Journal of Advances in Medical and Pharmaceutical Sciences

22(4): 16-24, 2020; Article no.JAMPS.56753
ISSN: 2394-1111

Prophylactic and Therapeutic Effect of Aqueous Stem Extract of *Costus afer* on Lipids and Atherogenic Profile of Albino Rats in Acetaminophen Induced Liver Toxicity

L. L. Nwisah[1], T - E. G. Davies[1] and E. S. Bartimaeus[1*]

[1]Department of Medical Laboratory Science, Rivers State University, Port Harcourt, Nigeria.

Authors' contributions

This work was carried out in collaboration among all authors. Authors ESB and LLN designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors TEGD and ESB managed the analyses of the study. Author LLN managed the literature searches. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/JAMPS/2020/v22i430165
Editor(s):
(1) Dr. Cyprian Ogbonna Onyeji, Obafemi Awolowo University, Nigeria.
Reviewers:
(1) Adegbite Adesola Victor, Ladoke Akintola University of Technology, Nigeria.
(2) Vinod Kumar Gauttam, IES University, India.
(3) Awatef Ali, Alexandria University, Egypt.
Complete Peer review History: http://www.sdiarticle4.com/review-history/56753

Original Research Article

Received 23 February 2020
Accepted 29 April 2020
Published 25 May 2020

ABSTRACT

Background: Medicinal plants are widely used in Nigeria because they are believed to be effective in the treatment of various medical conditions and are also easily accessable with minimal side effect.
Aim: This study evaluates the prophylactic and therapeutic effects of different doses (200 mg/kg, 400 mg/kg and 800 mg/kg body weight) of *Costus afer* on lipid profile of 50 male albino rats.
Methodology: The research study was divided into 2 phases with 25 rats used for each phases. The 25 rats used for each phase were randomly selected into 5 groups with each group containing 5 rats. The rats used for the prophylactic phase were induced with 800 mg/kg body weight paracetamol for liver toxicity after administration of the various concentrations of aqueous stem extract of *C. afer* for 28 days while those used during the therapeutic phase were administered with the various concentrations of aqueous stem extract of *C. afer* following confirmation of liver toxicity using 800 mg/kg body weight acetaminophen. The effect of the aqueous extract was assessed by

**Corresponding author: E-mail: ebbyagana@gmail.com;*

measuring the serum concentration of total cholesterol, triglycerides and high density lipoprotein using Randox reagent, while low density lipoprotein was calculated from the other parameters. Atherogenic ratios were also computed. The result obtained from the experiment was subjected to statistical analysis using Graph pad prism version 5.3 and values were considered significant at $p<0.05$.

Results: Total cholesterol, triglycerides and LDL levels were significantly ($p<0.05$) reduced and HDL significantly increased in the treatment groups (prophylactic and therapeutic phases) compared to the positive control. When both phases were compared, total cholesterol and triglycerides showed significant ($p<0.05$) difference in concentration in groups fed with 400 mg/kg, 200 mgkg while LDL-C showed significant ($p<0.05$) variation between the two phases only at 400 mg/kg body weight. The extracts were also found to significantly ($p<0.05$) reduce the atherogenic status of the albino rats in both phases of treatment and between each treatment phase.

Conclusion: Findings from this study suggest that *Costus afer* possesses the ability to regulate paracetamol induced dyslipidaemia and improve the anti-atherogenic status of treated albino rats.

Keywords: Costus afer; lipoproteins; cardiovascular disease; albino rats; atherogenic indexes.

1. INTRODUCTION

The use of herbs and plant extracts in the treatment of various disease conditions in our society today is on the increase. Many prefer these extracts and herbs to the usual orthodox medicine. In most cases these alternative therapy prove very effective, hence, their use in treatment of a wide range of illnesses including organ damage [1]. *Costus afer* (*C. afer*) is one of 150 species of stout, perennial and rhizomatous herbs of the genus *Costus* and family Costaceae. It can be found in the forest belt of Senegal, South Africa, Guinea, Niger, Sierra Leone and Nigeria. *C. afer* isalso known as Ginger Lily or Bush-cane, “Irekeomode” (in Yoruba), “opete” (in Igbo) and “ting” (in Khana) languages. The plant bears white and yellow flowers. The stem, seeds and rhizomes are harvested from the wild plant and contain several bioactive metabolites [2].

