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HEPATO PROTECTIVE POTENTIAL OF FRESH *ELAEIS GUINEENSIS* SEED EXTRACT ON RATS EXPOSED TO PYRETHROID-BASED MOSQUITO COIL FUMES

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ABSTRACT

This study investigated the effect of fresh *Elaeis guineensis* seed extract on rats that were exposed to pyrethroid-based mosquito coil fumes. In a random selection, six groups of rats each containing six rats were arranged. The 1st group received distilled water and chicken feed, the 2nd group was daily exposed to pyrethroid-based mosquito coil smoke for one hour. The 3rd group was also exposed to smoke from mosquito coil, but in addition administered 2ml/kg body weight of Vitamin E orally. The 4th and 5th groups were also exposed to smoke from mosquito coil and in addition treated orally with oil palm seed extract (2ml/kg and 4ml/kg body weight), respectively. The 6th group was administered oral dose (2ml/kg body weight) of *Elaeis guineensis* seed extract alone. After twenty-eight days, the animals were sacrificed in painless manner and blood as well as homogenates was obtained for biochemical analysis. Results indicated a significant ($P<0.05$) increase in liver enzymes (alkaline transferase, aspartate transaminase, alkaline phosphatase and total protein levels) for the 2nd group compared to the 1st group which served as normal control. Also, a measure of antioxidant activities and stress indication showed that myeloperoxidase, reduced glutathione, superoxide dismutase, catalase, peroxidase, advanced oxidation protein product as well as lipid peroxidation levels were all elevated significantly ($p<0.05$) in the 2nd group than 1st group. But when *Elaeis guineensis* seed extract was administered at 2ml/kg and 4ml/kg per body weight, it led to a significant ($P<0.05$) decrease of these biochemical parameters in 4th, 5th and 6th groups compared to the 2nd group which served as positive control. In conclusion, from the observed improvements in biochemical and oxidative stress markers, it is conceivable that *Elaeis guineensis* seed extract may potentially offer natural protection in rats against hepato toxicity induced by smoke from mosquito coils.

KEYWORDS: Elaeis Guineensis, pyrethrins, insecticides, Mosquito coils, toxicity, liver.

INTRODUCTION

Malaria is one of the commonest sicknesses that have continued to plague nations of the third world and developing countries, especially in the African continent (CDC, 2021). As a matter of fact, it is even worse within same climes, where many of the population are unemployed, and those gainfully employed are mostly low-income earners (CDC, 2021). It is reported that over 90% of all deaths due to malaria occur in sub Saharan Africa (Stonely, 2023; WHO, 2023). In fact only four sub Saharan nations alone accounted for half of the entire number of deaths from malaria worldwide in 2020 (WHO, 2023) and it has been reported to be endemic in Africa and the most populous black African nation, Nigeria that has the highest burden of malaria worldwide (CDC, 2021; WHO, 2022). It is thus little wonder that a very common means of preventing malaria in these climes may appear crude, unrefined, to the extent that residents have opted to make do with various forms and brands of mosquito coils or sticks (Abdullah *et al*, 2017) which are light up and kept inside and around homes and residences, mostly at night, while sleeping as a preventive measure against teaming populations of mosquitoes (Abdullah *et al*, 2017). Although this practice may come with its attendant health hazard, the populace are still increasing patronage due in part to non-availability of better alternative, but largely owing to the easy accessibility and affordability of these coils (Abdullah *et al*, 2017; Naz *et al*, 2019).

There are various substances in the composition of these coils such as metal fumes particles and reactive oxygen

species, binders and colours that have capacity to negatively influence body cells/tissues function (Naz *et al*, 2019; Liu *et al*, 2020). But the main active component is pyrethrin which constitutes approximately four percent of the whole coil mass and has over a century now been in use as an insecticide (Liu *et al*, 2020).

It has been reported that this active component deplete antioxidants to cause stress, and also distort the cell signaling process and nervous system in insects to eventually paralyze those insects (Naz *et al*, 2019; Jegede et al, 2015; Liu *et al*, 2020). White blood cells have been seen to be abnormally increased due to prolonged inhalation of fumes from pyrethrin-based coils, also causing mutations in macrophages inside lungs' alveoli, and bone marrow (Liu *et al*, 2020; Naz *et al*, 2019).

