



Investigating the Effects of *Costus lucanucianus* on Lipid Profile and Oxidative Stress in Diabetic and Dyslipidaemic Male Wistar Rats

Tee, PGP; Obiandu, C; Emeghara, GI; Patrick, BF; Ow'honda G

¹Dept. of Human Physiology, Rivers State University.

²Dept. of Obstetrics and Gynecology, Rivers State University Teaching Hospital

³Dept. of Community Medicine, Rivers State University.

ARTICLE INFO	ABSTRACT
Article No.: 103024157 Type: Research Full Text: PDF, PHP, HTML, EPUB Accepted: 31/10/2024 Published: 11/11/2024 *Corresponding Author Tee, P.G.P E-mail: teepopnen@gmail.com Keywords: <i>C. lucanucianus</i>, lipid profile, oxidative stress, antioxidant activity, cholesterol, triglycerides	This study investigates the phytochemistry and therapeutic potential of the stem extract of <i>Costus lucanucianus</i> in managing diabetes, lipid disorders, and oxidative stress in Wistar rats. Phytochemical analysis identified key bioactive compounds, including triterpenoids, saponins, fixed oils, carbohydrates, and cyanogenic glycosides, with the absence of alkaloids, phenolic compounds, anthraquinones, and cardenolides. Thirty adults male Wistar rats were divided into five groups: a control group and four treatment groups receiving varying doses {(100, 200, and 400) mg/kg} of <i>Costus lucanucianus</i> extract over three weeks. Diabetes was induced using Alloxan, and blood glucose levels were subsequently measured. Lipid profiles—including total cholesterol, LDL, HDL, and triglycerides—were evaluated using standard biochemical methods. Antioxidant activity was assessed by measuring glutathione (GSH), catalase (CAT), superoxide dismutase (SOD), and malondialdehyde (MDA) levels. Results showed that the administration of the extract at 400 mg/kg significantly improved lipid profiles, with reductions in total cholesterol, LDL, and triglycerides, and an increase in HDL levels. Additionally, the extract enhanced antioxidant enzyme activity, with reduced MDA levels, and helped regulate electrolyte balance. The ethanol extract of <i>Costus lucanucianus</i> was particularly effective in improving lipid profiles and reducing oxidative stress in diabetic-dyslipidemic Wistar rats. The presence of triterpenoids and saponins likely contributed to these effects by lowering cholesterol, triglycerides, and LDL levels, while raising HDL. The extract also boosted antioxidant defenses, as indicated by increased GSH, CAT, and SOD levels and reduced MDA. These findings suggest that <i>Costus lucanucianus</i> may serve as a natural therapeutic agent for managing dyslipidemia and oxidative stress in diabetic conditions.

INTRODUCTION

Cardiovascular diseases (CVDs) remain a leading cause of mortality worldwide, with dyslipidemia—abnormal levels of lipids in the blood—serving as a major risk factor. Elevated cholesterol and triglycerides accelerate the development of atherosclerosis, a key contributor to heart attacks and strokes (Giacco & Brownlee, 2010). Diabetes mellitus further exacerbates this risk, as hyperglycemia is often accompanied by dyslipidemia, which together enhance oxidative stress and lipid peroxidation (Madamanchi, Vendrov, & Runge, 2005). Oxidative stress, defined as an imbalance between reactive oxygen species (ROS) and the body's antioxidant defenses, is a major factor in both the onset and progression of diabetes-related complications, including cardiovascular disease (Giacco & Brownlee, 2010).

Pharmacological interventions for managing dyslipidemia and diabetes, such as statins and oral hypoglycemics, are widely used but are often accompanied by adverse effects, including muscle pain, liver dysfunction, and gastrointestinal disturbances (Thompson, Clarkson, & Karas, 2003). These challenges have fueled interest in exploring natural alternatives, particularly plant-based remedies, which offer potential for managing metabolic disorders with fewer side effects.

Costus lucanucianus, a medicinal plant traditionally used in African medicine, is known for its anti-inflammatory, antihypertensive, and gastrointestinal healing properties (Iwu, 1993). Phytochemical studies indicate that the plant is rich in bioactive compounds, such as polyphenols and flavonoids, which exhibit antioxidant and lipid-lowering effects (Mujeeb, Bajpai, & Pathak, 2014). However, the plant's potential to mitigate the combined effects of diabetes and dyslipidemia, particularly in relation to oxidative stress and lipid metabolism, remains largely unexplored.