This plant contains some active ingredients (phytochemical constituents) as well as vitamins and minerals, which contributes to its therapeutic effects. The presence of major phytochemical components in Costus plant shows a wide range of biological effects leading to their protective and disease preventive attributes. The plant exhibits the following actions: antioxidant, hormonal action, and stimulation of enzymes, interference with DNA replication, anti-microbial effect, and physical action [2]. Extracts from the roots, barks, seeds and fruits of these plants are used in the preparation of syrups in traditional medicine as cough suppressant and in the treatment of oxidative related diseases [3].

About 75% of human population is using herbal medicines with the trend increasing globally [4] and about 60% to 85% of the populations of every nation of the developing world rely on herbal or indigenous forms of medicine. Herbs and herbal products and or supplements are forms of plant materials used as complementary or alternative medicines throughout the world [1]. In certain African countries for instance, up to 90% of the population still rely exclusively on plants as a source of medicine [5].

Costus afer (Costaceae) is one of such medicinal plants in Nigeria and other parts of the world. The root, stem and leaves are reportedly used in the treatment of diabetes mellitus. Apart from the hypoglycaemic property of *Costus afer,* it has been reported that it can also relieve other possible complications arising from diabetic conditions. It is therefore regarded as an hepatoprotective agent [6]. In another animal diabetic model, it was discovered that the administration of eremanthin and costunolide, isolated from Costus species resulted in reduction in total cholesterol and low density lipoprotein cholesterol, triglycerides, and increased high density lipoprotein cholesterol. It has further been reported that ethanol extract of Costus species root effectively reversed hyperlipidaemia [7]. Although several studies have been conducted on *C. afer*, most of these studies focused on the utilization of the extract in post therapeutic reversal of diabetic complications. Furthermore, studies on the impact of extract of *C. afer* following prophylactic use or pretreatment before inducement of organ is rare. Thus, this present study was designed to evaluate the pretreatment effect of stem extract of C*ostus afer* on lipids and atherogenic profile of Albino rats in acetaminophen induced liver toxicity.

2. MATERIALS AND METHODS

2.1 Sample Collection and Identification

The stems of *Costus afer* plant were collected from agricultural farm in Aluu, University of Port Harcourt. Rivers State. The plant was identified and authenticated by the Department of Plant Pathology and Biotechnology, Rivers State University, Port Harcourt, Nigeria.

2.2 Sample Processing and Extraction

After identification, the samples were washed and shade dried in a well ventilated place for 24hrs to allow the water to drain off and avoid contamination with dust. The stems were then cut with a sharp stainless steel knife into small bits and then crushed using a mechanical blender (NAKAI, Model No. 462, 230V-, 50Hz, 300W). One thousand grams (1000 g) of the ground stem was weighed with a weighing balance (JT3003D, Shandhai Science Instrument, Co, Ltd Zhejiang, China), strained and marc pressed and the liquid was allowed to stand for about 12 hours. The aqueous liquid extract was then filtered and the sediment concentrated into syrup using a rotary extractor (OE-RX20-EA Model # 700-041-006) at 4000 rounds per minute (rpm).

2.3 Animal Care and Handling

The animals used for the study were 50 male albino rats that were purchased from the Faculty of Pharmaceutical Sciences Animal House, Abuja Campus, University of Port-Harcourt, Rivers State, Nigeria. They were weighed and grouped based on their body weight and allowed free access to feed and water *ad libitium* for a period of ten days to acclimatize to the new housing condition. Then different concentrations of the stem extract were given to the rats.

They were housed in standard cage and maintained in standard laboratory condition at ambient temperature (25±2°C) with relative humidity (55-64%) and light and dark conditions (12/12h). They were fed with standard diet. Top Feed Premier Feeds (Broiler finisher) manufactured by Premier Feed Mills Co. Ltd. (A subsidiary of Flour Mills Nig. Plc., Lagos State) was purchased for proper nutrition at Choba, Port Harcourt. Animal ethics and proper handling method were strictly adhered to [8]. The bedding of the cage (sawdust) was always changed daily and the cage also washed and disinfected weekly.

