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Effect of Aqueous Extract of *Irvingia wombolu* Seeds on Lipid Profile and Atherogenic Indices in Hyperlipidemic 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

The effect of aqueous extract of Irvingia wombolu seeds on lipid profile and atherogenic indices in hyperlipidemic wistar rats was evaluated. Forty five (45) wistar rats were grouped into five groups of nine rats each. The animals were allowed seven days acclimatization period. Group one was the control group and it received normal rat chow and water throughout the study. Groups 2 to 5 were given high fat diet for 14 days after which they were fed with normal rat chow till the end of the study. At the end of the 14 days, group 2 was not treated while group 3-5 were treated with 250, 500 and 1000mg/kg body weight aqueous extract of Irvingia wombolu seed respectively for 28 days. The lipid profile of animals was assayed three times: first after 14 days induction period (phase 1) i.e day 0 of treatment, second was taken 14 days after treatment (phase 2), third was taken 28 days after treatment (phase 3).The study lasted for 49 days and distilled water was used as a vehicle for the extract.In phase 1, there was a significant decrease ($p<0.05$) in HDL (high

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density lipoprotein) level in all groups (2-5) compared to the control.there was a significant increase ($p<0.05$) in LDL (low density lipoprotein), Total cholesterol, Triglyceride, VLDL (very low density lipoprotein), Non HDL, Cardic risk factor, Atherogenic coefficient, Atherogenic index of plasma levels in all groups (2-5) compared to the control. All doses of aqueous extract of Irvingia wombolu seed were able to increase HDL level and decrease other lipid profile parameters and atherogenic indices in hyperlipidemic rats. Thus, aqueous extract of Irvingia wombolu seed has antidyslipidemic potential.

Keywords: Aqueous extract; irvingia wombolu; rat chow; atherogenic indices; hyperlipidemic.

1. INTRODUCTION

Hyperlipidemia is a disorder of lipid metabolism that results in an elevated level of circulating cholesterol and/or triglycerides, also known as triacylglycerols (TG) [1]; [2]. It is the most prevalent form of dyslipidemia. Dyslipidemia usually involve elevated plasma levels of triglycerides (TG), total cholesterol, low density lipoprotein (LDL) and very low density lipoprotein (VLDL) cholesteroland a low level of high density lipoprotein (HDL) cholesterol [1]; [3]. This disorder is associated with the development of atherosclerosis, particularly coronary heart disease (CHD), stroke, peripheral vascular disease, which are the major cardiovascular diseases (CVD) [2].

nuts and seeds forms important parts of healthy dietary patterns and eating plans such as the healthy Nordic diet, the Dietary Approaches to Stop Hypertension (DASH) [2]. Interest in nuts for prevention of cardiometabolic disease emerged in 1992 after Fraser et al. [4] reported a lower risk of fatal coronary heart disease (CHD) and myocardial infarction (MI) among frequent nut consumers (>4 servings per week) in the Adventist Health Study [4]. This was followed by intervention studies that found significant reductions in total and LDL-cholesterol from walnuts or almonds [5,6,7] and other large prospective cohort studies from the USA [8]. The US Food and Drug Association approved a qualified health claim regarding nuts (42 g/day) for reduced risk of heart disease in 2003, while a health claim related to walnuts and improved endothelium-dependent vasodilation is approved in the European Union [9].

Due to the economic situation of the country, it has been expensive to purchase convectional drugs. This has made medicinal plants and some food supplements receive a lot of attention for the prevention and treatment of various types of diseases. Moreover popularly used convectional hypolipedemic drugs have shown numerous side effects.

*Irvingia spp.*is a fruit eaten in Nigeria and its seed is generally used as a soup thickener. It is a goodsubstitute for okra (*Hibiscus esculentus*), groundnut (*Arachis hypogea*) and melon seeds (*Cucurbita spp*), in traditional soups of people of West and Central Africa [10]. Several studies have shown that the fruit, bark, leaf and seed of the *Irvingia species* variety are successful in the treatment of various ailments [11,12,13,14].

