvastatin	3.00 ± 0.00[a]

significant ($p < 0.05$) in Groups one, two and five when compared to day zero (i.e. before Triton-X administration). This probably implies that Triton-X at the dosage employed, 400 mg/kg or for the length of time given, induced hyperlipidaemia, even though differences in the rats' metabolism may account for the differences in the statistics exhibited in their significance.

There was a significant increase ($p < 0.05$) in protein levels at 72h, when 50mg/kg of the aqueous fruit extract of *S. macrocarpum* was administered to the hyperlipidaemic rats when compared with the positive control (Table 1). The α-solanidine, nicotinic acid, cholestyramine and simvastatin also had higher protein levels when compared to the positive control. There was no change in the albumin ($p > 0.05$) throughout the study. This higher values of protein in the extract than in the positive control probably supports the hepatoprotective ability of the aqueous fruit extract of *S. macrocarpum*. Cholestyramine is not systematically absorbed, so it is quite safe (Hardrnan and Limbird, 2001). The same hepatoprotective effect cannot be said of α-solanidine because it is a single chemical and there is a possible increase of toxicity for single chemicals (Brevoort, 1998). Simvastatin according to literature can lead to increased transaminases activity three times the upper limit of normal (ULN) soon after initiation of therapy and hepatitis can also occur (ANONb, 2007), whilst biochemical function indices should be measured 2-4 weeks after initiation of therapy with nicotinic acid (Hardrnan and Limbird, 2001). Thus, hepatoprotective ability of simvastatin and probably nicotinic acid are not guaranteed after long period of use.

The total bilirubin for the hyperlipidaemic rats were significantly lower ($p < 0.05$) when the extract and cholestyramine were administered when compared to the values recorded for α-solanidine, nicotinic acid and

simvastatin throughout the period of study. Increase in bilirubin values may be caused by liver damage, excessive haemolysis/destruction of RBC, obstruction of the biliary tract (obstructive jaundice) and in drug-induced reactions (Mukherjee, 1988; Odutola, 1992; Sood, 2006). In the present study, the 50 mg/kg each of aqueous fruit extract of *S. macrocarpum* and cholestyramine are probably not toxic. The same thing cannot be said of α-solanidine, nicotinic acid and simvastatin. Also the bilirubin values in the positive control (rats that received only Triton-X), were the highest throughout the period of study. This implies that the Triton had caused excessive destruction of the RBCs (Hall *et al*., 2000).

From Table 3, the result of the liver enzymes showed that the extract and cholestyramine had significantly low ($p < 0.05$) values of AST throughout the study period whilst ALT and ALP, decreased at 72h when compared to α-solanidine, nicotinic acid and simvastatin. In fact, α-solanidine and simvastatin had very high levels of these liver enzymes. Decrease in liver enzymes indicates hepatoprotective effect (Iweala and Okeke, 2005; Kim et al., 2006; Atangwho et al., 2007) whilst an increase in the liver enzymes is an indication of liver damage (Odutola, 1992; Atangwho et al., 2007). Apart from the best known antioxidants such as vitamin A, C and E and the mineral selenium, some flavonoids (secondary metabolites) and vitamin precursors synthesized by plants are required to be taken from outside to establish the balance by quenching the excess free radical species (FRS) (Sharma et al., 2009; Agrawal and Sharma, 2012). The extract of *S. macrocarpum* from elemental analysis and phytochemistry has been shown to contain selenium and flavonoids (Sodipo et al., 2008) which are good antioxidants which can decrease lipid peroxidation. The elemental analysis also revealed high concentrations of Ca, Mg and Fe, which are said to be responsible for antioxidant potentials as found in *Emblica officinalis* (Melita et al., 2010). Mg and Ca are essential for the activity of antioxidant enzymes such as superoxide dismutase and catalase (Mehta et al., 2010). Also, according to Harbone et al., 1999, flavonoids and flavonols constitute the bulk of phenolic compounds and are known to be the most diverse and potent classes of phytochemical antioxidants. As antioxidants, flavonoids have been reported to be able to interfere with the biochemical pathways involved in the generation of reactive oxygen species (ROS), quenching free radicals, chelating transition metals and rendering them redox inactive in the Fenton reaction (Heim, 2002; Sharma *et al.,* 2009). Therefore, the presence of flavonoids other polyphenololic and their multifaceted activities makes *S. macrocarpum* extract a good candidate for exploration of antioxidants. Terpenoids as found *S. macrocarpum* (Sodipo *et al.,* 2008) are also potent antioxidants (Sharma *et al.,* 2009).

Therefore, from the result obtained in this study, the aqueous fruit extract of *S. macrocarpum* and cholestyramine probably had protective effects on the liver of Triton-X-induced hyperlipidaemic rats, but the same thing could not be said of α-solanidine, nicotinic acid and simvastatin.

CONCLUSION

The aqueous fruit extract of *S. macrocarpum* and cholestyramine probably had hepatoprotective effects on triton-X induced hyperlipidaemic rats when compared to α-solanidine, nicotinic acid and simvastatin which may be toxic under the condition of study.

