Asian Hematology Research Journal

5(4): 41-50, 2021; Article no.AHRJ.72819

Effects of Ethanolic Leaf Extract of *Cymbopogon citratus* on Haematological and Biochemical Parameters of Swiss Albino Mice Infected With *Plasmodium berghei* Nk 65

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Authors' contributions

This work was carried out in collaboration among all authors. Author ROA designed the study, performed the statistical analysis, wrote protocol, and wrote the first draft of the manuscript. Authors EOD and SKA managed the literature searches and analyses of the study. All authors read and approved the final manuscript.

Article Information

Editor(s):
(1) Dr. Juan Carlos Troiano, University of Buenos Aires, Argentina.
Reviewers:
(1) Jorge Alberto Alfonso Toledo, Universidad Nacional Autónoma de México (UNAM), Mexico.
(2) Sabira Sultana, Government College University Faisalabad, Pakistan
Complete Peer review History: https://www.sdiarticle5.com/review-history/72819

Original Research Article

Received 22 June 2021
Accepted 28 August 2021
Published 20 December 2021

ABSTRACT

This study was carried out to determine the haematological and biochemical effects of ethanolic leaf extract of *Cymbopogon citratus* in swiss albino mice infected with *Plasmodium berghei* (NK65). A total of 16 albino mice were randomized into four groups of four mice each for acute toxicity and body weight of mice were measured before and after acute toxicity. A total of 35 mice were randomized into five groups; 1, 2 and 3 (treatment groups), 4 (positive control group) and 5 (negative control group) for biochemical and haematological assay. The mice in all groups were infected intraperitoneally with 0.2 mL of *Plasmodium berghei* and were treated for six consecutive days orally with ethanol leaf extract dosages of 200, 400 and 800mg/kg body weight, standard antimalarial drug (chloroquine) as positive control and normal saline as negative control respectively. Haematological analysis revealed significant ($P < 0.05$) decreased in value of pack cell volume (PCV) haemoglobin (HB), red blood cell (RBC), white blood cell (WBC) and platelet (PLT) for mice of negative control (infected, but not treated), compared to infected and ethanolic treated groups that recorded high values while mice of chloroquine treated group showed highest value of

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PCV, HB, RBC and PLT. There was a significant difference in the level of AST and ALT levels in mice of all groups. The observed values of AST and ALT level in the highest ethanol extract treated group (800mg/kg) was 181.00±1.00, 20.00±1.00, these values was lower compared to the groups tested with 200 mg/kg (192.00±2.00, 35.00±1.0) and 400 mg/kg (192.00±2.00, 35.00±1.0) of the extract and significantly increased (P<0.05) compared with the mice of positive controls group (180.00±2.00, 20.00±1.0). This study revealed the potency of *Cymbopogon citratus* as a future herbal candidate that can enhances and boost biochemical and haematological indices.

Keywords: Cymbopogon citrates; Plasmodium berghei; bioactive compounds; heamatology.

1. INTRODUCTION

Malaria is a vector-borne life threatening disease and one of the deadliest infectious disease that have a significant burden on economic stability. According to the latest World malaria report, there were 229 million cases of malaria in 2019 compared to 228 million cases in 2018. The estimated number of malaria deaths stood at 409 000 in 2019, compared with 411 000 deaths in 2018 [1]. There are five parasite species that cause malaria in humans, and two of these species *P. falciparum* and *P. vivax* – pose the greatest threat. In 2018, *Plasmodium falciparum* accounted for 99.7% of estimated malaria cases in the WHO African Region, 50% of cases in the WHO South-East Asia Region, 71% of cases in the Eastern Mediterranean and 65% in the Western Pacific. *P. vivax* is the predominant parasite in the WHO Region of the Americas, representing 75% of malaria cases [1]. *P. falciparum* is found in most tropical and sub-tropical regions of the world, such as sub-Saharan Africa, and is the most dangerous of the five in terms of mortality and morbidity, whereas, *P. malariae* and *P. ovale* are rare and account for less than 1% of all confirmed malaria cases [2]. The fifth species (*P.knowlesi*) which causes malaria in macaque monkey, has recently been reported to infect humans in Southeast Asia. It infects monkey primarily and occurs rarely in human, the infection does occur when an *Anopheles* mosquito infected from monkey bites human [1].The current efforts to reduce the global burden of malaria are threatened by the rapid emergence and spread of *P. falciparum* resistance to antimalarial drugs [3]. *P. berghei,* a rodent malaria parasite, is commonly used to assay antimalarial activity of medicinal plant extracts as well as conventional antimalarial drugs. The common strains of *P. berghei* are ANKA, K173, NK65, SP11, and LUKA. *P. berghei* provides a well-established experimental model of malaria infection, producing pathological symptoms which closely mimic those of human malaria [4].