There is no study showing the use of *Irvingia wombulu* in the management or treatment of dyslipidemia. This study explored the potentials of aqueous extract of *Irvingia wombulu* in the management of dyslipidemia.

2. MATERIALS AND METHODS

2.1 Collection and Preparation of Plant Materials

The fruit of *Irvingiawombolu* were collected from Sagbama village Bayelsa state,Nigeria. The pulp was removed to expose the nut which was cracked to obtain the seeds. The seeds were washed and dried in a laboratory drier set at 50^0 C after which it was ground with a manual grinder. Five hundred grams of ground seeds were extracted with hot water and extract was oven-dried in a water bath to form sludge

2.2 Experimental Design

Forty five (45) albino ratsgrouped into five groups of nine rats each were used (two control and three test groups).The animals were purchased from Veterinary Department of University of Nigeria, Nsukka Enugu state and housed at the animal house of Department of Biochemistry, University of Port-Harcourt. Each group was housed in separate well ventilated cages with adequate provision of feed and clean water. Animals were fed with normal rat chow

and water throughout the duration of study.The weight of the animals after seven days acclimatization was recorded as the initial weight of the animals. The body weights of the animals were taken four times;7 days after acclimatization, 14 days after induction, 14 daysafter treatment and28daysafter treatment.The lipid profile of animals was assayed three times: first after 14 days induction period (phase 1) i.e day 0 of treatment, second was taken 14 days after treatment (phase 2), third was taken 28 days after treatment(phase 3). Distilled water was used as a vehicle for the aqueous extract andthe study lasted for49 days.

2.3 Induction of Hyperlipidemia

Induction of hyperlipidemia was achieved by the method described by Onyeike et al*.* [15] with a little modification. The animals were fed with normal rat chow supplemented with 2% egg yolk and 2% groundnut oil for fourteen days**.** The success of the induction was confirmed by analyzing for LDL, HDL, triglyceride and total cholesterol using blood samples of animals (three from each group)**.**

2.4 Determination of the Plasma Lipid Profiles/Indices

Plasma total cholesterol (TC), HDL-cholesterol (HDLC)and triglyceride (TG) were assayed with commercial test kits(Biosystem S.A Spain) following the manufactural instruction. Plasma LDL-cholesterol was calculated using the Friedewald equation [16], as follows: *LDLC = TC – HDLC – TG/2.2. VLDLC = TG/2.2.*

The level of Non-HDL density lipoproteins in the plasma were calculated using the method described by Brunzell et al. [17]; Non-HDL cholesterol = [TC] – [HDL]

The atherogenic indices were calculated as:

Cardiac Risk Ratio (CRR) = TC/HDLC

Atherogenic Coefficient (AC) = (TC–HDLC)/HDLC

Atherogenic Index of Plasma (AIP) = log(TG/HDLC)

2.5 Statistical Analysis

SPSS software was used. All values were expressed as mean ± SD (standard deviation). One –way ANOVA test was performed and differences were considered significant at 95% confidence level ($P < 0.05$).

3. RESULTS

The result of HDL levels of hyperlipidaemic induced animals fed with aqueous extract of *Irvingia wombolu* in Table 2 shows that in phase 1, there was a significant decrease ($p<0.05$) in HDL level in all groups (2-5) compared to the normal control after feeding with high fat diet. In phase 2, there was an increase in HDL level in all treated groups (3-5) when compared to the positive control. Groups 4 was significant ($p<0.05$) when compared to the positive control. In phase 3, there was a significant increase ($p<0.05$) in HDL levels in treatment groups (3,4,5) when compared to positive control.