Since it thus appear at the moment that malaria illness is endemic to this clime, and may not be eradicated soon, necessitating a likely continuous patronage of some of this hazardous substances as preventive measure, this research is undertaken with the objective of deepening awareness and exploring natural and cheap resource in alleviating such hazardous effects of these repellents that have been and may still remain in use for a long time; with particular focus on hepatotoxicity.

Therefore, one naturally available resource – the oil palm seed, more commonly identified locally as palm kernel or in colloquial parlance as "banga seed" comes readily to fore. It goes by the scientific name *Elaeis guineensis* seed, and is derived from same oil palm tree as the red oil palm,. It is that endocarp of the red oil palm fruit from which red oil is derived, but different in that, its oil is not red; and it is credited with good nutritional control of lipid profile and lots of antioxidant properties (Anderson int'l Corp; Ajuwon *et al*, 2013).

Emmanuel *et al*, (2021) reported that oil palm seed plays role in reducing oxidative stress, protecting heart tissues, and it promotes repairs leading to recovery in hearts where reperfusion injury may have occurred. Thus, this study aim to investigate the effect of fresh *Elaeis guineensis* seed extract on the liver of rats exposed to pyrethroid based mosquito coil fumes, as well as antioxidant activities.

METHODS

A total of thirty six (36) male rats were used for this study. They were procured from the animal house in the Department of Pharmacology, University of Port Harcourt, Rivers State. The rats were kept in standard cages and allowed to acclimatize for a period of two weeks, during which they freely accessed pellet feed and clean water.

Fresh *Eleasis guineensis* fruit was obtained from Niger Delta University Farm, sun dried and the shell was broken to release the palm seed endocarp. Approximately 10g of the seed was weighed and homogenized with 100ml of corn oil to give a solution of oil palm seed extract. The mixture was filtered with double cheese cloth and the filtrate collected was stored in the refrigerator for use. The extract was administered twice daily (12 hours interval) at doses of 2ml/kg body weight and 4ml/kg body weight to the rats with the aid of gavaging tube.

Experimental Design

Thirty (36) male rats were randomly divided into six groups (1^{st} to 6^{th}) kept in separate cages, consisting of six animals each (n = 6) and administered as follows

1^{st} group: The rats were kept in cages which were properly ventilated without exposure to mosquito coil, and given chicken feeds with distill water only (designated as normal control).

2^{nd} group: These were subjected to whole body inhalation of smokes from repellent (pyrethroid based mosquito coil) for 1hour per day with the aid of a film cupboard for a period of 28 days (designated as positive control).

3^{rd} group (Standard Control): They were housed properly ventilated cages with no repellent and administered 2ml/kg body weight of Vitamin E orally for 28 days.

4^{th} group: Animals were treated as 2^{nd} group but in addition administered *Eleasis guineensis* seed extract at 2ml/kg body weight for 28 days (designated as mosquito Coil and extract).

5^{th} group: The rats were treated as 4^{th} group except that the dose of the extract was increased to 4ml/kg body weight.

6^{th} group: Animals were treated as 1^{st} group but in addition given 2ml/kg body weight of fresh *Eleasis guineensis* seed for the duration of the experiment.

At the end of 28 days, 24hours of the last exposure to the mosquito repellent and treatment with aqueous extract of oil palm seed, all rats were sacrificed under light anesthesia, blood sample aspirated into sample bottles and prepared for biochemical estimations. The liver was harvested and a part of it homogenized and used for antioxidant analysis, whereas the other part was used for histopathological examination.

Biochemical analysis were all in strict adherence to protocols as written on kits (Stambaugh & Post, 2004; Desai & Ray, 2014; Walker et al, 1990; Beutler, 1989).

RESULTS

Results of the effect of fresh *Elaeis guineensis* seed extract on pyrethroid based mosquito coil fumes are presented in the tables below;

Table 4.1: **Mean values of liver enzymes and protein levels in rats exposed to mosquito coil fumes and treatment with fresh *Eleasis guineensis* seed extract.**

Groups/Parameters	AST(U/L)	ALP (U/L)	ALT (U/L)	TP (mg/ml)
1st group (normal control)	34.60 ±3.96[a]	20.60 ±3.63[a]	52.00±3.36[a]	6.50 ± 1.16[a]
2nd group (positive control)	41.80 ±2.29[b]	26.40 ±3.21[b]	81.00±13.24[b]	8.50±1.46[b]
3rd group (standard control, 200mg Vitamin E,)	32.60 ± 3.79[ab]	19.10 ±3.75[ab]	51.40±9.88[ab]	5.98± 1.10[ab]
4th group (2ml/kg body weight of extract)	38.20 ± 4.45[c]	23.80±3.50[c]	70.80±11.89[c]	6.94±1.67[c]
5th group (4ml/kg body weight of extract)	36.20 ±2.25[d]	20.80 ±3.30[d]	61.60±15.02[d]	5.70±1.91[d]
6th group (2ml/kg body weight of extract)	31.20 ±2.25[a]	19.80 ±3.31[a]	51.60±15.02[a]	5.56±1.90[a]

Values are expressed as mean ±SEM. Mean with same superscript letters on the same column are not significantly different (P <0.05).

