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Research Article

Effects of Aqueous Extracts of *Elaeis Guineensis* Fruits on Haematological and Biochemical Parameters in Rats

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Abstract

This study evaluated the haematological and biochemical effects of aqueous extracts of *E. guineensis* fruits on rats. In this study, 45 rats randomly distributed into 5 groups comprising 5 rats in group 1 as the normal control whereas groups 2 - 5 comprising 10 rats each served as the treatment groups. Five rats each from group 2 - 5 were treated with 100, 200, 400 and 600 mg/kg body weight of fresh and fermented aqueous extract of *E. guineensis* fruits respectively for 28 days. Standard methods and analytical grade chemicals and reagents were used in this study. All the extract-treated rats showed an increase in PCV count. Rats administered fermented extract (100 - 400 mg/kg/day) and fresh extract (100 mg/kg/day) showed elevated RBC counts relative to the control. Group 2 - 5 rats administered with fresh and fermented aqueous extracts of *E. guineensis* respectively showed significant (P<0.05) increase in WBC counts with increasing doses of the extracts when compared with the control. Only group 2 rats that received fresh extract showed significant (P<0.05) increase in haemoglobin (Hb) concentration while groups 4 and 5 rats treated with fresh and fermented aqueous extracts of *E. guineensis* respectively showed significant (P < 0.05) decrease in Hb concentrations relative to the control. Significant (P < 0.05) dose-dependent increase in lactate dehydrogenase (LDH) and gamma glutaryl transferase (GGT) activities were observed in all the rats treated with graded doses of the extracts except for group 2 treated with a fresh aqueous extract that showed significant (P < 0.05) decrease in GGT activities. The histomorphology of the hearts observed in the rats showed that the rats treated with 100 - 400 mg/kg/day of the extracts had normal histomorphology. Rats treated with 600 mg/kg/day of fresh and fermented extracts respectively showed multifocal areas of myocardial degeneration and necrosis. The findings of this study indicate that ingestion of high doses of aqueous extract of *E. guineensis* fruits could negatively alter haematological indices, cardiac functions and morphology as demonstrated by the significant increase in LDH and GGT activities in the treated rats.

Keywords: *E. guineensis Fruits; Haematology; Lactate Dehydrogenase; Gamma Glutaryl Transferase; Heart Histology*

Introduction

The highest gamma-glutamyl transferase (GGT) activities are found in kidney and liver with low activities being detected in the serum of normal healthy individuals free from medical conditions that could lead to elevated serum activity of the enzyme. Many studies have demonstrated strong linkage of increase in GGT activity in serum with the increase in arteriosclerosis, hypertension, stroke, diabetes, liver disease, cardiovascular disease, diabetes, cardiac and other vascular diseases [1-3]. Lactate dehydrogenase (LDH) occurs in almost all tissues that carry out glucose metabolism notably in red blood cells, liver cells and heart muscles, where it occurs at varying concentrations. It catalyses the reversible conversion of lactate to pyruvate together with reversible conversion of NAD^+ to NADH under limiting the oxygen supply to ensure continued energy generation from glucose metabolism [4]. A dehydrogenase is a member of the class of enzymes involved in the transfer a hydride from one molecule to another in biochemical reactions. It is used as a marker of common injuries and diseases such as heart failure due to its release to serum during tissue damage. High activities of LDH occur in heart, liver, skeletal muscle, kidney, and erythrocytes; lesser activities are found in the lung, smooth muscle, and brain [5]. High serum LDH activities can be caused by various cancers and its serum activity can be used to monitor patient response to cancer treatment [5]. Also, increased activities of LDH are associated with cancers, cardiac, hepatic, skeletal muscle, and renal diseases, as well as in necrosis, hypoxia, pre-eclampsia, hematologic and neoplastic disorders [6-8].

Elaeis guineensis is a perennial palm tree that bears palm fruits in bunches containing about 1000 - 3000 seeds, which serves as a major source of palm oil and palm kernel oil [9]. The aqueous extracts of *E. guineensis* fruits are rich in abundant antioxidant components, fatty acids, proteins, carbohydrates [10]. The extract has also been shown to contain a high level of saturated fats especially that negatively impair lipid profile and could have adverse effects of the heart functions [11,12]. Previous studies have shown that rats fed low to high doses of fermented aqueous extracts of *E. guineensis* fruits suffered kidney and liver damage [13]. This study investigated the effects of aqueous extracts of *E. guineensis* fruits on the haematological indices and some biochemical parameters in rats.

Materials and Methods

Collection and preparation of palm fruits

Freshly ripe palm oil fruits were collected from the Obeakpu palm oil milling site in Njaba, Imo State and they were identified as *Elaeis guineensis* fruits by Dr. Ibe. K. Ndukwe of the Department of Forestry, College Natural Resources and Environmental Management, Michael Okpara University of Agriculture, Umudike. The ripe palm fruits were selected, parboiled under high temperature (120 - 140°C) for 2 hours and crushed with mortar and pestle. Crude palm oil was extracted with water and the resulting aqueous portion (palm oil mill effluents) was first filtered with a mesh cloth followed with Whatman No. 1 filter paper. The filtrate was divided into two, one portion was preserved in a refrigerator (i.e. fresh aqueous extracts of palm fruits) and the second portion was allowed to ferment for 21 days (fermented aqueous extracts of palm fruits). The fresh and fermented aqueous extracts of palm fruits were respectively concentrated to dryness in a water bath at 50^0c.

