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Evaluation of Anti-obesity Potentials of Phenolic-Rich Fraction of *Solanum aethiopicum* L. and *Solanum macrocarpon* L on Diet-induced Obesity in Wistar Rats

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

Antiobesity effect of phenolic rich fractions of fresh fruits of *Solanum aethiopicum* and *Solanum macrocapon* on cafeteria diet (CD)-induced obesity was investigated using Wistar rats to explore the potential of *S. macrocapon* and *S. aethiopicum* in the management of obesity. Phenolic-rich extracts (free and bound phenolics) were obtained from *S. macrocapon* and *S. aethiopicum* by extraction with 80% (v/v) acetone and ethyl acetate respectively. Obesity was induced in Wistar rats with CD for 42 days after which they were treated with phenolic-rich extracts of *S. aethiopicum* and *S. macrocapon* at 200 mg/kg BW and 400 mg/kg BW for six weeks. Body weights and blood glucose were monitored weekly. Lipid profiles (Total Cholesterol (TC), Triglyceride (TG), High Density Lipoprotein -cholesterol (HDL-C), Very Low Density Lipoprotein – cholesterol (VLDL-C) and Low Density Lipoprotein – cholesterol (LDL-C)), Aspartate Transaminase (AST), Alanine Transaminase (ALT), Alkaline Phosphatase (ALP), urea, creatinine, total protein, albumin,

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atherogenic coefficient (AC) and cardiac risk ratio (CRR) were estimated in the plasma. Treatment with phenolic-rich extracts of *S. macrocapon* and *S. aethiopicum* caused decrease in lee index, atherogenic coefficient, blood glucose level, plasma TC, TG, LDL-c, VLDL-c, ALT, AST, AC, CRR and increase in HDL-c, urea, creatinine, total protein and albumin concentrations relative to the obese rats. Conclusively, the phenolic-rich extracts of *S. macrocapon* and *S. aethiopicum* possess antiobesity potential and could be employed in the management of obesity.

Keywords: Cafeteria diet; atherogenic index; overweight; obesity.

1. INTRODUCTION

Obesity which is characterised by an increase in the size and/or number of adipocytes in the adipose tissue has been identified to be one of the top 10 global health problems and the leading preventable cause of death worldwide [1]. Studies by the World Health Organization (WHO) indicated that at least 2.8 million people die each year as a result of being over- weight or obese [2]. The worldwide prevalence of obesity nearly tripled between 1975 and 2016. In 2016, more than 1.9 billion adults (18 years and older) were overweight of which over 650 million (over 205 million men and 297 million women) were obese [3].

Obesity impart health risk and plays important role in the pathogenesis of some disorders, such as cardiovascular diseases (mainly heart disease and stroke), diabetes mellitus, hypertension, dyslipidemia, insulin resistance, musculoskeletal disorders (especially osteoarthritis – a highly disabling degenerative disease of the joints); atherosclerosis, arthritis disorder and some cancers including endometrial, breast, ovarian, prostate, liver, gallbladder, kidney, and colon [1,3].

Various factors such as sedentary life style, increased intake of high calorie (energy and fat) food, an increase in physical inactivity, changing modes of transportation, genetic determinants, psychological and behavioural determinants may lead to obesity [4]. One of the most common factors that contributed to obesity is high carbohydrate diet (HCD) consumption.

Solanum aethiopicum L. (Ethiopian eggplant) and *Solanum macrocarpon L.* (Gboma eggplant) are African eggplants with enormous nutritional, medicinal and economic values that are widely cultivated in Nigeria and across the African continent [5,6]. African eggplants are called Dauta in Hausa; Afufa or Añara in Igbo and Igba, Igbagba or Itan in Yoruba regions of Nigeria [7]. They can be eaten raw, boiled or fried as ingredient of stews, soups and vegetable sauces.