AST-Aspartate transferase, ALP-Alkaline phosphatase, ALT-Alanine transaminase, TP-Total Protein, MDA-Lipid Peroxidation.

Table 4.1 reveals serum values for liver enzymes and total protein analyzed in wistar rats. For AST activity, serum values analyzed showed a significant (P<0.05) increase of 41.80±2.29U/L in 2nd group compared to 34.60±3.96U/L in 1st group. But a significant (P<0.05) decrease of 32.60±3.79U/L was observed in 3rd group compared to 34.60±3.96U/L in 1st group. When rats were treated with 2ml/kg and 4ml/kg aqueous extract of *Elaeis guineensis* seed, a significant (P<0.05) decrease of 38.20±4.45U/mg and 36.20 ±2.25U/L were observed in 4th and 5th groups when compared to 41.80±2.29U/L in 2nd group. Whereas a non-significant (P<0.05) decrease of 31.20±2.25U/L was observed in 6th group when compared to 1st group.

Serum values for the liver enzyme ALP analyzed, showed higher significant (P<0.05) values for ALP levels of 26.40 ±3.21U/L in 2nd group when compared to 1st group. A significant (P<0.05) decrease of 19.10±3.75U/L was observed in 3rd group compared to 1st group. Treatment of wistar rats with 2ml/kg and 4ml/kg aqueous seed extract of *Elaeis guineensis*, showed significantly (P<0.05) lower (23.80±3.50U/mg and 20.80 ±3.30U/L) serum ALT respectively compared to 2nd group. While a non-significant (P<0.05) decrease of 19.80 ±3.30U/L was observed in 6th group when compared to 1st group.

Serum values for the liver enzyme ALT analyzed, showed higher significant (P<0.05) ALT levels (81.00±13.24U/L) in 2nd group compared to 1st group. A significant (P<0.05) decrease (51.40±9.88) was observed in 3rd group compared to 1st group. Treatment of wistar rats 4th and 5th with 2ml/kg and 4ml/kg aqueous extract of *Elaeis guineensis* seed, showed significantly (P<0.05) lower (70.80±11.89U/mg and 61.60±15.02U/L) serum ALT levels respectively compared to 2nd group. Meanwhile, a non-significant (P<0.05) decrease of 51.60±15.0U/L was observed in 6th group when compared to 1st group.

Protein analysis showed a significantly (P<0.05) higher (8.50±1.46mg/ml) level in 2nd group compared to 1st group. And a significant (P<0.05) decrease (5.98±1.10mg/ml) was observed in 3rd group than 1st group. Treatment of wistar rats with 2mgl/kg and 4ml/kg aqueous extract of *Elaeis guineensis* seed, showed significantly (P<0.05) lower (6.94±1.67mg/ml and 5.70±1.91mg/ml) protein levels respectively compared to 2nd group. While a non-significant (P<0.05) decrease (5.56±1.90mg/ml) was observed in 6th group when compared to 1st group.

Table 4.2: Mean values of antioxidant status of rat liver exposed to pyrethroid based mosquito coil and treatment with fresh *Elaeis guineensis* seed extract.

