EFFECTS OF *Corchorus olitorius*, *Myrianthus arboreus* AND *Annona muricata* AQUEOUS LEAVES EXTRACTS ON BODY WEIGHT, BLOOD GLUCOSE LEVELS AND LIPID PROFILE OF ALLOXAN- INDUCED DIABETIC RATS

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ABSTRACT
Background: Many traditional leafy vegetables have been reported to have possible metabolic benefits in the prevention and management of non-communicable diseases (NCDs).
Objective: This study investigated the effects of *Corchorus olitorius*, *Myrianthus arboreus* and *Annona muricata* aqueous leaves extracts on body weight, blood glucose levels and lipid profile of alloxan- induced diabetic rats.
Materials and methods: Fresh leaves of *Corchorus olitorius* (wild okro), *Myrianthus arboreus* (browse plant) and *Annona muricata* (sour sop) were collected from Obollo-Etiti in Udenu L.G.A, Enugu State. The leaves were systematically processed into an extracts. Half of the leave extracts were used to determine the pytochemical (alkaloids, flavonoids, saponnins and phenolics) composition of the
extracts using standard methods. The other halves of the extracts were used to formulate diet with rat chow for the study. Thirty five male adult albino rats were randomized into seven groups for the experimental study. The feeding trial lasted for 14 days. The biochemical parameters (fasting blood glucose and lipid profile) and body weights of study groups were determined at baseline and at the end of the study using standard assay. Statistical analysis was carried out using IBM SPSS statistics software version 21. Paired sample T- test was also used to compare baseline values and end values.
Results: The result of the phytochemical analysis of the extracts showed that *Annona muricata* had the highest phytochemical compositions. The animal studies showed that the leave extracts of *Corchorus olitorius*, *Myrianthus arboreus* and *Annona muricata* at different levels of supplementation increased the mean body weight of the diabetic rats ($p>0.05$). The extracts caused significant ($p<0.05$) decrease in blood glucose levels, serum TC, TG and LDL-C and increased serum HDL-C levels of the rats.
Conclusion: The aqueous extracts of *Corchorus olitorius*, *Myrianthus arboreus* and *Annona muricata* leaves have antidiabetic potentials.

Keywords: Leaves extracts, body weight, blood glucose, lipid profile, diabetic rats.

INTRODUCTION

Diabetes is among the chronic diseases seen as global epidemics that pose a great public health challenge in Nigeria. Rapid change in disease pattern has occurred as a result of shifts in diet and physical activity patterns, termed “nutrition transition"- adoption of a more westernized lifestyle, economic development, diversification in food availability, inappropriate dietary patterns and decreased physical activity (1).

Diabetes mellitus is a metabolic disorder of multiple aetiology characterized by chronic hyperglycaemia and associated with impaired carbohydrate, protein and fat metabolism (2). These abnormalities are as a result of either inadequate insulin secretion or impaired insulin action or both (3). Diabetes mellitus is also characterized by glucosuria and several microvascular and macrovascular complications (4). The complications of diabetes mellitus are linked to oxidative stress induced by chronic hyperglycaemia which overcomes the body's natural anti-oxidant system (5, 6). In later stages of diabetes, lipid metabolism is affected and seen as hyperlipidaemia and hypercholesterolaemia which are risk factors for artherosclerosis (7, 8). Epidemiological studies have shown that the incidence of diabetes mellitus is on the increase and it is estimated that the number of diabetics will increase to 380 million worldwide by the year 2025 (9). There is yet no effective cure for diabetes and the available drugs and insulin currently used in managing the disease are associated with several side effects resulting from their adulteration (10). The undesirable side effects and high cost of anti-diabetic drugs has led to search for plants with hypoglycaemic properties and their use in the management of diabetes mellitus (11, 12).

Medicinal plants have been reported to be widely used in the management of chronic diseases all over the world (13, 14). In Nigeria, several plants species have been reported to possess medicinal values and used in the treatment of many ailments including diabetes and its complications (15). Several species of medicinal plant leaves used in traditional treatment and management of diabetes worldwide have been evaluated (16, 17). According to Brai *et al.* (16) and Gondwe *et al*. (17), the hypoglycaemic properties of plant leaves used in the management of diabetes are due to the content of phytochemicals and other bioactive compounds in those leaves. Momo *et al*. (18) observed

that traditional leafy vegetables have possible metabolic benefits in the prevention and management of diabetes by improving carbohydrate metabolism and lowering blood lipid levels, however, there is still a dearth of information on the health benefits of under-utilized indigenous leaves with regard to blood glucose and lipid control. The present study focused on the effects of aqueous leaves extracts of *Corchorus olitorius*, *Myrianthus arboreus* and *Annona muricata* on body weight, blood glucose and lipid profile of alloxan –induced diabetic rats.