Collection and acclimatization of the experimental animals

Forty-five male Wistar albino rats weighing 120 – 140 g were purchased from the Department of Zoology, Animal House, University of Nigeria, Nsukka and acclimatized at the Animal House of the College of Natural Sciences, Michael Okpara University of Agriculture, Umudike for 7 days under 12 hours dark and light cycle with free access to standard animal feed and drinking water. The animals were handled in adherence with the National Institute of Health's guidelines for the care and use of Laboratory animals [14].

Experimental design

Forty-five male Wistar strain albino rats were used for the evaluation of the effects of aqueous extracts of palm fruits on haematological indices, biochemical indices and histology. The rats were divided into 5 groups with group 1 having five rats only and served as the normal control. Groups 2 - 5 had 10 rats each in which 5 rats in each group received fresh and fermented aqueous extracts of the palm fruits respectively for 28 days. The rats were sacrificed on the 29^{th} day and blood samples and organs were collected for analysis.

- **Group 1:** Group 1 rats were treated with 2ml/kg of normal saline orally every 24 hours for 28 days.

- **Group 2:** Five rats each in this group were treated with 100 mg/kg body weight of fresh and fermented aqueous extracts of palm fruits every 24 hours for 28 days respectively.
- **Group 3:** Five rats each were treated with 200 mg/kg body weight of fresh and fermented aqueous extracts of palm fruits every 24 hours for 28 days respectively.
- **Group 4:** Five rats each were treated with 400 mg/kg body weight of fresh and fermented aqueous extracts of palm fruits every 24 hours for 28 days respectively.
- **Group 5:** Five rats each were treated with 600 mg/kg body weight of fresh and fermented aqueous extract of palm fruits every 24 hours for 28 days respectively.

Determination of acute toxicity

The acute toxicity of the aqueous extracts was determined using male albino mice as described by Lorke's Method [15].

Determination of haematological Indices

The haematological indices including haemoglobin (Hb) concentration, packed cell volume PCV), total white blood cell count (WBC) and red blood cell (RBC) count were determined as outlined by the methods of Dacie and Lewis [16].

Assay of lactate dehydrogenase activities

Lactate dehydrogenase activities were assayed according to the method of Henry [17]. In this method lactate dehydrogenase catalyzes the conversion of lactate to pyruvate in the presence of NAD^+ which is subsequently reduced to NADH. The rate of NADH formation measured at 340 nm is directly proportional to the lactate dehydrogenase activities in the serum.

Assay of gamma glutaryl transferase activities

Gamma-glutamyltransferase activities were assayed by the colourimetric method described by Teitz [18]. The substrate L- γ-glutamyl-3-carboxy-4-nitroanilide, in the presence of glycylglycine is converted by γ-Glutamyl transferase in the serum to 5-amino-2-nitrobenzoate which can be measured at 405 nm.

Histological analysis and examination

The rats were humanely sacrificed after the treatments on the 29th day of the study. The hearts were harvested from the rats and heart sections excised for histopathological study. The excised heart sections were fixed in 10% phosphate-buffered formalin for 48 hours and subsequently trimmed, dehydrated in 4 grades of alcohol (70%, 80%, 90% and absolute alcohol), cleared in 3 grades of xylene and embedded in molten wax to enable them to solidify. The solidified blocks were sectioned, 5μm thick with a rotary microtome, floated in water bathe and incubated at 60°C for 30 minutes. The 5μm thick sectioned tissues were cleared in 3 grades of xylene and rehydrated in 3 grades of alcohol (90%, 80% and 70%). The sections were then stained with Hematoxylin for 15 minutes. Blueing was made with ammonium chloride and differentiation carried out with 1% acid alcohol before counterstaining with Eosin. Permanent mounts were made on degreased glass slides using a mountant. The prepared slides were examined with a Motic™ compound light microscope using x4, x10 and x40 objective lenses. The photomicrographs were taken using a Motic™ 9.0 megapixels microscope camera at x100 and x400 magnifications.

Statistical analysis

The data obtained were statistically with one-way analysis of variance (ANOVA) using Statistical Product and Service Solutions (SPSS) version 22. The means were compared using Duncan multiple range tests and significance was established at 95% confidence level ($p < 0.05$).

Results

The acute toxicity study showed that the aqueous extracts caused no death or adverse reactions to the albino mice after 24h of the administration of each of the extracts.

The percentage packed cell volume (PCV) of rats treated with fresh and fermented aqueous extract of palm fruits respectively showed that the normal control rats had high PCV levels as shown in figure 1. Treatment with fermented aqueous extract of palm fruits caused significant ($P < 0.05$) increase in PCV levels in group 3 when compared with normal control. Group 5 rats treated with a high dose of the fresh aqueous extract of palm fruits showed significant ($P < 0.05$) increase in PCV levels, while all other groups treated with graded doses of the fresh aqueous extract of palm fruits showed no significant ($P > 0.05$) increase in PCV levels when compared with normal control. It was observed that there were significant ($P < 0.05$) difference in PCV levels of groups 3 and 5 treated with fermented aqueous extract when compared with their corresponding groups treated with equivalent doses of fresh aqueous extract of palm fruits.