Groups/Parameters	MPO(U/mg)	GSH(nmol/mg)	SOD(U/mg)	CAT(U/mg)	PER(U/mg)	AOPP(U/mg)	MDA(U/mg)
1st group (Normal Control)	4.27±0.79[a]	3.31±0.83[a]	3.08±0.93[a]	11.19±3.08[a]	0.72±0.03[a]	4.41±1.22[a]	5.98±1.35[a]
2nd group (Positive Control)	4.89±0.98[b]	4.18±0.98[b]	3.94±0.82[b]	12.67±4.79[b]	0.82±0.06[b]	5.41±1.31[b]	6.96±1.53[b]
3rd group (Standard Control, 200mg Vitamin E)	3.33±0.80[ab]	2.62±0.75[ab]	2.99±0.73[ab]	10.07±3.35[ab]	0.55±0.02[ab]	3.40±1.00[ab]	5.04±1.78[ab]
4th group (Mosquito Coil and extract, 2ml/kg body weight)	3.27±0.76[c]	2.66±0.68[c]	2.62±0.84[c]	10.43±3.69[c]	0.59±0.02[c]	3.70±1.06[c]	5.06±1.76[c]
5th group (Mosquito coil and extract, 4ml/kg body weight)	3.33±0.74[d]	2.62±0.65[d]	2.99±0.73[d]	10.97±3.35[d]	0.55±0.02[d]	3.40±1.00[d]	5.04±1.78[d]
6 th group (Extract, 2ml/kg body weight)	3.23±0.73[d]	2.42±0.63[d]	2.40±0.73[d]	10.97±3.35[d]	0.50±0.02[d]	3.33±1.01[d]	5.01±1.78[d]

Values are expressed as mean ±SEM. Mean with same superscript letters on the same column are not significantly different (P <0.05).

MPO-Myeloperoxidase, GSH-Reduced Glutathione, SOD-Superoxide Dismutase, CAT-Catalase, PER-Peroxidase, AOPP- Advanced Oxidation Protein Products.

Table 4.2 revealed values for antioxidant enzymes in rat liver homogenates. For MPO activity, values analyzed showed a significant (P<0.05) increase (4.89±0.98U/mg) in 2nd group compared to (4.27±0.79U/mg) in 1st group. However a significant (P<0.05) decrease (3.33±0.80U/mg) was observed in 3rd group relative to (4.27±0.79U/mg) in 1st group. When wistar rats was treated with 2ml/kg and 4ml/kg aqueous seed extract of *Elaeis guineensis*, significant (P<0.05) decreases (3.27±0.76U/mg and 3.33±0.74U/mg) were observed in 4th and 5th groups compared 4.89±0.98U/mg) in 2nd group. Whereas a significant (P<0.05) decrease (3.23±0.73U/mg) was observed in 6th group relative to 1st group.

Values for GSH analyzed, showed significantly (P<0.05) higher (4.18±0.98nmol/mg) GSH level in 2nd group than 1st group. But a significant (P<0.05) decrease (2.62±0.75nmol/mg) was observed in 3rd group relative to 1st group. Treatment of wistar rats with 2ml/kg and 4ml/kg aqueous extract of *Elaeis guineensis* seed, revealed significantly (P<0.05) lower (2.66±0.68nmol/mg and 2.62±0.65nmol/mg) GSH levels respectively compared to 2nd group. Whereas a significant (P<0.05) decrease (2.42±0.63nmol/mg) was observed in 6th group compared to 1st group.

Analysis of SOD level, reveals significantly (P<0.05) higher (3.94±0.82U/mg) SOD in 2nd group relative to (3.08±3.08U/mg) in 1st group. But a significant (P<0.05) decrease (2.99±0.73U/mg) was observed in 3rd group when compared to 1st group. Treatment of wistar 4th and 5th rats with 2ml/kg and 4ml/kg aqueous extract of *Elaeis guineensis* seed, showed significantly (P<0.05) lower (2.62±0.84U/mg and 2.99±0.73U/mg) SOD level respectively when compared to 2nd group. Also, a significant (P<0.05) decrease (2.40±0.73U/mg) was observed in 6th group relative to 1st group.

Values for CAT activity analyzed showed a significantly (P<0.05) higher (12.67±4.79U/mg) CAT level in 2nd group than 1st group. A significant (P<0.05) decrease (10.07±3.35U/mg) was observed in 3rd group compared to 1st. Treatment of wistar 4th and 5th rats with 2ml/kg and 4ml/kg aqueous extract of *Elaeis guineensis* seed, showed significantly (P<0.05) lower (10.43±3.69U/mg and 10.97±3.35U/mg) CAT activity respectively when compared to 2nd group. While a significant (P<0.05) decrease (10.97±3.35U/mg) was observed in 6th group to 1st group.

For peroxidase activity, values analyzed showed a significant (P<0.05) increase (0.82±0.06U/mg) in 2nd group compared to (0.72±0.03U/mg) in 1st group. However a significant (P<0.05) decrease (0.55±0.02U/mg) was observed in 3rd group compared to (0.72±0.03U/mg) in 1st group. When wistar rats were treated with 2ml/kg and 4ml/kg aqueous extract of *Elaeis guineensis seed*, significant (P<0.05) decrease (0.59±0.02 U/mg and 0.55±0.21 U/mg) were observed in 4th and 5th groups compared to (4.89±0.28 U/mg) in 2nd group. Whereas a significant (P<0.05) decrease (0.50±0.21U/mg) was observed in 6th group when compared to 1st group.

