



## **Synergistic Effect of Coconut Water and Garlic Tincture on Lipids and Oxidative Profile of Albino Rats Treated with High Fat Diet and Alcohol**

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### **Authors' contributions**

*This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.*

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### **ABSTRACT**

**Aim:** This study evaluated the combined effect of coconut water and garlic tincture on lipid and antioxidants profile of albino rats fed with high fat diet and alcohol.

**Study Design:** This study is a non-randomized experimental study design.

**Place and Duration of Study:** Rivers State University Chemical Pathology Laboratory, Department of Medical Laboratory Science, the study was done between 20<sup>th</sup> November, 2018-30<sup>th</sup> June 2019.

**Methodology:** A total number of 45 Wister albino rats were used with the weight ranged from 120-200 grams. The animals were grouped into two major groups, the control Group A and the test Group B. Blood samples were collected via cardiac puncture into heparinized bottle for standard laboratory investigation of lipid profile, and Superoxide dismutase (SOD), Total antioxidant capacity (TAC) and Malondialdehyde (MDA). Plasma SOD and MDA were determined using ELISA methods, TAC was determined using FRAP Colorimetric method while lipid profile were determined using enzymatic method.

**Results:** The results revealed that, alcohol induced oxidative stress group exhibited significant differences in MDA levels amongst the groups, and no significance differences in SOD and TAC

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levels as compared with negative control groups. There were significant differences in the Total Cholesterol and low density lipoprotein levels, amongst the groups. However, these changes appear to improve with coconut water and garlic tincture treatment. Treatment with coconut water alone following 30% alcohol treatment, showed a significant decrease in MDA level, no significant increase in SOD and TAC. Similar observation was recorded for the garlic tincture treatment alone. Treatment with low dose of combined coconut water with garlic tincture following 30% alcohol treatment, shows significant decrease in MDA level, significant increase in SOD, no significant increase in TAC. Treatment with low and higher doses of combined coconut water with garlic tincture following HFD treatment showed similar results, no significant decrease in TG levels, a significant decrease in MDA, TC and LDL levels, a significant increase in TAC and HDL levels and no significant increase in SOD. However, no difference was observed at higher dose. Histological findings revealed changes in hepatocellular architecture, such as inflammatory cell aggregates, dilation of sinusoidal space, fatty droplet after treatment with alcohol and high fat diet. However, upon garlic tincture and coconut water treatment, there was amelioration of these abnormalities.

**Conclusion:** The mixture of coconut water and garlic tincture seem to exerted an antioxidant and antiatherogenic effect on alcohol-induced oxidative stress and HFD-induced dyslipidaemia in rats.

*Keywords: Antioxidant; alcohol; hyperlipidemia; coconut-water; garlic; tincture.*

## 1. INTRODUCTION

Coconut water in its natural form is a nutritious and refreshing beverage that is consumed all over the globe due to its beneficial properties [1,2,3]. However, part of which is dependent upon cultural belief [4,1]. Coconut water has been used for ages as food and medicines. The medicinal importance is applied as oral rehydration, treatment of gastroenteritis, diarrhea, cholera and others; and these benefits have successfully been applied in several parts of the world today [2]. Coconut water is sterile and contains both inorganic and organic compounds which are important in assisting the antioxidant system of the body [5].

Garlic is a widely distributed plant. Garlic (*Allium sativum*) is a commonly used for flavoring and has been traditionally popular in Nigeria [6]. Garlic contains compounds that are aromatic sulphur based, which contribute to its characteristic odour and taste [7]. It has been use over the years for its medicinal purposes [8].

Garlic tincture preparation involves infusion of garlic in alcohol or distilled water. Garlic is macerated in one of these liquids, and then pressed to release all of the potent chemicals that make garlic such a boon to good health.

