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Research Article
Evaluation of Antioxidant Activity of Aqueous Extracts of Palm Fruits (*Elaeis guineensis*)

[1]Uroko Robert Ikechukwu, [1]Agbafor Amarachi, [1]Uchenna Oluomachi Nancy, [1]Achi Ngozi Kalu, [1]Egba Simeon Ikechukwu, [2]Nweje-Anyalowu Paul Chukwuemaka and [3]Ngwu Ogochukwu Rita

[1]Department of Biochemistry, College of Natural Sciences, Michael Okpara University of Agriculture, Umudike, Abia-State, Nigeria
[2]Department of Biochemistry, Faculty of Biological Sciences, University of Nigeria Nsukka, Enugu-State, Nigeria
[3]Department of Biochemistry, Faculty of Natural Sciences, Caritas University, Amorji Nike, Enugu State, Nigeria

Abstract

Background and Objective: Local consumers of whole palm fruit extract claim that it is rich in nutraceutical properties. This claim has not been validated as there is no scientific evidence or data to take back up. This study was designed to investigate *in vitro* antioxidant activity of the aqueous extracts of palm fruits and their effects on the antioxidant parameters of male Wistar albino rats with a view of improving human health. **Materials and Methods:** The acute toxicity study was carried out with 18 male Wistar albino mice while 45 male Wistar albino rats were used for the study of the effects on antioxidant parameters. The rats were grouped into 5 groups: Group 1 serving as normal control and received 2 mL kg^{-1} b.wt., of normal saline. Five rats each in group 2-5 received 100, 200, 400 and 600 mg kg^{-1} b.wt., of the fresh and fermented extracts of palm fruits respectively for 28 days and the rats were sacrificed on the day 29. The data obtained were statistically analyzed using one way analysis of variance and t-test. **Results:** The aqueous extracts were relatively safe as their administration resulted to no death or adverse reactions. The extracts possess high total antioxidant capacity, ferric reducing antioxidant power and effectively inhibited lipid peroxidation depicted by low concentrations of thiobarbituric acid and malondialdehyde. In addition, the extracts exhibited a dose dependent increase in percentage inhibition of 1,1-Diphenyl-2-picrylhydrazyl radicals. The extracts caused a dose dependent significant ($p<0.05$) decrease in catalase activity and significant increase in superoxide dismutase activity of all the rats administered the extracts. Whereas, the fermented extract administration led to significant ($p<0.05$) dose dependent increase in myeloperoxidase and glutathione peroxidase activity in the rats, the fresh extract caused significant ($p<0.05$) decrease in myeloperoxidase and glutathione activity of group 2 rats and a dose dependent increase in groups 3-5. **Conclusion:** These findings suggest that the extracts possess antioxidant properties which could effectively prevent oxidative stress, lipid peroxidation, ameliorate damage and associated health consequences resulting from activity of excess free radicals, if taking in adequate concentration.

Key words: Palm fruits, oxidative stress, lipid peroxidation, antioxidant enzymes, *in vitro* antioxidant activity

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Corresponding Author: Uroko Robert Ikechukwu, Department of Biochemistry, College of Natural Sciences, Michael Okpara University of Agriculture, Umudike, Abia-State, Nigeria Tel: +2348065914471

Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

The oxidative damage results from the excessive Reactive Oxygen Species (ROS) and nitrogen radicals, which are formed naturally in the body. These oxidants are produced in normal aerobic metabolism in mitochondria, peroxisomes and cytosol including in the activation of polymorphonuclear leukocytes and iron or copper mediated catalysis[1]. Inadequate antioxidants, which are compounds that protect the cellular system from potentially harmful substances that can cause excessive oxidation, could cause oxidative damage to DNA, lipids, proteins and other biomolecules[2]. Under normal physiological condition, there is a balance between free radicals and antioxidant molecules and deviation from this equilibrium state results in oxidative stress which could critically affect healthy biological system[3]. Ineffective antioxidant activity against oxidant species in the body result to a disease or medical conditions due to oxidative damages to proteins, lipids and DNA molecules accumulate during life and also are capable of promoting ageing process[4].