MATERIALS AND METHODS

Study design
Experimental study design was employed.

Collection of samples
Fresh leaves of *Corchorus olitorius* (wild okro), *Myrianthus arboreus* (browse plant) and *Annona muricata* (sour sop) were collected from a farm in Obollo-Etiti in Udenu L.G.A, Enugu State. The leaves were identified in the Harbarium Centre of the Department of Botany, University of Nigeria, Nsukka.

Preparation of samples

The leaves were plucked out from the stem, washed with clean tap water, allowed to drain and shade dried at room temperature. The shade dried leaves were ground using Warburg laboratory blender. Two hundred grammes (200 g) each of the shade dried crushed leaves were soaked separately in 400 ml distilled water for 24 hours. The mixture was filtered with muslin cloth in a funnel. The residue was discarded and the extract was retained and used for the study.

Phytochemical analysis

Saponins was determined by method described by Obadoni and Ockuko (19). The flavonoids content was determined using the method described by Boham and Kocipai (20). The method of Harborne (21) was used for alkaloids determination.

Rat study

Animal and housing
Thirty-five male adult albino rats weighing between 100-150g were obtained from the Department of Zoology, Faculty of Biological Sciences, University of Nigeria, Nsukka. The rats were randomly allotted to seven (7) groups (six experimental groups and one control group) of five rats each on the basis of their body weight. The difference in weight of rats in each group was not more than five grammes (5g). The rats were housed in individual stainless-steel metabolic cages. The rat study lasted for 20 days. Four days for acclimatization, 2 days for inducement of diabetes and the remaining days (14) were for the experiment.

Diabetes induction
Diabetes was induced by injecting the rats with a single intra-peritoneal (I.P) injection of 120mg/kgBW of alloxan monohydrate suspended in normal saline, after an overnight fasting on the 4th day (22). The induced rats were allowed free access to animal feed and water as well as 5% glucose solution to avoid possible effect of hypoglycemia for 48 hours. After 48 hours (on the 6th day), diabetes was confirmed using an Accu- Chek glucometer. Rats that had fasting blood sugar levels $\geq$ 200mg/dl were considered diabetic and included in the study (22).

Feeding of the rats
All rats were fed animal feed and water *ad libitum* throughout the period of the experiment. After inducement of diabetes, the rats were fed animal feed in addition to extracts in varying levels according to their groups. The leaves extracts were fed orally early in the morning to the test groups with the aid of an oral canola for the fourteen (14) days feeding trial.

Table 1: Experimental design

Groups of rats	Diet	Dose of extract (mg/kgBW)	Number of days	Number of rats
1: Normal	RDA	0	14	5
2: Diabetic	COAE	100	14	5
3: Diabetic	COAE	300	14	5
4: Diabetic	MAAE	100	14	5
5: Diabetic	MAAE	300	14	5
6: Diabetic	AMAE	100	14	5
7: Diabetic	AMAE	300	14	5

RDA= Rat diet alone, COAE= *Corchorus olitorius* aqueous extract, MAAE = *Myrianthus arboreus* aqueous extract, AMAE = *Annona muuricata* aqueous extract Group1= normal control rats fed rat diet alone , Group 2= diabetic rats fed 100mg/kgBW of COAE , Group 3= diabetic rats fed 300mg/kgBW of COAE , Group 4= diabetic rats fed 100mg/kgBW of MAAE, Group 5= diabetic rats fed 300mg/kgBW of MAAE, Group 6= diabetic rats fed 100mg/kgBW of AMAE, *G*roup 7= diabetic rats fed 300mg/kgBW of AMAE.

Collection of blood samples Blood samples were collected from the retro-bulba plexus of the medial canthus of the eyes of the rats after an overnight fast using heparinised bottles, on days 6 and 20 and analyzed for the following lipid parameters (total cholesterol, triglyceride, low-density lipoprotein cholesterol and high-density lipoprotein cholesterol.