Oxidative stress tends to occur when there is a disturbance such that the equilibrium between free radicals or reactive oxygen species (ROS) and the endogenous defense mechanisms is altered. It is simply put as the disturbance in the balance between oxidant-antioxidant states

which favours the production of oxidant species over antioxidant. Oxidative stress has been involved in so many notable diseases like heart disease, kidney disease, liver disease, diabetes, cancer and so on. Oxidative stress plays key role roles in hastening aging, inflammation, and as well contributes in variety of degenerative disease conditions such as, atherosclerosis, cardiovascular diseases, cancer, kidney diseases, liver diseases, cataract, central nervous system disorders, Alzheimer's disease, etc. [9]. Oxidative stress can exert its damage to the body via DNA oxidation, proteins oxidation and lipids peroxidation. Once low density lipoprotein (LDL) is oxidized it's then taken up by macrophages to form foam cells which lead to atherosclerosis. Hyperlipidemia which is known for high plasma level of triglyceride, total cholesterol and low density lipoprotein (LDL), and decreased high density lipoprotein (HDL), is a risk factor of cardiovascular disease. Research has shown close relationship between oxidative stress and low HDL [10], and high plasma, LDL and triglycerides levels [11]. Lipid peroxidation, an index of oxidative stress also correlated with low HDL levels, irrespective of age, gender [12]. Oxidative stress has been implicated in various pathological processes that may lead to injury to all the important cellular components which lead to many disease conditions. More also, hyperlipidemia contributes to the high risk of cardiovascular disease and has consequently caused death. There is a growing concern in our society on the simpler and cost effective way of reducing hyperlipidemia that has no severe side effect.

Over the years, garlic and coconut water have been used as spice and drink respectively, which have generated a lot of interest throughout human history as a medicinal panacea. There is a dearth of information on the synergistic effect of combine coconut water and garlic tincture on oxidative stress and dyslipidemia. This study examined the combine effect of coconut water and garlic tincture in oxidative stress and dyslipidemic condition.

## 2. MATERIALS AND METHODS

### 2.1 Experimental Animals and Design

A total number of 45 Wistar albino rat (*Ratus rattus*) with weight ranged from 120-200 grams were used for this study. The rats were housed in standard cage with a habituation condition of 25–32°C and the relative humidity of 45 ± 5% with 12 hours' light and dark cycle. The animals were allowed to feed *ad libitum* for 10 days to acclimatize with the new housing condition. The following approach was employed in grouping the animals; the animals were grouped into two groups, control GROUP A and test Group B subjected to different treatment as shown in the table below.

### 2.2 Plant Selection and Authentication

Coconut and garlic were purchased from local market and certified by a Botanist.

#### 2.2.1 Garlic tincture preparation and administration

Garlic tincture was prepared by method described by [13]. The dish was then weighed on a triple beam balance and the weight of extract was calculated as follows:

Weight of extract = weight of evaporating dish after evaporation – weight of evaporating dish before addition of extract. The filtrate was given to the rats at different concentration and at different time intervals for the period of 28 days. The administration of the treatment was via oral route after proper calculation of the dose was made for 200mg/kg/bw and 400mg/kg/bw of garlic tincture. The amount of the garlic in 1ml was determined by evaporating the tincture (using a rotary extractor at 40°C as described by [13]).

#### 2.2.2 Coconut water preparation and administration

The coconut water was collected and filtered for use. The administration of the treatment was via

oral route after proper calculation of the dose was made for 4ml/100g/ bw and 8ml/100g/bw of coconut water.

#### 2.2.3 High fat diet (HFD)

The high fat diet was prepared based method described by Marques et al., 2016.

### 2.3 Animal Sacrifice and Blood Collection

At the end of the treatment period, (28days) rats in all the groups were anaesthetized with chloroform and whole blood sample collection was by cardiac puncture into heparinized bottles, which was then centrifuged at 3,000 rpm for 10 minutes, then separated into plain bottles and labeled accordingly. They were stored in the laboratory freezer frozen (- 20°C) until the time for biochemical analysis.

After dissection, the livers were excised and collected in a sterile universal container containing 10% neutral formalin for tissue processing.

### 2.4 Determination of Biochemical Parameters

The Total Antioxidant capacity (TAC) in the sample was assayed using FRAP (Ferric antioxidant powder / ferric reducing ability of plasma) Colorimetric method (Benzie & Strain, 1996). Superoxide Dismutase (SOD) activity Rat SOD1 (Superoxide Dismutase 1, Soluble) assay procedure was done by ELISA method described by [14] Zhao et al., [13].

Malondialdehyde (MDA) assay procedure was done by ELISA method.

Triglyceride, total cholesterol, and high density lipoprotein were determined using enzymatic method. Low Density Lipoprotein (LDL) results were calculated using Friedwald Equation[15,14].