There are increase in levels of consumption of aqueous extracts of palm fruits directly through the consumption of whole palm oil as seen in "Ofe akwu" which is an indigenous Igbo soup and many other local dishes in Igbo land. It is also consumed indirectly through the consumption of commercially available palm oil in which either fresh or fermented aqueous extracts of crude palm oil were reused to produce. The consumption of aqueous extracts of palm fruits may be beneficial to humans as it has been reported that the aqueous extracts of palm fruits are rich in polyphenols known to be a potent antioxidant that could scavenge free radicals[1]. Aqueous extracts of palm fruits have low pH, high fatty acid, low protein and carbohydrate, 90-95% water and high mineral content (Mainly nitrogen, potassium, magnesium and calcium and oil and grease)[5-7]. It has also been reported to be rich in β-carotene, a provitamin which is converted in the body to a vitamin A. The β-carotene is a precursor of vitamin A that plays major roles in the maintenance of strong bones, healthy skin, teeth and hair. It can also be utilized in the production of vitamin E (tocopherol) which is a potent antioxidant, protecting the cells against effects of free radicals in the body[8]. The amount of β-carotene in aqueous extracts of palm fruits is closely related to that obtained from the palm oil in which β-carotene concentration ranges between 400 and 3500 ppm. Oil palm fruits are the richest plant source of pro-vitamin A (carotene) and vitamin E[7-8]. Carotenoids have been extensively used in food, cosmetic and pharmaceutical industries and their consumption through whole palm oil could provide additional health benefit[9]. This study was designed to investigate the *in vitro* and *in vivo* antioxidant properties of fresh and fermented aqueous extracts of palm fruits in order to maximize the potentials of the extract in ameliorating oxidative damage caused by free radicals and the associated health consequences on humans.

MATERIALS AND METHODS

The study was carried out between March, 24 and August, 25, 2016 at the Department of Biochemistry, College of Natural Sciences, Michael Okpara University of Agriculture, Umudike Abia State, Nigeria.

Preparation of aqueous extract of palm fruit: Palm oil fruit bunches were collected from the Obeakpu palm oil milling site in Njaba, Imo State were threshed manually using axe to remove the fruits from bunches. Loose fruits were handpicked and boiled using high temperature wet-heat treatment (120-140°C) for 2 h and crushed with the aid of mortar and pestle. The oil was extracted with water and the kernels including other solid wastes were removed leaving behind the aqueous portion. A volume, 20 L of freshly prepared aqueous extract of palm fruit was obtained and first filtered with a mesh cloth to remove suspended solids and then filtered with Whatman filter paper No. 1. The filtrate was divided into two equal volumes, one portion was stored in a refrigerator and the other portion was kept out a refrigerator to ferment for 21 days. This was done to mimic the situations where people consume the aqueous extracts freshly through "Ofe akwu or banga soup" and the second situation where it is used as water substitute to produce palm oil irrespective of its age. The two extracts were concentrated to dryness in a water bath at 50°C and were used for the study.

Collection of animals for the study: The animals were obtained from the Animal House of the Department of Zoology, University of Nigeria, Nsukka. The animals were acclimatized at the Animal House of the Department of Biochemistry, College of Natural Sciences, Michael Okpara University of Agriculture, Umudike for 7 days under 12 h dark and light cycle with free access to standard animal feed and water.

Experimental design: A total of 45 male Wistar albino rats and 18 male albino mice were used for this study. The mice were divided into 2 major groups of 9 mice each. Each of the 2 groups were then divided into 3 groups of 3 mice each and used for the phase 1 and phase 2 of the acute toxicity study, respectively. The rats were divided into 5 groups with

group 1 having 5 rats and served as the normal control. The remaining 4 groups had 10 rats each with 5 rats in each group receiving fresh and fermented aqueous extracts, respectively for 28 days after which the rats were sacrificed on day 29 and blood samples collected for biochemical analysis.

Group 1: Normal saline was administered orally daily for 28 days

Group 2: Five rats each received 100 mg kg^{-1} b.wt., of fresh and fermented aqueous extracts 28 days, respectively

Group 3: Five rats each received 200 mg kg^{-1} b.wt., of fresh and fermented aqueous extracts for 28 days, respectively

Group 4: Five rats each received 400 mg kg^{-1} b.wt., of fresh and fermented aqueous extracts for 28 days, respectively

Group 5: Five rats each received 600 mg kg^{-1} b.wt., of fresh and fermented aqueous extract for 28 days, respectively

Acute toxicity study and lethality test: The acute toxicity study of the fresh and fermented aqueous extracts of palm fruit were carried out according to the method described by Lorke[10].

Assay of catalase activity: The assay of catalase (CAT) activity was carried out by the method described by Aebi[11].

Principle: The principle of the assay is based on the fact that ultraviolet absorption of hydrogen peroxide can be easily measured at 240 nm. On the decomposition of hydrogen peroxide by catalase, the absorption decrease with time and this decrease is proportional to catalase activity.

Determination of the concentration of malondialdehyde (MDA): The concentration of the concentration of malondialdehyde (MDA), a lipid peroxidation product (MDA) was determined by the method described by Wallin *et al.*[12].

Principle: The principle for the method is based on the fact that thiobarbituric acid (TBARS) reacts with malondialdehyde (MDA) to give a red or pink colour, which absorbs maximally at 532 nm.