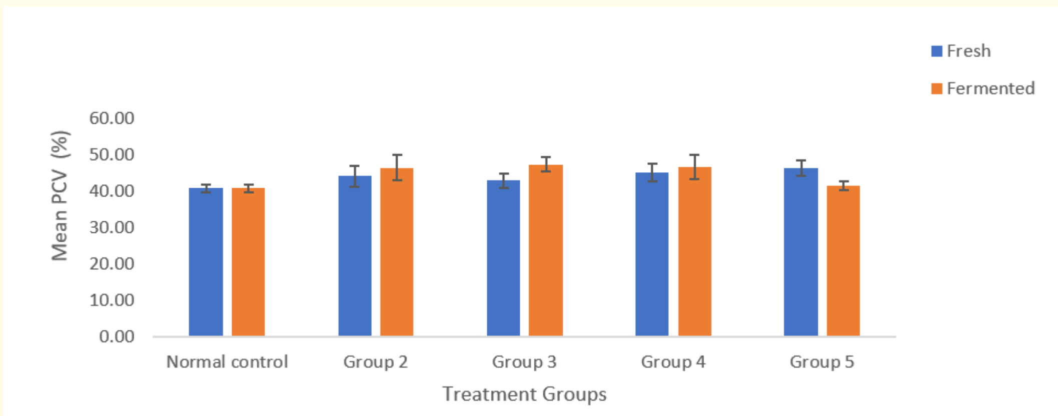

Figure 1: *Percentage Packed Cell Volume of Male Wistar Albino Rats Administered with Graded Doses of Fresh and Fermented Aqueous Extracts of Palm Fruits.*

The red blood cell (RBC) counts in figure 2 showed significant ($P < 0.05$) increase in RBC counts of groups 2 - 4 rats treated with graded doses of fermented aqueous extract of palm fruit when compared with normal control and corresponding groups treated with equivalent doses of fresh aqueous extract respectively. However, no significant ($P > 0.05$) decrease in RBC counts was observed in group 5 treated with a high dose of fermented aqueous extract of palm fruits when compared with corresponding group 5 rats treated with an equivalent dose of the fresh aqueous extract and normal control respectively.

The data in figure 3 show white blood cell (WBC) counts of Wistar albino rats treated with normal saline and aqueous extracts of palm fruits respectively. Normal control rats showed moderately low WBC counts when compared with all the tested groups. However, groups 2 - 5 rats treated with fresh and fermented aqueous extracts of palm fruits respectively exhibited dose-dependent significant ($P < 0.05$) increase in WBC counts when compared with normal control. There was no significant ($P < 0.05$) difference observed in the WBC counts of groups 2 - 3 treated with fresh and fermented aqueous extracts of palm fruits respectively. However, there was significant ($P < 0.05$) increase in WBC counts of group 5 treated with fermented aqueous extract when compared to corresponding WBC counts of group 5 rats treated equivalent dose of fresh aqueous extract of palm fruits.

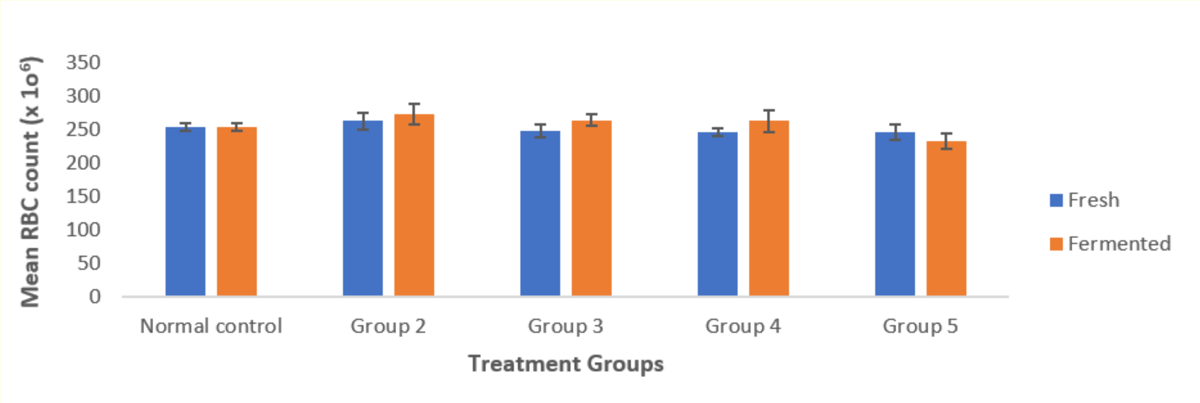

Figure 2: *Red Blood Cell Counts of Male Wistar Albino Rat Treated with Graded Doses of Fresh and fermented Aqueous Extracts of Palm Fruits.*