Their indigenous medicinal uses range from weight reduction to treatment of several ailments including asthma, allergic rhinitis, nasal catarrh, skin infections, rheumatic disease, swollen joint pains, gastro-esophageal reflux disease, constipation and dyspepsia [8]. The folkloric use of the plants in local foods and medicinal preparations have been supported by several researchers who reported significant analgesic, anti-inflammatory, anti-asthmatic, anti-glaucoma, hypoglycemic, hypolipidemic, and weight reduction effects of eggplants, on test animals and humans [8,9].

Currently, drugs available in the market for treatment of obesity can be divided into two major classes one being orlistat, which reduces fat absorption through inhibition of pancreatic lipase and the second is sibutramine which is an anorectic or appetite suppressant. Both drugs have adverse effects which include increased blood pressure, headache, dry mouth, insomnia, and constipation [10]. Most of these anti-obesity drugs that were approved and marketed have now been withdrawn due to serious adverse effects. This made the naturopathic treatment of obesity that is cost effective and with minimal side effect gain momentum in the present scenario [11] hence this study which was taken up to assess the antiobesity potentials of phenolics of two indigenous eggplants, *S. aethiopicum L.* and *S. macrocarpon L.*, in Nigeria.

2. MATERIALS AND METHODS

2.1 Plant collection and Identification

Fresh fruits of *Solanum macrocarpon* and *Solanum aethiopicum* fruits were obtained, identified and authenticated at IFE Herbarium, Obafemi Awolowo University, Ile-Ife with voucher specimen no IFE/17573 and IFE/17543 respectively.

2.2 Experimental Animals

Healthy 42 adult female Wistar rats (90-100g) were obtained from Animal House, Anatomy Department, University of Ibadan, Ibadan, Nigeria, housed under 12 h light/dark cycle with free access to water and commercial food pellets (Ladokun Feeds Limited, Ibadan) and cared for as per regulation for the Care and Use of Laboratory Animals [12]. The rats were divided into 7 groups of 6 animals each.

2.3 Preparation of Extracts

Solanum macrocarpon and *Solanum aethiopicum* fresh fruits (2500g) were homogenised and extracted with 2000 mls of 80% acetone (v/v) for 10 hrs at room temperature and the filtrate was collected. The residue was hydrolysed with 20 ml of 4M NaOH at room temperature for 1 hr with shaking. The mixture was acidified to pH 2 with conc. HCl and further extracted with 200 mls of ethyl acetate (x6). The filtrates (acetone and ethyl acetate) were evaporated to dryness under reduced pressure to obtain the phenolic rich extracts [13] using rotary evaporator at 40ºC on Edward High Vaccum Pump, Model ED-100 (Edward Vaccum Components, Crawley, England) and stored at -4ºC until used.

2.4 Composition of Cafeteria Diet

Cafeteria diet is a high carbohydrate diet that consisted of condensed milk (40 g), bread (40 g), chocolate (15 g) biscuits (30 g), dried coconut (30 g), cheese (40 g) and boiled potatoes (50 g) mixed together [14] and air dried to form pellets. This was given twice daily (4g) per rats for 42 days.

2.5 Treatment Protocol

The animals were divided into seven groups of six animals each. The normal control group (group I) was fed laboratory pellet chow ad libitum. The cafeteria diet-control group (group II) received the CD in addition to the normal diet. Groups III and IV were fed with the CD along with the normal diet and received phenolics of *Solanum macrocarpon* at 200 and 400 mg/kg BW/day respectively. Groups V and VI were fed with the CD along with the normal diet and received phenolics of *Solanum aethiopicum* at 200 and 400 mg/kg BW/day respectively. Group VII was fed CD along with the normal diet and control drug (Orlistat) 50 mg/kg body weight/day. The treatment was continued for six weeks. The animals were weighed at the start of the experiment and then every week thereafter and blood glucose monitored according to GOD/POD method [15]. Lee index was calculated according to [16].