Assay of superoxide dismutase (SOD) Activity: The superoxide dismutase (SOD) activity was assayed by the method described by Fridovich[13].

Principle: The method is based on the ability of superoxide dismutase to inhibit the autoxidation of adrenaline. Superoxide generated by the xanthine oxidase reaction is cause the oxidation of adrenaline to adrenochrome. The concentration of adrenochrome produced per superoxide introduced increases with pH and also with increasing concentration of adrenaline.

Assay of glutathione peroxidase (GPx) activity: Glutathione peroxidase activity was assayed according to the method of described by Paglia and Valentine[14].

Principle: Glutathione peroxidase catalyses the oxidation of glutathione (GSH) by cumene hydroperoxide. In the presence of glutathione peroxidase and NADPH, the oxidized glutathione (GSSG) is immediately converted to the reduced form with a concomitant oxidation of NADPH to $NADP^+$. The decrease in absorbance of NADPH at 340 nm is proportional to glutathione peroxidase activity.

Statistical analysis: The results obtained were analyzed using the Statistical Products and Service Solutions (IBM Statistics SPSS 20) and the results were presented as Mean±Standard deviation[15]. Significant differences of the result were established by one-way analysis of variance (ANOVA) and the acceptable level of significance was $p<0.05$.

RESULTS

Percentage yield: After filtration and concentration, the concentrated aqueous extracts gave a total extract yield of 22.4% (22.4 g) for the fresh extract and 23.9% (23.9 g) for the fermented extract.

The data in Fig. 1 indicate that the aqueous extracts exhibited high antioxidant capacity at lower concentrations. The fermented aqueous extract showed higher antioxidant capacity when compared with the fresh aqueous extract which decreased progressively from 4.64-0.61 ascorbic acid equivalent as the concentrations increased from 31.25-2000 μg mL^{-1}. The fresh aqueous extract also had its highest and least antioxidant capacity at lower concentrations of 31.25 and 62.5 μg mL^{-1}, respectively, however, it showed increase in antioxidant capacity with increasing concentration of the aqueous extract than that observed with increasing concentrations of the fermented aqueous extract.

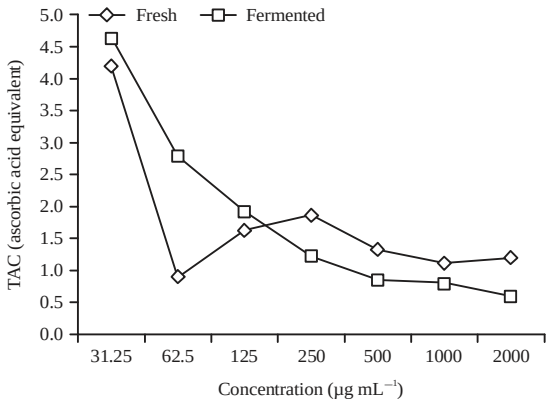

Fig. 1: Total antioxidant capacity of fresh and fermented aqueous extracts of palm fruits

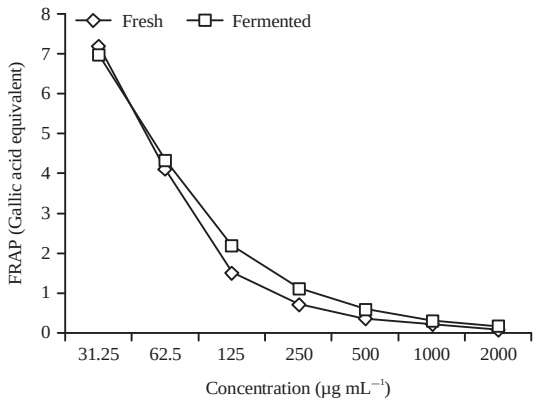

Fig. 3: Ferric Reducing Antioxidant Power (FRAP) of the fresh and fermented aqueous extracts of palm fruits

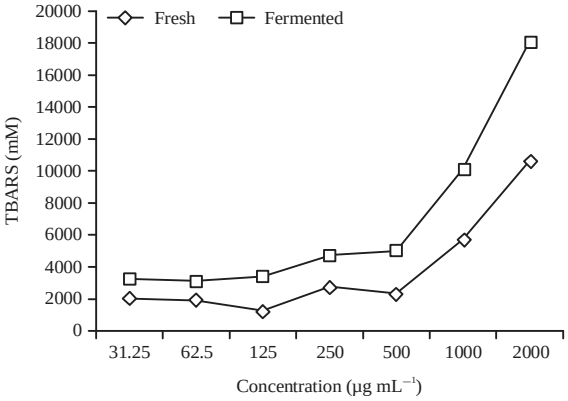

Fig. 2: Effects of the fresh and fermented aqueous extracts of palm fruits on thiobarbituric acid reactive substances (TBARS)

