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Hepatoprotective Potency of Ethanolic Extract of *Garcinia kola* (Heckel) Seed against Acute Ethanol-induced Oxidative Stress in Wistar Rats

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Authors' contributions

This work was carried out in collaboration with all authors. Author AIA conceptualized and designed the study and also wrote the manuscript. Author ACN managed the analyses of the study and the literature searches. Author JAE wrote the protocol while author KON performed the statistical analysis. All authors read and approved the final manuscript.

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ABSTRACT

Aim: Hepatoprotective potency of ethanolic extract of *Garcinia kola* (Heckel) seed against acute ethanol-induced oxidative stress in Wistar rats.
Materials and Methods: *G. kola* seeds were purchased from a local market in Ibadan, Nigeria. The seeds were chopped to smaller pieces after the outer coats were removed. They were air-dried and finally ground to fine powder using a blender. The powder was extracted using ethanol. 20 adult Wistar rats with body weight between 150 and 180 g were used for this study. They were acclimatized for 7 days during which they were fed ad libitum with standard feed and drinking water.

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They were randomly divided into 4 groups of 5 rats each. Animals in groups 1 and 2 were administered normal saline solution while those in groups 3 and 4 were administered *G. kola* extract for 28 days. The animals were administered the extract and saline solution at a dose of 4 mL per 100 g body weight 12 hourly via oral route. At the end of the treatment, they were fasted overnight and animals in groups 2 and 4 were exposed to a single dose of 70% ethanol at 12 mL/kg body weight to induce oxidative stress. After 12 hours of ethanol administration, the animals were anaesthetized using diethyl ether and were sacrificed. Biochemical parameters were determined using standard methods.

Results: Ethanol-induced oxidative stress significantly increased the activities of aspartate aminotransferase (AST), alanine aminotransferase (ALT), lactate dehydrogenase (LDH), lipid peroxidation (LPO), catalase (CAT), superoxide dismutase (SOD) and glutathione peroxidase (GPx) but decreased reduced glutathione (GSH). These effects were regulated by *G. kola* administration due to its phytochemical content and antioxidant potential.

Conclusion: Results from this present study have shown that *G. kola* possesses hepatoprotective potency against ethanol-induced oxidative stress.

Keywords: G. kola seed; hepatoprotective potency; ethanol-induced oxidative stress.

1. INTRODUCTION

Garcinia kola (Heckel) is forest tree indigenous to sub-Saharan Africa and has been referred to as a 'wonder plant' because almost every part of it has been found to be of medicinal importance [1]. It occurs naturally from Sierra Lone to Southern Nigeria and on into Zaire and Angola, but is further distributed by man and is often found cultivated around villages. *G. kola* belongs to a family of tropical plants known as Guttifera [2]. It is an evergreen tree grown in the tropical rainforest of West Africa [3,4]. It grows to a height of about 30 metres high, and the fruit, which is in the size of an orange, is smooth and reddish yellow with peach-like skin and yellow pulp and contains three or four seeds covered with brown seed coat [5]. The seed is an edible nut [4]. It is generally known and called Bitter Kola in Nigeria, and commonly called "Namiji goro" in Hausa, "Orogbo" in Yoruba and "Aku-ilu" in Igbo [6].

Fig. 1. *Garcinia kola* Seeds

The seed is a masticatory used in traditional medicine, cultural and social ceremonies. Extractive of the plant have been traditionally used for ailments such as laryngitis, liver diseases and cough [7]. The seeds are used to prevent or relieve colic, cure head or chest colds and relieve cough [8]. The seed also has anti-inflammatory, antimicrobial, antidiabetic and antiviral [9] as well as antiulcer properties [10].

Phytochemical and biochemical studies of *G. kola* showed the presence of sterols, terpenoids, flavonoids, glycosides, pseudotannins, saponin, proteins and starch [11,12]. Maduniyi [13] reported that some workers isolated kolanone, a poly-isoprenyl-benzophenone compound from the fruit pulp. *G. kola* is a reasonable source of ascorbic acid, some micro-elements including nitrogen, potassium, phosphorus, magnesium and calcium, a trace amount of chromium [14]. Another medicinal constituent of *G. kola* is hydroxycitric acid (HCA) [15]. Xanthones, xanthone derivatives, and polyisoprenylated benzophenones have also been isolated from *G. kola* [16,17]. Plants have been reported to possess hepatoprotective potential due to their phytochemical content.