### 2.5 Histopathological Study

The experimental animals were sacrificed at the end of the 28 days of treatment. After dissection, the liver tissues were excised and collected in a sterile universal container containing 10% neutral formalin. The tissue sample was fixed in formaldehyde solution for 24hrs, then it was dehydrated in increasing grades of alcohol (75, 90, and 100% alcohol), the tissue was then cleared in 3 grades of xylene and embedded in molten wax, then allowed to solidify for proper

sectioning. The tissue was then section using microtome to get a thin section of 5µm which was then floated in water bath and incubated at 60°C for 30 minutes. Microscopic slide was used to collect the sample, then placed on a hot plate. When the tissue has properly adhered to the slide it was then dewaxed in 3 grades of xylene and hydrated in descending grades of alcohol (100, 90 and 75% respectively), washed in water and then stained with haematoxylin for 15 minutes. The slides were differentiated in acid-alcohol, blueing, then counterstained with Eosin-Y stain and xylene. Finally, the slides were mounted with a mounting medium called DPX (Distyrene, Plasticizer and Xylene) and then examined under the microscope using x100 objective. The photomicrography was taken using coupled microscope.

## 2.6 Statistical Analysis

The statistical analysis was carried out using analysis of variance (ANOVA) and Turkey's Multiple Comparison Test. The data were expressed as Mean ± Standard Deviation and at  $p < 0.05$ , data were considered significant. Graph pad prism 5.0 statistical software was used for the analysis

## 3. RESULTS AND DISCUSSION

### 3.1 Results

The comparison of oxidant and lipid profile of control and test groups as shown in table 2. There were no significant differences amongst groups A1, A2, B1, B2, and B3 for **SOD** ( $F=2.29$ ,  $P=0.0566$ ). Similar observation was recorded for **TAC** ( $F=2.522$ ,  $p=0.0848$ ).

However, there were significant differences amongst the control and test groups for **MDA** ( $F=17.3$ ,  $P=0.0001$ ). A2 was significantly higher than A1, comparison between A1 and B1, A1 and B2, A1 and B3 shows no significant difference, B1 was significantly lower than A2, B2 was significantly lower than A2, and, B3 was significantly lower than A2. There were no significant differences among A1, A2, B1, B2, and B3 for **TG** ( $F=2.8$ ,  $P=0.0617$ ), the same observations were recorded for **HDL** ( $F=1.538$ ,  $P=0.2416$ ).

However, there were significant differences among the control and test groups for **TC** ( $F=6.752$ ,  $P=0.0026$ ) and A2 was significantly higher than A1, B1 shows significant increase than A1, and the same was recorded between B2 and A1. There were significant differences amongst the control and test groups for **LDL** ( $F=4.896$ ,  $P=0.01$ ). A2 was significantly higher than A1.

**Table1. Grouping of experimental animals**

Groups	Treatments	Dosage/Administration
Group A1	Negative control	Distilled water + normal meal
Group A2	Positive control 1 (oxidative stress control)	7ml/kg/bw of 30% alcohol
Group A3	Positive control 2 (hyperlipidemic control)	High Fat Diet (HFD)
Group B1	Oxidative stress + coconut water	7ml/kg/bw of 30% alcohol + 4ml/100g/bw coconut water
Group B2	Oxidative stress + garlic tincture	7ml/kg/bw of 30% alcohol + 200mg/kg/bw of garlic tincture
Group B3	Oxidative stress + coconut water + garlic tincture	7ml/kg/bw of 30% alcohol + 4ml/100g/BW coconut water + 200mg/kg/bw garlic tincture
Group B4	Oxidative stress + increase dose coconut water + garlic tincture	7ml/kg/bw of 30% alcohol + higher dose of the coconut water and garlic tincture (8ml/100g/bw and 400mg/kg/bw respectively).
Group B5	hyperlipidemia + low coconut water + garlic tincture	High Fat Diet (HFD) + coconut water and garlic tincture (4ml/100g/BW and 200mg/kg/bw respectively).
Group B6	hyperlipidemia + coconut water + garlic tincture	High Fat Diet (HFD) + double dose of the coconut water and garlic tincture (8ml/100g/BW and 400mg/kg/bw respectively).