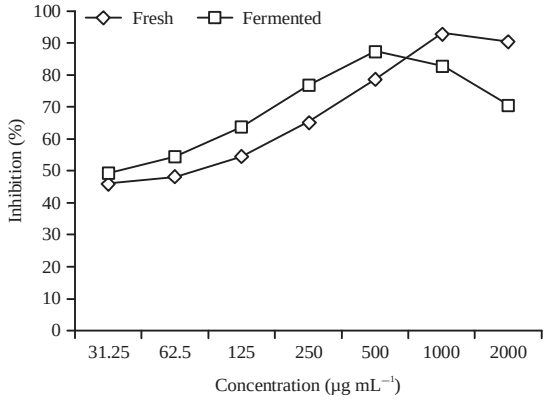

Fig. 4: Scavenging activity on DPPH radicals of fresh and fermented aqueous extracts of palm fruits

The evidence in Fig. 2 showed that the fresh and fermented aqueous extracts of palm fruits caused generation of low concentration of lipid peroxidation product, thiobarbituric acid reactive substances (TBARS) which increased with increasing concentrations of the extracts. Within concentration range of 31.25-500 µg mL^{-1} of both the fresh and fermented aqueous extracts low concentrations of TBARS were observed, however, higher concentrations of TBARS were observed at 1000-2000 µg mL^{-1} of both fresh and fermented aqueous extracts of palm fruits.

The data in Fig. 3 show the ferric reducing antioxidant power of fresh and fermented aqueous extract of palm fruits in relation to their concentration. The reducing powers of the fresh and fermented aqueous extracts were high at low concentrations but decreased drastically with increasing concentrations of the aqueous extracts. Fresh aqueous extract had the highest FRAP at low concentrations and lower FRAP at higher concentrations when compared to the FRAP of the fermented aqueous extracts of the palm fruits.

The scavenging effects of the aqueous extracts of palm fruits on DPPH radicals increased progressively with the concentration increase from 31.25-500 and 31.25-1000 µg mL^{-1} for the fermented and fresh aqueous extracts, respectively as shown in Fig 4. The percentage inhibition was near perfect (93%, at 1000 µg mL^{-1}) for fresh extract and highest percentage inhibition of observed for the fresh aqueous extract was 87.21% at 500 µg mL^{-1}. The EC50 values for the extracts were found to be 1.27 and 1.79 µg mL^{-1} for the fresh and fermented aqueous extracts, respectively.

The result of the acute toxicity study of the aqueous extracts of palm fruits in Table 1 showed that the extracts were relatively non-toxic as no death or adverse reactions were observed in the mice after 24 h of the administration of the graded doses of the extracts to the mice.

The data in Fig. 5 show the malondialdehyde concentration of male Wistar albino rats administered graded doses of aqueous extracts with the control that received normal saline having the least MDA concentration. The aqueous extracts caused significant ($p<0.05$) decrease in MDA

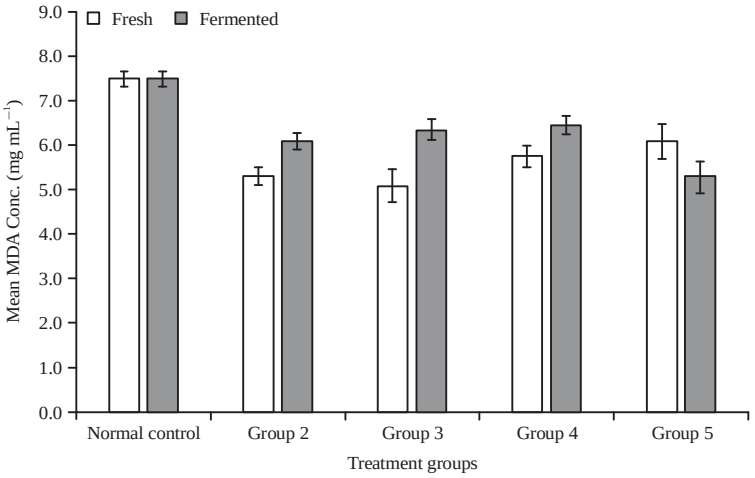

Fig. 5: Malondialdehyde concentration of rats administered fresh and fermented aqueous extracts of crude palm fruit
Each bar represent Mean±Standard Deviation