Biochemical analyses

Fasting blood sugar determination

This was determined after an overnight fast on days 0, 6 and 20 by conducting a tail tip cut at the tail of the animals, a drop of capillary blood was obtained and the blood was allowed to cover the reagent pad of the strip, which was then inserted into the glucometer. The blood glucose level in mg/dl was read on the meter.

Blood lipid determination

A portion of each blood samples were centrifuged at 5000rpm for 10minutes. The supernatant (serum) collected was used for lipid analysis. Triglycerides was determined by the method of Richmond (23). Total cholesterol was determined after enzymatic hydrolysis and oxidation of the sample as described by Roeschlau (24). Low-density lipoproteins (LDL and VLDL) and chylomicron fractions in the sample were precipitated quantitatively by the addition of phosphotungstic acid in the presence of magnesium ions. The mixture was allowed to stand for 10 minutes at room temperature centrifuged for 10 minutes at 4000rpm. The supernatant represented the HDL-C fraction. The cholesterol concentration in the HDL fraction, which remains in the supernatant was determined. The concentration of LDL cholesterol was calculated in mmol/L using Friedewald, Levy and Fradrickson (25) equation as stated below:

$$\text{LDL-C} = \text{TC} - (\text{HDL-C} + \frac{\text{TGL}}{2.2})$$

Statistical analysis

All statistical analysis was carried out using IBM SPSS Statistics software version 21. All values obtained were expressed as means and standard deviation. Paired sample T- test was used to compare baseline values and end values. The differences in means were considered significant at $p<0.05$.

RESULTS

Table 2 shows the phytochemical composition of *Corchorus olitorius, Myrianthus arboreus* and *Annona muricata* leaves extracts. Alkaloid value was 40.80 mg for *Corchorus olitorius*, 31.30 mg for *Myrianthus arboreus* and 29.20 mg for *Annona muricata.* The *Corchorus olitorius, Myrianthus arboreus* and *Annona muricata* contained 12.90, 22.00, 23.60 mg for flavonoid, 11.70, 21.20, 21.70 mg for saponnins, 16.20, 17.30 and 29.00 mg for phenolics, respectively.

Table 2: Phytochemical composition of *Corchorus olitorius, Myrianthus arboreus* and *Annona muricata* leaves extracts (mg/ml)

Samples	Alkaloids	Flavonoids	Saponnins	Phenolics
Corhorus olitorius	40.80±0.10	12.90±0.26	11.70±0.29	16.20±0.07
Myrianthus arboreus	31.30±0.23	22.00±0.35	21.20±0.11	17.30±0.25
Annona muricata	29.20±0.38	23.60±0.28	21.70±0.29	29.00±0.17

Mean ±standard deviation of three determinations.

Table 3 shows the mean body weight of rats in different groups fed animal feed supplemented with *Corchorus olitorius, Myrianthus arboreus* and *Annona muricata* leaves extracts**.** The mean body weight of rats fed the extracts increased at the end of the experiment ($p> 0.05$), except for rats in group 7 that had decrease in mean body weight ($p>0.05$). The body weight gain of group 1 rats was 143.93 g. The group 2 rats fed 100 mg/kgBW of *Corchorus olitorius* of leaf extract had 17.68 g body weight gain. When extract was increased to 300 mg/kgBW, the weight gain was 3.86 g. When animal feed was supplemented with 100 mg/kgBW of *Myrianthus arboreus* leaf extract, it caused 11.14 g increase in body weight of the rats. Group 5 fed 300 mg/kgBW of *Myrianthus arboreus* leaf extract had 3.74 g increase in weight gain. When animal feed was supplemented with 100 mg/kgBW *Annona muricata* leaf extract, it caused 13.14 g increase in body weight of the rats. Conversely, when the level of extract was increased to 300 mg, it caused 5.08 g decrease in body weight of the rats.