**Table 2. Antioxidant and lipids profile levels of control and test groups exposed to alcohol and treated with mixture of coconut water and garlic tincture**

GROUPS	SOD	TAC	MDA	TG	TC	HDL	LDL
A1 CONTL	2.025± 1.03	0.9 ± 0.36	73.93 ± 13.34	1.34 ±0.61	4.66 ± 0.40	1.23 ±0.19	2.93 ±0.38
A2 CONTL	0.63 ± 0.61	0.38 ± 0.19	227.55 ±70.76	1.92 ±0.13	6.17 ± 0.12	1.01 ± 0.05	4.28 ± 0.12
B1	1.8 ± 0.57	1.15 ± 0.47	82.93 ± 13.31	1.85 ±0.16	5.63 ± 0.42	1.13 ± 0.11	3.65 ± 0.46
B2	1.78 ± 0.82	0.85 ± 0.49	70.35 ± 12.89	1.85 ±0.05	5.67 ± 0.52	1.1 ± 0.08	3.73 ± 0.56
B3	2.25 ± 0.5	1.13 ± 0.39	65.5 ± 5.47	1.91 ±0.08	5.32 ± 0.53	1.10 ± 0.15	3.37 ± 0.58
p-value	0.0566	0.0848	< 0.0001	0.0617	0.0026	0.2416	0.01
F-values	2.927	2.522	17.3	2.839	6.752	1.538	4.896
Tukey's Mul	Summary	Summary	Summary	Summary	Summary	Summary	Summary
A1 vs A2	ns	Ns	***	ns	**	ns	**
A1 vs B1	ns	Ns	ns	ns	*	ns	ns
A1 vs B2	ns	Ns	ns	ns	*	ns	ns
A1 vs B3	ns	Ns	ns	ns	ns	ns	ns
A2 vs B1	ns	Ns	***	ns	ns	ns	ns
A2 vs B2	ns	Ns	***	ns	ns	ns	ns
A2 vs B3	*	Ns	***	ns	ns	ns	ns
B1 vs B2	ns	Ns	ns	ns	ns	ns	ns
B1 vs B3	ns	Ns	ns	ns	ns	ns	ns
B2 vs B3	ns	Ns	ns	ns	ns	ns	ns

**Table 3. Antioxidant and lipids profile levels of control and test groups exposed to HFD and treated with mixture of coconut water and garlic tincture**

<b>GROUPS</b>	<b>SOD</b>	<b>TAC</b>	<b>MDA</b>	<b>TG</b>	<b>TC</b>	<b>HDL</b>	<b>LDL</b>
A1 CONTL	2.025± 1.03	0.9 ± 0.36	73.93 ± 13.34	1.34 ± 0.61	4.66 ± 0.40	1.23 ± 0.19	5.94 ± 0.43
A3 CONTL	0.83 ± 0.33	0.38 ± 0.34	301.13 ± 36.08	2.09 ± 0.08	7.98 ± 0.29	0.96 ± 0.11	3.16 ± 0.54
B4	1.65 ± 0.81	1.1 ± 0.59	69.28 ± 8.89	1.80 ± 0.06	5.18 ± 0.46	1.22 ± 0.9	2.89 ± 0.35
B5	1.88 ± 0.49	0.7 ± 0.29	146.13 ± 44.26	1.47 ± 0.37	5.01 ± 0.20	1.46 ± 0.11	3.41 ± 0.76
B6	1.75 ± 0.65	0.95 ± 0.06	132.1 ± 48.42	1.09 ± 0.42	5.52 ± 0.59	1.62 ± 0.21	3.41 ± 0.76
p-value	0.1872	< 0.0001	0.0145	0.1061	< 0.0001	0.0002	< 0.0001
F-values	1.771	30.13	4.435	2.304	41.63	11.71	25.22
Tukey's Multiple Comparison Test	Summary	Summary	Summary	Summary	Summary	Summary	Summary
A1 vs A3	ns	***	ns	ns	***	***	***
A1 vs B4	ns	ns	ns	ns	ns	ns	ns
A1 vs B5	ns	ns	ns	ns	ns	ns	ns
A1 vs B6	ns	ns	ns	ns	ns	*	ns
A3 vs B4	ns	***	ns	ns	***	ns	***
A3 vs B5	ns	***	ns	ns	***	**	***
A3 vs B6	ns	***	*	ns	***	***	***
B4 vs B5	ns	*	ns	ns	ns	ns	ns
B4 vs B6	ns	ns	ns	ns	ns	*	ns
B5 vs B6	ns	ns	ns	ns	ns	ns	ns