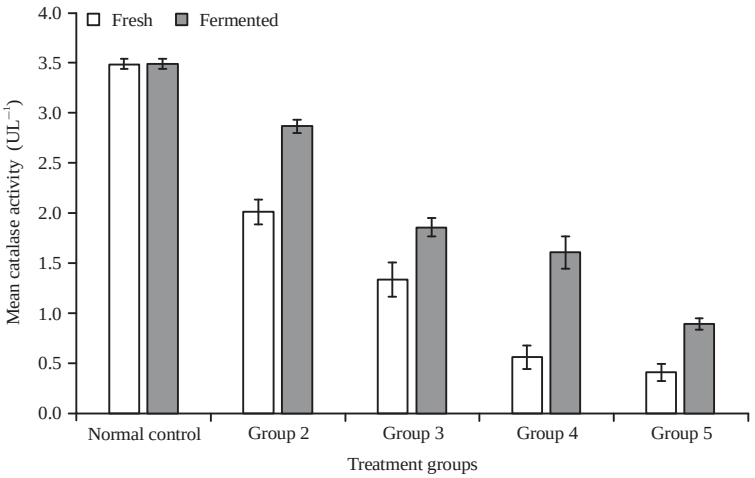

Fig. 6: Catalase activity of rats administered fresh and fermented aqueous extracts of palm fruit
Each bar represent Mean±Standard Deviation

Table 1: Acute toxicity of aqueous extracts of palm fruits

Dosage (mg kg^{-1} b.wt.)	Mortality	
Phase I		
Group 1	10	0/3
Group 2	100	0/3
Group 3	500	0/3
Phase II		
Group 4	1000	0/3
Group 5	2900	0/3
Group 6	5000	0/3

concentration in rats administered various doses of fresh aqueous extracts of palm fruits when compared with the normal control. However, rats administered fermented aqueous extract showed no significant decreases in MDA concentration except the group 5 that exhibited significant ($p<0.05$) decrease in MDA concentration when compared with the MDA concentration of the normal control. The groups of rats administered fresh aqueous extract of palm fruits showed more decrease in MDA concentration when compared with those rats administered fermented aqueous extract though non-significant.

Figure 6 shows the catalase activity of the male Wistar albino rats administered aqueous extracts of palm fruits with the normal control having higher catalase activity than rats administered the aqueous extracts. The aqueous extracts caused significant ($p<0.05$) dose dependent decrease in catalase activity in rats administered graded doses of the fresh and fermented aqueous extracts, respectively. When the catalase activity of the groups that received fresh and fermented aqueous extracts, respectively were compared, the rats that received fresh aqueous extracts show more

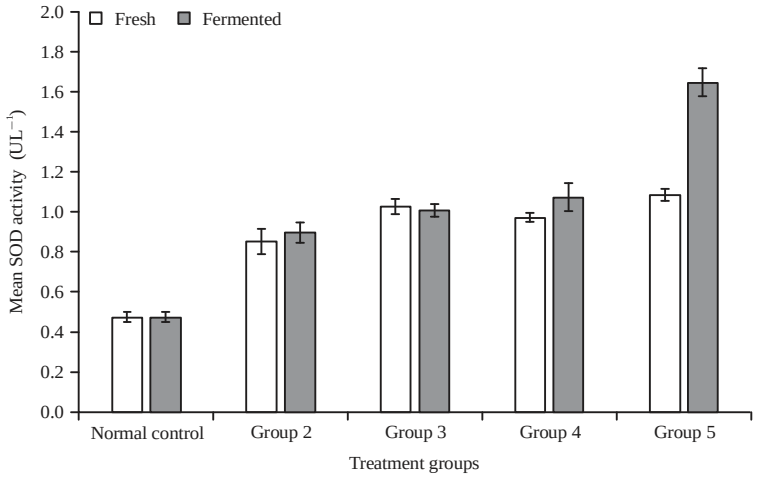

Fig. 7: Superoxide dismutase activity of rats administered fresh and fermented aqueous extracts of crude palm oil
Each bar represent Mean±Standard Deviation

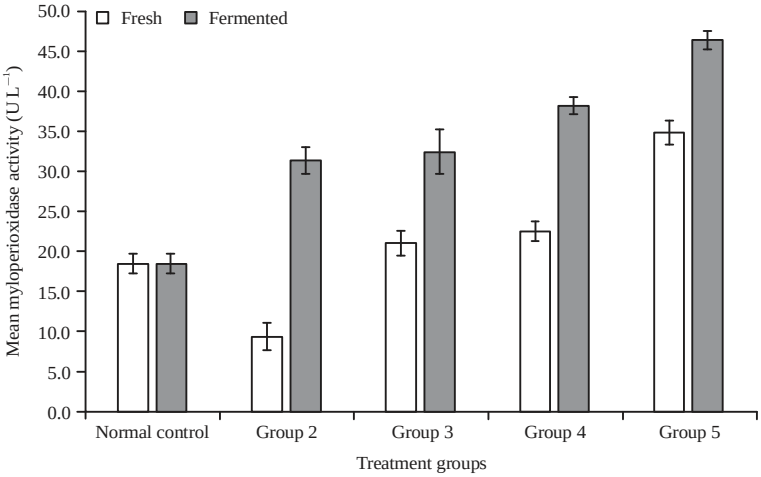

Fig. 8: Myeloperoxidase activity of male Wistar albino rats administered aqueous extracts of palm fruits
Each bar represent Mean±Standard Deviation

significant ($p<0.05$) decrease in catalase activity than the catalase activity of those rats that received equivalent doses of the fermented aqueous extract.