2.4 Experimental Design

The animals were divided into 10 experimental groups of 5 rats each. The first five groups were used for the pretreatment phase.

- Goup 1: Albino rats were given distilled water alone and normal feed (negative control).
- Group 2: Albino rats were given distilled water and normal feed for 28 days before induction with with 800 mg/kg body weight of acetaminophen (paracetamol) (positive control).
- Group 3: Albino rats were given normal feed and 200 mg/kg body weight of *Costus afer* stem extract for 28 days before induction of liver damage with 800 mg/kg body weight of acetaminophen.
- Group 4: Albino rats were given normal feed and 400 mg/kg body weight of *Costus afer* stem extract for 28 days before induction of liver damage with 800 mg/kg body weight of acetaminophen.
- Group 5: Albino rats were given normal feed and 800 mg/kg body weight of *Costus afer* stem extract for 28 days before induction of liver damage with 800 mg/kg body weight of acetaminophen.

The second five groups of the albino rats were used for the post treatment phase. Each group contains five albino rats.

- Goup 1: Albino rats were given distilled water alone and normal feed (negative control) for 28 days.
- Group 2: Albino rats were induced with 800 mg/kg body weight of acetaminophen (paracetamol) (positive control) and given distilled water and normal feed for 28 days after induction.
- Group 3: Albino rats were induced with with 800 mg/kg body weight of acetaminophen (paracetamol) and were given normal feed and 200 mg/kg body weight of *Costus afer* stem extract for 28 days after nduction of liver damage.
- Group 4: Albino rats were induced with with 800 mg/kg body weight of acetaminophen (paracetamol) and were given normal feed and 400 mg/kg body weight of *Costus afer* stem extract for 28 days after induction of liver damage.
- Group 5: Albino rats were induced with with 800 mg/kg body weight of acetaminophen (paracetamol) and were

given normal feed and 800 mg/kg body weight of *Costus afer* stem extract for 28 days after induction of liver damage.

2.5 Calculation of Dosage of Paracetamol

The weight of the rats were measured and 800 mg/kg body weight of rat of acetaminophen was given to them intraperitoneally according to their weight based on [9]. Liver toxicity was ascertained by using six rats; three for negative control and the other three was induced for liver damage with 800 mg/kg of paracetamol. Then the liver enzymes for the two trial groups were measured after three days. Enzymes level of the positive control were found to be elevated than those of rats fed only with feed and distilled water.

2.6 Calculation of Concentration of Extract (mg)

This was done following the guidelines of [10].

2.7 Blood Sample Collection

At the end of the treatment period, (28 days) rats in all the groups were anaesthetized with chloroform and dissected, and blood samples collected by jugular puncture into plain bottles, spun using a centrifuge at 4000 rpm and serum transferred into other plain bottles and stored in the laboratory freezer frozen at (0-4°C) until time for analysis.

2.8 Lipid Profile Assays

Total cholesterol (TC), triacylglycerol (TG) and high-density lipoprotein cholesterol (HDL-C) were determined using rat commercial kits (Randox Laboratory Ltd., UK). Low-density lipoprotein cholesterol (LDL-C) concentration was determined by difference according to the formula described by [11].

2.9 Calculation of Atherogenic Indexes

The Atherogenic ratioswere calculated as follows:

Atherogenic Index of Plasma (AIP) = log TG/HDL-C [12];
Cardiac Risk Ratio-1 (CRR-I) = TC/HDL-C [13,14];
Cardiac Risk Ratio-11 (CRI-II) = LDL-C/HDL-C [13,14];
Atherogenic Coefficient (AC) = (TC– HDL-C)/HDL-C [15].

2.10 Statistical Analysis

The results were analyzed statistically using Statistical Analysis System (SAS). STAT 15.1 developed by SAS Institute, North Carolina State University, USA. Data were presented as mean ± SEM, comparison of means of groups that were more than two was done using analysis of variance (ANOVA) and the Tukey test of multiple comparison was used to test for variance within and across groups. Variations in means of parameters was considered statistically significant at $p< 0.05$.