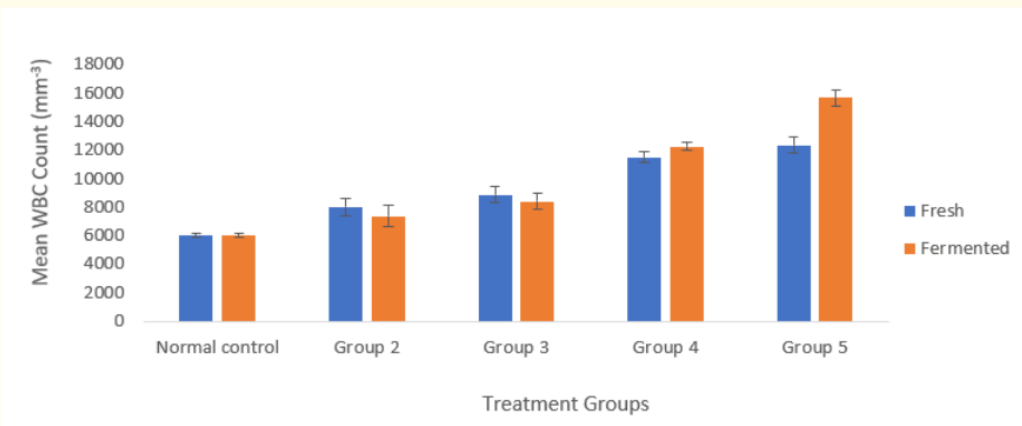

Figure 3: *White Blood Cell Counts of Male Wistar Albino Rat Treated with Graded Doses of Fresh and Fermented Aqueous Extracts of Palm Fruits.*

Figure 4 showed haemoglobin (Hb) concentration of male Wistar albino rats administered normal saline and aqueous extracts of palm fruits respectively for 28 days. Group 2 rats treated with fresh and fermented aqueous extract of palm fruits respectively showed significant ($P < 0.05$) and no significant ($P > 0.05$) increase in haemoglobin concentrations when compared with the normal control rat administered normal saline. However, groups 4 and 5 rats treated with fresh and fermented aqueous extracts of palm fruits respectively showed significant ($P < 0.05$) decrease in Hb concentrations when compared with the normal control.

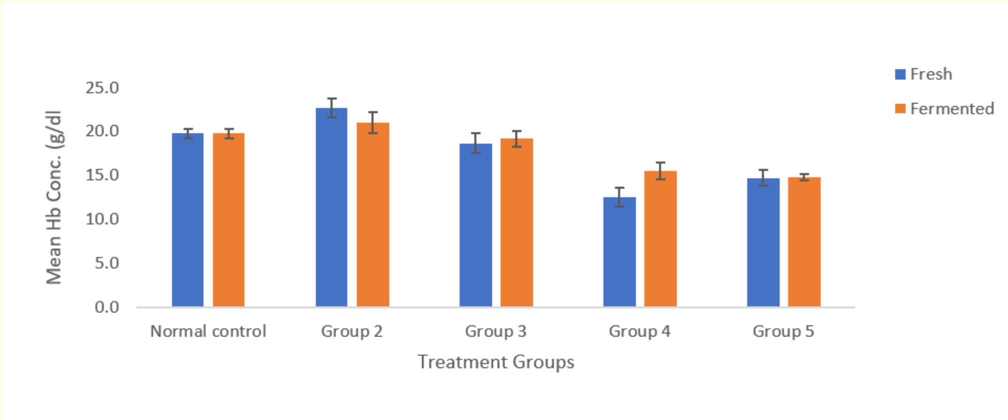

Figure 4: *Haemoglobin Concentration of Male Wistar Albino Rat Treated with Graded Doses of Fresh and Fermented Aqueous Extracts of Palm Fruits.*

Lactate dehydrogenase (LDH) activities of male Wistar albino rats treated grade doses of fresh and fermented aqueous extracts of palm fruits show that normal control rats had low dehydrogenase activity (Figure 5). Significant ($P < 0.05$) dose-dependent increase in LDH activities were observed in all the groups treated with fresh and fermented aqueous extracts of palm fruits respectively when compared with the normal control. Lactate dehydrogenase activities of groups 3 - 5 that received fermented aqueous extract were significantly ($P < 0.05$) higher than their corresponding groups that received equivalent doses of fresh aqueous extract of palm fruits.

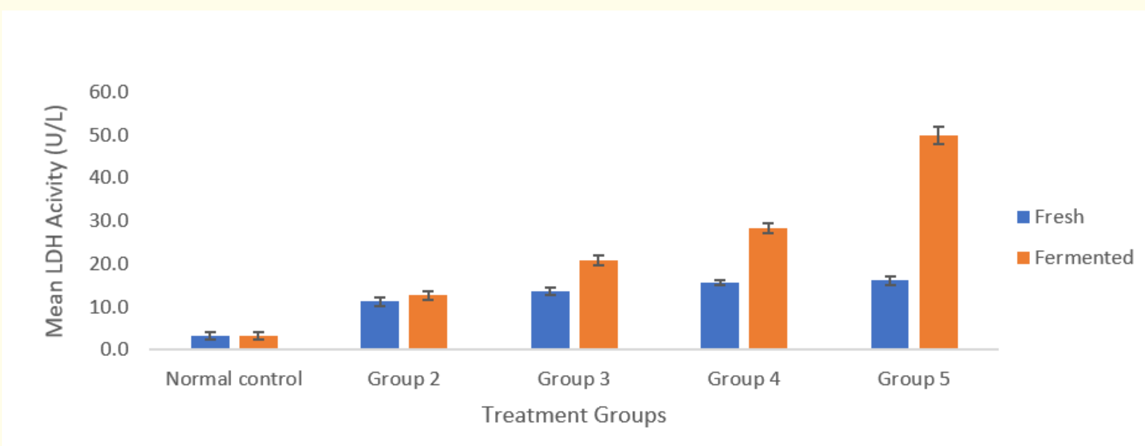

Figure 5: *Lactate Dehydrogenase Activities of Male Wistar Albino Rats Treated with Fresh and Fermented Aqueous Extracts of Palm Fruits.*