LDL levels of hyperlipidaemic induced animals fed with aqueous extract of *Irvingia wombolu* seed shows that in phase 1, there was a significant increase ($p<0.05$) in LDL level in all groups (2-5) compared to the normal control after feeding with high fat diet. In phase 2, there was a significant decrease ($p<0.05$) in LDL level in all treated groups (3-5) when compared to the positive control. In phase 3, there was a significant decrease ($p<0.05$) in LDL level in treated groups (3-5) when compared to the positive control as shown in Table 3 shows.

In phase 1, there was a significant increase ($p<0.05$) in total cholesterol level in all groups (2-5) compared to the normal control after feeding with high fat diet. This is an indicator of positive induction since hyperlipaemia is linked with an increase in total cholesterol level. In phase 2, there was a significant decrease ($p<0.05$) in total cholesterol level in all treated groups (3-5) when compared to the positive control. In phase 3, there was a significant decrease ($p<0.05$) in total cholesterol level in treated groups (3-5) when compared to the positive control as shown in Table 4.

There was a significant increase ($p<0.05$) in triglyceride level in all groups (2-5) compared to the normal control after feeding with high fat diet. In phase 2, there was a significant decrease ($p<0.05$) in triglyceride level in all treated groups (3-5) when compared to the positive control. In phase 3, there was a significant decrease ($p<0.05$) in triglyceride level in treated groups (3-5) when compared to the positive control as shown in Table 5

Table 1.Animal grouping and treatment

Groups	Treatment
1 (Normal control)	Feed and water only throughout the duration of study.
2 (Positive control)	Feed supplemented with hyperlipidemic diet formulation for 14 days then feed and water for the remaining days of the study.
3 (AQ_{250mg})	Feed supplemented with hyperlipidemic diet formulation for 14 days then treated with 250mg/kg body weight aqueous extract of *Irvingia wombolu* seed for 28 days.
4 (AQ_{500mg})	Feed supplemented with hyperlipidemic diet formulation for 14 days then treated with 500mg/kg body weight aqueous extract of *Irvingia wombolu* seed for 28 days.
5 (AQ_{1000mg})	Feed supplemented with hyperlipidemic diet formulation for 14 days then treated with 1000mg/kg body weight aqueous extract of *Irvingia wombolu* seed for 28 days.

Table 2. High density lipoprotein (HDL) levels in the test and control animals

Diet groups	Phase 1	Phase 2	Phase 3
Normal control	0.96 ± 0.08^{b}	0.97 ± 0.10^{b}	1.00 ± 0.20^{b}
Positive control	0.68 ± 0.07^{a}	0.65 ± 0.13^{a}	0.63 ± 0.21^{a}
AQ_{250mg}	0.67 ± 0.06^{a}	0.70 ± 0.17^{a}	$0.87\pm0.21^{a,b}$
AQ_{500mg}	$0.80\pm0.10^{a,b}$	0.87 ± 0.12^{b}	0.90 ± 0.20^{b}
AQ_{1000mg}	0.60 ± 0.10^{a}	0.70 ± 0.26^{a}	$0.73\pm0.05^{a,b}$

Values expressed as Mean ± S.D (n=3) at p<0.05 significance level.[a] means value is significantly different when compared to normal control[b]means value is significantly different when compared to positive control.Phase 1= day 0 i.e after 14 days induction period, phase 2= after 14 days treatment period, phase 3= after 28 days treatment period. AQ= aqueous extract

Table 3. Low density lipoprotein (LDL) levels in the test and control animals

Diet groups	Phase 1	Phase 2	Phase 3
Normal control	1.24 ± 0.16^{b}	1.38 ± 0.03^{b}	1.77 ± 0.68^{b}
Positive control	2.48 ± 0.30^{a}	2.72 ± 0.19^{a}	3.13 ± 0.94^{a}
AQ_{250mg}	$2.83\pm0.67^{a,b}$	$1.97\pm0.55^{a,b}$	$1.96\pm0.68^{a,b}$
AQ_{500mg}	$2.20\pm0.00^{a,b}$	$2.00\pm0.20^{a,b}$	$2.00\pm0.36^{a,b}$
AQ_{1000mg}	2.43 ± 0.21^{a}	$2.27\pm0.41^{a,b}$	$2.17\pm0.83^{a,b}$