3. RESULTS

The mean ±SD of serum total cholesterol, high density lipoprotein cholesterol, low density lipoprotein cholesterol and triglycerides of albino rats following pretreatment with various concentrations of *C. afer* stem extract is shown in Table 1. The table shows that there was a significant reduction in the level of total cholesterol of the pretreated albino rats after administration of paracetamol ($p<0.0001$, $F=39.8$). The level of HDL-C was also seen to have increased significantly ($p<0.0113$, $F=16.4$) in the pretreated albino rats when compared to the positve control that recieived paracetamol. Significant reduction in the concentrations of LDL-C ($p<0.0001$, $F=81.5$) and triglycerides ($p=0.0192$, $F=13.0$) in the albino rats pretreated with various concentrations of *C. afer* was also observed.

In the albino rats post treated with various concentrations of *C. afer* for 28 days after paracetamol induced liver injury, the total cholesterol concentration was observed to decrease significantly ($p<0.0001$, $F=11.6$) when compared with positive control that received the paracetamol poisoning.

Similarly, the concentrations of LDL-C of the post treated albino rats was observed to reduce significantly ($p<0.0001$, $F=24.0$) when compared to the concentration obtained from the albino rats that were given 800 mg/kg body weight of paracetamol. A similar significant decrease in the concentration of triglycerides was also observed ($p=0.0192$, $F=3.8$). However, the concentration of HDL-C significantly ($p<0.0001$, $F=34.8$) increased in the albino rats that were post treated with the various concentrations of *C. afer* for 28 days after induction of liver injury with paracetamol (Table 2).

Comparison of the effect of the various concentrations of the *C. afer* extract on the lipid profiles of the albino rats between the pretreatment and post treatment phases shows no significant variation (p>0.05) except in the albino rats that received 400 mg/kg body weight of the *C. afer* where significant (p<0.05) variation was observed in the level of the lipoproteins (Table 3).

The effect of aqueous stem extract of *C. afer* on atherogenic status of the albino rats was also investigated. The albino rats in the experimental groups in both treatment phases exhibited

Table 1. Mean ±SD of lipid profile of albino rats in the pre-treatment phase

Groups	TC (mmol/L)	HDL-C (mmol/L)	TG (mmol/L)	LDL-C (mmol/L)
NC (Group 1)	2.5±0.1^{a}	1.8±0.1^{a}	1.2±0.2^{a}	1.2±0.1^{a}
PC(Group 2)	5.3±0.3^{c}	0.9±0.1^{b}	2.4±0.3^{b}	3.3±0.2^{b}
200 mg/kg body weight (Group 3)	3.0±0.2^{bc}	1.1±0.1^{bc}	1.4±0.2^{a}	1.3±0.1^{a}
400 mg/kg body weight (Group 4)	2.9±0.1^{bc}	1.2±0.1^{bc}	0.9±0.1^{a}	1.2±0.1^{a}
800 mg/kg body weight (Group 5)	2.6±0.2^{b}	1.1±0.1^{bc}	1.2±0.2^{a}	1.2±0.1^{a}
F-value	39.8	16.4	13.0	81.5
P-value	<0.0001	0.01129	<0.0001	<0.0001

Key: NC- negative control, PC- positive control, TC- total cholesterol, HDL-C- high density lipoprotein cholesterol, TG- triglycerides, LDL-C- low density lipoprotein cholesterol. Mean ±SD with superscripts of different alphabets are significantly different from each other at p<0.05

Table 2. Mean concentration of lipid profile of albino rats in post-treatment phase

Groups	TC (mmol/L)	HDL-C (mmol/L)	TG (mmol/L)	LDL-C (mmol/L)
NC (Group 1)	2.5±0.1^{a}	1.8±0.1^{a}	1.2±0.2^{a}	0.20±0.1^{a}
PC (Group 2)	3.9±03^{b}	0.8±0.04^{b}	1.8±0.1^{b}	2.3±0.3^{b}
200 mg/kg body weight (Group 3)	2.9±0.1^{a}	1.4±0.1^{a}	1.3±0.2^{a}	1.0±0.2^{a}
400 mg/kg body weight (Group 4)	2.5±0.1^{a}	1.3±0.1^{a}	1.1±0.1^{a}	0.7±0.1^{a}
800 mg/kg body weight (Group 5)	2.7±0.1^{a}	1.5±0.1^{a}	1.2±0.2^{a}	0.8±0.4^{a}
F-value	11.6	34.8	3.8	24.0
P-value	p<0.0001	p<0.0001	0.019247	p<0.0001