Values for AOPP level analyzed, showed a higher significant (P<0.05) values of AOPP levels 5.41±1.31U/mg in 2nd group than 4.41±1.22U/mg in 1st group. A significant (P<0.05) decrease (3.40±1.00U/mg) was observed in 3rd group compared to 1st group. Treatment of wistar rats with 2ml/kg and 4ml/kg aqueous extract of *Elaeis guineensis* seed, showed significantly (P<0.05) lower (3.70±1.06 and 3.40±1.00U/mg) AOPP level respectively when compared to 2nd group. Also, a significant (P<0.05) decrease (3.33±1.01) was observed in 6th group compared to 1st group.

Values for lipid peroxidation analyzed, showed significantly (P<0.05) higher (6.96± 0.53U/mg) MDA levels in 2nd group compared to 1st group. And a significant (P<0.05) decrease (5.04±0.78U/L) was observed in 3rd group compared to 1st group. Treatment of wistar rats with 2ml/kg and 4ml/kg aqueous extract of *Elaeis guineensis* seed, showed significantly (P<0.05) lower (5.06± 0.76 and 5.04±1.78U/mg) MDA level respectively when compared to 2nd group. Also, a significant (P<0.05) decrease (5.01±1.78U/mg) was observed in 6th group compared to 1st group.

Histology of the Liver

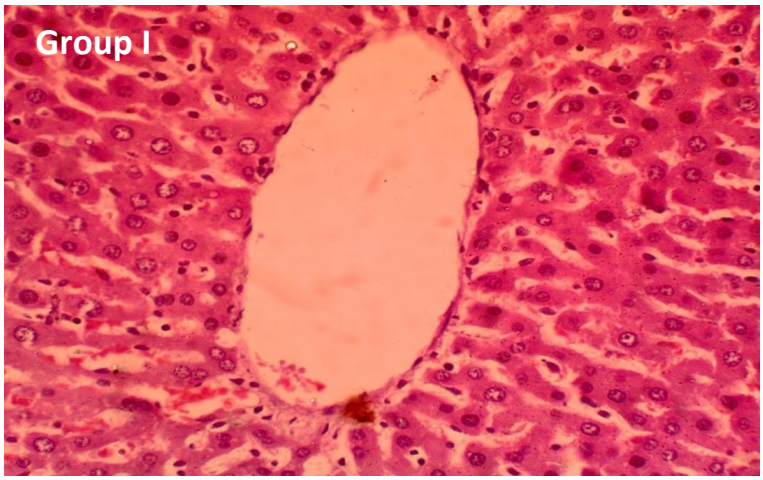

Plate 1: (Normal control): liver of rat showing normal parenchymal architecture. Central vein (CV). H&E, x500.

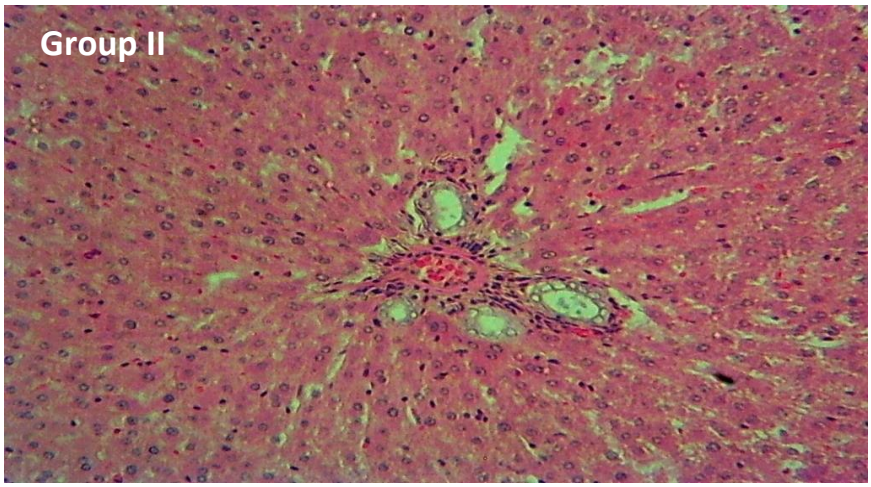

Plate 2: (Positive control): showing widespread hepatocellular degeneration and multifocal necrosis, accompanied by several apoptotic hepatocytes (arrows). Hepatic artery (HA); Bileductus's (*). H&E x400.