Values expressed as Mean ± S.D (n=3) at p<0.05 significance level.[a] means value is significantly different when compared to normal control. [b] means value is significantly different when compared to positive control. Phase 1= day 0 i.e after 14 days induction period, phase 2= after 14 days treatment period, phase 3= after 28 days treatment period. AQ= aqueous extract

There was a significant increase ($p<0.05$) in VLDL level in all groups (2-5) compared to the normal control after feeding with high fat diet. In phase 2, there was a significant decrease ($p<0.05$) in VLDL level in all treated groups (3-5) when compared to the positive control. In phase 3, there was a significant decrease ($p<0.05$) in VLDL level in treated groups (3-5) when compared to the positive control as shown in Table 6

In phase 1, there was a significant increase ($p<0.05$) in Non-HDL level in all groups (2-5) compared to the normal control after feeding with high fat diet. In phase 2, there was a significant decrease ($p<0.05$) in Non-HDL level in all treated groups (3-5) when compared to the positive control. In phase 3, there was a significant decrease ($p<0.05$) in Non-HDL level in treated groups (3-5) when compared to the positive control as shown in Table 7.

Table 4. Total Cholesterol levels in the test and control animals

Diet groups	Phase 1	Phase 2	Phase 3
Normal control	2.65±0.07[b]	2.85±0.21[b]	3.00±0.20[b]
Positive control	4.00±0.26[a]	4.00±0.10[a]	4.40±0.90[a]
AQ_{250mg}	4.40±0.66[a,b]	3.20±0.69[a,b]	3.10±0.10[b]
AQ_{500mg}	3.77±0.21[a,b]	3.27±0.30[a,b]	3.20±0.30[a,b]
AQ_{1000mg}	3.70±0.44[a,b]	3.40±0.62[a,b]	3.20±0.53[a,b]

Values expressed as Mean ± S.D (n=3) at p<0.05 significance level.[a] means value is significantly different when compared to normal control. [b] means value is significantly different when compared to positive control. Phase 1= day 0 i.e after 14 days induction period, phase 2= after 14 days treatment period, phase 3= after 28 days treatment period. AQ= aqueous extract

Table 5. Triglyceride levels in the test and control animals

Diet groups	Phase 1	Phase 2	Phase 3
Normal control	1.00±0.00[b]	1.10±0.00[b]	0.50±0.17[b]
Positive control	1.38±0.30[a]	1.38±0.17[a]	1.40±0.60[a]
AQ_{250mg}	1.97±0.70[a,b]	1.17±0.31[b]	0.60±0.10[b]
AQ_{500mg}	1.70±0.17[a,b]	0.87±0.06[b]	0.63±0.60[a,b]
AQ_{1000mg}	1.53±0.58[a,b]	0.90±0.10[b]	0.70±0.00[a,b]

Values expressed as Mean ± S.D (n=3) at p<0.05 significance level.[a] means value is significantly different when compared to normal control. [b] means value is significantly different when compared to positive control. Phase 1= day 0 i.e after 14 days induction period, phase 2= after 14 days treatment period, phase 3= after 28 days treatment period. AQ= aqueous extract

Table 6. Very Low Density Lipoprotein (VLDL) levels in the test and control animals

Diet groups	Phase 1	Phase 2	Phase 3
Normal control	0.45±0.00[b]	0.50±0.00[b]	0.23±0.11[b]
Positive control	0.64±0.10[a]	0.63±0.06[a]	0.64±0.14[a]
AQ_{250mg}	0.90±0.30[a,b]	0.53±0.15[b]	0.27±0.06[b]
AQ_{500mg}	0.77±0.12[a,b]	0.40±0.00[b]	0.30±0.00[b]
AQ_{1000mg}	0.67±0.29[a]	0.43±0.06[b]	0.30±0.00[b]