Cymbopogon citratus is a widely distributed perennial herbs that belongs to the family Poaceae. It is commonly called lemongrass, citronella grass or fever grass [5]. According to Vazquez-Briones [6], Cymbopogon is a genus of about 55 species derived from the Greek words kymbe (boat) and pogon (beard), referring to the flower spike arrangement and citratus (Latin) means lemon-scented leaves. Lemon grass can grow up to 1 meter with numerous stiff leafy stems arising from short rhizomatous roots and has been cultivated over many years for medicinal purposes in different regions of the world [7].

According to Christopher et al. [8] therapeutic potential of medicinal herbs could be associated to the presence of secondary metabolites. The biological effects ascribed to *Cymbopogon citratus* have been attributed to its primary bioactive constituents derived from its leaves, stem and roots. Secondary metabolites such as citral (3, 7-dimethyl-2, 6-octadienal), myrcene and citronellal have been isolated from lemon grass and were characterized as antimalarial compounds. These isolated compounds show pronounced activity against Plasmodium species [9]. Bioactive constituents such as ketones, alcohols, phenols, terpenes, flavonoids, saponins, steroids, tannins, alkaloids, geranial, terpernoids, polyphenols, esters, aldehyde and fatty acids have been isolated and analysed [10]. The most essential compounds in *Cymbopogon citratus* according to literatures are essential oil and flavonoids, which contributed to the pronounced therapeutic and pharmacological activities of the plant [11]. The present study is aimed at determining the biochemical and haematological effect of ethanolic leaf extracts of *Cymbopogon citratus* in Swiss albino mice infected with *Plasmodium berghei.*

2. MATERIALS AND METHODS

Fresh leaves of *Cymbopogon citratus* were collected from a farmland within Seebi, Ilesha-

Owo Express way, Akure, Ondo State, Nigeria. Identification and authentication were carried out and the voucher specimen number of the plant Bio/ FUTA/ 99 was left in the herbarium of the Department of Crop Soil and Pest Management, School of Agricultural Technology, Federal University of Technology, Akure, Ondo State, Nigeria.

2.1 Extraction of Plant Material

The leaves were washed, cut into smaller pieces and air dried for 3 weeks at room temperature (28±3°C) and were pulverized into fine powder by a high-speed blender. A mass of five hundred grams (500 g) of the grounded powder was soaked into 3000 millimetre of 75% ethanol for 72 hours and then filtered using a millipore filter (pore size 0.7um). The extracts was concentrated using rotary evaporator at a temperature of 40°C. It was further heated over a water bath to obtain a solvent-free extract and was thereafter stored in the refrigerator at 4°C [12].

2.2 Assemblage of Experimental Mice

A total of 51 healthy Swiss Albino mice of weighs between 20-25 g was obtained from Institute for Advance Medical Research and Training (IMRAT), University College Hospital, University of Ibadan, Oyo State, Nigeria. They were transferred to Microbiology laboratory, at Federal University of Technology, Akure (FUTA). Mice were housed in plastic cages with wood saw dust beddings. They were fed with pellets (Supreme Pet food) and water *ad libitum* and acclimatized for 7 days at room temperature (29-30^{o}C) before the commencement of the experiment. Chloroquine sensitive strain of malaria parasite (*Plasmodium berghei* NK 65) in a donor mouse was also acquired from IMRAT.

2.3 Acute Toxicity Test

The toxicological test for *Cymbopogon citratus* was carried out according to Organization for Economic Cooperation and Development (OECD) guidelines [13] with slight modification as employed by Dada and Muhammed [12]. A total of 16 healthy mice were randomized into four groups of four mice per group. Each mouse in groups were treated with 250 mg/kg, 500 mg/kg and 1000 mg/kg body weight of the extract, respectively. The control group received normal saline. Before commencing the treatment, the body weight of mice was recorded. The mice were observed visually daily for 14 days throughout the experiment for signs of toxicity and behavioral.