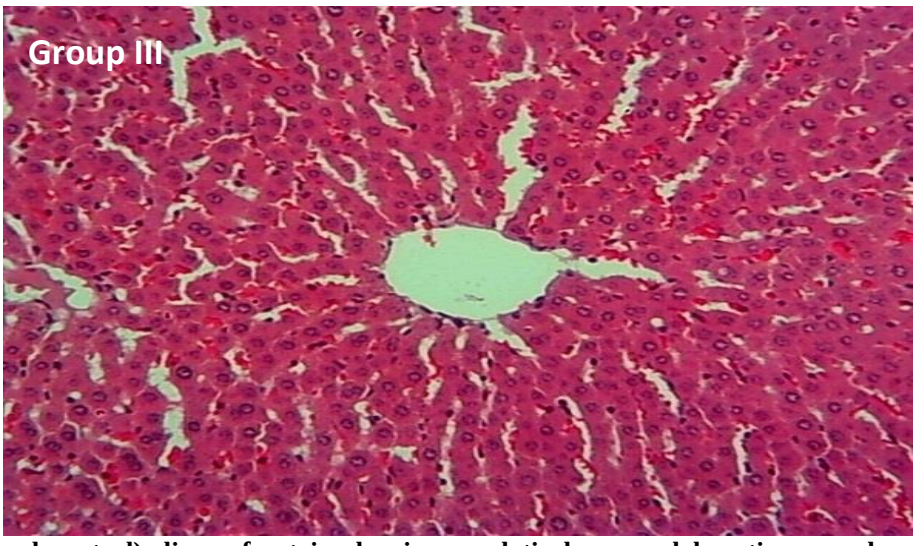

Plate 3: (Standard control): liver of rat in showing a relatively normal hepatic parenchymal architecture. Central vein (CV).H&E x400.

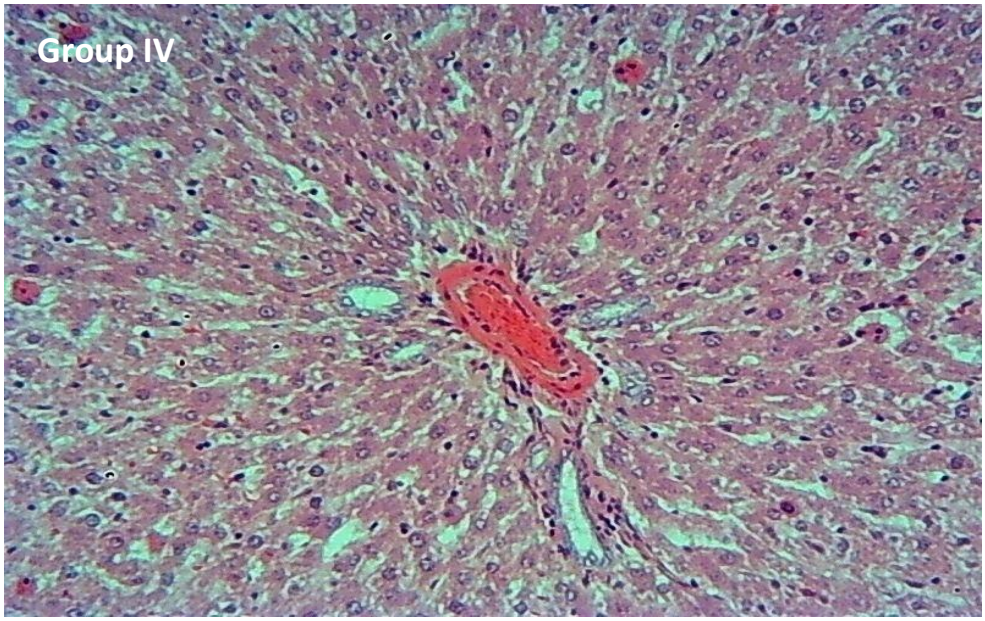

Plate 4: (Test I): liver of rat in showing a relatively normal hepatic parenchymal architecture. Central vein (CV). H&E x400.