Values expressed as Mean ± S.D (n=3) at p<0.05 significance level.[a] means value is significantly different when compared to normal control. [b] means value is significantly different when compared to positive control. Phase 1= day 0 i.e after 14 days induction period, phase 2= after 14 days treatment period, phase 3= after 28 days treatment period. AQ= aqueous extract

Cardiac risk ratio levels of hyperlipidemic induced animals fed with aqueous extracts of *Irvingia wombolu* shown in Table 8 reveals that there was a significant increase ($p<0.05$) in cardiac risk ratioin all groups (2-5) compared to the normal control after feeding with high fat diet. In phase 2 and 3, there was a significant decrease ($p<0.05$) in cardiac risk ratio in all treated groups (3-5) when compared to the positive control.

The atherogenic coefficient levels of hyperlipidemic induced animals fed with aqueous extracts of *Irvingia wombolu* in Table 9 shows that In phase 1, there was a significant increase ($p<0.05$) in atherogenic coefficient in all groups (2-5) compared to the normal control after feeding with high fat diet. In phase 2 and 3, there was a significant decrease ($p<0.05$) in atherogenic coefficientin all treated groups (3-5) when compared to the positive control.

The atherogenic index of plasma in hyperlipidaemic induced animals fed with aqueous extracts of *Irvingia wombolu* as seen in Table 10 shows that In phase 1, there was a significant increase ($p<0.05$) in atherogenic index of plasma in all groups (2-5) comparedto the normal controlafter feeding with high fat diet. In phase 2 and 3, there was asignificant decrease ($p<0.05$) in atherogenic index of plasma in all treated groups (3-5) when compared to the positive control.

It was observed that In phase 1, there was a significant difference ($p<0.05$) in weight in groups 2,4,5, when compared to the normal control after feeding with high fat diet. In phase 2, group 3 showed a significant increase ($p<0.05$) in weight when compared to the positive control. In phase 3, group 5 showed a significant increase ($p<0.05$) in weight when compared to the positive control. In phase 4, group 5 and 6 showed a significant increase ($p<0.05$) in weight when compared to the positive control as shown in Table 11.

Table 7. Non- High Density Lipoprotein (NON-HDL) levels in the test and control animals

Diet groups	Phase 1	Phase 2	Phase 3
Normal control	1.69±0.16^{b}	1.88±0.11^{b}	2.00±0.20^{b}
Positive control	3.32±0.23^{a}	3.35±0.15^{a}	3.77±1.07^{a}
AQ_{250mg}	3.73±0.71^{a,b}	2.50±0.62^{a,b}	2.23±0.29^{a,b}
AQ_{500mg}	2.97±0.12^{a,b}	2.33±0.23^{a,b}	2.30±0.26^{a,b}
AQ_{1000mg}	3.10±0.44^{a}	2.70±0.70^{a,b}	2.47±0.58^{a,b}

Values expressed as Mean ± S.D (n=3) at p<0.05 significance level.[a] means value is significantly different when compared to normal control. [b] means value is significantly different when compared to positive control. Phase 1= day 0 i.e after 14 days induction period, phase 2= after 14 days treatment period, phase 3= after 28 days treatment period. AQ= aqueous extract

Table 8. Cardiac Risk Ratio in the test and control animals

Diet groups	Phase 1	Phase 2	Phase 3
Normal control	2.78±0.32^{b}	2.94±0.08^{b}	3.07±0.59^{b}
Positive control	5.91±0.55^{a}	6.15±0.86^{a}	8.03±4.82^{a}
AQ_{250mg}	6.69±1.61^{a}	4.67±1.15^{a,b}	3.71±0.90^{b}
AQ_{500mg}	4.74±0.36^{a}	3.70±0.09^{b}	3.64±0.66^{b}
AQ_{1000mg}	6.27±1.01^{a}	5.57±3.01^{a,b}	4.43±1.00^{a,b}