Table 3 shows the mean body weight of rats in different groups fed animal feed supplemented with *Corchorus olitorius, Myrianthus arboreus* and *Annona muricata* leaves extracts**.** The mean body weight of rats fed the extracts increased at the end of the experiment (p>

0.05), except for rats in group 7 that had decrease in mean body weight (p>0.05). The body weight gain of group 1 rats was 143.93 g. The group 2 rats fed 100 mg/kgBW of *Corchorus olitorius* of leaf extract had 17.68 g body weight gain. When extract was increased to 300 mg/kgBW, the weight gain was 3.86 g. When animal feed was supplemented with 100 mg/kgBW of *Myrianthus arboreus* leaf extract, it caused 11.14 g increase in body weight of the rats. Group 5 fed 300 mg/kgBW of *Myrianthus arboreus* leaf extract had 3.74 g increase in weight gain. When animal feed was supplemented with 100 mg/kgBW *Annona muricata* leaf extract, it caused 13.14 g increase in body weight of the rats. Conversely, when the level of extract was increased to 300 mg, it caused 5.08 g decrease in body weight of the rats.

Table 3: Mean body weight (g) of rats in different groups fed animal feed supplemented with *Corchorus olitorius, Myrianthus arboreus* and *Annona muricata* leaves extracts.

Groups of rats	Baseline value (Pre-treatment BW)	End value (Post-treatment BW)	Increase in BW	Decrease in BW	% increase in BW	% decrease in BW
1	101.72±12.85[a]	245.65±27.21[b]	143.93	-	141.50	-
2	138.30±12.69[a]	155.98±18.59[a]	17.68	-	12.78	-
3	139.26±14.98[a]	143.12±18.38[a]	3.86	-	2.77	-
4	136.54±11.48[a]	147.68±16.29[a]	11.14	-	8.16	-
5	138.02±23.78[a]	141.76±22.52[a]	3.74	-	2.71	-
6	139.02±14.41[a]	152.16±9.04[a]	13.14	-	9.45	-
7	140.22±12.79[a]	135.14±26.24[a]	-	5.08	-	3.62

Mean ± SD. Values on the same row with different superscripts are significantly different at p<0.05.
Key:
BW= body weight, Group1= normal control rats fed rat diet alone, Group 2= diabetic rats fed 100mg/kgBW of *C. olitorius* extract, Group 3= diabetic rats fed 300mg/kgBW of *C. olitorius* extract, Group 4= diabetic rats fed 100mg/kgBW of *M. arboreus* extract, Group 5= diabetic rats fed 300mg/kgBW of *M. arboreus* extract, Group 6= diabetic rats fed 100mg/kgBW of *A. muricata* extract, Group 7= diabetic rats fed 300mg/kgBW of *A. muricata* extract.

Table 4 presents the fasting blood sugar levels of rats in different groups fed animal feed supplemented with *Corchorus olitorius, Myrianthus arboreus* and *Annona muricata* leaves extracts. The FBS of rats in groups 2- 7 decreased significantly (p< 0.05). However, there was no significant (p>0.05) difference in the control group. The control group of rats had a negative value of 6.80 mg/dl or 9.32% decrease. The rats in group 2 fed 100 mg *Corchorus olitorius* had a negative value of 244.40 mg/dl or 59.70% decrease. The rats in group 3 fed 300 mg *Corchorus olitorius* had a negative value of 267.80 mg/dl or 68.99% decrease. Rats fed animal feed supplemented with 100 mg of *Myrianthus arboreus* had a negative value of 267.40 mg/dl or 66.32% decrease. When the supplement was increased to 300mg, it caused 293.60 mg/dl or 76.99% decrease in FBS. When animal feed was supplemented with 100 mg/kgBW of *Annona muricata* leaf extract, it caused 318.60 mg/dl or 79.97% decrease in FBS of the rats. Conversely, when the level of supplement was increased to 300 mg, it caused 198.20 mg/dl or 50.25% decrease in FBS of the rats.

Table 4: Fasting blood sugar levels of rats in different groups fed animal feed supplemented with *Corchorus olitorius, Myrianthus arboreus and Annona muricata* leaves extracts (mg/dl)

Groups of rats	Baseline value (Pre-treatment FBSL)	End value (Post-treatment FBSL)	Decrease in FBSL	% decrease in FBSL
1	73.80±9.3[a]	67.00±7.74[a]	6.80	9.32
2	409.40±161.52[b]	165.00±95.46[a]	244.40	59.70
3	388.20±131.68[b]	120.40±53.81[a]	267.80	68.99
4	403.60±104.96[b]	136.20±72.76[a]	267.40	66.32
5	381.40±20.85[b]	87.80±22.65[a]	293.60	76.99
6	398.40±11.61[b]	79.80±20.02[a]	318.60	79.97
7	394.40±21.52[b]	196.20±95.37[a]	198.20	50.25

Mean ± SD. Values on the same row with different superscripts are significantly different at $p<0.05$.