The result in Fig. 7 shows the superoxide dismutase activity of the rats administered fresh and fermented aqueous extracts of palm fruits with the lowest activity observed in the normal control rats. All rats that received graded doses of the fresh and fermented aqueous extract showed significant ($p<0.05$) increase in SOD activity when compared with the SOD activity observed in the normal control rats. There were no significant differences observed in the SOD activity of groups 2-4 rats that received varied doses of fresh and fermented aqueous extracts of palm fruits, respectively. However, group 5 rats that received fermented aqueous extract showed significant ($p<0.05$) SOD activity when compared to corresponding group 5 rats that received equivalent dose of fresh aqueous extract of palm fruits.

The result in Fig. 8 shows the myeloperoxidase activity of rats administered fresh and fermented aqueous extracts of palm fruits, respectively. Normal control rats exhibited moderate myeloperoxidase activity when compared to rats that received fresh and fermented aqueous extracts of palm fruits. It was observed that group 2 rats that received the lowest dose of fresh aqueous extract recorded a marked significant ($p<0.05$) decrease in myeloperoxidase activity when compared with the normal control rats. It was further observed that groups 3 and 4 rats that received moderate to high doses of the aqueous extract showed non-significant

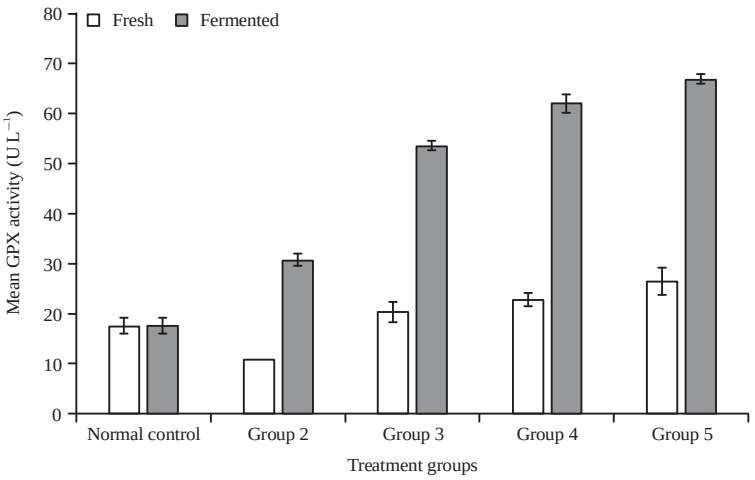

Fig. 9: Glutathione peroxidase activity of male Wistar albino rats aqueous extracts of palm fruits
Each bar represent Mean±Standard Deviation

(p>0.05) increase in myeloperoxidase activity while the group 5 rats that received higher dose of the same fresh extract showed significant increase in myeloperoxidase activity when compared with the normal control rats.

The glutathione peroxidase (GPx) activity of the male Wistar albino rats administered graded doses of fresh and fermented aqueous extracts of palm fruits, respectively in Fig. 9 shows significant (p<0.05) decrease in glutathione peroxidase activity in group 2 rats that received low dose of the fresh extract relative to the normal control rats. With exception to the group 5 rats that received higher dose of the same aqueous extract which showed significant (p<0.05) increase in glutathione activity, groups 2 and 3 rats that received the same extract showed non-significant increase in glutathione peroxidase activity when compared to the normal control. Whereas, the groups of rats administered graded doses of the fermented aqueous extract exhibited a dose dependent significant (p<0.05) increase in their glutathione peroxidase activity when compared with the normal control rats.