Values expressed as Mean ± S.D (n=3) at p<0.05 significance level.[a] means value is significantly different when compared to normal control. [b] means value is significantly different when compared to positive control. Phase 1= day 0 i.e after 14 days induction period, phase 2= after 14 days treatment period, phase 3= after 28 days treatment period. AQ= aqueous extract

Table 9. Atherogenic Coefficient in the test and control animals

Diet groups	Phase 1	Phase 2	Phase 3
Normal control	1.78±0.32^{b}	1.94±0.08^{b}	2.07±0.59^{b}
Positive control	4.91±0.54^{a}	5.15±0.86^{a}	7.03±4.82^{a}
AQ_{250mg}	5.69±1.61^{a,b}	3.67±1.15^{a,b}	2.71±0.90^{b}
AQ_{500mg}	3.74±0.36^{a}	2.70±0.09^{a,b}	2.64±0.66^{b}
AQ_{1000mg}	5.27±1.10^{a,b}	4.57±3.01^{a,b}	3.43±1.00^{a,b}

Values expressed as Mean ± S.D (n=3) at p<0.05 significance level.[a] means value is significantly different when compared to normal control. [b] means value is significantly different when compared to positive control. Phase 1= day 0 i.e after 14 days induction period, phase 2= after 14 days treatment period, phase 3= after 28 days treatment period. AQ= aqueous extract

Table 10. Atherogenic index of plasma in the test and control animals

Diet groups	Phase 1	Phase 2	Phase 3
Normal control	0.02±0.04[b]	0.06±0.05[b]	-0.31±0.09[b]
Positive control	0.30±0.13[a]	0.33±0.08[a]	0.35±0.17[a]
AQ_{250mg}	0.45±0.17[a]	0.22±0.04[a]	-0.16±0.16[a,b]
AQ_{500mg}	0.33±0.03[a]	0.00±0.05	-0.15±0.07[a]
AQ_{1000mg}	0.39±0.22[a]	0.13±0.24[a,b]	-0.02±0.03[a.b]

Values expressed as Mean ± S.D (n=3) at p<0.05 significance level.[a] means value is significantly different when compared to normal control. [b] means value is significantly different when compared to positive controlPhase 1= day 0 i.e after 14 days induction period, phase 2= after 14 days treatment period, phase 3= after 28 days treatment period. AQ= aqueous extract.

Table 11. Changes in Weightin the test and control animals

Diet groups	Phase 1	Phase 2	Phase 3	Phase 4
Normal control	65.63±12.94[b]	95.71±9.98	108.00±18.12	106.00±14.73[b]
Positive control	102.78±8.33[a]	106.56±16.85	114.83±20.80	123.67±26.08[a]
AQ_{250mg}	69.44±11.02[b]	91.78±10.95[b]	116.17±7.78	123.67±13.05[a]
AQ_{500mg}	100.00±0.00[a]	109.78±14.26	121.33±20.78	136.67±8.33
AQ_{1000mg}	102.78±8.33[a]	99.56±21.55	131.00±15.13[a,b]	141.67±18.77[a,b]

Values expressed as Mean ± S.D (n=3) at p<0.05 significance level.[a] means value is significantly different when compared to normal control.
[b] means value is significantly different when compared to positive control
Phase 1=weight after acclimatization, phase 2= weight at day 0 i.e after 14 days induction period phase 3= after 14 days treatment period, phase 4= after 28 days treatment period
AQ= aqueous extract