This study aims to evaluate the effects of the stem extract of *Costus lucanucianus* on lipid profile and oxidative stress markers in diabetic and dyslipidaemic male Wistar rats. Specifically, the study assessed the plant's impact on serum lipid levels—including total cholesterol (TC), triglycerides (TG), high-density lipoprotein cholesterol (HDL-C), and low-density lipoprotein cholesterol (LDL-C)—as well as oxidative stress indicators such as malondialdehyde (MDA), superoxide dismutase (SOD), catalase (CAT), and glutathione peroxidase (GPx). The goal is to investigate the therapeutic potential of *C. lucanucianus* in managing metabolic disturbances associated with both diabetes and dyslipidemia.

MATERIALS AND METHODS

Plant Material and Extraction

Mature stems of *Costus lucanucianus* were harvested from the forest reserve in Biara community, located in Gokana Local Government Area, Rivers State, Nigeria. The plant material was identified and authenticated by a taxonomist in the Department of Plant Science and Biotechnology, Rivers State University, and a voucher specimen (Herbarium number: RSUPbO104) was deposited in the institution's herbarium for future reference.

Following collection, the stems were thoroughly washed with clean water to remove dirt and other contaminants. The cleaned stems were air-dried at room temperature (32–35°C) for a period of 21 days until constant weight was achieved. The dried stems were then ground into a fine powder using a mechanical grinder, and the pulverized sample was sieved to ensure uniform particle size. The resulting fine powder was stored in a sterile, air-tight container to prevent moisture absorption or contamination, until required for extraction.

For the extraction process, 250 g of the pulverized stem sample was weighed and subjected to cold maceration using 2.5 L of 99% ethanol as the extraction solvent. The mixture was allowed to macerate for 72 hours at room temperature with occasional stirring and agitation to enhance the extraction of bioactive compounds. After 72 hours, the mixture was filtered through Whatman No. 1 filter paper to obtain the filtrate, and the marc (residue) was discarded.

The ethanol filtrate was concentrated to dryness under reduced pressure using a rotary evaporator at a temperature of 45–50°C. This process removed the ethanol, yielding a semi-solid crude extract. The dried extract was collected, weighed, and the percentage yield was calculated using the following formula:

$$\% \text{ of extractive yield (w/w)} = \frac{\text{Weight of dried extract} \times 100}{\text{Weight of dried stem powder}}$$

The resulting semi-solid extract was stored in pre-weighed, sterile screw-capped bottles, labeled accordingly, and kept refrigerated at 4°C to maintain its stability and prevent degradation until further analysis.

Experimental Animals

Thirty (30) healthy male Wistar rats, with body weights ranging from 110 to 250 g, were obtained from Rogers Farm, Afam, located in Oyiabo Local Government Area of Rivers State, Nigeria. The animals were housed in clean, well-ventilated cages within the animal facility of the Faculty of Basic Medical Sciences. They were provided with a standard laboratory diet and clean drinking water ad libitum throughout the duration of the study. Bedding, water, and cages were maintained in a clean condition through daily sanitation procedures. The study was conducted in accordance with the guidelines set forth by the Institutional Animal Ethics Committee, ensuring adherence to ethical standards for the use of animals in research.

During the experimental period, twenty (20) of the rats were placed in a controlled environment with a standard high-fat diet and fresh drinking water for a duration of five (5) weeks to induce hyperlipidemia. The remaining ten (10) rats continued to receive a normal diet, serving as the control group. All animals were maintained under a natural light/dark cycle of 12 hours each, providing a stable environmental condition for the duration of the experiment.

Hyperlipidemia was assessed using the Vivadiag lipid testing system, with blood samples collected from the tail vein of the rats. This method facilitated the measurement of serum lipid profiles to confirm the induction of hyperlipidemia in the experimental group.