DISCUSSION

The study investigated the antioxidant properties of aqueous extracts of palm fruits and their effects on the antioxidant parameters in male Wistar albino rats. The high antioxidant capacity exhibited by the extracts at low concentrations could be ascribed to the synergistic action of the multi-antioxidant components of the extracts. The observed antioxidant effects suggest that individuals who consume food rich in the extracts could effectively reduce oxidative damage caused by oxidative stress resulting from free radicals generated in the body. It further indicates that individuals need not to consume excess of these extract before they can achieve the desired health benefits. The inhibition of production of the lipid peroxidation product (i.e., thiobarbituric acid reactive substances [TBARS]) in the presence of low concentrations of the extract could be due to the antioxidant activity of the bioactive components in the extracts. The extracts possess antioxidant potential capable of preventing lipid peroxidation and its associated adverse health effects. The increase TBARS concentration observed with increasing concentration of the extracts may be due to feedback inhibition of antioxidant activity of some the antioxidant components at excess concentration and ability of some antioxidant components to function as pro-oxidants at higher concentrations. Although, these extracts possess high antioxidant activity at low concentrations, excessive consumption of these extracts could induce oxidative stress due to their ability to induce lipid peroxidation at higher concentrations. The higher ferric reducing antioxidant powers demonstrated by the extracts most especially at lower concentrations further indicate antioxidant activity of the extracts. The antioxidants in the aqueous extracts caused rapid conversion of the ferric ion (Fe^{3+}) to ferrous ions (Fe^{2+}) used in this method to the ferrous form. Thus, the extracts could be said to possess desirable antioxidant properties capable of protecting individuals against endogenous and exogenous free radicals that could cause oxidative damage to lipid membrane, DNA and proteins with resultant health effects. Most researchers have attributed the antioxidant activities of many plant extracts including palm fruits to the presence of appreciable amount of ascorbic acid, vitamin E, carotenoids, selenium, flavonoids, tannins and diverse

phenolic constituents[16]. These compounds carry out their antioxidant activities possibly by acting as reducing agents, chelating agents, hydrogen donors, or singlet oxygen quenchers[17]. The progressive increase in the percentage inhibition of DPPH radicals demonstrated by the fresh and fermented aqueous of palm fruits may be attributed to the richness of the extracts in antioxidant components. Highest percentage inhibition of the DPPH radicals for the fresh and fermented aqueous extracts at 500 and 1000 μg mL^{-1} respectively show that these concentrations are the most effective concentrations for scavenging free radicals, which is an indication that antioxidant components of the extracts are able to work synergistically to prevent oxidative damage caused by free radicals. However, the decreased DPPH scavenging activity observed when higher concentrations were used could be attributed to feedback inhibition of antioxidant activity by the excess antioxidants components available to scavenge few free radicals. The findings also show that fresh extract possesses better antioxidant activity than the fermented extract which could be attributed to decomposition of the antioxidant components in the fermented extract to components with lesser antioxidant activity. The patterns of the total antioxidant capacity, ferric reducing power, inhibition of lipid peroxidation and DPPH radicals scavenging activity exhibited by the fresh and fermented extracts suggest that the extracts have similar antioxidant mechanisms. The antioxidant activity observed in this study is in-line with higher antioxidant activity of aqueous extracts of date palm reported by El-Nekeety *et al.*[18]. They observed no death and adverse reactions in rats from acute toxicity study of the fresh and fermented aqueous extracts of palm fruits indicate that the extracts are relatively safe to a larger extent. However, excessive consumption may be chronically toxic and elicit adverse reactions or even death. Thus, indiscriminate consumption of these extracts should be avoided to avert any adverse health effects as even drinking water could toxic if consumed in excess. There may be presence of toxic components in the extracts which may be in far lower concentrations than the required toxic dose and continuous consumption of these extract most especially in excess over a long time could lead to bioaccumulation of toxic components in organs and tissues and subsequently cause toxicity. Free radicals induce lipid peroxidation in the presence of less antioxidant to quench the reactions of free radicals[19]. The significant ($p<0.05$) decrease in MDA concentrations observed in rats administered the aqueous extracts indicate that the richness of the extracts in antioxidant components which could have prevented lipid peroxidation and oxidative stress resulting from reactive oxygen species/free radicals generated from normal metabolic reactions and leakages from incomplete transfer of electrons in electron transport chain. The significantly ($p<0.05$) higher levels of MDA concentrations observed in the control rats in this study suggests that free radicals could have been generated from respiratory burst and leakage from metabolic reactions causing lipid peroxidation in normal rats depicted by the elevated concentration of malondialdehyde a product of lipid peroxidation though biochemically and physiologically may not be significant as the observed levels of MDA in the control rats are within normal physiological range. The reduction in the MDA concentration could be attributed to induction of antioxidant enzymes activity like SOD and presence of abundant non enzymatic antioxidants which mop up free radicals that may lead to increased lipid peroxidation[20-21]. The MDA concentration is not static in normal control rats rather it fluctuates base on prevailing physiological condition which could become problematic when there is excessive increment or deviation from the normal physiological range leading to damage of important cellular components and associated health consequences. Consumption of adequate aqueous extract most especially the aqueous extract of palm fruits in the form of whole palm oil (i.e., palm oil+aqueous extract) as seen in "ofe akwu or banga soup" commonly consumed in South-East Nigeria could confer some health benefits such as prevention of lipid peroxidation and oxidative stress caused by free radicals and thus prevent such consumers from suffering their adverse health consequences. The dose dependent significant ($p<0.05$) decrease in the catalase activity in this study could be attributed to antioxidant potentials of the extracts which stimulated catalase activity leading possibly to decrease in hydrogen peroxide concentration as it was converted rapidly to water and oxygen by catalase than its rate of production. The extracts could have inhibited production hydrogen peroxide, thereby reducing its amount available to catalase which is manifested by decrease in catalase activity. The significant decrease ($p<0.05$) in catalase activity in rats administered the fresh extract when compared with those rats administered fermented aqueous extract may be an indication that the fresh extract possesses more potentials of induction of catalase expression and activity resulting in reduction in hydrogen peroxide concentration and decrease in catalase activity than the fermented aqueous extract of palm fruits as some bioactive antioxidant components responsible for increased antioxidant activity observed in the fresh extract might have been metabolized to lesser bioactive antioxidant components during fermentation or decay of the fermented aqueous extract. The induction of antioxidant enzymes activity (catalase, superoxide dismutase,