There were no significant differences amongst A1, A2, B4, B5, and B6 for **SOD** ( $F=2.29$ ,  $P=0.0566$ ). However, there were significant differences amongst the control and test groups for **TAC** ( $F=30.13$ ,  $P=0.0001$ ). A3 was significantly lower than A1, B4 was significantly higher than A3, B5 was significantly higher than A3, and B6 was significantly higher than A3. Similarly, B5 was significantly higher than B4. There were significant differences amongst the control and test groups for **MDA** ( $F=4.435$ ,  $P=0.0145$ ). However, B6 was significantly lower than A3. Similarly, there were significant difference amongst the control and test groups for **TC** ( $F=41.63$ ,  $P=0.0001$ ). A3 was significantly higher than A1, B4 was significantly lower than A3, B5 was significantly lower than A3 and similarly, B6 was significantly lower than A3. There were significant difference among the control and test groups for **HDL** ( $F=11.71$ ,

$P=0.0002$ ). A3 was significantly lower than A1, B5 was significantly higher than A3, and B6 was significantly higher than A3. Similarly, B6 was significantly higher than B4. However, there were no significant difference between A1 vs B4, A1 vs B5, B4 vs B5, B5 vs B6, and A3 vs B4. There were significant differences among the control and test groups for **LDL** ( $F=25.22$ ,  $P=0.0001$ ). A3 was significantly higher than A1, B4 was significantly lower than A3, B5 was significantly lower than A3 and similarly, B6 was significantly lower than A3.

Micrograph of liver tissues of group A1 (Negative Control) magn.X400 H&E stain. Histology showing normal liver architecture with normal hepatocytes (HC), central vein (CV) and sinusoidal space (SP).

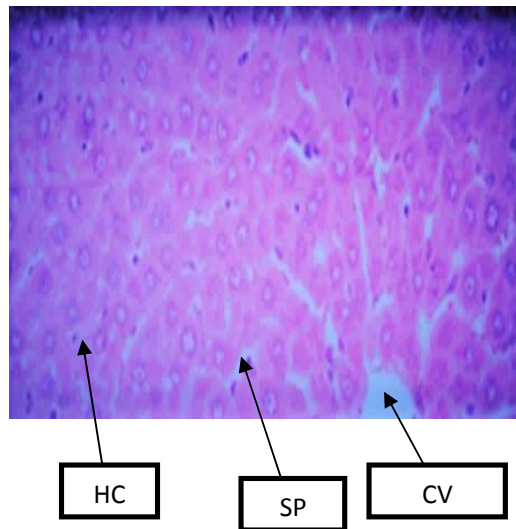


Plate 1. The histology of rat liver of the negative control group

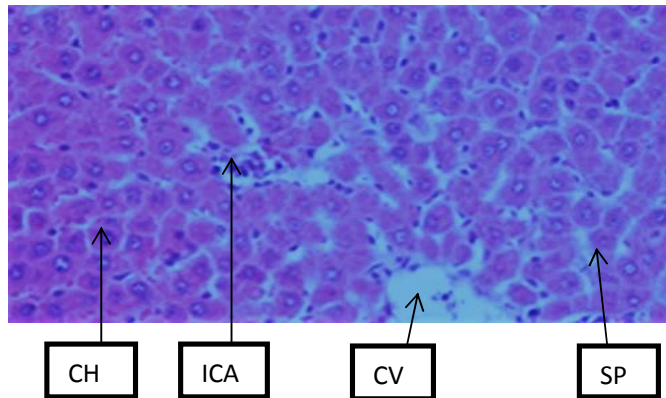


Plate 2. The histology of rat liver of the positive control group treated with alcohol only

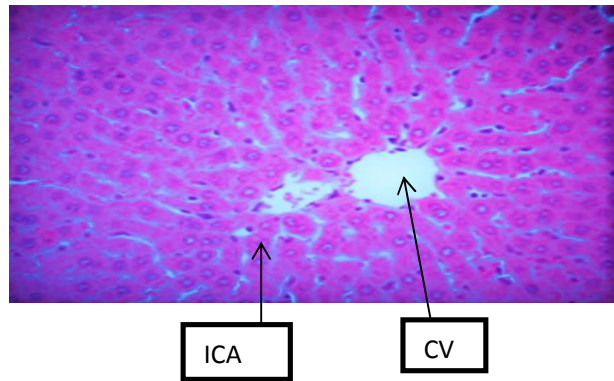


Micrograph of liver tissues of group A2 (Positive Control Group) magn.X400 H&E stain. Histology shows inflammatory cell infiltration (ICA), Cellular hypertrophy (CH), dilation of sinusoidal space (SP) and mild fatty changes.