Key:

FBSL= fasting blood sugar level, Group1= normal control rats fed rat diet alone, Group 2= diabetic rats fed 100mg/kgBW of *C. olitorius* extract, Group 3= diabetic rats fed 300mg/kgBW of *C. olitorius* extract, Group 4= diabetic rats fed 100mg/kgBW of *M. arboreus* extract, Group 5= diabetic rats fed 300mg/kgBW of *M. arboreus* extract, Group 6= diabetic rats fed 100mg/kgBW of *A. muricata* extract, *G*roup 7= diabetic rats fed 300mg/kgBW of *A. muricata* extract.

Table 5 shows total cholesterol levels of rats fed leaves extracts of *Corchorus olitorius, Myrianthus arboreus and Annona muricata*. The TC levels of rats in group 1 decreased by 2.53% relative to baseline value. The rats in group 2 had a decrease value of 6.70% relative to baseline value. Group 3 rats had decreased value of 9.09% ($p< 0.05$). At the 100 mg supplementation of the *M. arboreus* extract to animal feed for group 4 rats, the extract caused a decrease of 0.04 mmol/L or 9.95% relative to baseline value ($p> 0.05$). When the level of supplementation was raised to 300 mg (group 5), the TC decreased to 0.46 mmol/L or 11.33% which was significant ($p< 0.05$). There was a significant decrease of 0.44 mmol/L or 11.17% in TC value of group 6 rats ($p< 0.05$). The 300 mg level of supplementation of the *A. muricata* extract for group 7 rats caused decrease of 0.50 mmol/L or 12.44% in TC.

Table 5: Total cholesterol levels of rats fed leaves extracts of *Corchorus olitorius, Myrianthus arboreus and Annona muricata* (mmol/L)

Groups of rats	Baseline value (Pre-treatment TC)	End value (Post-treatment TC)	Decrease in TC	% decrease in TC
1	3.16±0.11[a]	3.08±0.22[a]	0.08	2.53
2	3.88±0.08[a]	3.62±0.26[a]	0.26	6.70
3	3.96±0.18[b]	3.60±0.16[a]	0.36	9.09
4	4.02±0.18[a]	3.98±0.18[a]	0.04	9.95
5	4.06±0.21[b]	3.60±0.37[a]	0.46	11.33
6	3.94±0.19[b]	3.50±0.15[a]	0.44	11.17
7	4.02±0.18[b]	3.52±0.14[a]	0.50	12.44

Mean ± SD. Values on the same row with different superscripts are significantly different at $p<0.05$.

Key:

TC= total cholesterol, Group1= normal control rats fed rat diet alone, Group 2= diabetic rats fed 100mg/kgBW of *C. olitorius* extract, Group 3= diabetic rats fed 300mg/kgBW of *C. olitorius* extract, Group 4= diabetic rats fed 100mg/kgBW of *M. arboreus* extract, Group 5= diabetic rats fed 300mg/kgBW of *M. arboreus* extract, Group 6= diabetic rats fed 100mg/kgBW of *A. muricata* extract, *G*roup 7= diabetic rats fed 300mg/kgBW of *A. muricata* extract.

Table 6 shows triglycerides levels of rats fed leaves extracts of *Corchorus olitorius, Myrianthus arboreus and Annona muricata*. Group1 rats had a slight decrease of 0.02 mmol/L or 1.54% in TG (p> 0.05). Group 2 rats had a decrease value of 0.44 mmol//L or 22.00% in TG. However, group 3 rats had a decrease value of 0.52 mmol/L or 23.64% in TG (p< 0.05). There was decrease of 0.18 mmol/L or 9.28% in TG value in group 4 rats relative to baseline value (p> 0.05). The 300 mg level of supplementation of *M. arboreus* extract for rats in group 5 caused a decrease in TG of 0.36 mmol/L or 18.18% (p< 0.05). Rats in group 6 had decreased value of 0.18 mmol//L or 10.23% (p> 0.05). However, group 7 rats had a decrease value of 0.44 mmol/L or 23.66%.in TG (p< 0.05).