G. kola also contains toxic substances such as tannins, phytic and hydrocyanic acids at a low concentration. Other constituents include ash and crude protein, crude fiber, crude lipid, water–soluble oxalate, terpenoids and fat [5].

Excessive acute or chronic alcohol consumption poses a serious health hazard and can result into several metabolic disorders in hepatic and extra-hepatic diseases [18]. Alcohol is a commonly used hepatotoxin in experimental hepatopathy. Although the pathogenesis of alcohol-induced liver disease is not clearly defined, there is

evidence that ethanol-induced liver injury is due to oxidative stress that leads to fibrosis and impaired liver functions [19]. Alcohol overuse is also characterized by central nervous system (CNS) intoxication symptoms, impaired brain activity, poor motor coordination, and behavioral changes [20]. Excessive alcohol consumption commonly causes hepatic, gastrointestinal, nervous and cardiovascular injuries leading to physiological dysfunctions [21]. Cellular disturbances resulting from excessive alcohol consumption results in increased formation of oxidative stress biomarkers such as malondialdehyde (MDA); reduction in the level of reduced glutathione and a decrease in the activities of antioxidant enzymes [22,23]. Free radicals and reactive oxygen species (ROS) have been implicated in the oxidative damage of biomolecules and various organs of the body. Studies have shown the crucial role free radicals play in the pathogenesis of many human diseases namely, cardiovascular and pulmonary diseases, some types of cancer, immune/autoimmune diseases, inflammation, diabetes, cataracts and brain dysfunction such as Parkinson and Alzheimer [24]. However, the deleterious effect of free radicals can be corrected by antioxidants – both enzymatic and nonenzymatic. Oxidative stress is known to arise when there is an imbalance between free radical production (especially reactive oxygen species; ROS) and endogenous antioxidant defense system. This shift in balance is associated with oxidative damage to a wide range of biomolecules including lipids, proteins, and nucleic acids, which may eventually impair normal functions of various tissues and organs [25]. This study therefore focuses on the hepatoprotective potency of *G. kola* seeds against acute ethanol-induced oxidative stress in Wistar rats.

2. MATERIALS AND METHODS

2.1 Preparation of Extract

G. kola seeds were purchased from a local market in Ibadan, Nigeria. It was extracted according to the methods of Igboko [11]. The seeds were chopped to smaller pieces after the outer coats were removed. They were air-dried in the laboratories for 21 days and were milled into fine powder using an electric blender. 500 g of the powder was transferred to an 80% ethanol solution in a 1 litre round-bottomed flask, and kept airtight for 72 hours with continuous stirring. It was filtered using Whatmann's filter paper and the filtrate was concentrated by using a rotary evaporator at 40°C. The resulting residue was further air-dried. The percentage yield of the extract was 14.72%. It was preserved for further analysis.

2.2 Experimental Design and Animal Treatment

20 adult male Wistar rats with weighing between 150 and 180 g were used for this study. They were acclimatized for 7 days during which they were fed *ad libitum* with standard animal feed and clean drinking water and were housed in clean cages placed in well-ventilated housing conditions (under humid tropical conditions) throughout the period of the experiment. All the rats received humane care according to the criteria outlined in the '*Guide for the Care and Use of Laboratory Animals*' prepared by the National Academy of Science and published by the National Institute of Health. The rats were randomly divided into 4 groups of 5 each. Animals in groups 1 and 2 were administered saline solution while those in groups 3 and 4 were administered *G. kola* extract for twenty-eight days. The animals were administered the extract and saline solution at a dose of 4 mL per 100 g body weight 12 hourly via oral route. At the end of the treatment, they were fasted overnight and animals in groups 2 and 4 were exposed to a single dose of 70% ethanol at 12 mL/kg body weight to induce oxidative stress. The dosage of ethanol used in this study has been documented to induce tissue toxicity and oxidative damage in rats [26]. After 12 hours of ethanol administration, the animals were anaesthetized using diethyl ether and were sacrificed. Activities of liver enzymes were determined using the plasma. Liver was excised, weighed and homogenized in 50 mmol/L Tris–HCl buffer (pH 7.4) and then centrifuged at 5000 × g for 15 minutes for biochemical analysis. Supernatants were immediately kept frozen for further analysis.