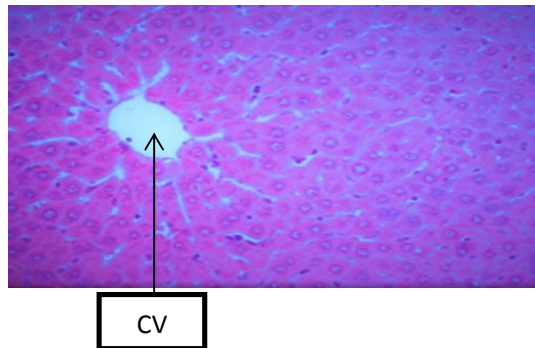
Micrograph of liver tissues of group B3 (4 ml/100 g/bw and 200 mg/kg/bw respectively) magn.X400 H&E stain. Histology shows reduced ethanol induced abnormalities such as vesicular fatty changes and inflammation cell aggregate.

Micrograph of liver tissues of group B4, The results of treatment groups supplemented with higher dose of coconut water and garlic tincture (i.e. 8 ml/100g/bw and 400mg/kg/bw respectively) shows normal appearance of hepatocytes.

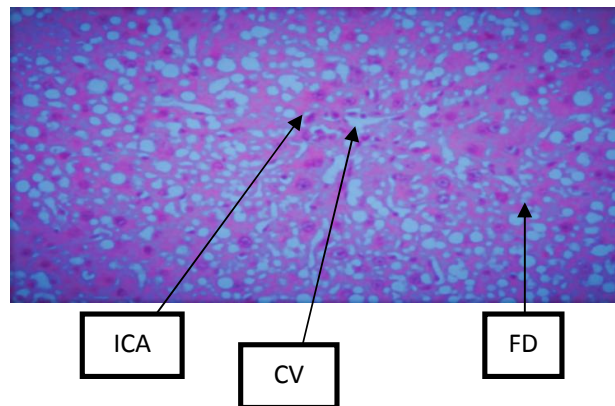
Micrograph of liver tissues of group A3 (high fat diet fed positive control group) shows rat liver abnormality such fatty droplet (FD), congestion of central vein (CV) and inflammatory cell aggregate(ICA) in hepatocytes.