Table 6: Triglycerides level of rats fed leaves extracts of *Corchorus olitorius, Myrianthus arboreus and Annona muricata* (mmol/L)

Groups of rats	Baseline value (Pre-treatment TGL)	End value (Post-treatment TGL)	Decrease in TGL	% decrease in TGL
1	1.30±0.19[a]	1.28±0.16[a]	0.02	1.54
2	2.00±0.55[a]	1.56±0.30[a]	0.44	22.00
3	2.20±0.32[b]	1.68±0.31[a]	0.52	23.64
4	1.94±0.21[a]	1.76±0.27[a]	0.18	9.28
5	1.98±0.13[b]	1.62±0.08[a]	0.36	18.18
6	1.76±0.27a	1.58±0.27[a]	0.18	10.23
7	1.86±0.21[b]	1.42±0.29[a]	0.44	23.66

Mean ± SD. Values on the same row with different superscripts are significantly different at p<0.05.

Key:

TGL= triglycerides level, Group1= normal control rats fed rat diet alone, Group 2= diabetic rats fed 100mg/kgBW of *C. olitorius* extract, Group 3= diabetic rats fed 300mg/kgBW of *C. olitorius* extract, Group 4= diabetic rats fed 100mg/kgBW of *M. arboreus* extract, Group 5= diabetic rats fed 300mg/kgBW of *M. arboreus* extract, Group 6= diabetic rats fed 100mg/kgBW of *A. muricata* extract, *G*roup 7= diabetic rats fed 300mg/kgBW of *A. muricata* extract.

Table 7 presents high density lipoprotein -cholesterol levels of rats fed leaves extracts of *Corchorus olitorius, Myrianthus arboreus* and *Annona muricata*. The HDL-C of rats in groups 3-7 increased significantly (p< 0.05). However, there was no significant (p>0.05) difference in group 2 rats. The group 1 rats had a negative value of 0.10 Mmol/L or 6.02% decrease in HDL-C (p> 0.05). Rats in group 2 had a positive value of 20.31% relative to baseline value. The rats in group 3 fed 300 mg of *Corchorus olitorius* leaf extract had an increase of 30.90% in HDL-C. The rats in group 4 had a positive value of 1.48 mmol/L/ or 0.34% increase. When the level of supplement was increased to 300 mg, it caused an increase of 0.48 mmol/ L in HDL-C. Group 6 rats had positive increased value of 30.51%. The increase of 52.73% for HDL-C levels of rats in group 7 was positive.

Table 7: High density lipoprotein -cholesterol level of rats fed leaves extracts of *Corchorus olitorius, Myrianthus arboreus and Annona muricata* (mmol/L)

Groups of rats	Baseline value (Pre-treatment HDL-C)	End value (Post-treatment HDL-C)	Increase in HDL-C	Decrease in HDL-C	% increase in HDL-C	% decrease in HDL-C
1	1.66±0.21[a]	1.56±0.11[a]	-	0.1	-	6.02
2	1.28±0.24[a]	1.54±0.11[a]	0.26	-	20.31	-
3	1.10±0.23[a]	1.44±0.11[b]	0.34	-	30.90	-
4	1.14±0.17[a]	1.48±0.08[b]	0.34	-	29.82	-
5	1.02±0.08[a]	1.48±0.08[b]	0.46	-	45.10	-
6	1.18±0.13[a]	1.54±0.11[b]	0.36	-	30.51	-
7	1.10±0.19[a]	1.68±0.08[b]	0.58	-	52.73	-

Mean ± SD. Values on the same row with different superscripts are significantly different at p<0.05.

Key:

HDL-C= high density lipoprotein – cholesterol, Group1= normal control rats fed rat diet alone, Group 2= diabetic rats fed 100mg/kgBW of *C. olitorius* extract, Group 3= diabetic rats fed 300mg/kgBW of *C. olitorius* extract, Group 4= diabetic rats fed 100mg/kgBW of *M. arboreus* extract, Group 5= diabetic rats fed 300mg/kgBW of *M. arboreus* extract, Group 6= diabetic rats fed 100mg/kgBW of *A. muricata* extract, *G*roup 7= diabetic rats fed 300mg/kgBW of *A. muricata* extract.