2.4 Preparation of Inoculums

The method described by Essien et al. [14], Dada and Oloruntola [12] was used for the inoculation of malaria parasites. Chloroquine sensitive strain of malaria parasite (*Plasmodium berghei* NK 65) in a donor mouse was obtained. By cardiac puncture, parasitized blood were withdrawn from the infected mouse with a syringe, transferred into a screw cap sterile plastic tube containing 0.9% normal saline to obtain 1x10^{7} *Plasmodium berghei* infected erythrocytes. Thirty - five (35) mice were randomized into five groups of seven mice each. Mice in Group 1, 2, 3, 4 and 5 were infected intraperitoneally with 0.2 millimetre of 1x10^{7} standard inoculum of chloroquine-sensitive *P. berghei* after the parasitaemia level of the infected mouse had been ascertained to be high.

2.5 Administration of Leaf Extract and Drug

The dosages of the extract were prepared by dissolving 0.4 g, 0.8 g and 1.6 g of the extract in 20 millimetre of distilled water each in sterile universal bottle based on the body weight and total number of mice per group to obtain 200, 400 and 800 mg/kg body weight respectively [15]. The leaf extract, Chloroquine and normal saline were administered orally to the test groups, positive group, and the negative group, respectively. A stainless metallic feeding cannula attached to a syringe was used during oral administration to deliver the compound into the stomach [12]. The Parasitaemia level was determined daily for six days.

2.6 Haematological Analysis

This was carried out using the method of Dada and Ogundolie [16] to know the effects of ethanol leaf extract of *Cymbopogon citratus* on Swiss albino mice. Red blood cells (RBC), White blood cells (WBC), Platelet, Packed Cell Volume (PCV), haemoglobin concentration (HB), Mean Cell haemoglobin Concentration (MCHC), Mean Cell Corpuscular Volume (MCV), Mean Cell haemoglobin (MCH), Lymphocyte, Neutrophil, Monocyte and Eosinophil was assessed. On the sixth day of the experiment, the mice were subjected to euthanasia under chloroform, dissected and blood was collected through cardiac puncture in an ethylene diamine tetra-acetic acid (EDTA) bottles and the blood

parameters were analyzed using Abacus 380 hematology analyzer.

2.7 Biochemical Assays

Blood was collected from mice in a lithium heparin bottle through cardiac puncture. The alanine transaminase (ALT) and aspartate transaminase (AST), total bilirubin, creatinine, blood urea nitrogen (BUN), cholesterol, triacylglycerol, high density lipoprotein (HDL) and low density lipoprotein (LDL) were determined with Automated Refloton machine using the recommended test strips [16].

2.8 Statistical Analysis

All data were expressed as mean ± S.E. One-way analysis of variance was used to analyze data. P<0.05 was considered significant difference between means (Duncans multiple range test).

3. RESULTS

3.1 Percentage Yield of the Ethanolic Leaf Extract of *Cymbopogon citratus*

Percentage yield of the ethanolic leaf extract of *Cymbopogon citratus* after extraction recovered was 13.2% (48.56/368g).

3.2 Acute Toxicity Test of the Leaf Extract of *Cymbopogon citratus*

Toxicological test of *Cymbopogon citratus* leaf extract in mice showed no noticeable sign of toxicity in the mice after 14 days and no death or mortality recorded for all the doses tested (250, 500 and 1000 mg/kg). This was a clear indication that doses used were safe. No physical and behavioral signs of overtoxicity such as decreased motor activity, decreased body/limb tone, writhing, respiration, and death amongst others were observed.

3.3 Effects of the Leaf Extract of *Cymbopogon citratus* on Body Weight of Mice before and after Acute Toxicity Test

The result obtained from Fig. 1 showed decreased in body weight of mice after administration at concentration tested 500mg/ml (18-16g) and increased in body weight of mice administered with 1000mg/ml (18- 20g) while there was no decrease at concentration 250mg/ml.