**Plate 3. The histology of rat liver of the combined (4ml/100g/BW and 200mg/kg/bw)**

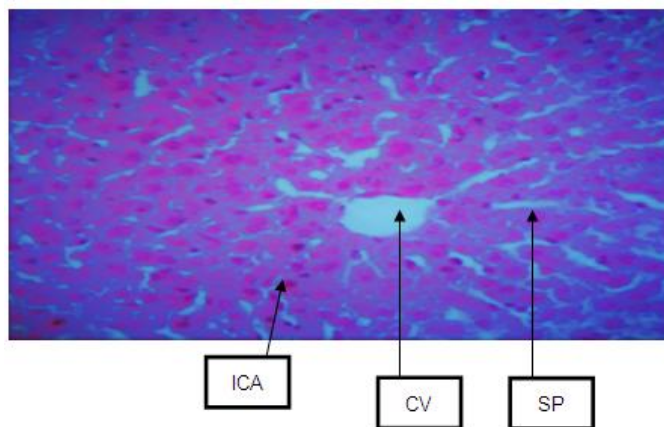


**Plate 4. The histology of rat liver of double dose (8ml/100g/BW and 400mg/kg/bw)**

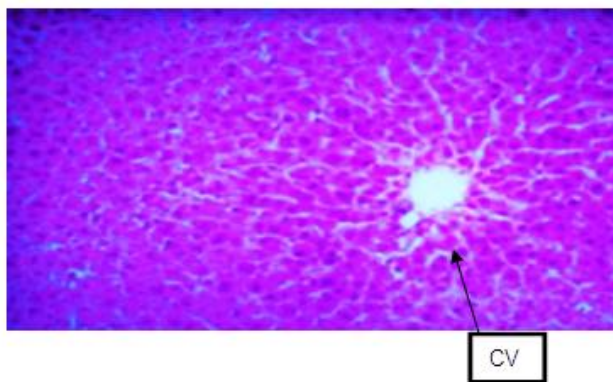


**Plate 5 The histology of rat liver of the Positive Control group treated with High Fat Diet**





**Plate 6. The histopathology of the rat liver of the group treated with low dose combined**



**Plate 7. The histology of rat liver of the group treated with double dose of the combined (8ml/100g/BW and 400mg/kg/bw)**

Micrograph of liver tissues of group B5 (low dose treatment). The histopathological findings revealed reduction of High Fat Diet-induced abnormalities such as vesicular fatty changes and inflammation.

Micrograph of liver tissues of group B6 (higher dose of treatment). The histology showing normal liver architecture with central vein (CV) and normal hepatocytes (HC).

#### 4. DISCUSSION

From the study, the findings revealed that group treated with 30% alcohol alone, had their plasma concentration of antioxidant enzyme superoxide dismutase (SOD) and Total antioxidant capacity (TAC) reduced though not statistically significant while their plasma malondialdehyde (MDA) significantly increased when compared with the normal control. This finding is in connection with what have been reported by [16], that excessive consumption of ethanol can to cause oxidative stress. The breakdown of alcohol leads to process of uncoupling the electron transport chain (ETC) causes increased production of free radicals such as  $H_2O_2$ , hydroxyl radical ( $\bullet OH$ -) and superoxide anion ( $O^-$ ). The enzyme, cytochrome P450 2E1 (CYP2E1) activity can also be induced by alcohol which in other hand metabolizes alcohol to produce reactive oxygen species (ROS) and this metabolism of alcohol can also enhance the production of other alcohol-derived free radicals such as 1-hydroxyethyl radical [17].

This study was attempted at investigating the possibility of coconut water and garlic tincture having a better health outcome when combined in modulating lipid and oxidant variables in rat fed with high fat diet (HFD) and alcohol-induced oxidation respectively. The results showed that treatment with garlic tincture alone were able to modulate lipid peroxidation as evident by the significant decreased in malondialdehyde (MDA), and mark improved level of superoxide dismutase (SOD) and total antioxidant capacity (TAC) which although were not statistically significant at  $p < 0.05$  level of significance. This finding is consistent with that recorded by [18] Numair [17], who reported that garlic is capable of reducing lipid peroxidation and improve antioxidant status. The reason for the variation may due to the difference in duration of treatment. Similar observation was recorded for those treated with coconut water only, which is in line with the findings by [19] Loki and Rajamohan

(2013), that coconut water significantly reduced lipid peroxidation in an experimental rat due to its content in vitamins C.

However, the administration with combined mixture of garlic tincture and coconut water when compared to the control group, proved to effectively modulate oxidative stress biomarkers concentrations by causing a significant increase in antioxidant enzymes and total antioxidant capacity (TAC) as well as significantly decreasing the plasma malondialdehyde (MDA) concentration which is evident by significant increase in Superoxide dismutase (SOD) and total antioxidant capacity (TAC), and a significant decrease in MDA level. Similar observation was recorded with the group administered with the increased dose of the combined. However, there were no significant difference recorded between the groups administered with single dose and those with increased dose of the combined.

The increase in antioxidant enzymes activity and the decreased level lipid peroxidation with malondialdehyde as a biomarker indicates that administration of coconut water help to lower hydrogen peroxide concentration and its decomposition and subsequently reduce oxidative stress. This is in line with [20] Bhagya et al., [19], who stated that coconut water increases the levels of antioxidant enzymes thereby decreasing tissue lipid peroxides.