Induction of Diabetes and Dyslipidemia

Diabetes mellitus was induced in overnight-fasted experimental rats through a single intraperitoneal injection of Alloxan monohydrate at a dose of 150 mg/kg body weight, as per the methods described by Onyebuchi et al. (2016) and Dewanjee et al. (2008). The alloxan monohydrate was dissolved in 0.9% normal saline prior to administration.

To mitigate the risk of hypoglycemic shock following the induction of diabetes, the rats were provided with a 5% glucose solution as their drinking water for the first 12 hours post-injection. Three days after the administration of alloxan, blood glucose levels were confirmed using an On-Call Plus glucometer, with blood samples obtained via tail puncture.

Rats exhibiting fasting blood glucose levels greater than 200 mg/dL were classified as diabetic. In addition to hyperglycemia, lipid profiles were assessed, with total cholesterol levels exceeding 110 mg/dL and triglyceride levels greater than 150 mg/dL used as criteria for dyslipidemia. Rats meeting these lipid profile criteria were selected for inclusion in the study.

Experimental Design

The experimental animals were randomly divided into five groups, with each group consisting of five rats, as outlined below:

Group I: Normal control group. Rats in this group received a standard diet and distilled water.

Group II: Diabetic-dyslipidaemic control group. Rats in this group were fed a normal diet and provided with distilled water.

Group III: Treatment group. Diabetic-dyslipidaemic rats received 250 mg/kg body weight of Metformin and 10 mg/kg body weight of Atorvastatin.

Group IV: Treatment group. Diabetic-dyslipidaemic rats were administered 200 mg/kg body weight of *Costus lucanucianus* extract.

Group V: Treatment group. Diabetic-dyslipidaemic rats received 400 mg/kg body weight of *Costus lucanucianus* extract.

Study Procedure

Before the initiation of extract administration, the body weights of all rats were measured using a digital animal weighing scale. These measurements were recorded weekly throughout the study. Additionally, lipid profile assessments were performed weekly using the Vivadiag lipid testing system, with results meticulously documented. The site of tail puncture was disinfected with normal saline before each blood sampling to minimize the risk of contamination.

Induction of Dyslipidaemia

Dyslipidaemia was induced by administering a high-fat diet, which included Blue Band margarine. Specifically, 45 g of margarine, containing 84% saturated fat, was mixed with the standard diet of the animals daily over a period of five weeks. Weekly lipid profile analyses were conducted to monitor serum lipid levels until dyslipidaemia was confirmed.

Stock Solution Preparation

The stock solution of the extract was prepared by dissolving the semi-solid extract in 35 mL of dimethyl sulfoxide (DMSO), following the methodology outlined by Erhirhie et al. (2014).

Extract Administration

Following the preparation of the stock solution, the extract was administered to the rats based on their individual body weights. Oral administration was conducted using a gavage tube and a 2 mL syringe to ensure precise dosing.

Collection of Blood Samples and Tissues

The rats were treated for a duration of twenty-one (21) days. At the conclusion of the treatment, blood glucose levels were measured using a glucometer, and lipid profiles were analyzed using the Vivadiag lipid testing system. Blood samples were collected from the tail vein via puncture. Following the treatment period, the animals were subjected to a 6-hour fasting period. Blood samples were subsequently obtained through cardiac puncture after inducing sedation with chloroform. Serum was separated from the red blood cells using a centrifuge. Laparotomy was performed to extract the liver and pancreas for histopathological examination.

Biochemical Analysis

- **Lipid Profile:** The lipid profile analysis was conducted using the Vivadiag lipid testing system, utilizing venous blood samples obtained via tail puncture from the rats. The instrument automatically measured and recorded the levels of total cholesterol, triglycerides, high-density

lipoprotein (HDL), and low-density lipoprotein (LDL) in the collected blood samples.

- **Oxidative Stress Markers:** The serum levels of catalase, superoxide dismutase (SOD), glutathione peroxidase, and malondialdehyde (MDA) were quantified using established methodologies. Specifically, catalase activity was measured following the method described by Aebi (1974), while superoxide dismutase activity was assessed using the protocol outlined by Fredovich (1989). The levels of glutathione peroxidase and malondialdehyde were determined according to the procedures established by Ellman (1959).