3.4 Haematological Analysis

The haematological analysis (Table 1 and 2) revealed significant (P < 0.05) decreased in value of PCV, HB, RBC, WBC and PLT for mice of group 5 (infected, but not treated), compared to infected treated with 200, 400 and 800 mg/kg body weight extract (groups 1, 2 and 3) that recorded high values, with mice of chloroquine treated group showed highest value of PCV, HB, RBC and PLT. The values of PCV, RBC, HGB and PLT, was observed to be lower in negative control group compare to mice in extract treated groups, for group 1 (29.00±1.00, 4.88±0.00, 9.69±0.18, 61.70±0.60), group 2 (30.00±1.00, 5.23±0.02, 10.00±0.00, 72.33±2.51), group 3 (40.00±1.00, 6.85±0.05, 13.06±0.20, 89.00±2.00). These values were significantly different (P< 0.05) from group 5 (infected and not tested) that recorded (20.33±0.57, 3.54±0.00, 5.36±2.13, 61.06±0.11), Mice in group 4 (mice treated with Chloroquine) had the highest value of (41.00±1.00, 7.22±0.22, 14.00±0.20, 93.00±1.00).

There was increase in the MCV (Mean Corpuscular Volume) values of mice in extract tested groups, groups 1 (59.61±0.33), group 2 (57.52±0.50) and 3 (59.13±0.81) compared to the negative group (55.77±0.69). However, MCV of mice in groups 1, 2 and 3 was not significantly different (P<0.05) from mice in group 4 treated with chloroquine (58.39±0.53). The mean cell haemoglobin (MCH) values in mice of groups 1, 2, 3, and 4 (ethanol extract and chloroquine) increased after treatment, compared with mice of group 5 (negative control). However, no significant different (P < 0.05) between mean cell haemoglobin concentration (MCHC) of all groups. Also, no significant difference (P <0.05) between mean cell haemoglobin (MCH) values mice of groups. White Blood Cell (WBCs) counts in mice of groups 5 (negative control) increased significantly (P <0.05) compared with all the treatment groups that were significantly decreased. Similar trend was the case of lymphocyte count, the higher the concentrations of the extracts, the lower the count, interestingly, in neutrophil counts, negative control mice (infected not treated) showed the highest count compared to treatments groups. The chloroquine treated group (positive control) count was higher than all extract treated groups. The obtained values of monocyte for negative control was

higher compared to all treatment groups. Considering the treatment groups, the chloroquine treated group monocyte counts was lower than ethanol extract treated groups, with ethanolic extract groups having the higher count. There is no significant difference ($P < 0.05$) between eosinophil counts of group 1, 2, and similar trend were observed for groups 3 and 4. Mice of negative control showed significantly lower eosinophil compared to all treatments groups.

3.5 Biochemical Analysis in Mice

Table 3 showed the result of biochemical assay of all mice administered with different doses of the ethanol leaf extract of *Cymbopogon citratus.* There was increase in the level of ALT (Alanine Transaminase) and AST (Aspartate Transaminase) in group 5 (infected and not treated) these values are (46.00±1.00 and 301.33±1.52) respectively, compared to the extract treatment mice in group 1, 2 and 3 which are, (35.00±1.0, 192.00±2.00), (29.00±1.00, 185.00±5.00), (21.00±1.0, 181.00±1.00) respectively while that of group 4 are (20.00±1.00, 180.00±2.00). There is no significant difference ($P<0.05$) in the total bilirubin levels observed for all groups of mice. Similar observations existed between creatinine levels of all mice. The values of cholesterol and triglycerides in mice of group 5 (negative control) was significant higher than other groups. In groups treated with extract, the levels of cholesterol and triglycerides were significantly ($P<0.05$) lower in the highest dose (800 mg/kg b. w.) compared with other doses. The values of high-density lipoprotein (HDL) and low density lipoprotein (LDL) obtained in mice of group 5 (negative control) was significantly ($P<0.05$) higher than the one obtained for other groups treated with extract. There is a significant ($P<0.05$) difference between the obtained values of HDL of all extracts treated groups.