Key: NC- negative control, PC- positive control, TC- total cholesterol, HDL-C- high density lipoprotein cholesterol, TG- triglycerides, LDL-C- low density lipoprotein cholesterol. Mean ±SD with superscripts of different alphabets are significantly different from each other at p<0.05

Table 3. Comparison of lipid profiles of albino rats in pre-treatment and post treatment phases

Parameters	Groups	t-values	p-values	Remarks
TC	A1 VS A2	0.5	0.3	NS
	B1 vs B2	2.6	0.01	S
	C1 vs C2	0.2	0.4	NS
HDL-C	A1 vs A2	1.6	0.07	NS
	B1 vs B2	0.9	0.2	NS
	C1 vs C2	1.5	0.08	NS
TG	A1 vs A2	0.6	0.3	NS
	B1 vs B2	1.9	0.04	S
	C1 vs C2	0.6	0.3	NS
LD:L-C	A1 vs A2	2.0	0.04	S
	Bi vs B2	3.0	0.01	S
	C1 vs C2	0.9	0.2	NS

Key: TC-total cholesterol, HDL-C- high density lipoprotein cholesterol, TG- triglycerides, LDL-C-low density lipoprotein cholesterol, A1- 200 mg/kg body weight, B1- 400 mg/kg body weight. C1- 800 mg/kg body weight C. afer extract during pretreatment phase, A2- 200 mg/kg body weight, B2- 400 mg/kg body weight. C2- 800 mg/kg body weight C. afer extract during post treatment phase, NS-not significant (p>0.05), S-significant (p<0.05)

moderate cardiovascular risk (0.22) with AIP and high cardiovascular risk (6.22) with CRR-I and 3.94 with CRR-II in the pretreatment phase and moderate CVD risk (0.22) with AIP, high CVD risk (5.0) and 3.04 with CRR-I and CRR-II respectively in the post treatment phase. The study shows that the stem extract reversed the atherogenic status of the albino rats. The moderate and high atherogenic risk status observed in the induced albino rats were reversed to normal in the albino rats that were either pretreated or post treated with the various concentrations of the stem extact of *C. afer* (Tables 4 and 5).

The study further showed that the anti-atherogenic effect of *C. afer* was more profound in the albino rats that were post treated with the stem extract than in the pretreatment phase (Table 6).

4. DISCUSSION

The present study was focused on investigating the effect of *Costus afer* on the lipid profile and

Table 4. Atherogenic index and cardiovascular risk ratios of albino rats in pre-treatment phase (mean±SD)

Groups	CRR-I	CRR-II	AIP
NC (Group 1)	1.4±0.1	0.12±0.03	0.13±0.1
PC (Group 2)	6.22±0.5	3.94±0.4	0.22±0.1
200 mg/kg body weight extract (Group 3)	2.14±0.1	1.21±0.2	0.11±0.02
400 mg/kg body weight extract (Group 4)	2.32±0.01	0.81±0.2	0.14±0.03
800 mg/kg body weight extract (Group 5)	2.2±0.1	0.7±0.1	0.10±0.03

Key: NC- negative control, PC- positive control, CRR-I-cadiac risk ratio I, CRR-II- cadiac risk ratio II, AIP-atherogenic index of plasma. Abnormal values for cardiovascular risk: Atherogenic index of plasma (AIP): low risk > 0.1, intermediate risk 0.1-0.24, high risk >0.24 [16], Cardiac risk ratio 1 (CRR-I) > 3.0 and Cardiac risk ratio II (CRR–II > 3.3 [17]

Table 5. Atherogenic index and cardiovascular risk ratios of albino rats in post-treatment phase (mean±SD)

Groups	CRR-I	CRR-II	AIP
NC (Group 1)	1.40±0.1	0.12±0.03	0.13±0.1
PC (Group 2)	5.0±0.5	3.04±0.4	0.22±0.1
200 mg/kg body weight extract (Group 3)	2.14±0.1	0.73±0.1	0.12±0.1
400 mg/kg body weight extract (Group 4)	1.93±0.1	0.55±0.1	0.11±0.02
800 mg/kg body weight extract (Group 5)	1.84±0.1	0.5±0.1	0.14±0.04