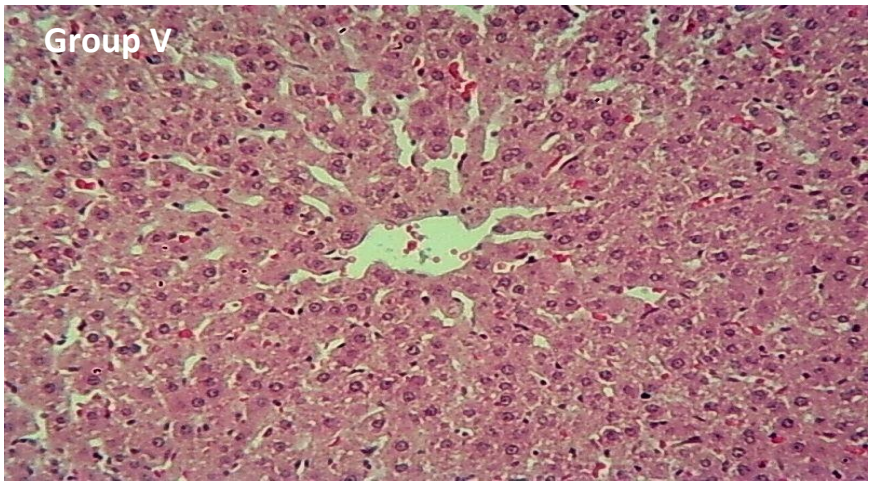

Plate 5: (Test II): liver of rat in showing a relatively normal hepatic parenchymal architecture. Central vein (CV). H&E x400.

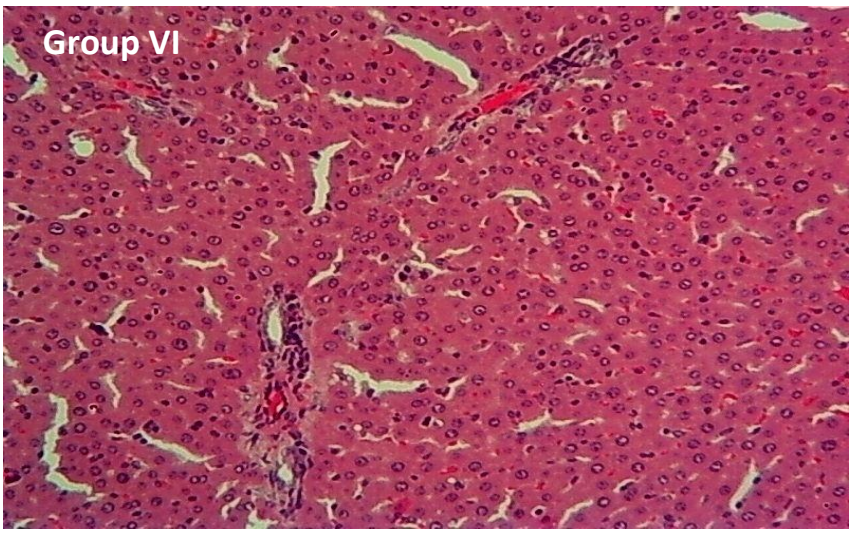

Plate 6: (Test III): liver of rat in showing a relatively normal hepatic parenchymal architecture. Central vein (CV). H&E x400.

DISCUSSION

Considering the seeming or reported endemic status of malaria in some clime, and the widespread patronage of available and cheap varieties of repellents including the pyrethroid based mosquito coils which may be hazardous to human health; awareness of exploration of the long time known medicinal plants/ herbal remedies is being brought to fore (Al-Mamun *et al*, 2017).

More specifically, the oil palm seed – palm kernel seed or "banga seed" that has been experimentally reported to exhibit some antioxidant, nutritional and lipid regulatory properties (Ajuwon *et al*, 2013) was investigated in this research design whether it may proffer health benefit that could protect the liver tissue from toxicity caused by chronic exposure to unhealthy fumes emitted from repellents.

The enormity of the pivotal physiological role played by the liver cannot be overemphasized; ranging from synthesis of essential proteins, enzymes and hormones, to metabolic functions, and release of various landmark substances (Alanine aminotransferase – ALT, Aspartate transferase – AST, Alkaline phosphatase – ALP) that are considered as biochemical markers indicative of the health status (per given time) of the liver in particular (Ghouri *et al*, 2010; Xing-Jiu *et al*, 2016; Singh, 2013; Ujjawal *et al*, 2014).