4. DISCUSSION

In this study, haematological parameters and biochemical assay of ethanolic leaf extract of *Cymbopogon citratus* on Swiss albino mice was investigated. The results of acute toxicity test implied that ethanolic extracts of *Cymbopogon citratus* at the different dosages tested (250mg/kg, 500mg/kg and 1000mg/kg body weight) in this study were not toxic to the mice. The extract can therefore be considered safe, because no death and general sign of toxicity observed. The findings disagree with Ukpai and Amaechi, [17] who reported that acute toxicity of the ethanolic leaf extracts of *Cymbopogon citratus* was considered slightly toxic However, this finding agreed with Kiliobas [18], whose report showed that *Cymbopogon citratus* is non-toxic at the dosages tested. The significant increase ($P < 0.05$) in RBC counts and its indices of the groups treated with the extract compared with the negative control group suggests that the extract enhanced erythropoietic activities in mice, this agreed with Dada and Muhammed [19], and the significant decrease ($P < 0.05$) of these parameters in the negative control group (infected not treated) in this study is in consonant with the findings of Bankole et al. [20] who reported that it is expected and could be due to anaemia as a result of the increased destruction of the infected RBC by plasmodium. The presence of plasmodium parasites in the bloodstream results in anaemia due to active lysing of RBC or hemolysis. The ethanolic extract treatment groups significantly increased ($P < 0.05$) in HB level compared to negative control, this agreed with Asangha et al. [21] that reported that hemoglobin is significantly reduced in high parasitaemia and decreased hemoglobin observed in the negative control is due to the reason that malaria parasite growing in the erythrocytes degrades heamoglobin. The MCV of the extracts treated groups increased, this corroborate the report of Asangha et al. [21], who showed significant increase ($P < 0.05$) of MCV in groups of mice treated extract when compared with negative control and suggested that, the increased MCV from the group treated with the extracts is a pointer to a possible macrocytic anemia inferred from the study. The increase in MCH and MCHC are expected, as these two parameters were not measured directly, but calculated from RBC, HB and MCV, this is in consistent with Dada and Muhammed, [19]. Platelets act as acute phase reactant to infection or inflammation. The significant increases in the PLT counts in the extract treated groups compared with negative control is expected this suggesting their possible role as acute phase reactant to infection induced by *Plasmodium berghei* in mice as a result of treatments. Also, increased platelet counts for extract treated groups compared with negative control, agrees with Balogun et al. [22], that some extract have stimulatory effect on platelet production, probably by enhancing thrombopoietins secretion. Indicators of inflammation and infections like WBC increased whereas lymphocytes, decreased in the negative control group

Table 1. Haematological parameter of the infected mice treated with ethanol extract of *Cymbopogon citratus*

Groups	PCV	RBC	HGB	MCV	MCH	MCHC	PLT X 10^3
1	29.00±1.00^{c}	4.88±0.00^{b}	9.69±0.18^{bc}	59.61±0.33^{d}	19.79±0.25^{b}	33.48±0.50^{a}	61.70±0.60^{a}
2	30.00±1.00^{c}	5.23±0.02^{c}	10.00±0.00^{c}	57.52±0.50^{b}	19.23±0.25^{b}	33.33±0.00^{a}	72.33±2.51^{b}
3	40.00±1.00^{e}	6.85±0.05^{d}	13.06±0.20^{e}	59.13±0.81^{c}	19.40±0.40^{b}	33.41±0.52^{a}	89.00±2.00^{cd}
7	41.00±1.00^{e}	7.22±0.22^{d}	14.00±0.20^{f}	58.39±0.53^{bc}	19.46±0.50^{b}	33.44±0.50^{a}	93.00±1.00^{d}
8	20.33±0.57^{a}	3.54±0.00^{a}	5.36±2.13^{a}	55.77±0.69^{a}	18.62±0.54^{ab}	33.50±0.50^{a}	61.06±0.11^{a}

Data are presented as Mean +/- 1 SE (n=3).;

Values with the same superscript letter (s) along the same column are not significantly different (P<0.05); Legend: Group 1: P. berghei + 0.2 ml 200mg/kg ethanolic extract. Group 2: P. berghei + 0.2 ml 400mg/kg ethanolic extract. Group 3: P. berghei + 0.2 ml 800 mg/kg body weight ethanolic extract leaf extract. Group 4: P. berghei + 5 mg/kg body weight Chloroquine. Group 5: P. berghei +0.2 ml normal Saline;

Red blood cells (RBC), White blood cells (WBC), Platelet, Packed Cell Volume (PCV) and haemoglobin concentration (Hb), Mean Corpuscular Volume (MCV), Mean Cell Haemoglobin Concentration (MCHC), Mean Cell Haemoglobin (MCH)