2.6 Blood Biochemical Analysis

On day 42, blood was collected via cardiac puncture into tubes containing anticoagulant and subjected to centrifugation at 3000 rpm for 10 minutes at room temperature to obtain the plasma. The plasma levels of glucose, total cholesterol, triglycerides , high density protein (HDL), LDL, VLDL , AST, ALT , ALP , creatinine , Urea , Albumin and total protein were estimated using biochemical kits (Randox Diagnostics Kits). The atherogenic index of plasma (AIP) was calculated by using: AIP = log (TGs / HDL).

2.7 Estimation of Organ Weights

Liver, kidney, heart, and spleen were aseptically removed and weighed.

2.8 Data Analysis

Results were expressed as mean ± SEM. Comparisons between different groups were done using one-way analysis of variance (ANOVA) followed by Tukey–Kramer multiple comparisons test using Graph Pad Prism Instat Software. A probability level of less than 0.05 was accepted as statistically significant.

3. RESULTS

3.1 Effect of Phenolic Rich Extract of *S. macrocarpon* and *S. aethiopicum* on Body Weights and Organ Weights

Table 1 shows changes in body weight in the different group of animals during the experiment. Consumption of CD for six weeks produced a significant ($P < 0.01$) increase in body and organ weights compared to the consumption of normal pellet chow (normal control group). Treatment with phenolic rich fractions of SM and SE at a dose of 200 and 400 mg/kg bwt significantly ($P < 0.01$) reduced the increase in organs and body weights when compared to the CD control group. Treatment with orlistat also reduced the increase in body weight, significantly ($P < 0.01$).

Table 1. Effect of phenolics of *S. macrocarpon* and *S. aethiopicum* on the body and Organ Weights of Experimental Rats

Groups	% BW Gain	Liver (g)	Kidney (g)	Heart (g)	Spleen (g)
Control	25.13 ± 0.13	5.75 ± 0.61	1.18 ± 0.08	0.74 ± 0.03	0.75 ± 0.03
Obese	48.50 ± 1.50[a]	7.57 ± 0.38[c]	1.74 ± 0.04[a]	1.13 ± 0.03[a]	0.95 ± 0.05[a]
Obese + S.M (200 mg/kg BW)	32.21 ± 6.68[c, d]	7.35 ± 0.35[c, d]	1.40 ± 0.00[c,d]	0.80 ± 0.00[b,c]	0.70 ± 0.00[c,d]
Obese + S.M (400 mg/kg BW)	30.67 ± 13.70[c, d]	7.45 ± 0.45[c, d]	1.57 ± 0.03[a,d]	0.67 ± 0.03[b,c]	0.81 ± 0.01[c,d]
Obese + S.A (200 mg/kg BW)	37.93 ± 7.93[c, d]	5.45 ± 0.45[c, d]	1.26 ± 0.05[b,c]	0.79 ± 0.01[b,c]	0.82 ± 0.02[c,d]
Obese + S.A (400 mg/kg BW)	18.00 ± 14.32[b, c]	7.35 ± 0.35[c, d]	1.40 ± 0.00[b,c]	0.80 ± 0.10[b,c]	0.88 ± 0.12[c,d]
Obese + Orlistat (50 mg/kg BW)	14.89 ± 4.56[b, c]	6.20 ± 0.60[c, d]	1.37 ± 0.09[b,c]	0.85 ± 0.05[b,c]	0.70 ± 0.00[c,d]

Values are presented as mean ± SEM of six (6) replicates. ([a]) and ([b]) represent significant difference at p < 0.05 when compared to the control and Obese respectively, ([c]) and ([d]) represent non-significant difference at p < 0.05 when compared to control and Obese respectively, S.M – Solanum macrocapon, S.A- Solanum aethiopicum.

3.2 Effect of Phenolics of *S. macrocarpon* and *S. aethiopicum* on the Lee Index, Blood Glucose Level, Total Protein, Albumin and Cardiac Risk Ratio of Experimental Rats

Table 2 show changes in the lee index, blood glucose level, total protein, albumin and cardiac risk ratio. Treatment with phenolics of SM and SA caused a decrease in lee index, blood glucose level and cardiac risk ratio and increase in total protein and albumin when compared to the CD control group.