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REFERENCES

Abdulraman H, Akan JC, Sodipo OA, Onyeyili PA (2010). Effect of aqueous root-bark extract of *Vitex domina* sweet on hematological parameters in rats. J. Am. Sci. 68-12.

Afonja OA (1997). Basic Clinical Biochemistry Practice Manual; 85pp.

Agrawal A and Sharma B. (2012). Natural products and their antioxidants potentials. Indian J. **8** (2): 72-87.

ANONa (2007). Solasodine. http://www.chendel.com/products/solasodine htm. Access Date: 26/5/2007.

ANONb (2007). Arrow-simvastatin. http://www. Medsafe. gov.nz/profs/ Datasheet/ Arrow simvastatintab. htm. Access Date: 25/11/2008.

Atanghwo IJ, Ebona PE, Egbung CE, Eteng MU and Eyong EU (2007). Effect of *Veronia amygdalina* Del. on liver function in alloxan-induced hyperglycaemic rats. J. Pharm. Biores. **4**(1): 25-31.

Brevoort P (1998). *Botanical Quality-Extraction/Standardization*. A paper presented at Botanicals for the Twenty-First Century Organized by DIA (Drug Information Association), the Mount Nelson Hotel, Cape Town, South Africa. 24th-26th February.

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

Dixit S and Ali H (2010). Antioxidant potential of some medicinal plants of Central India. J. Cancer Therapy. **1**: 87-90.
Doumas BT, Watson WA and Biggs HG (1971). Albumin standards and the measurement of scrum albumin with bromocresol green. *Clin, Chem. Acta*. **3**: 87-96.
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.
Fernando MR, Wickramansingbe SMD, Nalinle I, Thabrew MI, Ariyanando PL, Karunanayake EH (1991). Effects of *Artocarpus heterophyllus* and *Asteracanthus longifolia* on glucose 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.
Hall JA, Gradin JL, Andreason CB and Wander RC (2000). Use of a nonionic detergent (Triton WR1339) in healthy cats to assess hepatic secretion of triglyceride. Am. J. Vet. Res. 61(8): 941-950.
Harbone JB, Baxter H and Moss GP (1999). Phytochemical dictionary; Handbook of bioactive compounds from plants. 2nd ed. London, Taylor & Francis.
Hardman JG and Limbird LE (2001). Goodman and Gilman's The Pharmacological Basis of Therapeutics 10th ed. McGraw Hill Co. U.S.A. pp. 971-1001.
Heim KE, Tgliaferro AR and Babliya DJ (2002). Flavonoid antixodant chemistry, metabolism and structure – activity relationships. J. Nutr. Biochem. 13:572-584.
Iweala EEJ and Okeke CU (2005). Comparative Study of the hyoglycaemic and biochemical effect of *Catharanthus roseus* Linn, family Apocynaceae (Madagascar periwinkle) and chlorpropamide (diabenese) on alloxan – induced diabetic rats. Biokemistri. 17 (2): 149-156.
Kim SJ, Ju, JB, Choii CW and Kim MC(2006). Hypoglycaemic and antihyperglycaemic effect of four Korean medicinal plants in alloxaninduced diabetic rats. Ann. J. Biochem. Biotech. 2 (4): 154-160.
Lin J, Opuku AR, Geheeb-Keller M, Hutchings AD, Terbianche SE, Jager 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.
Mehta S, Rai PK, Rai DK, Rai WK, Rai AK, Bicanic D, Sharma B and Watal G (2010). LIBS-based in seeds of Emblica officinalis Food Biophysics. 5 : 186-192.
Mitall GC, Aguwa CN, Ezeinu BU and Akubue P1 (1981): Preliminary pharmacological studies on antivenom action of Diodia scandens leaves. Niger. J. Pharm 12:432-436.
Moss DW, Henderson RA, and Kacher JF (1986). Enzymes In: Textbook of Clinical Chemistry. N.W. Tietz, ed. W.B. Saunders, Philadelphia, U.S.A. 674-678; 708-709.
Moure A, Cruz JM, Franco D, Dominguez JM, Senerit J, Dominguez H, Nunez MJ, Parajaeo JC (2001). Natural antioxidants from residual sources. Food Chem. 72:145-171.
Mukherjee KL (1988). Medical Laboratory Technolo: A Procedure Manual for Routine Diagnostic lets. Vol. III. Tata McGraw Hill Pub. Co. Ltd, New Deihid; 1,282.
Nduka N (1997). Clinical Biochemistry for Students of Chemical Pathology, 1st ed. Longman Lagos: Nigeria Plc, 122-123.
NIH (1990): National Institute of the Health. Recommendations for Improving Cholesterol Measurement. A Report from the Lab Standardization Panel of the National Cholesterol Education Programme. NIH Publication No. 90-2564.
Nwanjo HU (2006). Antioxidant activity of the exudates from *Aloe barbadensis* leaves in diabetic rats. Biokemistri. 18 (2): 77-81.
Odutola AA (1992). Rapid Interpretation of Routine Clinical Laboratory Tests S. Asekome and Company, Zaria, Nigeria; 112.
Olaniyi AA (1998). Essential Medicinal Chemistry. 3rd ed. Hope Publishers, Ibadan, Nigeria. pp. 334-341.
Peters TT, Biamonte GT and Doumas BT (1982). Protein (total protein) in serum, urine and cerebrospinal fluid, albumin in serum. In: Selected Methods of Clinical Chemistry, W.R. Faulkner and S. Meiters, eds, Vol. 9 American Association for Clinical Chemistry, Washington D.C. U.S.A. 30-35.
Rai DK, Sharma RK, Rai PK, Watai G and Sharma B (2011). Role of aqueous extract of *Cynodon dactylon* in prevention of carbofuran-induced oxidative stress and acetycholinesterase inhibition in rat brain: *Cellular and Molecular Biology*. **57** (1): 135-145.
Repetto MG and Llesuy SF (2002). Antioxidant properties of natural components used in popular medicine for treating. *Brazilian J. Med. Biolog. Res.* 35 (35): 523-534.
Sharma RK, Chatterji S, Rai DK, Mehta, Rai PK, Singh RK, Watai G and Sharma B (2009). Antioxidant activities and phenolic contents of the aqueous extract of some Indian medicinal plants. J. Medicinal Plants Res. **3** (11): 944-948.
Sodipo OA, Abdulrahman FI, Akan JC and Akinniyi JA (2008). Phytochemical screening and chemical constituents of the fruit of *Solanum macrocarpum* Linn. Continental J. Appl. Sci. **3**: 88-97.
Sodipo OA, Abdulrahman FI, Sandabe UK and Akinniyi FI (2009). Effect of *Solanum macrocarpum* Linn. on biochemical liver function in diet-induced hypercholesterolaemic rats. Nig. Vet. J. 30 (1): 1-8.