4. DISCUSSION

Hyperlipidemia is associated with high LDL, triglyceride and total cholesterol levels as well as low HDL levels. Pharmacological induction of hyperlipidemia by using high fat diet acts by increasing availability of acetyl CoA which in turn increases the rate of cholesterol synthesis [18]. Fatty acids are assembled in triglycerides hence excess fatty acid leads to an accumulation of triglyceride which increases LDL level and reduces HDL level. When particles of oxidized LDL find their way to the endothelial arterial walls, they form plaques which narrow the artery thus increasing the risk of arteriosclerosis and other cardiovascular diseases.HDL on the other hand possesses cardio-protective properties due to its ability to reverse transport of cholesterol back to the liver. It removes excess cholesterol from peripheral tissues and esterifies it with the aid of the enzyme lecithin/cholesterol acyltransferasebefore delivery to the liver for synthesis of lipoproteins and bile acids as well as egesting from the body [19,3].

All concentrations of aqueous extract of *Irvingia wombolu* seed reduced triglyceride, LDL and total cholesterol levels while increasing HDL level at 14days and 28 days of treatment. This is in agreement with several studies [20,21,22,23] that suggested that intake of the *I. gabonensis* variant reduced serum lipids and increased HDL. This can be attributed to the presence of dietary phytochemicals in the sample which perform a number of functions. These phytochemicals according to Nwatu, (2016) include: Polyphenols: they regulate expression of genes involved in lipid accumulation [24] and prevent LDL oxidation by leptin regulation [25]. Flavonoids: catechins especially epiallocatechin gallate, isoflavones reduces fat absorption as well as leptin, plasma levels of triglycerides and cholesterol [26]. It reduces activity of glycerol-3-phosphate dehydrogenase involved in lipid synthesis [27]. They inhibit oxidative stress and preserve HDL associated serum paraoxonase activity (Fuhram and Auram, 2001).Terpenes are ligands with potential to activate PPARɣ (a dietary lipid sensor that control energy homeostasis, lipid and carbohydrate disorders [28,29]. In adipocytes, it regulates transcription of PPARɣ target genes, induces expression of adiponectin and inhibits MCP-1 [30]. It also suppresses inflammatory signaling exchange

between adipocytes and macrophages [29]. Phytosterols compete with cholesterol for micelle formation in the intestinal lumen thus inhibiting cholesterol absorption [31]. They influence intestinal genes and transcription factors [32]. It is a selective bile acid receptor modulator that regulates expression of a subset farnesoid X receptor (FXR) and decreases expression of bile acid activated genes [33]. It inhibits adipocyte differentiation and is involved in PPARγ expression [34] Anthocyanins have multiple pharmacological actions like anti-hyperlipidemia [35] Saponins interfers with intestinal absorption of cholesterol thereby reducing LDL, triglycerides and cholesterol and increasing HDL [36] Alkaloids lower glucose levels hence are beneficial in treating hyperlipidemia [37].

Atherogenic indices serves as a powerful pointer of the risk of heart diseases, the lower the value, the lower the risk of developing cardiovascular disease and vice versa [38]. In this study, aqueous extract of *Irvingia wombolu* seeds reduced atherogenic indices indicating the cardio-protective property of the aqueous extracts of all dosages and duration of usage. Lower atherogenic index is protective against coronary heart disease [38].

The animals increased in weight as treatment progressed to 28 days after treatment. This increase in weight may be due to their increase in age. This disagrees with the work of Ngondi et al. [39] which suggested that extracts of *I. Gabonensis* significantly decreased body weight of obese persons in Cameroun. Animals used for this study were not obese which may justify inability of the extracts to reduce weight. It however agrees with the work of Hossain et al. [23] which showed that extracts of *I. Gabonensis* had no effect on body weight of diabetic persons [40,41,1].

5. CONCLUSION

All doses of aqueous extract showed a progressive decrease in LDL, triglyceride and total cholesterol level in addition to increase in HDL with values of 28 days lower than 14 days after treatment commenced. It also reduced the atherogenic indices of the rats. This shows antidyslipidemic property of the of *Irvingia wombolu* seeds.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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