3.3 Effect of Phenolic Extract of SM and SA on Plasma Lipid Profile

Feeding of cafeteria diet caused a significant ($P < 0.01$) increase in serum levels of total-cholesterol, LDL, VLDL and triglycerides as compared to normal diet fed rats (Table 3.). In contrast, SM and SA treatments significantly ($P < 0.01$) inhibited the increase in the plasma levels of total-cholesterol, triglycerides, LDL, and VLDL, which were induced by a cafeteria diet. However, the HDL concentration was significantly ($P < 0.01$) increased by SM and SA treatments in comparison to the CD control group.

3.4 Effect of Phenolic Extract of SM and SA on Biochemical Parameters

Feeding of cafeteria diet caused a significant ($P < 0.01$) increase in AST, ALT and atherogenic coefficient and decrease in ALP, urea and creatinine levels as compared to normal diet fed rats (Table 4). Treatment with phenolics of SM and SA, however, reversed the increase in the levels of AST, ALT and atherogenic coefficient.

4. DISCUSSION

Various animal models of obesity have been used to emulate obesity-like condition in humans, in order to develop effective anti-obesity treatments. Among the animal models of obesity, high carbohydrate diet – induced obesity is the simplest obesity induction model, the one that possibly resembles the reality of obesity in humans [17]. This model has the advantage of being comparable, at least in its basic characteristics (self-selection, excess energy intake), to human obesity induced by energy-dense diets [18]. The composition and variety of cafeteria foods exert synergistic effects on the development of obesity and induces hyperphagia in rats which results in higher fat stores [19]. The present study showed that the administration of a variety of highly palatable, energy rich, high carbohydrate cafeteria diet for six weeks, in rats, produced obesity-like conditions, with significant increase in body weight.

There was a significant increase in body weight in the group of animals fed with cafeteria diet (55.37±3.31%Δ) compared to the control group (18.93±3.47%Δ) during the treatment period possibly due to the accumulation of fats in the adipose tissue. The administration of phenolics of SM and SA significantly reduced the increased body weight induced by CD. The body weight gain of groups treated with *SM.* phenolics decreased with increase in concentration 32.21±6.68%Δ (200 mg/kg BW) to

Table 2. Effect of Phenolics of *S. macrocarpon* and *S. aethiopicum* on the lee index, Blood Glucose level, total protein, albumin and cardiac risk ratio of Experimental Rats

Groups	Lee Index (g/cm)	Blood glucose (mg/dl)	Total protein (g/dl)	Albumin (g/dl)	Cardiac risk ratio
Control	0.2843 ± 0.01	73.00 ± 2.58	12.33 ± 3.34	8.70 ± 0.30	2.87 ± 0.34
Obese	0.3017 ± 0.003[c]	116.40 ± 4.00[a]	8.81 ± 0.81[a]	5.81 ± 0.81[a]	9.11 ± 1.00[a]
Obese + S.M (200 mg/ kg BW)	0.2948 ± 0.01[c, d]	87.50 ± 2.50[a, b]	11.33 ± 0.31[c, d]	8.05 ± 0.66[c, d]	6.62 ± 0.40[c, d]
Obese + S.M (400 mg/kg BW)	0.2944 ± 0.01[c, d]	95.50 ± 1.50[a, b]	10.47 ± 0.89[c, d]	9.01 ± 0.99[c, d]	2.72 ± 0.95[c, d]
Obese + S.A (200 mg/kg BW)	0.2725 ± 0.01[c, d]	98.00 ± 1.00[a, d]	11.58 ± 0.18[c, d]	4.68 ± 0.06[c, d]	4.97 ± 1.46[c, d]
Obese + S.A (400 mg/kg BW)	0.2555 ± 0.001[b, c]	94.00 ± 4.00[a, b]	10.70 ± 0.30[c, d]	8.18 ± 1.82[c, d]	3.36 ± 0.95[c, d]
Obese + Orlistat (50 mg/kg BW)	0.2782 ± 0.01[c, d]	98.00 ± 2.00[a, d]	13.20 ± 1.93[c, d]	6.78 ± 1.03[c, d]	5.21 ± 2.56[c, d]

Values are presented as mean ± SEM of six (6) replicates. ([a]) and ([b]) represent significant difference at p < 0.05 when compared to the control and Obese respectively, ([c]) and ([d]) represent non-significant difference at p < 0.05 when compared to control and Obese respectively, S.M – Solanum macrocapon, S.A- Solanum aethiopicum.