Table 2. Hematological Differential Parameters of the infected and treated mice

Groups	WBC(x10mc^{3})	LYMPH (%)	MON (%)	EOSIN (%)	NEUT (%)
1	12.00±1.01^{c}	83.5±1.20^{d}	4.00±0.20^{e}	2.10±0.01^{d}	18.51±0.85^{a}
2	11.33±2.15^{bc}	79.0±0.33^{b}	2.00±0.51^{b}	2.1±0.03^{b}	22.10±0.64^{a}
3	7.65±3.76^{d}	72.11±1.76^{e}	2.20±0.33^{c}	3.2±0.00^{c}	26.00±0.80^{a}
4	12.41±3.11^{a}	77.3±0.50^{a}	1.00±0.61^{a}	3.17±0.01^{a}	32.75±0.00^{a}
5	19.35±7.81^{a}	70.5±1.33^{a}	5.25±0.11^{a}	1.00±0.33^{ab}	37.40±0.01^{a}

Data are presented as Mean +/- 1 SE (n=3).

Values with the same superscript letter (s) along the same column are not significantly different (P<0.05); Legend: Group 1: P. berghei + 0.2 ml 200mg/kg ethanolic extract. Group 2: P. berghei + 0.2 ml 400mg/kg ethanolic extract. Group 3: P. berghei + 0.2 ml 800 mg/kg body weight ethanolic extract leaf extract. Group 4: P. berghei + 5 mg/kg body weight Chloroquine. Group 5: P. berghei +0.2 ml normal Saline;

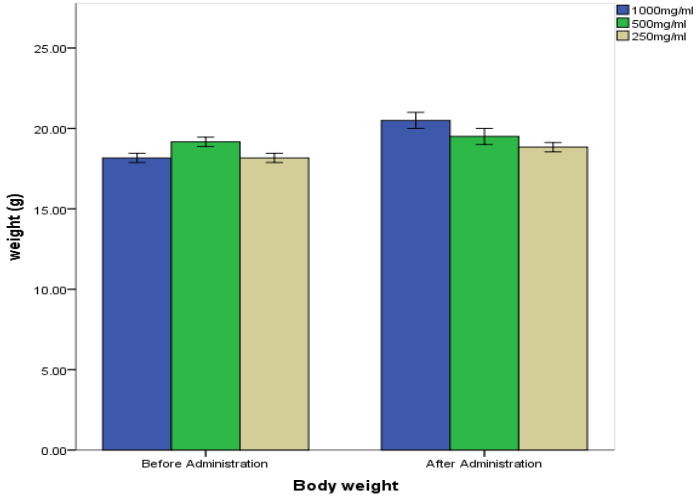
White blood cells (WBC), Lymphocyte, Neutrophil (NEUTR), Monocyte (MONO) and Eosinophil (EOS)

Table 3. Biochemical parameters of the infected mice treated with ethanol extract of *Cymbopogon citratus*

Groups	AST (NL)	ALT (NL)	T.BIL (mg/dl)	BUN 9mg.dl)	CREAT (mg/dl)	CHOL (mg/dl)	TRIG (mg/dl)	HDL (mg/dl)	LDL
1	192.00±2.00^{c}	35.00±1.0^{d}	0.20±0.00^{b}	20.00±1.0^{d}	0.91±0.00^{c}	40.00±2.00^{e}	52.00±1.00^{f}	12.00±0.00^{b}	17.50±0.5^{c}
2	185.00±5.00^{b}	29.00±1.0^{c}	0.20±0.00^{b}	11.83±0.7^{a}	0.61±0.01^{a}	38.00±1.00^{d}	40.33±0.5^{d}	11.06±0.11^{a}	19.33±0.57^{d}
3	181.00±1.00^{a}	21.00±1.0^{a}	0.10±0.00^{a}	12.00±0.5^{ab}	0.60±0.00^{a}	32.00±1.00^{b}	35.00±1.00^{b}	11.16±0.20^{a}	15.00±1.00^{b}
4	180.00±2.00^{a}	20.00±1.0^{a}	0.20±0.00^{b}	12.00±0.0^{ab}	0.60±0.00^{a}	30.00±1.00^{a}	30.00±1.00^{a}	11.06±0.10^{a}	13.00±0.00^{a}
5	301.33±1.52^{f}	46.00±1.0^{e}	0.60±0.00^{d}	25.00±1.0^{e}	0.90±0.00^{c}	44.66±0.57^{g}	56.00±1.00^{h}	14.06±0.12^{f}	19.60±0.52^{d}

Data are presented as Mean +/- 1 SE (n=3).