Table 8 shows low density lipoprotein-cholesterol levels of rats fed leaves extracts of *Corchorus olitorius, Myrianthus arboreus* and *Annona muricata*. The rats fed control diet had 0.26 mmol/L or 16.99 % increase in LDL- C (p< 0.05). Rats whose diets were supplemented with 100 and 300 mg each of *C. olitorius* leaf extract had negative values of 0.16 mmol/L or 7.80% and 0.45 mmol/L or 18.52% decrease in LDL- C, respectively (p> 0.05). Group 4 rats had negative decreased value of 0.29 mmol/L or 12.45% in LDL-C (p> 0.05). The decrease values of 0.66 mmol/L or 25.98%, 0.72 mmol/L or 30.38% and 0.92 mmol/L or 37.10% in LDL-C levels of rats in groups 5, 6 and 7 rats, respectively were negative (p< 0.05).

Table 8: Low density lipoprotein-cholesterol levels of rats fed leaves extracts of *Corchorus olitorius, Myrianthus arboreus* and *Annona muricata* (mmol/L)

Groups of rats	Baseline value (Pre-treatment LDL-C)	End value (Post-treatment LDL-C)	Increase in LDL-C	Decrease in LDL-C	% increase in LDL-C	% decrease in LDL-C
1	1.53 ± 0.08^{a}	1.79 ± 0.15^{b}	0.26	-	16.99	-
2	2.05 ± 0.28^{a}	1.89 ± 0.25^{a}	-	0.16	-	7.80
3	2.43 ± 0.44^{a}	1.98 ± 0.26^{a}	-	0.45	-	18.52
4	2.33 ± 0.21^{a}	2.04 ± 0.45^{a}	-	0.29	-	12.45
5	2.54 ± 0.26^{b}	1.88 ± 0.33^{a}	-	0.66	-	25.98
6	2.37 ± 0.20^{b}	1.65 ± 0.11^{a}	-	0.72	-	30.38
7	2.48 ± 0.27^{b}	1.56 ± 0.19^{a}	-	0.92	-	37.10

Mean ± SD. Values on the same row with different superscripts are significantly different at p<0.05.

Key:
LDL-C= low density lipoprotein – cholesterol, Group1= normal control rats fed rat diet alone, Group 2= diabetic rats fed 100mg/kgBW of *C. olitorius* extract, Group 3= diabetic rats fed 300mg/kgBW of *C. olitorius* extract, Group 4= diabetic rats fed 100mg/kgBW of *M. arboreus* extract, Group 5= diabetic rats fed 300mg/kgBW of *M. arboreus* extract, Group 6= diabetic rats fed 100mg/kgBW of *A. muricata* extract, *G*roup 7= diabetic rats fed 300mg/kgBW of *A. muricata* extract.

DISCUSSION

Phytochemical analysis is very useful in the evaluation of some active biological components of some vegetables and plants. In this study, the phytochemical screening of the extracts revealed the presence of alkaloids, flavonoids, saponins and phenolics in higher amounts. The quantitative phytochemical screening of the leaf extracts agreed with previous studies (26-38). Phytochemical is a natural bioactive compound found in plants, such as vegetables, fruits, medicinal plants, leaves and roots that work with nutrients and fibres to protect the body against diseases (29). These activities could be attributed to their ability to neutralize and quench free radicals through their antioxidant effects (30). Saponins are known to lower blood cholesterol by binding with cholesterol in the intestinal lumen, preventing its absorption and/or by binding with bile acids, causing a reduction in the enterohepatic circulation of bile acids and increase its fecal excretion (31, 32). Increased bile acid excretion is offset by enhanced bile acid synthesis from cholesterol in the liver and consequent lowering of the blood cholesterol (32). It has been reported that flavonoids and phenolics are free radical scavengers that prevent oxidative cell damage, and have strong anti-cancer activities (30, 33). Phytochemicals of different plant origin showed a promising hypoglycaemic and hypolipidaemic effects, as demonstrated in diabetic animal models (34, 35).

Alloxan induces diabetes in experimental animals by destroying the beta cells of the Islets of Langerhans in the pancreas leading to reduction in the synthesis and release of insulin thereby inducing hyperglycemia (36). This model has been used to study the anti-diabetic effects of several plant products (37). Alloxan has been shown to induce free radical generation and cause tissue injury. The pancreas is especially susceptible to action of alloxan-induced free radical damage. The resultant effect which is insulin deficiency, leads to various metabolic alterations in the animals such as, increase in blood glucose, total cholesterol and triglyceride levels (38). Hyperglycemia and dyslipidemia as well as oxidative stress generally coexist in diabetic subjects.