Table 3. Effect of Phenolics of *S. macrocarpon* and *S. aethiopicum* on the plasma Lipid profile of Experimental Rats

Groups	Total Cholesterol (mg/dl)	Triglycerides (mg/dl)	HDL (mg/dl)	LDL (mg/dl)	VLDL(mg/dl)
Control	138.00 ± 7.47	145.10 ± 8.30	50.44 ± 1.51	61.96 ± 12.02	29.01 ± 1.66
Obese	170.10 ± 11.29[a]	189.10 ± 14.78[a]	19.50 ± 0.48[c]	122.30 ± 12.65[c]	37.83 ± 2.96[c]
Obese + S.M (200 mg/kg BW)	139.90 ± 7.20[c, d]	153.20 ± 13.91[c, d]	23.34 ± 2.77[c, d]	99.20 ± 8.75[c, d]	30.64 ± 2.78[c, d]
Obese + S.M (400 mg/kg BW)	120.80 ± 5.25[b, c]	120.80 ± 5.25[b, c]	51.57 ± 20.07[c, d]	45.09 ± 13.77[b, c]	24.17 ± 1.05[b, c]
Obese + S.A (200 mg/kg BW)	112.54 ± 1.38[b, c]	112.50 ± 1.38[b, c]	24.84 ± 7.56[c, d]	65.19 ± 6.45[b, c]	22.51 ± 0.28[b, c]
Obese + S.A (400 mg/kg BW)	107.50 ± 1.97[b, c]	109.20 ± 0.25[b, c]	34.92 ± 10.44[c, d]	50.76 ± 8.52[b, c]	21.85 ± 0.05[b, c]
Obese + Orlistat (50mg/kg BW)	111.34 ± 2.90[b, c]	167.50 ± 11.25[b, c]	32.04 ± 11.44[c, d]	45.80 ± 10.32[c, d]	33.49 ± 2.25[c, d]

Values are presented as mean ± SEM of six (6) replicates. ([a]) and ([b]) represent significant difference at p < 0.05 when compared to the control and Obese respectively, ([c]) and ([d]) represent non-significant difference at p < 0.05 when compared to control and Obese respectively S.M – Solanum macrocapon, S.A- Solanum aethiopicum.

Table 4. Effect of Phenolics of *S. macrocarpon* and *S. aethiopicum* on the AST, ALT, ALP activity, Urea, Creatinine and Atherogenic index of Plasma (AIP) Concentrations of Experimental Rats

Group	AST (IU/L)	ALT (IU/L)	ALP (IU/L)	Urea (mg/dl)	Creatinine (mg/dl)	AIP
Control	263.16 ± 8.42	0.647 ± 0.02	8.14 ± 2.48	39.05 ± 4.48	1.14 ± 0.35	0.042
Obese	379.60 ± 12.70[a]	0.732 ± 0.00[a]	5.66 ± 5.11[c]	23.30 ± 1.74[a]	0.35 ± 0.10[c]	0.219
Obese + S.M (200 mg/ kg BW)	340.00 ± 11.05[a, d]	0.704 ± 0.01[c, d]	4.93 ± 45.12[c, d]	32.46 ± 2.89[c, d]	0.67 ± 0.09[c, d]	0.090
Obese + S.M (400 mg/kg BW)	378.68 ± 1.32[a, d]	0.700 ± 0.00[c, d]	5.24 ± 2.21[c, d]	27.53 ± 1.18[c, d]	0.71 ± 0.19[c, d]	0.040
Obese + S.A (200 mg/kg BW)	313.70 ± 3.68[a, b]	0.724 ± 0.00[a, d]	4.97 ± 0.83[c, d]	30.85 ± 5.14[c, d]	1.02 ± 0.31[c, d]	0.082
Obese + S.A (400 mg/kg BW)	348.20 ± 1.84[a, d]	0.708 ± 0.00[c, d]	3.43 ± 0.43[c, d]	28.39 ± 1.61[c, d]	0.91 ± 0.01[c, d]	0.058
Obese + Orlistat (50 mg/kg BW)	318.40 ± 6.32[a, b]	0.752 ± 0.00[a, d]	38.73 ± 31.28[c, d]	32.78 ± 4.29[c, d]	0.50 ± 0.00[c, d]	0.069