Gamma-glutamyl transferase (GGT) activities of male Wistar albino rats treated with aqueous extracts of palm fruits and normal saline respectively indicated low GGT activity for normal control rats. Fresh aqueous extract administration caused no significant (P > 0.05) decrease in GGT activity observed in group 2 and no significant (P > 0.05) increase in GGT activity of corresponding group 2 rats treated with an equivalent dose of fermented aqueous extract of palm fruits when compared with normal control. Groups' 3 - 5 rats treated with moderate to high doses of fresh and fermented aqueous extracts of palm fruits respectively showed significant (P < 0.05) increase in GGT activity when compared with the normal control. Rats in groups 3 that received the fresh aqueous extract had significantly (P < 0.05) higher GGT activities when compared with the GGT activity of group 3 rats treated with an equivalent dose of fermented aqueous extract of palm fruits.

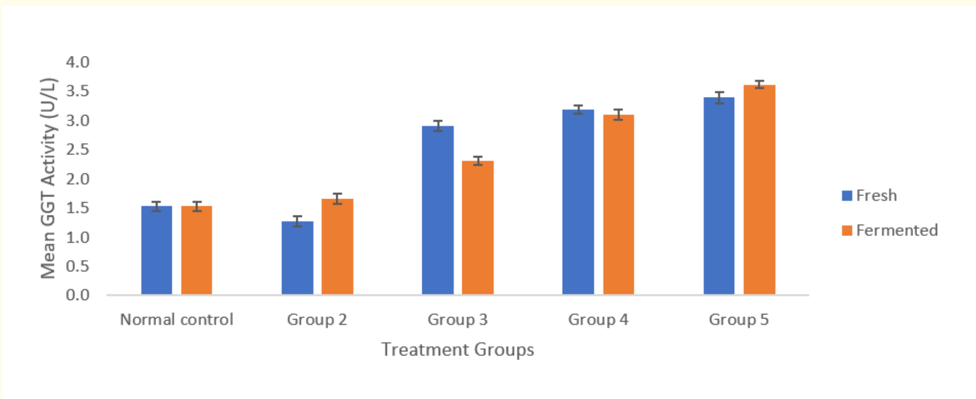

Figure 6: *Gamma Glutaryl Transferase Activities of Male Wistar Albino Rats Treated with Fresh and Fermented Aqueous Extracts of Palm Fruits.*

Morphology of heart from (GROUP 1) normal control rats that received normal saline

Sections of the heart collected from the animals in this group showed the normal myocardial histo-architecture of laboratory rodents (Figure 7). The sections showed normal epicardial, myocardial and endocardial layers. The myocardium showed normal myocytes arranged in overlapping bundles, surrounded by a rich network of blood vessels and capillaries (blue arrow) embedded in a connective tissue matrix. The myocytes contain single centrally located oval to elongated hypochromatic nuclei (white arrow). Fibroblasts of the connective tissue matrix appear as spindle-shaped cells with spindle-shaped hyperchromatic nuclei (black arrow). H and Ex400.

Effects of moderate doses of fresh and fermented aqueous extracts of *E. guineensis* fruits (100 and 200 mg/kg body weight) on rat heart histomorphology

The heart sections from rats groups 2a - 4b administered with 100, 200 and 400 mg/kg of the fresh and fermented aqueous extracts of palm fruits, respectively showed the normal myocardial histo-architecture of laboratory rodents (Figure 8 - 13). The sections showed normal epicardial, myocardial and endocardial layers. The myocardium showed normal myocytes arranged in overlapping bundles, surrounded by a rich network of blood vessels and capillaries (blue arrow) embedded in a connective tissue matrix. The myocytes contained single centrally located oval to elongated hypochromatic nuclei (white arrow). Fibroblasts of the connective tissue matrix appear as spindle-shaped cells with spindle-shaped hyperchromatic nuclei (black arrow).

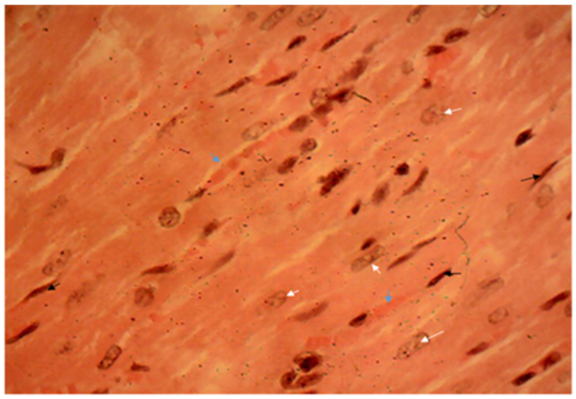

Figure 7: *Histomorphology of Heart from a Normal Control Rat that Received 2ml/kg of Normal Saline (Group 1).*