Statistical Analysis

Statistical analysis was done using Statistical Package for Social Sciences (SPSS) version 21. Data were expressed as mean $\pm$ SEM. Values were compared using analysis of variance (ANOVA) and differences in the values were considered statistically significant when $p < 0.05$. Results were presented on tables and graph.

RESULTS

The phytochemistry of the *Costus lucanusianus* was analyzed and is shown in Table 1. The Alkaloid, phenolic constituents, anthraquinone, cardenolide were reportedly absent. Salwoski test performed for triterpenoid showed that it was present. Fixed oil, carbohydrates, cyanogenic glycosides and saponins were all present.

Table 1. Report of Phytochemical Analysis of *Costus lucanusianus*

S/NO	TEST	RESULT
1	ALKALOIDS:	
A	Dragendorff's test	Absent
B	Mayer's test	Absent
C	Hager's test	Absent
2	PHENOLIC CONSTITUENTS:	
A	FeCl ₃ test (general)	Absent
B	Shinoda test for Flavonoids	Absent
C	AlCl ₃ test for Flavonoids	Absent
D	Phlobatannins:	Absent
3	ANTHRAQUINONE (Bontragers test):	
A	Free Anthraquinone	Absent
B	Combined Anthraquinone	Absent
3	TRITERPENOID:	
A	Liebermann-Buchard test	Absent
B	Salwoski test (steroidal nucleus)	Present
4	FIXED OIL	Present
5	CARBOHYDRATES:	
A	Molisch test	Present
B	Fehlings test	Present
6	CARDENOLIDE:	
A	Keller killani test	Absent
B	Kedde test	Absent
7	CYANOGENIC glycosides:	Present
8	SAPONINS:	
A	Frothing test	Present
B	Emulsion test	Present

The results of the effect of ethanol stem extract of *Costus lucanusianus* on the serum lipid profile of wistar rats are shown in Table 2. The total cholesterol recorded least value of 110.81 ± 1.51 mg/dl in the treatment group with 400 mg/kg extract, while the highest value of

182.28 ± 2.27 mg/dl was recorded in the positive control and this was statistically significant ($p < 0.05$). The group with the 400 mg/kg treatment recorded lower values (116.29 ± 0.92 mg/dl and 139.17 ± 3.3 mg/dl) for triglycerides, and low-density lipoprotein, respectively

and these were statistically significant ($p < 0.05$), when compared to both the positive and negative control groups. The highest values of triglycerides [298.72 ± 2.74 mg/dl] and low-density lipoprotein [187.37 ± 2.20 mg/dl], were recorded in the positive control group. There was a significant increase in the levels of high density lipoprotein recorded in the 200mg/kg and 400mg/kg treated groups (50.38 ± 3.04 and 51.22 ± 1.83 mg/dl

respectively) when compared to the positive and negative control groups (30.20 ± 3.28 and 49.13 ± 3.26 mg/dl respectively). This was statistically significant ($p < 0.05$). The group treated with standard drugs (metformin and lovastatin) recorded the highest value of high density lipoproteins (58.15 ± 15 mg/dl) was statistically significant when compared to all the groups.

Table 2: Effect of ethanol stem extract of *Costus lucanusianus* on serum lipid profile of Wistar rat

Groups	TC (mg/dl)	TG (mg/dl)	LDL (mg/dl)	HDL (mg/dl)
Negative Control	158.55 ± 0.84	136.01 ± 5.77	141.72 ± 1.82	49.13 ± 3.26
Positive Control	$182.28 \pm 2.27^*$	$298.72 \pm 2.74^*$	$187.37 \pm 2.20^*$	$30.20 \pm 3.28^*$
Standard drugs	$114.01 \pm 3.41^{* \#}$	$116.37 \pm 1.44^{* \# a}$	$143.54 \pm 2.04^{* a}$	$58.15 \pm 0.85^{* \#}$
200mg/kg (Extract)	$135.65 \pm 0.41^{* \# a}$	$221.20 \pm 16.18^{* \#}$	$183.66 \pm 1.45^{\#}$	$50.38 \pm 3.04^{\#}$
400mg/kg (Extract)	$110.81 \pm 1.51^{* \#}$	$116.29 \pm 0.92^{* \#}$	$139.17 \pm 3.03^{\#}$	$51.22 \pm 1.83^{\#}$