2.3 Biochemical Analyses

2.3.1 Determination of hepatic marker enzymes activities

Alkaline phosphatase (ALP), aspartate aminotransferase (AST), alanine aminotransferase (ALT) and lactate dehydrogenase (LDH) activities were determined using Randox commercial Enzyme kits produced by Randox Laboratories Limited, United Kingdom according to the method of Reitman and Frankel [27].

2.3.2 Determination of oxidative stress biomarkers

Determination of lipid peroxidation (LPO), reduced glutathione (GSH), catalase (CAT), superoxide dismutase (SOD) and glutathione peroxidase (GPx) were carried out according to the methods previously described by Airaodion et al. [28].

2.4 Statistical Analysis

Results are expressed as mean ± standard error of the mean (S.E.M). The levels of homogeneity among the groups were assessed using One-way analysis of variance (ANOVA) followed by Turkey's test. All analyses were done using Graph Pad Prism Software Version 5.00 and p values < 0.05 were considered statistically significant.

3. RESULTS

An observable finding of this research was that ethanol administration unhinged and perturbed the activities of hepatic marker enzymes and oxidative stress biomarkers in the animals used. Pretreatment of animals with *G. kola* seed extract for 28 days minimized these perturbations as shown in Tables 1 and 2.

4. DISCUSSION

Analysis of hepatic indices revealed that the activities of AST, ALT, ALP and LDH were not significantly different when animals treated with *G. kola* seed extract only for 28 days were compared with those of the control group at $P<0.05$ (Table 1). However, the activities of AST, ALT, ALP and LDH were observed to have significantly increased in animals induced with 70% ethanol without pretreatment with *G. kola* extract when compared with those of the control and *G. kola* extract only groups at $P<0.05$ (Table 1). This is suggestive that ethanol administration caused hepatic injury in the animals used in this study [29]. In furtherance to this, a significant decrease was observed in the activities of AST, ALT, ALP and LDH in animals pretreated with *G. kola* seed extract before the induction of oxidative stress by ethanol administration when compared with those induced without pretreatment at $P<0.05$. This might indicate that pretreatment with *G. kola* seed extract led to increased transcription of some genes used in glucose uptake, glycolysis and lipogenesis [30, 31]. Glucose suppresses the induction of inducible operons by inhibiting the synthesis of cyclic adenosine monophosphate (cAMP). cAMP is needed in the activation of catabolite activator protein (CAP) which binds to the promoter CAP site and stimulates the binding of ribonucleic acid (RNA) polymerase to the promoter for the initiation of transcription, but cAMP must be available to bind to CAP which binds to deoxyribonucleic acid (DNA) to facilitate transcription [32]. In the presence of glucose, adenylase cyclase (AC) activity is blocked. AC is required to synthesize cAMP from adenosine triphosphate (ATP) [31,32]. Thus, when cAMP level is depleted, CAP is inactive and transcription halts. Therefore, the effect of glucose in inhibiting these inducible enzymes is by lowering cyclic AMP level. The *G. kola* seed extract might have lowered cAMP in animals used in this study thereby leading to suppression of these inducible enzymes. ALT has been reported to be the most dependable indices for hepatic injury due to the fact that it is solely confined to the liver [32], unlike AST and LDH which are also found in other organs of the body such as the kidneys, brain, and hearts [33]. The significant decrease observed in the activities of ALT and AST in *G. kola*-treated animals when compared to those induced without pretreatment showed that *G. kola seed* protected the liver from damage by ethanol-induced oxidative stress, thus possesses hepatoprotective potential. Igboko, [11] has reported that *G. kola* seed have high phytochemical content while Oloyede and Afolabi [34] reported its antioxidant potential. Its hepatoprotective activities could be attributed to the presence of these phytochemicals and antioxidants. However, Chinedu et al. [35] reported that aqueous extract of *G. kola* seed had no significant effect on the activity of AST when they studied the acute administration of aqueous extract of *G. kola* on daily blood glucose level and selected biochemical indices in longevity Wistar albino rats.

Alkaline phosphatase (ALP) has been reported to be involved in the hydrolysis of a variety of phosphomonoester substrates [32]. It is a marker enzyme for the plasma membrane and endoplasmic reticulum of tissues [36]. It is often employed to assess the integrity of the plasma membrane, because it is localized mainly in the microvilli in the bile canaliculli, situated in the plasma membrane. Since ALP has been reported to hydrolyze phosphate monoesters, its significant increase in ethanol-induced animals without pretreatment with *G. kola* seeds extract could lead to a threat to the life of the cells that

depends on different phosphate esters for their vital process as it might constitute indiscriminate hydrolysis of phosphate esters metabolite of the hepatocyte [37]. As a result of this, the facilitation of the transfer of metabolites across the cell membrane of ethanol-induced animals without pretreatment may be adversely affected. This adverse effect was observed to be minimized by treatment with *G. kola* seeds extract prior to ethanol administration. In contrast to the result of this present study, Chinedu et al. [35] reported that *G. kola* seed significantly increased the activity of ALP when they studied the acute administration of aqueous extract of *Garcinia kola* on daily blood glucose level and selected biochemical indices in longevity Wistar albino rats.