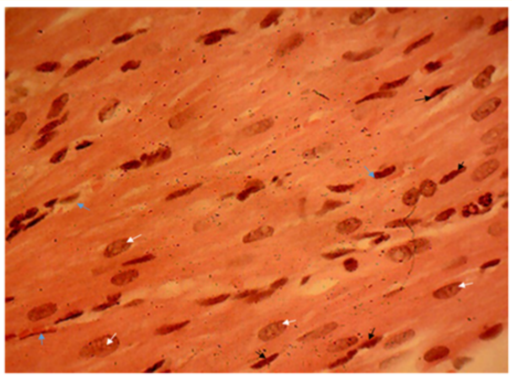

Figure 8: *Histomorphology of Heart from Rats that Received 100mg/kg of Fresh Aqueous Extract of E. guineensis Fruits (Group 2a).*

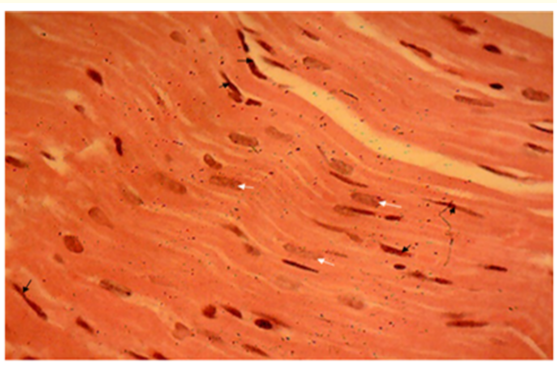

Figure 9: *Histomorphology of Heart from Rats that Received 100mg/kg of Fermented Aqueous Extract of E. Guineensis Fruits (Group 2b).*

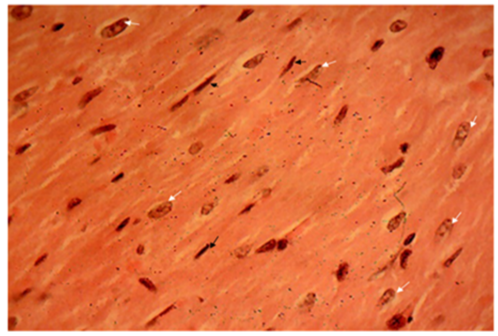

Figure 10: *Histomorphology of Heart from Rats that Received 200mg/kg of Fresh Aqueous Extract of E. guineensis Fruits (Group 3a).*

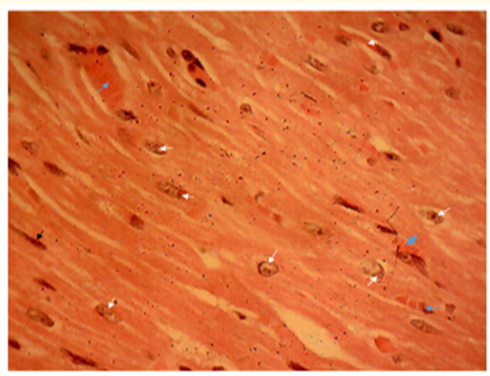

Figure 11: *Histomorphology of Heart from Rats that Received 200mg/kg of Fermented Aqueous Extract of E. Guineensis Fruits (Group 3b).*

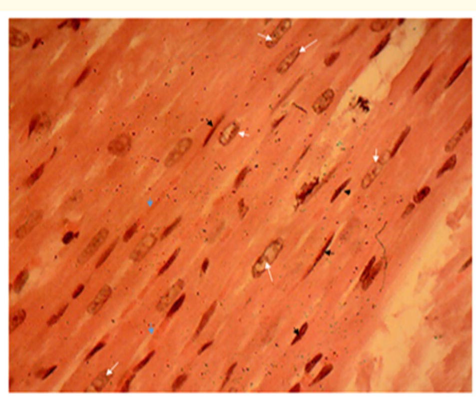

Figure 12: *Histomorphology of Heart from Rats that Received 400mg/kg of Fresh Aqueous Extract of E. guineensis Fruits (Group 4a).*

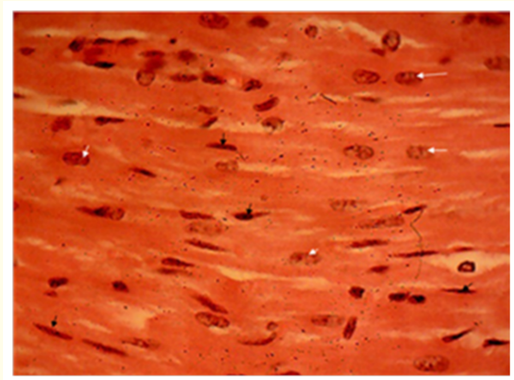

Figure 13: *Histomorphology of Heart from Rats That Received 400mg/kg of Fermented Aqueous Extract of E. Guineensis Fruits (Group 4b).*

Effects of a high dose of fresh and fermented aqueous extracts of *E. guineensis* fruits (600 mg/kg body weight) on rat heart histomorphology (GROUPS 5a – 5b)

Sections of the cardiac muscle collected from the rats in the group 5a that received 600 mg/kg body weight of the fresh aqueous extract of the palm fruits showed multifocal areas of myocardial degeneration and necrosis (arrow) (Figure 14). The affected myocardial cells show loss of architecture, loss of striation and single large clear cytoplasmic vacuoles which peripherally displaced the pyknotic nuclei (white arrow). However, the sections of the heart collected from the animals in the group 5b that received 600 mg/kg body weight of the fermented aqueous extract of the palm fruits showed multifocal areas of myocardial necrosis with moderate infiltration of mononuclear inflammatory leucocytes (arrow) (Figure 15). Blood vessel (B).