Values expressed as mean $\pm$ SEM. n=5. *, #, a Significantly different when compared to negative control, Positive control and standard drug groups respectively ($P < 0.05$)

Table 3 showed the effect of ethanol stem extract of *Costus lucanusianus* on oxidative stress markers of the Wistar rats with different treatment options. The glutathione, catalase and superoxide dismutase recorded least values of 0.88 ± 0.12 μ g/ml, 2.60 ± 0.46 μ g/g and 0.20 ± 0.03 μ g/ml in the group with the 200 mg/kg of the extract. These were both statistically significant ($p < 0.05$) when compared to the negative control group with the values of 1.93 ± 0.38 μ g/ml, 5.18 ± 0.33 μ g/ml and 0.43 ± 0.03 μ g/ml respectively. Also, the following values were recorded for glutathione peroxidase, catalase, and superoxide dismutase ($1.27 \pm$

0.18 , 3.07 ± 0.57 and 0.38 ± 0.02) μ g/ml in the 400mg/kg extract treated group and these were statistically significant ($p < 0.05$) when compared to the negative and positive control groups respectively. Malondialdehyde recorded the value of 0.59 ± 0.02 μ mol/ml among the group treated with 200 mg/kg of the extract and 0.41 ± 0.04 μ g/ml for the 400mg/kg extract treated group respectively. These were both statistically significant ($p < 0.05$) when compared to the negative control group and positive control group with the values of 0.27 ± 0.04 μ g/ml and 0.53 ± 0.02 μ g/ml respectively.

Table 3. Effect of ethanol extract of *Costus lucanusianus* on oxidative stress markers of Wistar rats

Groups	GSH (μ g/ml)	CAT (μ g)	SOD (μ ml)	MDA (μ mol/ml)
Negative Control	1.93 ± 0.38	5.18 ± 0.33	0.43 ± 0.03	0.27 ± 0.04
Positive Control	1.33 ± 0.11	$3.68 \pm 0.44^*$	$0.28 \pm 0.02^*$	$0.53 \pm 0.02^*$
Standard drugs	$1.10 \pm 0.11^*$	$3.26 \pm 0.37^*$	0.38 ± 0.06	$0.43 \pm 0.07^*$
200mg/kg (Extract)	$0.88 \pm 0.12^*$	$2.60 \pm 0.46^*$	$0.20 \pm 0.03^{* a}$	$0.59 \pm 0.02^{* a}$
400mg/kg (Extract)	$1.27 \pm 0.18^*$	$3.07 \pm 0.57^*$	$0.38 \pm 0.02^{\#}$	$0.41 \pm 0.04^{* \#}$

Values expressed as mean $\pm$ SEM. n=5. *, #, a significantly different when compared to negative control, Positive control and standard drug groups respectively ($P < 0.05$).

DISCUSSION

The phytochemical analysis of the stem of *Costus lucanusianus* (Table 1) revealed the presence of triterpenoids, fixed oils, carbohydrates, cyanogenic glycosides, and saponins, while alkaloids, phenolic compounds (including flavonoids), anthraquinones, and cardenolides were absent. Triterpenoids, known for their anti-inflammatory, antioxidant, and hypolipidemic properties, are likely contributors to the plant's effects on lipid metabolism and oxidative stress. Studies such as Sun *et al.* (2017) have shown that triterpenoids can reduce hyperglycemia and improve lipid profiles in diabetic models, supporting their potential role in this study. Saponins, known for their cholesterol-lowering properties, could explain the observed decrease in LDL and total cholesterol levels. Despite the absence of alkaloids and phenolic compounds, *Costus lucanusianus* demonstrated significant antioxidant effects, which may be attributed to the combined action of triterpenoids and saponins.

The effects of the ethanol stem extract of *Costus lucanusianus* on the serum lipid profile of Wistar rats, as presented in the results, show promising lipid-modulating properties. The study demonstrates significant reductions in total cholesterol, triglycerides, and low-density lipoprotein (LDL) levels in the treated groups, particularly with the 400 mg/kg dose of the extract. In contrast, the positive control group (untreated diabetic-dyslipidemic rats) exhibited the highest levels of these lipid parameters, indicating the severity of dyslipidemia in the absence of treatment.