Values are presented as mean ± SEM of three (3) replicates. ([a]) and ([b]) represent significant difference at p < 0.05 when compared to the control and Obese respectively, ([c]) and ([d]) represent non-significant difference at p < 0.05 when compared to control and Obese respectively, S.M – Solanum macrocapon, S.A- Solanum aethiopicum.

30.67±13.70%Δ (400 mg/kg BW) while body weight gain of rats treated with *SA* also decreased with increase in concentration 37.93±7.93%Δ (200 mg/kg BW) to 18.00±14.32%Δ (400 mg/kg BW) (Table 1). This observation is in compliance with the report of [13]. *Solanum* species such as *S. elaeagnifolium*, *S. melongena*, *S. gilo*and *S. aethiopicum* have been reported to reduce weight gains in animals [8,9,5]. Weight reduction effect of egg plants may be due to their low energy density which may be attributed to the high moisture, fiber and low fat contents they possessed [20,21,22,23].

Administration of Cafeteria diet increased the relative weight of heart, liver, kidney and spleen of obese group relative to the control. This could be related to accumulation of triglycerides and cholesterol in these organs [24]. The relative weights of the heart, liver, kidney and spleen were significantly reduced in the treated groups as compared to the obese rats (Table 1). Possibly because of the lower fat content in those tissues or as a result of the reduction in accumulated fat due to lipolysis owing to phenolic's role in altering energy expenditure by increasing the expression of lipolytic proteins or inhibition of lipogenesis by reduced expression of Fatty acid synthase and related enzymes.

Lee index is also an estimate of body fat and obesity. This study showed increase in the lee index of rats fed with CD relative to the control. The administration of Phenolics of *SA.* and *SM.* lowered the lee index of the treated rats when compared to the obese rats in a dose dependent manner (Table 2).

A significant increase in plasma glucose level was observed in rats fed with CD when compared to control group. This could be attributed to defective insulin signaling or a decreased insulin efficiency to induce glucose transport from the blood into key target cells such as muscle and fat (adipocyte) cells [25]. Treatment with phenolics of *SM* and SA lowered the blood glucose level in a dose dependent manner (Table 2).

Significant increase in total cholesterol (TC), LDL-C, VLDL and TG and a decrease in HDL was observed in rats fed with CD when compared to the control thereby reduces the HDL/LDL ratio. Thus, alteration of lipid profiles can be used as an index of obesity. This alteration has been identified as one of the risk factors for cardiovascular diseases [26]. Elevated level of total cholesterol in the blood has been reported as a powerful risk factor for coronary disease. Administration of phenolics of SM and SA significantly reduced TC, LDL-C, VLDL and TG and increased the HDL levels (Table 4). *Solanum* cultivars have been reported to have cholesterol reducing potential in a dose dependent manner which is in agreement with the current findings. The cholesterol-lowering effect of phenolics of SM and SA could be as a result of the ability of phenolics to bind cholesterol and bile acids, and increase their removal via the feces. It could also be attributed to a reduction in the activities of the liver enzyme 3-hydroxy-3-methyl glutaryl coenzyme A (HMG-CoA) reductase, which is a rate-limiting enzyme in cholesterol biosynthesis. Hypolipidemic potentials of ripe *Solanum melongena* and *Solanum gilo* fruits in hypercholesterolemia rabbits have been reported [27].