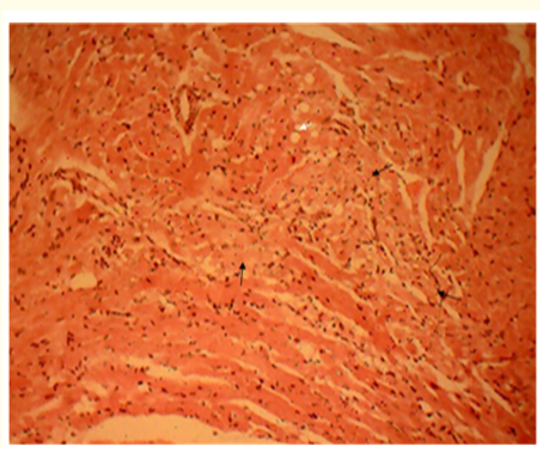

Figure 14: *Histomorphology of Heart from Rats that Received 600mg/kg of Fresh Aqueous Extract of E. guineensis Fruits (Group 5a).*

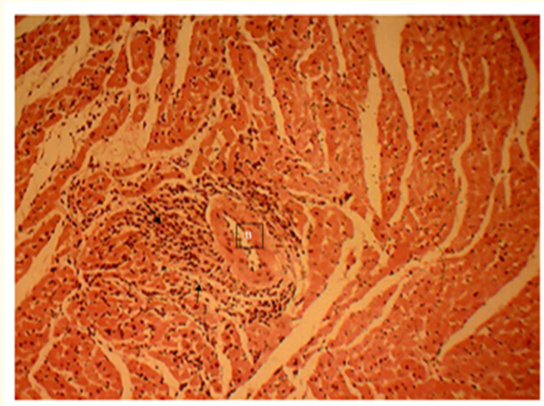

Figure 15: *Histomorphology of Heart from Rats that Received 600 mg/kg of Fermented Aqueous Extract of E. Guineensis Fruits (Group 5b).*

Discussion

This study evaluated the haematological, biochemical and histological effects of aqueous extracts of E. guineensis fruits on rats. The acute toxicity study of the aqueous extracts of palm fruits using male Wistar albino mice showed that these extracts are relatively safe for consumption as no death or adverse effects like loss of appetite, loss of hairs; drowsiness, stooling, and restlessness were observed. However, the absence of observable signs of acute toxicity observed in these mice even when the highest dose of the aqueous extracts were administered do not guarantee that these extract may not be toxic on prolonging consumption. Most plant extracts are not acutely toxic but are sub-chronic and chronically toxic on prolong consumption. Thus, care should be taken when consuming these extracts to avoid harming oneself unknowingly.

The significant increase in packed cell volume (PCV) counts of male Wistar albino rats administered graded doses of fresh and fermented aqueous extract of palm fruits respectively can be attributed to the packed cell volume-boosting potential of the aqueous extract. The extract may be rich in phytoconstituents that have positive effects on haematopoietic cells leading to increased packed cell volume observed in this study. This extract could play a vital role in the management of anaemia and blood loss due to its ability to replenish and boosting packed cell volume in normal rats. Thus, the findings of this study are in agreement with previous researchers that plant extracts that stimulate an increase in red blood cells and packed cell volume could be used for efficient management of anaemic conditions [19, 20]. Also, consumption of fermented aqueous extract of palm fruits in high concentration could impair or cause a decrease in packed cell volume. This suggests that fermentation might have converted its phytoconstituents to more bioactive metabolites that have positive effects on the haematopoietic cells at low concentrations, and at higher concentration causes a decline in PCV counts. Thus, a fermented aqueous extract of palm fruits should be consumed in low concentration while the fresh extract should be consumed in high concentration to maximize their positive effects on PCV counts.

The significant increase in red blood cells (RBC) counts in groups 2 – 4 could be attributed to the blood-boosting effects of the fermented extract which contains bioactive compounds that effectively stimulated haematopoietic cells to produce more red blood cells. It may have masked the available red blood cell deceiving the haematopoietic cells to produce more red blood cells. It could also cause increase stability of RBC thereby prolonging their circulation in the blood. Also, the significant increase in RBC count in group 2 rats administered fresh aqueous extract of palm fruits indicated that the fresh extract has better stimulatory effects on haematopoietic cells at lower concentrations than the fermented aqueous extract. This implies that bioactive constituents in the fresh extract could have been converted to more potent bioactive constituents in the fermented extract that exhibited better stimulatory or inductive effects on the haematopoietic cells than the fresh extract at higher concentrations.

White blood cells defend the body against infections and invasion by foreign organisms, because of this, individuals or animals with very low white blood cell count are prone to infectious diseases contrary to those with normal white blood cell counts [21]. The dose-dependent significant increase in white blood cell counts observed in all the groups treated with graded doses of the aqueous extracts could be attributed to the stimulatory effects of these extracts on the innate immune system. These extracts may be rich in bioactive principles that mimic foreign antigens or behave as false antigens that elicit production of an increased number of white blood cells as an antigenic response against presumed foreign invaders. These extracts could play a vital role in boosting the innate immune system most especially in immunosuppressed patients. However, cautions should be taken in the consumption of these extracts as excessive induction of white blood cell production could lead to autoimmune disease.