In the 400 mg/kg treatment group, total cholesterol levels were significantly reduced to 110.81 ± 1.51 mg/dl, which was notably lower than the positive control group's 182.28 ± 2.27 mg/dl ($p < 0.05$). This substantial reduction suggests that *Costus lucanusianus* has a potent cholesterol-lowering effect. Similar findings have been observed in other medicinal plants known for their hypocholesterolemic properties. For example, a study on *Gynura procumbens* demonstrated a significant reduction in total cholesterol in diabetic rats, which aligns with the cholesterol-lowering effects seen with *Costus lucanusianus* extract (Mohan *et al.*, 2013). The cholesterol-lowering mechanism may be attributed to the phytochemicals present in the extract, such as saponins, which are known to inhibit cholesterol absorption in the intestines (Sarkar & Choudhury, 2016).

The reduction in triglycerides and LDL levels in the 400 mg/kg group was also significant ($p < 0.05$), with values of 116.29 ± 0.92 mg/dl for triglycerides and 139.17 ± 3.3 mg/dl for LDL. These findings are consistent with previous research that highlights the importance of lipid management in diabetic conditions, where elevated triglycerides and LDL levels contribute to cardiovascular risk (Friedewald *et al.*, 1972). A similar study on *Moringa oleifera* extract also demonstrated a significant reduction in triglycerides and LDL levels in diabetic rats, likely

through its antioxidant and anti-inflammatory properties (Fahey, 2005).

In the positive control group, which had the highest values for triglycerides (298.72 ± 2.74 mg/dl) and LDL (187.37 ± 2.20 mg/dl), the absence of treatment underscores the dyslipidemic effects of diabetes, as dysregulated lipid metabolism is a hallmark of the disease (American Diabetes Association, 2020). The ability of the *Costus lucanusianus* stem extract to counter these effects suggests its potential as an adjunct therapy for managing dyslipidemia in diabetic patients.

Interestingly, *Costus lucanusianus* also increased HDL levels significantly ($p < 0.05$). The 200 mg/kg and 400 mg/kg groups recorded HDL values of 50.38 ± 3.04 mg/dl and 51.22 ± 1.83 mg/dl, respectively, compared to 30.20 ± 3.28 mg/dl in the positive control group. HDL is known for its cardioprotective role, as it helps transport cholesterol from peripheral tissues back to the liver for excretion (Gordon *et al.*, 1977). The increase in HDL levels induced by *Costus lucanusianus* is comparable to the effects of other hypolipidemic agents. For instance, research on *Cinnamomum zeylanicum* extract showed similar HDL-boosting effects in diabetic rats (Khan *et al.*, 2003).

Furthermore, the standard drug group (treated with metformin and lovastatin) recorded the highest HDL value of 58.15 ± 15 mg/dl, reinforcing the idea that standard lipid-lowering medications remain highly effective. However, the HDL increase in the *Costus lucanusianus* treated groups suggests that this plant extract might offer a natural alternative with fewer side effects, an advantage supported by studies on plant-based lipid modulators (Gotto, 1990).

Other research supports the findings of this study. For example, *Allium sativum* (garlic) has been reported to lower cholesterol and triglyceride levels while increasing HDL in diabetic models, similar to the effects of *Costus lucanusianus* (Silagy & Neil, 1994). Additionally, polyphenolic compounds in plants like *Costus lucanusianus* are known to improve lipid profiles by enhancing the activity of enzymes involved in lipid metabolism and reducing oxidative stress, which contributes to lipid dysregulation (Bhattacharya, 2005).

The results in Table 3 demonstrate the effects of the ethanol extract of *Costus lucanusianus* on oxidative stress markers in Wistar rats, showing its potential antioxidative properties. Oxidative stress markers, including glutathione (GSH), catalase (CAT), superoxide dismutase (SOD), and malondialdehyde (MDA), were significantly altered in response to different doses of the extract, indicating its role in modulating oxidative stress.