Key: NC- negative control, PC- positive control, CRR-I-cadiac risk ratio I, CRR-II- cadiac risk ratio II, AIP-atherogenic index of plasma. Key: NC- negative control, PC- positive control, CRR-I-cadiac risk ratio I, CRR-II-cadiac risk ratio II, AIP- atherogenic index of plasma. Abnormal values for cardiovascular risk: Atherogenic index of plasma (AIP): low risk > 0.1, intermediate risk 0.1-0.24, high risk >0.24 [16], Cardiac risk ratio 1 (CRR-I) > 3.0 and Cardiac risk ratio II (CRR–II > 3.3[17]

Table 6. Comparison of atherogenic indexes and cardiovascular risk ratios of albino rats in pre-treatment and post treatment phases

Parameters	Groups	t-values	p-values	Remarks
AIP	A1 VS A2	1.9	0.05	S
	B1 vs B2	2.1	0.04	S
	C1 vs C2	2.8	0.02	S
CRR-I	A1 vs A2	1.7	0.07	NS
	B1 vs B2	2.20	0.04	S
	C1 vs C2	2.8	0.1	NS
CRR-II	A1 vs A2	3.2	0.01	S
	B1 vs B2	0.3	0.4	NS
	C1 vs C2	1.0	0.2	NS

Key: AIP-atherogenic index of plasma, CRR-I- Cardiac risk ratio I, CRR-II-cardiac risk ratio II, A1- 200 mg/kg body weight, B1- 400 mg/kg body weight. C1- 800 mg/kg body weight C. afer extract during pretreatment phase, A2- 200 mg/kg body weight, B2- 400 mg/kg body weight. C2- 800 mg/kg body weight C. afer extract during post treatment phase, NS-not significant (p>0.05), S-significant (p<0.05)

atherogenic status of albino rats in both pretreatment phase (administration of various concentrations of *C. afer* for 28 days before induction of liver damage using acetaminophen) and post treatment phase (induction of liver damage with acetaminophen and treatment afterwards with various concentrations of *C. afer* stem extract). The result shows that mean concentrations of total cholesterol, low density lipoprotein and triglycerides in parcetamol treated group (positive control) were elevated compared to the *Costus afer* treated groups for both the pretreatment and the post treatment phases. This increase in lipids and lipoproteins were significant ($p<0.05$). It has been reported that the mechanism of acetaminophen metabolism by the liver involve the use of the cytochrome P450 pathway which often result in the generation of N-acetyl-p-benzoquinoneimine (NAPQI), which is a highly toxic reactive intermediate normally readily detoxified by conjugation with glutathione (GSH) [18,19] but if detoxification could not occur, series of activties are triggered resulting to liver damage [20,21]. The resultant effect of sustained over use of acetaminophen is the build up of N-acetyl-p-benzoquinoneimine (NAPQI) which covalently bind to cellular macro molecules causing acute hepatic necrosis [22] resulting defective liver metabolism of lipoproteins.

HDL is known as the good cholesterol, particularly because it functions to clear cholesterol from the arteries and delivers it back to the liver. Higher HDL level is associated with a lower risk of heart disease. In this study *Costus afer* increased the levels of HDL in costus treated albino rars significantly ($p<0.05$) compared to the positive control for both the pretreatment and post treatment phases. Though no difference was seen when both phase were compared this finding correlates with the study done by Amaechi et al. [23]. However, when this two phases were compared no significant ($p>0.05$) difference was observed except for the groups treated with 400 mg/kg of the plant extract ($p=0.01$). Total cholesterol, triglycerides and low density lipoprotein levels of albino rats in the pretreatment and post- treatment phases were significantly ($p<0.05$) reduced when the mean values were compared to the positive control. Comparing the total cholesterol, tryglycerides and low density lipoprotein concentrations in both the pretreatment and post treatment phases did not show any significant ($p>0.05$) difference except between the groups that were treated with 400 mg/kg body weight of the extract. This is in consonance with the work done by Ayakeme et al. [7] that confirms the ability of *Costus afer* to reduce the levels of total cholesterol, triglycerides and low density lipoprotein in animal models. Although the mechanism of actions of the constituents of the *Costus afer* extracts in lowering the levels of these lipoproteins has not been clearly elucidated, it has been reported that costus species contain eremanthin and costunolide which has potential to reduce total cholesterol, triglycerides and low density lipoprotein levels and increase high density lipoprotein levels [7].