Sodipo OA, Abduirahaman Fl, Sandabe UK and Akiniyi JA (2011). Biochemical liver function with aqueous fruit extract of *Solanum macrocarpum* Linn. in albino rats acutely administered triton-X to induce hyperlipidaemia. J. Appl. Pharm. Sci. **1** (8): 89-93.

Sodipo OA, Abdurahman FI and Sandabe UK (2012). Biochemical liver function with aqueous fruit extract of *Solanum macrocarpum* Linn. in albino rats chronically administered triton-X to induce hyperlipidemia. Fons Scientia. J. Pharm. Res. Basic and Appl. Sci. 1 (1): 17-20.

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

Spencer K and Price CP (1977). The determination of serum albumin using bromocresol green. In: Practical Clinical Biochemistry. Vol. II 54th ed. Heinemann Medical Books Ltd, London; pp. 553-554.

Tietz, NW (1994). Fundamentals of Clinical Chemistry with Clinical Correlation. Bailliere Tindall, London, 2334.

Tseng TH and Lee YJ (2006). Evaluation of natural and synthetic compounds from East Asiatic folk medicinal plants on the mediation of cancer. Anticancer Agents Med. Chem. 6:345-365.

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

Appendix I: Animal group and treatment.

Group one:	Rats in this group served as the negative control. They were fed with normal feed diet and given water *ad libitum*
Group two:	Rats in this group served as the positive control. They were fed with normal diet and given water *ad libitum.* They were also administered 400mg/kg triton-X orally (p.o) for 1 week to make them hyperlipidaemic.
Group three:	Rats in this group were fed with normal feed diet and given water *ad libitum*; administered 400mg/kg triton-X p.o. for 1 week and then given 50mg/kg aqueous fruit extract of *S. macrocarpum* i.p. from a stock concentration of 200mg/ml (2g extract dissolved in 10ml distilled water)
Group four:	Rats in this group were fed with normal feed diet and given water *al libitum*, administered 400mg/kg triton-X p.o. for 1 week and then given 50mg/kg α-solanidine i.p. – a steroidal glycoalkaloid that is found in the Solanaceae and is said to lower hyperlipidaemia (by dissolving 50mg of approximately 95% α-solanine while powder, Sigma, USA in 1ml distilled water H_2O to give a stock concentration of 50mg/ml)
Group five:	In this group rats were fed with normal feed diet, given water *ad libitum,* 400mg/kg triton-X p.o. for 1 week and then given 50mg/kg nicotinic acid B.P. orally – hypolipidaemic drug, from a stock concentration of 50mg/ml (by dissolving 50mg white round tablet in 1ml distilled water).
Group six:	Rats in this group were fed with normal feed diet, given water *ad libitum*, 400mg/kg triton-X p.o. for 1 week and then given 50mg/kg cholestyramine – a hypolipdaemic drug, (Questran, Bristol-Meyers Squibb) p.o. from a stock concentration of 100mg/ml (dissolving 1g powder in 10ml distilled water)
Group seven:	Rats in this group were fed with normal feed diet, given water *ad libitum*, 400mg/kg triton-X p.o. for 1 week and then given 50mg/kg simvastatine – hypolipidaemic drug (Gimvastat-10, Stallion Lab, PVT Ltd, India, NAFDAC Reg. No. A4-0010 with sole agent as Pharmabase Nig. Ltd) p.o. from a stock concentration of 10mg/ml (by dissolving 20mg light yellow film-coated tablets in 1ml distilled water).