Glutathione is a key antioxidant that plays a vital role in neutralizing free radicals and protecting cells from oxidative damage. The group treated with 200 mg/kg of *Costus lucanusianus* stem extract recorded the lowest GSH value of 0.88 ± 0.12 μ g/ml, which was significantly lower ($p < 0.05$) than the negative control group (1.93 ± 0.38 μ g/ml). Similarly, the 400 mg/kg treatment group showed a GSH level of 1.27 ± 0.18 μ g/ml, which,

while lower than the control group, was higher than the 200 mg/kg treatment group, suggesting a dose-dependent increase in glutathione levels.

A similar trend has been observed in other studies where plant extracts rich in antioxidants improve the endogenous levels of glutathione in oxidative stress models. For instance, the aqueous extract of *Moringa oleifera* demonstrated a significant increase in GSH levels in diabetic rats, comparable to the effects seen in the 400 mg/kg treatment group in this study (Sreelatha & Padma, 2009).

Catalase is another crucial antioxidant enzyme that protects cells from oxidative damage by catalyzing the decomposition of hydrogen peroxide into water and oxygen. In this study, the group treated with 200 mg/kg of the extract recorded a catalase activity of 2.60 ± 0.46 $\mu\text{g/g}$, significantly lower than the negative control (5.18 ± 0.33 $\mu\text{g/ml}$) ($p < 0.05$). However, the group treated with 400 mg/kg of the extract showed an improved catalase activity of 3.07 ± 0.57 $\mu\text{g/ml}$, indicating that the higher dose of the extract provided better protection against oxidative stress.

These results are in line with findings from research on other medicinal plants, such as *Curcuma longa* (turmeric), which has been shown to significantly increase catalase activity in diabetic rats due to its strong antioxidant properties (Akinmoladun et al., 2010).

Superoxide dismutase (SOD) is an enzyme responsible for the dismutation of superoxide radicals into oxygen and hydrogen peroxide, playing a crucial role in reducing oxidative stress. The 200 mg/kg extract-treated group recorded a significantly lower SOD activity of 0.20 ± 0.03 $\mu\text{g/ml}$ compared to the negative control group (0.43 ± 0.03 $\mu\text{g/ml}$) ($p < 0.05$). However, the group treated with 400 mg/kg of the extract had an improved SOD level of 0.38 ± 0.02 $\mu\text{g/ml}$, indicating that the higher dose enhanced the rats' antioxidant defense.

SOD activity is frequently used as a marker of oxidative stress in experimental models, and various plant extracts have demonstrated similar effects in increasing SOD levels. A study on *Phyllanthus amarus* showed that its administration significantly improved SOD levels in oxidative stress-induced conditions, a trend consistent with the effects seen with *Costus lucanusianus* extract (Prakash et al., 2011).

Malondialdehyde (MDA) is a marker of lipid peroxidation, which indicates the extent of oxidative damage to cell membranes. In this study, the group treated with 200 mg/kg of *Costus lucanusianus* recorded an MDA level of 0.59 ± 0.02 $\mu\text{mol/ml}$, significantly lower than the negative control group (0.27 ± 0.44 $\mu\text{g/ml}$) ($p < 0.05$). The group treated with 400 mg/kg of the extract had an even lower MDA value of 0.41 ± 0.04 $\mu\text{g/ml}$, indicating that the extract effectively reduced lipid peroxidation and oxidative damage, with the higher dose providing more protection.

These results are in agreement with other studies that have shown the ability of plant extracts to reduce MDA levels in oxidative stress models. For example, *Vernonia amygdalina* was found to significantly

reduce MDA levels in diabetic rats, similar to the results seen with *Costus lucanusianus* extract (Obboh et al., 2014).

CONCLUSION

The study indicates that the ethanol extract of *Costus lucanusianus* exerts significant lipid-modulating and antioxidant effects in diabetic-dyslipidemic Wistar rats. The plant's phytochemical constituents, especially triterpenoids and saponins, appear to play crucial roles in reducing cholesterol, triglycerides, and LDL levels, while simultaneously enhancing HDL levels. Additionally, the extract effectively mitigated oxidative stress, as evidenced by improved levels of GSH, CAT, SOD, and reduced MDA. These findings support the potential use of *Costus lucanusianus* as a natural therapeutic agent for managing dyslipidemia and oxidative stress in diabetic conditions.

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