Hyperlipidaemia is a heterogeneous disorder commonly characterized by elevation in concentration of total cholesterol, triglycerides, LDL and decrease in high density lipoprotein levels and is one of the greatest risk factors contributing to the prevalence and severity of atherosclerosis and subsequent coronary heart disease [24]. Atherosclerosis is a major contributor to the pathogenesis of heart and vascular diseases. Elevated blood concentration of cholesterol, especially in LDL-C, constitutes the key risk factor for atherosclerosis [25]. In this study, it was observed that the albino rats treated with various concentrations of *C. afer* stem extract exhibited reduced atherogenic potential which was evident in the reduction in the ratios of CRR-I, CRR-II and AIP when evaluated using established criteria of atherogenic index of plasma (AIP) [26], Cardiac risk ratio 1 (CRR-I) and Cardiac risk ratio II (CRR–II) [17]. The albino rats that were induced with acetaminophen exhibited higher atherogenic status and cardiovascular risk. This is in agreement with the work of [26] which suggests that the presence of cardiac glycoside and sterol present in *C. afer* may be cardioprotective. AIP calculation estimates the values of zone of atherogenic risk. It is also a critical index that can stand alone in the cardiac risk assessment. Therefore, the significant reduction in the atherogenic index of plasma (AIP) of the treatment groups in relation to the positive control suggests that *Costus afer* aqueous stem extract possesses anti-atherogenic capacity.

5. CONCLUSION

The present study demonstrated the potential of *C. afer* to shield the liver from chemical injury or damage as indicated by the findings observed in albino rats in the pretreatment phase. The dosage of 400 mg/kg body weight was found to reasonably reduce total cholesterol, triglycerides and low density lipoprotein levels while

potentially increasing the high density lipoprotei concentration in the post treatment phase. Post treatment of the albino rats also resulted in enhanced reduction of cardiovascular risk in the albino rats in the event of hepatocellular injury or damage.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

CONSENT

It is not applicable.

ETHICAL APPROVAL

All the animal experiments were conducted according to the ethical norms approved by the Institutional Ethical Committee.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Seeff LB, Curto TM, Szabo G. Herbal product use by persons enrolled in the hepatitis C Antiviral Long-Term Treatment Against Cirrhosis (HALT-C) Trial, Hepatology. 2008,47(2):605–612.
2. Godswill NA, Osillesi FO, Olugbenga AE. Anti-inflammatory activities of *Costus afer* Ker Gaul-hexane leaf fraction in Arthritis rat. Journal of Ethnopharmacology. 2014; 543-551.
3. Okwu DE. Phytochemicals and vitamin content of indigeneous spices of South Eastern Nigeria. Journal of Sustanable Agricultural. Environment. 2004;6:30-34.
4. Oreagba IA, Kazeem AO, Amachree M. Herbal medicine used among Africans. British Medical College of Complementary and Alternative Medicine. 2015;4(1):213–219.
5. Hostettmann K, Marston A, Ndjoko K, Jean-Luc Wolfender JL. The potential of African plants as a source of drugs. Current Organic Chemistry. 2000;4:973-1010
6. Omokhua GE. Medicinal and Socio-cultural Importance of *Costus afer* (Ker Grawl) in Nigeria. African Research Review. 2011;5: 282-287.
7. Ayakeme T, Essien E, Ogbomade R. Protective effect *of Costusafer* on lipid profile and hepatic damage in damage in ethanol-induced liver cirrhosis in rats. International Journal of Biochemistry Research and Review. 2015;6(2):53-61.
8. Asmare B. Farm animal welfare and handling in the tropics: The Ethiopia case advances in agriculture. 2014;1-7. Article ID: 428129. Available:http://dx.doi.org/10.1155/2014/428129
9. Tebekeme O. Paracetamol and hydrogen peroxide-induced tissue alterations are reduced by costusafer extract. American Journal of Research Medicine in Medical Sciences. 2018;2(2):66-72.
10. Erhihie EO, Ekene NE, Ajaghana DL. Guideline on dosage calculation and stock solution prepariton in experimental Animals studies. Journal of Natural Science Research. 2014;4(18):2225-2921.
11. Friedewald WT, Levy RI, Fredrickson DS. (1972) Estimation of the concentration of low density lipoprotein cholesterol in plasma without use of preparative ultra centrifuge. Clinical Chemistry. 1972;18: 499-502.
12. Dobiasova M. Atherogenic index of plasma [Log(Triglycerides/HDLCholesterol)]: Theoretical and practical implications. Clinical Chemistry. 2004;50:1113-1115.
13. Stampfer MJ, Sacks FM, Salvini S, Willett WC, Hennekens CH. A prospective study of cholesterol, apolipoproteins and the risk of myocardial infarction. New England Journal of Medicine. 1991;325:373-381.
14. Ridker PM, Stampfer MJ, Rifai N. Novel risk factors for systemic atherosclerosis: A comparison of C-reactive protein, fibrinogen, homocysteine lipoprotein(a), and standard cholesterol screening as predictors of peripheral arterial disease. Journal of American Medical Association. 2001;285:2481-2485.
15. Brehm A, Pfeiler G, Pacini G, Vierhapper H, Roden M. Relationship between Serum Lipoprotein Ratios and Insulin Resistance