Furthermore, [21] Vaidya, et al., [20], reported that garlic contains an active ingredient 2-propenesulfenic acid, that possesses an antioxidant property. Allicin (diallyl thiosulfinate) is the biologically active compound mainly found in the garlic extracts with antioxidant effect. Allicin is known to possess various biological activities including the antibacterial, antifungal, and inhibition of cancer promotion [7]. It has been reported that coconut water also contains micronutrients such as L-arginine, vitamin C (ascorbic acid), vitamin E ( $\alpha$ -tocopherol), which are biological antioxidants. Vitamin E ( $\alpha$ -tocopherol) acts as a 'chain breaker' for lipid peroxidation process in cell membranes and different lipid particles including low-density lipoprotein (LDL). Vitamin E act by intercepting lipid peroxy radicals ( $LOO^-$ ) and terminate the lipid peroxidation chain reactions [22,21].

The amino acid, L-arginine has been documented to have significantly inhibited the generation of the reactive oxygen species and lipid peroxidation. L-arginine is a source of nitric

oxide (NO) which inhibit xanthine oxidase and increase the level of superoxide dismutase (SOD), total antioxidant capacity (TAC) and vitamin C. when the activity of xanthine oxidase decreases the amount of superoxide will decrease and consequently, SOD level will increase because there will be less need for SOD for the oxidization of superoxide to hydrogen peroxide [23,22].

Furthermore, the results revealed that rats fed with high fat diet, led to their plasma triglyceride (TG), total cholesterol (TC) and low density lipoprotein (LDL) significantly increased while high density cholesterol (HDL)-Cholesterol level reduced significantly as compared to the negative control group. These results are in consonant with [10] (Marques et al., 2016) that attributed this to endogenous changes. Hyperlipidemia is a heterogeneous disorder commonly characterized by elevated serum total cholesterol, low density and very low-density lipoprotein cholesterol, triglycerides, and decreased 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 [24,23]. 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 [25,24].

The results showed that the administration of the mixture of garlic tinctures and coconut water in HFD fed rats proved to effectively modulate the plasma lipids profile as shown by significant decrease in total cholesterol (TC), cholesterol-low density lipoprotein (Cholesterol-LDL) level and, a statistical significant increase in cholesterol-High Density Lipoprotein (Cholesterol-HDL) level while no statistical significant decrease in triglyceride (TG). This result shows that there was a significant hypolipidaemic effect by the coconut water and garlic tincture treatment when combined, which is in line with that reported by [26,27] Sandhya et al., [25], and Biljana and Svetlana, [26] respectively. Garlic is proven to have beneficial effects for the prevention of cardiovascular diseases. Several studies have also shown that garlic contains active hypolipidemic components, known as diallyl disulfide and dipropyl disulfide [28,18]. Amagase et al., [29,27], also stated that allicin and other garlic compounds have hypocholesterolemic, hypolipidemic and antihypertensive activity. Experiment done on rat

fed with cholesterol diet shown a hypolipidemic effect by coconut water [26,25]. In the same note, it has been reported that significant decrease in serum lipid by garlic may be as a result of the inhibition of the rate limiting enzyme in cholesterol synthesis, 3-hydroxyl-3-methylglutaryl-CoA (HMG-CoA) reductase; [28].

Coconut water is capable of reducing lipid peroxidation content. The hypolipidemic effect of coconut water is attributed to the high content of L-arginine as it has been reported that L-arginine has antiperoxidative effect in high fat cholesterol fed rats [29].

The results showed that rat fed with high fat diet (HFD) have their plasma antioxidant capacity and the antioxidant enzymes activity reduced significantly while the plasma malondialdehyde increased significantly. This finding implies that the higher the atherogenic index the greater outcome of oxidative damage. The findings also revealed that the administration of combined garlic tinctures and coconut water in HFD rats proved to effectively modulate the plasma lipids and oxidative stress biomarkers concentrations by causing a significant increase in antioxidant enzymes (SOD) and total antioxidant capacity (TAC) while significantly decreasing the plasma malondialdehyde concentration similar to what was stated earlier. The effects can be attributed to the earlier stated reasons.

## 5. CONCLUSION

From the study, there was a record of improved modulation of oxidative stress and dyslipidaemia by coconut water and garlic tincture when combined. Therefore, it can be concluded that the mixture of coconut water and garlic tincture exerted an effective antioxidant activity and antiatherogenic effect on alcohol-induced oxidative stress and HFD-induced dyslipidaemia respectively.

## ETHICAL APPROVAL

This study was an animal study and followed the standard ethic guideline for the use of laboratory animals.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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