Values with the same superscript letter (s) along the same column are not significantly different (P<0.05); Legend: Group 1: P. berghei + 0.2 ml 200 mg/kg ethanolic extract. Group 2: P. berghei + 0.2 ml 400 mg/kg ethanolic extract.Group 3: P. berghei + 0.2 ml 800 mg/kg body weight ethanolic extract leaf extract. Group 4: P. berghei + 5 mg/kg body weight Chloroquine. Group 5: P. berghei +0.2 ml normal Saline; Alanine Transaminase (ALT), Aspartate Transaminase (AST), Total bilirubin (T. Bil.), Creatinine (Creat.), Blood Urea Nitrogen (BUN), Cholesterol (Chol), Triglycerides (Trig), High Density Lipoprotein (HDL) and Low-Density Lipoprotein (LDL)



Error bars +/- 1 SE

Fig. 1. Body Weight of Mice before and after Acute Toxicity test

compared with extract treated groups, this agreed with Cyril-Olutayo et al. [23].The decreased in lymphocyte count reported in the group treated higher doses of the extract agreed with Asangha et al. [21], who reported reduction in lymphocyte count in the group treated with high dose 400 mg/kg and said it might be due to the adverse effect of high dosage of the extracts. The increased neutrophil in negative control revealed that, neutrophils function as the first line of defense to eliminate *P. berghei* by phagocytizing the parasite [19] and it could be associated with responses to stress or excitement caused by malaria, this agrees with Lilik and Rahmi [24].

The increased levels of AST and ALT in mice of group 5 (infected not treated) could be due to findings of Akanbi [25], that increased level of AST and ALT is an indication of *P. berghei* infection and leakage from hepatic cell that were damaged due to activation induced by the parasite during the hepatic stage life cycle, and could also be attributed to the reason suggested by Ogundolie et al. [16] that very high level of AST and ALT are usually due to liver disorder or decreased blood flow to the liver caused by malaria infection. However, decrease in the ALT and AST in the mice administered 800 mg/kg compare to other groups could be as a result of hepatoprotective and nephroprotective ability of the leaf extract. The increased values of AST and ALT in ethanolic treated groups compared with group 4 (positive control) agreed with Dada and Muhammed [19], who narrated that, increase level of AST and ALT in mice of extracts treated groups could be due to the accumulation of free radical generated by the extract used to treat the mice. The results of lipid profile showed an increase in the concentration of total cholesterol and triacylglycerol in infected not treated group (group 5), compared to mice treated with ethanolic extract. This agreed with the finding of Uraku et al. [26] who reported elevated levels of LDL, total cholesterol and triglyceride in patients suffering from malaria. Also, the increase level of cholesterol in mice of group 5 (negative control) compared with other groups agrees with the report of Oloruntola et al. [12], who attached it to the decreased uptake of cholesterol by the infected red blood cells in high level of parasiteamia load. Studies by Muhammed et al. [19], have indicated that high plasma cholesterol, triglyceride and LDL- cholesterol are the major cause of cardiovascular disease. The low values of cholesterol, triglyceride and LDL- cholesterol in mice of ethanolic extract treated groups suggests it uses to prevent cardiovascular infection, this is in line with findings of Momoh et al. [27]. Also, the reduced levels of cholesterol in mice of extract treated groups (1, 2 and 3) might be due to the findings advanced by Lebari [28], that the leaf extract contain saponin, because saponin is a known antinutritional factor which reduces the uptake of certain nutrients especially cholesterol at the gut through intraluminal physiochemical interactions. The observed increase in triglycerides in mice of group 5 (negative control) could be due to reasons advanced by Muhammed et al. [29], that malaria has been implicated in rise of triglyceride concentration, because it is expected that the level of triglycerides should decrease as the parasite load increases. The reduced levels of triglycerides in mice of extracts treated groups compared with mice of infected not treated (negative control) group could be a pointer that *Cymbopogon citratus* extracts might be used to prevent cardiovascular diseases in malaria infected.

5. CONCLUSION

From the results of this preliminary work, it is concluded that ethanolic extract of *Cymbopogon citratus* showed the properties that can enhance and boost the biochemical and haematological parameters of malaria infected albino mice at the highest treatment dose (800mg/kg).

CONSENT

It is not applicable.

ETHICAL APPROVAL

The whole experimental management, handling and care were approved by the Research and Ethics Committee of the Department of Microbiology, School of Sciences, The Federal University of Technology, Akure, Nigeria.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
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