glutathione peroxidase and myeloperoxidase) by the aqueous extracts mopped up free radicals released from normal metabolic reactions and leakage of incompletely reduced oxygen from the electron transport chain in the mitochondria of the rats administered the extracts. The antioxidant activity demonstrated by both the fresh and fermented aqueous extracts could be attributed to the richness of the aqueous extracts in multi-antioxidant components such as β-carotene, flavonoids, total phenolics and vitamins A, E and C contents which prevent free radical damage, reducing risk of chronic diseases[7,9]. Thus, the consumption of dietary antioxidants from these extracts could be beneficial in preventing cardiovascular diseases, especially atherosclerosis normally associated with oxidative damage of biomolecules[22-23]. The aqueous extracts are rich in water soluble vitamins that are insoluble in oil (palm oil) are normally lost during production of palm oil through wastewater making palm oil deficient in most of these vitamins and other water soluble antioxidant components. Consumption of food rich in components of aqueous extracts of palm fruits in the form of whole palm oil (palm oil+aqueous extract) as practiced in South-Eastern Nigeria via consumption of "ofe akwu or banga soup" and other similar foods could confer some protections against free radicals generated during oxidative stress and prevent some diseases and conditions such as diabetes, cancer, ageing and other related adverse health effects. Most extracts exhibit antioxidant activity via induction of gene expression of antioxidant enzymes as observed in the catalase, myeloperoxidase, superoxide dismutase and glutathione peroxidase activity of the rats used in this study[24]. Synergistic action of non-enzymatic and enzymatic antioxidants (including endogenous and exogenous antioxidants) are required to fully combat or quench free radical reactions in the body as it has been shown that excessive production of free radicals such as superoxide radials under oxidative stress may inhibit the glutathione peroxidase activity, while excessive production of singlet oxygen, superoxide and peroxyl radical inhibits catalase activity[18]. Oxidative stress damages cellular components and result in medical conditions most especially when the host antioxidants are not sufficient to quench oxidative reactions due to excess reactive oxygen and nitrogen species. Catalase, glutathione peroxidase and superoxide dismutase protect the body from reactive oxygen species like O_2^-, OH^- and H_2O_2. It has been established that superoxide dismutase detoxifies superoxide radicals (O_2^-) to hydrogen peroxide (H_2O_2) whereas, glutathione peroxidase reduces H_2O_2 and hydroperoxide to non toxic products[25]. Excessive generation of reactive oxygen and nitrogen species could lead to depletion of antioxidant enzymes. Thus, agents that possess ability to induce the expression of genes coding for antioxidant enzyme and increase the concentrations and activities of antioxidant enzymes as seen in this study are highly valuable in ameliorating the effects of excess oxidants in the body. Consumption of adequate amount of vegetables and fruits known to possess significant antioxidant activity like palm fruits are required to maintain a healthy life.

CONCLUSION AND FUTURE RECOMMENDATION

The findings of this study show that the aqueous extracts palm fruits possess significant *in vitro* and *in vivo* antioxidant activity which could help in ameliorating the effects of oxidative stress resulting from free radicals from both endogenous and exogenous sources suggesting inclusion of the extract in diet could be beneficial to humans. It also suggested that the fresh extract possesses better antioxidant activity than the fermented extract and further studies are needed to fully identify and quantify the antioxidant component responsible for the antioxidant activity of aqueous extracts of palm fruits.

SIGNIFICANCE STATEMENTS

This study discovered the antioxidant properties of the aqueous extracts of palm fruits that can be beneficial for preventing oxidative damage to cellular components due to free radicals. This study will help the researcher to uncover the critical areas of antioxidants and free radical relationship that many researchers were not able to explore. Thus, a new concept on the use of palm fruits to manage oxidative stress may be achieved.

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