The significant elevation observed in the activities of hepatic biomarkers such as ALT, AST, ALP and LDH in animals induced with ethanol but without pretreatment with *G. kola* seeds when compared with the control animals and those pretreated with *G. kola* seeds before ethanol induction might be due to cellular necrosis of hepatocytes, which led to increase in the permeability of the tissue. Lactate dehydrogenase (LDH) has been reported to be a marker of cellular damage including hepatotoxicity [32]. The significant increase observed in the activity of LDH might be an indication of the beginning of cytolysis, which is a possible indication of membrane damage including the endothelial membranes of blood vessels. This perturbation of endothelial membrane, directly or indirectly includes the generation of reactive oxygen species in endothelial cells and tissues [38]. Free radicals has been reported to attack unsaturated fatty acids in the membranes resulting in membrane lipid peroxidation which down-regulates membrane fluidity, leakage of enzyme and loss of receptor activity as well as damage membrane proteins leading to cell inactivation [28,39]. As lipid peroxidation progressively increase, antioxidant defense system decrease equivalently resulting in oxidative stress [40]. This suggests that the administration of ethanol might have weakened the hepatic membrane of the rats used in this study with subsequent penetration and elevation of the hepatic biomarker enzymes.

Table 1. Effect of *G. kola* seeds on hepatic marker enzymes of experimental rats after 28 days of administration

Hepatic marker enzymes	Control	70% ethanol only	*G. kola* extract only	*G. kola* extract + 70% ethanol
AST (IU/L)	98.84±4.19^{a}	129.29±3.22^{b}	101.05±3.32^{ac}	112.18±5.03^{c}
ALT (IU/L)	46.19±7.24^{a}	59.26±4.03^{b}	45.02±3.97^{a}	49.00±4.33^{a}
ALP (IU/L)	14.52±2.57^{a}	23.04±3.11^{b}	14.62±2.26^{a}	16.77±3.29^{a}
LDH (IU/L)	167.24±9.13^{a}	211.32±75.32^{b}	170.85±7.43^{a}	189.28±3.94^{c}

Values are presented as Mean±S.E.M, where n = 5. Values with different superscript along the same row are significantly different at P<0.05.

Legend: AST = Aspartate Amino Transferase, ALT = Alanine Amino Transferase, ALP = Alkaline Phosphatase, LDH = Lactate Dehydrogenase

Table 2. Effect of *G. kola* on oxidative stress biomarkers of experimental rats after 28 days of administration

Oxidative stress biomarkers	Control	70% Ethanol only	*G. kola* extract only	*G. kola* extract + 70% ethanol
LPO (nmol MDA/mg protein)	13.13±1.00^{a}	22.30±2.78^{b}	12.26±1.84^{a}	14.00±2.02^{a}
GSH (mg/mL)	6.85±0.14^{a}	4.22 ±0.24^{b}	7.04±1.02^{a}	6.04±0.85^{a}
CAT (Mm H_2O_2/mg protein)	11.99±1.38^{a}	24.14±2.46^{b}	12.23±1.09^{a}	17.22±3.07^{c}
SOD (U/mg protein)	10.33±1.34^{a}	15.00±1.89^{b}	9.83±1.99^{a}	11.36±1.46^{ab}
GPx (U/mg protein)	4.92±1.00^{ac}	9.06 ±0..63^{b}	4.64±0.55^{a}	6.99±0.42^{c}

Values are presented as Mean±S.E.M, where n = 5. Values with different superscript along the same row are significantly different at P<0.05.