Additionally, the increase in haemoglobin concentrations observed in groups 2 and 3 administered graded doses of fresh and fermented aqueous extract of palm fruits respectively could be attributed to the pharmacologically active phytoconstituents present in these extracts. These phytoconstituents at moderate concentrations may be effective in stabilizing circulating haemoglobins and or induction of synthesis of more haemoglobin for the transport of oxygen and carbon dioxide in the blood. These extracts have been reported to rich in phytochemicals and antioxidant components with proven antioxidant activities that could ameliorate oxidative stress in the body and their effects on haemoglobins. Thus, stabilizing and extending the half-life of circulating haemoglobins in the blood [13]. Isaac *et al*., had also reported that these contain high iron contents that could aid in the synthesis of heme components of haemoglobins, which cause increase serum concentration of this protein [19].

Gamma-glutamyl transferase (GGT) is an enzyme usually found in cell membranes of many tissues mainly in the liver, kidney, gallbladder, heart, spleen; intestine, seminal vesicles and pancreas but liver and kidney are considered as major sources of the normal enzyme activity [22]. Increased GGT activity occurs in liver diseases, congestive heart failure, diabetes, or pancreatitis and may be used as an indicator of cardiovascular disease, hypertension fatty-liver disease, and predicts increased risk of mortality. Its increased activity may also be caused by alcohol abuse or use of drugs that are toxic to cell membranes of these tissues. Emerging pieces of evidence indicate that elevated serum GGT activity correlates with cardiovascular diseases making it a good cardiovascular risk marker and its accumulation in atherosclerotic plaques, further suggesting its potential role in the pathogenesis of cardiovascular diseases [23,24]. The increase in GGT activities observed in this study is in agreement with the findings of Ali *et al*., who reported multiple fold increase in GGT activities in heart failure patients compared with the normal control subjects at the absence of any other factors that could cause elevation of GGT activities [25]. The dose-dependent increase in GGT activities showed that the extract has adverse effects on heart integrity and functions and could be seen as a possible indicator of, arteriosclerosis, stroke, and diabetes liver disease, cardiovascular and haematological disorders [26-29].

The dose-dependent significant increase in the serum lactate dehydrogenase activities observed in the rats administered graded doses of fresh and fermented aqueous extract of palm fruits could be attributed to the effects of cardiotoxic phytoconstituents of the extracts that may have altered heart muscle tissue integrity and possibly heart functions. The increase in serum lactate dehydrogenase activity is proportional to the level of heart muscle tissue damage. Disruption of heart membrane integrity will increase the membrane permeability and leakage of lactate dehydrogenase into the serum resulting in the observed increase in serum lactate dehydrogenase activities. The abnormally high levels lactate dehydrogenase activities observed in rats administered the fermented aqueous extract is suggestive that the aqueous extracts contain high levels of pro-cardiotoxins that became more potent in the fermented aqueous extract than in the fresh aqueous extract of the palm fruits due to biotransformation caused by the fermentation. Thus, consumption of these aqueous extracts or their use as alternative water in the production of palm oil should be discouraged to protect human health. It has been suggested that an increase in serum lactate dehydrogenase activities could also arise from liver disorders and diseases like anaemia. The findings of this study are in line with previous reports that the measurement of lactate dehydrogenase activity, cardiac troponins and myoglobin concentrations are good predictive markers of cardiac disease [30]. The dose-dependent significant increase in lactate dehydrogenase activities together with multifocal areas of myocardial degeneration, necrosis and moderate infiltration of mononuclear inflammatory leucocytes observed from the histopathological examination of rats administered graded doses of the fresh and fermented aqueous extract of palm fruits show that consumption of high doses of these extract could greatly impair human health.

The dose-dependent increase in gamma-glutamyl activities of rats administered fresh and fermented aqueous extracts of palm fruits could be attributed to adverse effects of the extracts on the cell membrane of the heart muscle and other related organs such as liver, kidney and pancreas. At increased dose, the aqueous extract caused myocardial degeneration and necrosis of the cardiac muscle as depicted in the histomorphology of the hearts from the rats. These might have led to the increased serum level of GGT due to increased membrane permeability resulting from loss of cardiac muscle architecture. The increased GGT activity observed in this study suggests that consumption of aqueous extracts of palm fruits could lead to chronic health impact on the heart functions that may result in heart failure and even death if necessary precautions are not taken. Since increase serum GGT activities could have resulted from leakages from other organs such as liver, kidney, gallbladder, spleen, intestine and pancreas, the increased serum GGT activities observed in groups 2 - 4 may have come from these organs as none of their cardiac muscle histomorphology showed any abnormalities.

Conclusion

The findings of this study suggest that ingestion of high doses of aqueous extract of *E. guineensis* fruits could alter haematological indices and some biochemical functions as demonstrated by significant dose-dependent increase in LDH and GGT activities and should be avoided to maintain good health. Further studies are needed to isolate and characterize the phytoconstituents responsible for the bioactivities exhibited by these aqueous extracts.

Conflict of Interest

Authors have declared no conflict of interest.

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