The observed significant reduction in the blood glucose levels of the diabetic rats fed the leaves extracts of *C. olitorius*, *M. arboreus* and *A. muricata* is an indication that the extracts contain bioactive phytochemicals with potent anti-diabetic property. This result compared favourably with the fasting blood glucose lowering effects of *Barleria prionitis* (39). According to Iweala and Oludare (40), reduction in blood glucose by most bioactive compounds from plants might act by one of the several mechanisms including stimulation of insulin secretion, increased repair or proliferation of β-cells and enhancing the effect of insulin. The possible mechanism by which *C. olitorius*, *M. arboreus* and *A. muricata* leaves extracts reduced fasting blood glucose levels of diabetic rats in this study agrees with their findings.

The result of this study showed increase in mean body weight of animals with no significant percentage weight changes, indicating that the extracts were not toxic to the animals. The positive body weights of the rats were also a function of food intake. The control rats that consumed more food had more body weight relative to other groups. This observation agrees with reports of Mahmood *et al* (41) and Tanko *et al* (42) which attributed increase in mean body weight of rats fed plant extracts to increase in utilization of feed. Group 7 rats fed 300 mg/kgBW of *A. muricata* had a negative body weight. This indicates that this level of the extract had adverse effect on weight gain of the rats. This may be due to inadequate utilization of the feed to maintain growth.

The high concentration of total cholesterol, triglycerides, low density lipoprotein cholesterol and low HDL-C levels observed in diabetic rats compared to control rats in this study is consistent with reports of several studies demonstrating that a rise in glucose level on induction of diabetes, results in a corresponding increase in serum lipids (43-45). Hyperlipidaemia is a recognized complication of diabetes mellitus characterized by elevated levels of cholesterol, triglycerides, phospholipids and other lipoproteins (45). It has been reported that elevated serum lipids in diabetes is due to the increased mobilization of free fatty acids from peripheral fat depots as a result of inhibition of the hormone sensitive lipase (46). The excess fatty acids produced are converted into phospholipids and cholesterol, which together with excess triacylglycerols formed at the same time in the liver are discharged into the blood in form of lipoproteins. Thus, the marked hyperlipidemia observed in diabetic rats may be regarded as a consequence of uninhibited actions of lipolytic hormones in fats depots (47).

Treatment of diabetic rats with the leaves extracts of *C. olitorius*, *M. arboreus* and *A. muricata* caused significant decrease in serum TC, TG and LDL-C and increased serum HDL-C levels of the diabetic rats. The results of this study support earlier reports (45,48) and could be related to the presence of alkaloids, saponins, flavonoids and polyphenols known to reduce serum lipid levels in animals. The significantly lowered cholesterol levels may have contributed to the observed significant high serum high-density lipoprotein cholesterol in the animals. Significant lowering of total cholesterol and rise in HDL-C level is a very desirable biochemical state for prevention of atherosclerosis and ischaemic conditions (32). HDL-C function to remove cholesterol atheroma within arteries and transport it back to the liver for its excretion or reutilization, thus high level of HDL-C protects against cardiovascular diseases (31, 49). Therefore, the observed increase in the serum HDL-C level on supplementation of various levels of the extracts in alloxan-induced diabetic rats indicates that the extracts have HDL-C boosting effect. More so, the stabilization of serum triglyceride and cholesterol levels in rats by the leaves extracts may be attributed to increased glucose utilization and hence depressed mobilization of fat (18, 49). This implies that the plant extracts may be useful in reducing the

complications such as hyperlipidemia and hypercholesterolemia which often coexist in diabetics.

CONCLUSION

This study has shown that aqueous extracts of *Corchorus olitorius, Myrianthus arboreus* and *Annona muricata* leaves possess hypoglycaemic and hypolipidaemic effects in alloxan-induced diabetic rats. Administration of *Corchorus olitorius, Myrianthus arboreus* and *Annona muricata* leaves extracts tremendously increased the body weight, lowered the serum lipids and fasting blood sugar levels of the diabetic rats. The hypoglycaemic and hypolipidaemic potentials of these leaves might be due to their phytochemical constituents. These constituents are more concentrated in *Annona muricata* leaves extract. *Annona muricata* extract was more effective relative to *Corchorus olitorius* and *Myrianthus arboreus* extracts. This study supports the use of these leaves extracts in the management of diabetes mellitus.

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