Legend: LPO = lipid peroxidation, GSH = Glutathione, CAT = Catalase, SOD = Superoxide Dismutase, GPx = Glutathione Peroxidase

A significant difference was observed in the activity of AST when the control animals were compared with animals treated with *G. kola* seeds extract prior to ethanol administration. This corresponds to the findings of Airaodion *et al*. [39] who studied the ameliorative efficacy of phytochemical content of *Corchorus olitorius* seeds against acute ethanol-induced oxidative stress in Wistar rats but in contrast with those of Ogbuagu et al. [41] and Airaodion et al. [42] who observed a nonsignificant difference in the activity of AST when animals were pretreated with *Vernonia amygdalina* and *Talinum triangulare* leaves respectively.

Alcohol metabolism results in oxidative and nitrosative stress through increase in NADH/NAD^+ redox ratios, induction of nitric oxide synthase (NOS) and NADPH/xanthine oxidase [29]. Lipid peroxidation is a common feature of both acute and chronic alcohol consumption [39]. It is a primary mechanism of cell membrane destruction and cell damage [32]. The presence of a high concentration of oxidizable fatty acids and iron in liver significantly contributes to ROS production. A rise in lipid peroxidation level is only identified if there is oxidative damage due to the increase in free radical generation. Generally under normal conditions, the animals try to maintain a balance between generation and neutralization of ROS in cells and tissues. But, when organisms are subjected to external stress, the rate of production of ROS including O_2^-, H_2O_2, OH^-, ROO^{--}, exceeds their scavenging capacities [29]. All organisms have their own cellular antioxidant defense system composed of both enzymatic and non-enzymatic components. Enzymatic antioxidant pathway consists of SOD, CAT and GPx. Superoxide anion O_2^- is dismutated by SOD to H_2O_2, which is reduced to water and molecular oxygen by CAT or is neutralized by GPx, which catalyzes the reduction of H_2O_2 to water and organic peroxide to alcohols using GSH as a source of reducing equivalent. Glutathione reductase (GR) regenerates GSH from oxidized glutathione (GSSG), which is a scavenger of ROS as well as a substrate for other enzymes. Glutathione S-transferase (GST) conjugates xenobiotics with GSH for exclusion.

The result of the effect of *G. kola* seeds on oxidative stress biomarkers in this study is presented in Table 2. It was observed that acute ethanol exposure significantly elevated the malondialdehyde (MDA) levels in the liver suggesting an increased peroxidation and breakdown of the antioxidant defense mechanisms. Decomposition products of lipid hydroperoxide such as malanoldehyde and 4-hydroxynonenal, can cause chaotic cross-linkage with proteins and nucleic acids, which plays a vital role in the process of carcinogenesis. In this study, hepatic lipid peroxidation (LPO) activities were significantly higher due to ethanol administration. Furthermore, extensive injury to tissues in a free radical mediated LPO results in membrane damage and thus decreases the membrane fluidity. Treatment of animals with *G. kola* seed extract prior to ethanol intoxication significantly normalized these alterations leading to a significant decrease in MDA levels, suggesting its hepatoprotective potency against ethanol-induced oxidative stress. This corresponds to the study of Oyenihi et al. [38] who reported the hepato- and neuro-protective effects of watermelon juice on acute ethanol-induced oxidative stress in rats. It is also in agreement with the findings of Airaodion *et al*. [28] who reported the hepatoprotective effect of *Parkia biglobosa* on acute ethanol-induced oxidative stress in Wistar rats.

Glutathione (GSH) is a tripeptide (L-α-glutamylcysteinol glycine) which is highly abundant in all cell compartments and it is reported to be the predominant soluble antioxidant [32]. Glutathione directly quenches ROS such as lipid peroxides, and also plays a major role in xenobiotic metabolism [28,29]. Glutathione detoxifies hydrogen peroxide and lipid peroxide by donating electron to hydrogen peroxide to reduce it to water and oxygen protecting macromolecules such as lipids from oxidation [29,32]. In this study, the decrease in the reduced glutathione level in animals treated with ethanol only is connected with ethanol-induced oxidative stress and direct conjugation of GSH with acetaldehyde and other reactive intermediates of alcohol oxidation. This result is consistent with the finding of Pinto et al. [42] who reported that acute ethanol treatment could cause a reduction in the GSH levels in different cells. It is also in agreement with the study of Airaodion et al. [39] who observed a significant decrease in the concentration of GSH sequel to ethanol intoxication in Wistar rats. The significant increase in the GSH levels in the liver of *G. kola*-treated rats before the administration of ethanol might be because of the direct ROS—scavenging potential of *G. kola* or an increase in GSH synthesis. The antioxidant potential of *G. kola* reported by Oloyede and Afolabi [34] might also be responsible in this free radical-scavenging potency.