Reduction in total protein and albumin levels were observed in rats fed CD. Albumin binds various ligands such as free fatty acids, reduced level of albumin leads to increase level of free fatty acids which in turn leads to increase triglyceride synthesis evident in obesity. Plasma albumin levels are determined by rates of hepatic synthesis and secretion, exchanges between the intra- and extravascular compartments, lymphatic uptake, alterations in volume of distribution (including hemodilution), protein degradation [28]. The decreased plasma total protein and albumin concentrations in the rats fed with cafeteria diet might be an indicator of nutrition imbalance, liver disease, increased protein utilisation or degradation, increased glucocorticoids and increased plasma TNF- α level. Therefore, the reduced levels of plasma albumin might cause fluid to escape into extravascular tissues spaces, leading to increased vascular permeability, evident in localised oedema and reduce the delivery of nutrients to the tissues. Treatment of rats with phenolic extract of *SM.* and *SA* at 200 and 400 mg/kg BW increased the total protein and albumin concentrations relative to the obese rats (Table 2).

Increased levels of plasma ALT and AST observed in the cafeteria diet group, as shown in this study indicate alterations in liver metabolic functions. The administration of Phenolics of *SM.* and *SA.* were able to reduce the levels of ALT and AST in a dose dependent manner thereby reducing the risk of hepatic steatosis, one of the complications of obesity. ALP is present mostly

in cells lining the biliary duct of the liver and is used to diagnose obstruction to the biliary system. This study showed the reduced level in plasma ALP concentration in the obese rats. Administration of *SM.* and *SE.* increased the ALP in the treated rats in a dose dependent manner (Table 4). This result is similar to the effect of *Caralluma Fimbriata* on CD induced obese rats [29].

Urea and creatinine are considered as important markers of kidney dysfunction. Lower than normal levels of plasma urea and creatinine concentration are indications of deficiency in renal function. The increase in the plasma concentration of creatinine and urea observed in the treated groups were not statistically significant when compared to the control and obese rats (Table 4).

Atherogenic index of plasma is one of the powerful indicators of the risk of heart disease, the higher the value, the higher the risk of developing cardiovascular disease and vice versa [30]. In this study, it was observed that the phenolics of *SM* and *SA* reduced atherogenic index of plasma in a dose dependent manner (Table 4). Lower atherogenic index shows protection against coronary heart disease. AIP value of less than 0.10 predicts a low cardiovascular risk which was observed in animals treated with phenolic rich extracts of SM and SA.

These observed anti-obesity properties of eggplants may be attributed to the presence of certain phytochemicals such as fiber, ascorbic acid, phenols, anthocyanin, glycoalkaloids and α-chaconine [31] in the plants. Study by [32] on apple phenols in rats showed that the antiatherogenic and hypolipidemic effects are associated with the inhibition of cholesterol absorption in the intestines of the rats and promotion of cholesterol catabolism. Polyphenols and flavonoids have been shown to have antiobesity effects [19,33,34]. These two egg plants have been reported to present high level of total phenolics [6,35] hence the observed anti-obesity effect depicted by these plants in this study.

5. CONCLUSION

This study revealed that fruits of SA and SM possess anti-obesity potential in a concentration dependent manner. The observed anti-obesity effects of these plants in CD induced obesity are likely to be caused by their phenolic compounds. Therefore, these fruits could be employed in the management of obesity. Further identification and isolation of the active phenolic compounds responsible for this property is therefore required.

CONSENT

It is not applicable.

ETHICAL APPROVAL

All authors hereby declare that "Principles of laboratory animal care" (NIH publication No. 85-23, revised 1985) were followed, as well as specific national laws where applicable. All experiments have been examined and approved by the appropriate ethics committee".

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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