In the present study, evaluation of liver status in rats, following exposure to toxic repellents and administrations of oil palm seed aqueous extract showed a significant ($P<0.05$) increase of AST level in the 2nd group of rats (positive control) relative to 1st group (normal control). This observed increase of liver enzymes activity may be indicative of associated liver/hepatic damage most probably resulting from prolonged exposure to mosquito repellent and is in agreement with Idowu *et al*, (2016) and Abdullah *et al*, (2017).

However, in rat (4th, 5th and 6th) groups administered with 2ml/kg and 4ml/kg of oil palm seed extract, there were significant ($P<0.05$) decreases observed compared to positive control as captured in (Table 4.1). This reversal in enzyme activity may be an indication that, the aqueous extract of oil palm seed might have played a role to either prevent or reverse the damage done to the liver.

Similarly, serum levels of ALP and ALT which are reported as biomarkers of liver status were significantly ($P<0.05$) higher in the 2nd group of rats that were exposed to repellent smokes, than the 1st group (normal control) and others; again suggestive of hepatic damage perhaps due to chronic exposure to fumes from the mosquito repellent. Meanwhile, in those 4th, 5th and 6th groups of rats treated with 2ml/kg and 4ml/kg of oil palm seed, these ALP and ALT serum levels decreased significantly ($P<0.05$). This supports the preceding observation on AST, and by implication give credence to the assertion that oil palm seed extract possibly prevented or reversed hepatic damage in those rats. And it corroborates with studies by Emmanuel *et al*, (2021) wherein ALP, AST and ALT levels increased significantly following induction of toxicity by carbon tetrachloride, which was attenuated by Pretreatment with extracted red palm oil of *Elaeis guineensis* fruit pulp (Onakurhefe *et al*, 2020).

More again, chronic liver disease sometimes would elevate immunoglobulin, thereby increasing total protein measure in serum (Tian *et al*, 2014). And this study reveals significantly ($P<0.05$) higher total protein in the 2nd group than normal control (1st group); which was reversed in the 4th, 5th and 6th groups of rats that were treated with 2ml/kg and 4ml/kg of oil palm seed. This agrees with reports of Oguntibeju *et al*, (2010) and Al-Mamun *et al*, (2017) who worked with mice, exposed to mosquito repellent mat vapour.

Furthermore, the body is known to react against molecular substances that cause stress and harm (through oxidative processes) to its cells and tissues by matching force to those stressors / oxidative agents – through antioxidants' mopping / ravaging activities (Engwa, 2018; Rahal *et al*, 2014). Some antioxidants include reduced glutathione (GSH), Superoxide dismutase (SOD), Catalase (CAT), Myeloperoxidase (MPO), Peroxidases (PER), Advanced oxidation protein products – AOPP that all work to preserve the body from stress (Cristani *et al*, 2016; Haredy *et al*, 2017; Jawahar & Harikrishnan, 2017).

The antioxidant analysis regarding stress responses in this research reveals significantly ($p<0.05$) increased activities of these stress biomarkers in 2nd group of rats than control, implying that those rats had oxidative stress and damaged cells/tissues. But this condition was reversed in rats (4th, 5th and 6th groups) treated with the doses of *Elaeis guineensis* seed extract and depicts possible capacity of the extract to preserve rats from oxidative stress and damage or reverse such conditions altogether. These were supportive of similar studies by (Abubakar & Hassan, 2017; Uroko, 2019; Ajuwon *et al*, 2013; Gryszczyńska *et al*, 2017).

Moreover, the histological investigation indicates widespread hepatocellular degeneration and multifocal necrosis, accompanied by several apoptotic hepatocytes in the liver tissues of the 2nd group of rats exposed to repellent (plate 2). But when the 4th, 5th and 6th groups of rats were treated with doses of *Elaeis guineensis* seed extract, these disruptions were not seen (plate 4, 5 and 6), suggesting a reversal of the condition probably through tissue repair or outright preservation of those tissues from disruption ab initial. This corroborates with study by Flohé, (2020) iterating that oil palm fruit, at higher doses in particular, elicited hepatoprotective and

nephroprotetive effects in rats exposed to CCl_4 intoxication.

CONCLUSION

This study furthers awareness of the hazard on liver health associated with patronage of pyrethroid based mosquito coils. But also seeks to proffer possible mitigating measure against the health hazard; thus predicated on current empirical preceding analysis, it is conceivable that oil palm seed extract may reserve potentials to protect liver from damage and / or promote reparation of damaged liver.

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