in Obesity. Clinical Chemistry. 2004;50: 2316-2322.

16. Kamoru AA, Japhet OM, Adetunji AD, Musa MA, Hammed OO, Akinlawon AA, Abdufatah OA, Taofik AA, Kabiru AA, Roji SM. Castelli risk index, atherogenic index of plasma and atherogenic coefficient: Emerging risk predictors of cardiovascular disease in hiv-treated patients. Saudi Journal of Medical and Pharmaceutical Sciences. 2017;1101-1110. DOI: 10.21276/sjmps.2017.3.10.15
17. Genest J, Frohlich J, Fodor G, McPherson R. The working group on hypercholesterolemia and other dyslipidemias. Recommendations for the management of dyslipidemia and the prevention of cardiovascular disease: 2003 update. Canadian Medical Association Journal. 2003;169:921–924.
18. Mittal DK, Joshi D, Shukia S. Protective effects of *Polygonum bistort* (Linn.) and its active principle against acetaminophen-induced toxicity in rats. Asian Journal of Experimental Biology and Science. 2010; 1:951-958.
19. Dahlin DC, Miwa GT, Lu AY, Nelson SD. N-acetyl-P-benzoquinone imine: a cytochrome P-450-mediated oxidation product of acetaminophen. Proceedings of the National Academy of Science. 1984; 81:1327-1331.
20. Nelson SD. Molecular mechanisms of the hepatotoxicity caused by acetaminophen. Seminar of Liver Diseases. 1990;10:267-278.
21. Mitchell JR, Jollen DJ, Potter WZ, Giletten JR, Brodie BB. Acetaminophen-inducal hepatic necrosis. IV Protective role of glutathione. Journal of Pharmaceutical and Experimental Therapy, 1973;187(1):211 – 217.
22. Hinson JA, Monks TJ, Hong M, Highet RJ, Pohl LR. 3-(glu-tathion-S-yl) acetaminophen: A biliary metabolite of acetaminophen. Drug Metabolism and Disposition. 1982;10:47-50.
23. Amaechi EC, Ohaeri CC, Ukpai OM. Effect of lipid profile in albino rat. Journal of Plant Research. 2013;7:89-91.
24. Kolovou GD, Anagnostopoulou KK, Cokkino DV. Pathology of dyslipidaemia in the metabolic syndrome. Post Graduate Medical Journal. 2005;81(956):358-366.
25. Bonetti PO, Holmes DR, Lerman A, Barsness GW. Enhanced external counterpulsation for ischemic heart disease: what's behind the curtain? Journal of the American College of Cardiology. 2003;41(11):1918-1925.
26. Njoku UO, Nwodo OFC, Ogugofor A. Cardioprotective potential of methanol extract of *Costus afer* leaf on carbon tetrachloride-induced cardiotoxicity in albino rats. Asian Journal of Pharmaceutical Research and Health Care. 2017;9(2):51-58.

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sdiarticle4.com/review-history/56753