Catalase (CAT) contributes to ethanol oxidation [32], by oxidizing a small amount of ethanol in the presence of a hydrogen peroxide (H_2O_2) generating system to form acetaldehyde [28]. In this study, a significant increase was observed in the activity of CAT in control animals and those treated with *G. kola* extract only when compared with ethanol-induced animals with *G. kola* extract pretreatment. This corresponds to the findings of Airaodion et al. [39] who reported the ameliorative efficacy of *Corchorus olitorius* leaves on acute ethanol-induced oxidative stress in Wistar rats but is in contrast with another study of Airaodion et al. [28] who observed a nonsignificant difference when animals were treated with *Parkia biglobosa*. The activity of CAT in animals treated with *G. kola* prior to ethanol induction was significantly reduced when compared with those without *G. kola* pretreatment. This could be an indication that ethanol-induced oxidative stress generated elevated free radicals in the hepatocyte which CAT tend to combat, thereby elevating its activity. *G. kola* seeds were able to decrease the free radical generation leading to a significant reduction in the activity of CAT due to its antioxidant potential reported by Oloyede and Afolabi [34]. Increased CAT activity in this investigation following acute ethanol intoxication suggests elevated ethanol oxidation and formation of oxidizing product-acetaldehyde. This is in agreement with the study of Airaodion et al. [28] and Oyenihi et al. [38] who reported a significant increase in the activity of CAT following ethanol exposure.

Superoxide dismutase (SOD) has been reported to play a vital role in suppressing the activity of free radicals action [28]. SOD is the only enzymatic system quenching O_2- to oxygen and H_2O_2 and it is involved in combating oxidative stress [29]. These radicals are harmful to polyunsaturated fatty acids and proteins [28,32]. In this study, no significant difference was observed in the activity of SOD in control animals and those treated with *G. kola* seed extract only when compared with ethanol-induced animals with *G. kola* seed extract pretreatment. This is in consonance with the findings of Airaodion *et al*. [29] who reported the therapeutic effect of methanolic extract of *Telfairia occidentalis* leaves against acute ethanol-induced oxidative stress in Wistar rats. The activity of SOD in animals treated with *G. kola* prior to ethanol induction was reduced when compared with those without *G. kola* pretreatment. However, this reduction was not statistically different.

Glutathione peroxidase (GPx) is yet another enzymatic antioxidant that acts as a defense mechanism against oxidative stress [28,29]. In this present study, no significant difference was observed in the GPx activity in control animals when compared with ethanol-induced animals with *G. kola* extract pretreatment at $P<0.05$. The activity of GPx in animals treated with *G. kola* prior to ethanol exposure was significantly decreased when compared with those without *G. kola* pretreatment. This could be an indication that ethanol exposure generated increased free radicals in the hepatocyte which GPx tends to alleviate thereby increasing its activity. *G. kola* seed extract was able to decrease free radical generation leading to a decrease in the activity of GPx due to its antioxidant potential reported by Oloyede and Afolabi [34]. The increased GPx activity observed in ethanol-treated animals is in agreement with the findings of Ogbuagu *et al.* [41] and Airaodion et al. [42] who observed a significant difference in GPx activity when animals were pretreated with *Vernonia amygdalina* and *Talinum triangulare* leaves respectively but it's contrary the findings of Airaodion et al. [38] who reported a nonsignificant difference in GPx activity in the study of hepatoprotective effect of *Parkia biglobosa* on acute ethanol-induced oxidative stress in Wistar rats and that of Yang et al. [43] who also reported a nonsignificant difference in GPx activities in rats hepatocyte exposed to varying concentrations of ethanol at an incubation time of 12 hours. The toxicity of ethanol is related to the product of its metabolic oxidation. Acetaldehyde and acetate, produced from the oxidative metabolism of alcohol are capable of forming adducts with cellular macromolecules, causing oxidative damage and affecting metabolic processes [41,42]. CAT and GPx further detoxify H_2O_2 into H_2O and O_2 [28]. Thus, SOD, CAT and GPx function mutually as enzymatic antioxidative defense mechanism to counter the deleterious effect of ROS [32].

5. CONCLUSION

G. kola seed has been consumed for different purposes. Results from this present study have shown that it possesses hepato-protective potency against ethanol-induced oxidetive stress.

CONSENT

It is not applicable.

ETHICAL APPROVAL

Animal ethic Committee approval has been collected and preserved by the author**.**

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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