Effect of Ethanolic Leaf Extract of *Eucalyptus citriodora* Hook on Haematological Parameters of Swiss Albino Mice Infected with *Plasmodium berghei* NK 65

E. O. Dada¹ and D. Muhammed²*

¹Department of Microbiology, Federal University of Technology, P.M.B. 704, Akure, Ondo State, Nigeria.

²Department of Applied Biology, Federal Polytechnic of Oil and Gas, P. M. B. 5027, Bonny Island, Rivers State, Nigeria.

Authors’ contributions

This work was carried out in collaboration between both authors. Authors EOD and DM designed the study, author DM performed the statistical analysis, wrote protocol and wrote the first draft of the manuscript. Authors EOD and DM managed the analyses of the study. Authors DM and EOD managed the literature searches. Both authors read and approved the final manuscript.

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ABSTRACT

The incidence of severe anaemia in malaria as a result of *Plasmodium* infection, has necessitated the need for discovery and development of plant extract that could stimulates the production of red blood cells (erythropoiesis) and boost the immune system to fight the parasite. Acute toxicity of ethanolic leaf extract of *Eucalyptus citriodora* and effect of the leaf extract on haematological parameters in mice infected with *P. berghei* NK 65 were assessed. Mice were acclimatized for seven days before the commencement of infection and treatment. Twenty (20) mice were randomized into 5 groups of four mice each for acute toxicity test, and twenty-four (24) mice were randomized into six groups (groups 1, 2, 3, 4, 5 and 6) of four mice each, for haematological

*Corresponding author: E-mail: mdanjuma20@gmail.com;*
analysis. All mice were of body weights between 18-25 g. Mice of all groups were infected with *P. berghei*, except group 3 (normal control). Groups 4, 5 and 6 were treated with 0.2 mL of 200 mg/kg, 400 mg/kg and 800 mg/kg body weight of extract respectively. Mice in group 2 (positive control) were treated with 0.2 mL of 5 mg/kg body weight of chloroquine. Mice of group 1 (Negative control) were treated with 0.2 mL of normal saline, while mice of group 3 (normal control) were administered with 0.2mL of normal saline for four consecutive days. Standard methods were used to determined acute toxicity and haematological parameters of the mice. The phytochemical screening revealed the presence of alkaloids, saponins, tannins, anthraquinones, flavonoids and cardiac glycosides, and the extract was safe and nontoxic to all mice. Haematological analysis revealed an increase in values of packed cell volume, red blood cells, haemoglobin, platelet, lymphocyte, Mean Cell haemoglobin Concentration (MCHC), Mean Cell Corpuscular Volume (MCV) and Mean Cell haemoglobin (MCH) in mice of groups 4, 5 and 6 (Mice treated with different concentrations of the extract). Mice of group 3 had the highest value, followed by group 2 (chloroquine treated group). Mice of group 1 (negative control) showed lowest values of these parameters and highest WBCs counts. This study revealed the potency of *Eucalyptus citriodora* as a future herbal candidate that can enhances and boost haematological indices.

**Keywords:** *Eucalyptus citriodora; Plasmodium berghei; haematology; acute toxicity; albino mice.*

1. **INTRODUCTION**

Malaria is a life-threatening disease caused by parasites that are transmitted to humans through the bite of infected female *Anopheles* mosquitoes. Five *Plasmodium* species (*P. falciparum, P. malariae, P. ovale, P. vivax* and *P. knowlesi*) cause malaria in humans, with two of them (*P. falciparum* and *P. vivax*), pose the greatest threat [1]. *P. falciparum* is the most prevalent malaria parasite in Africa and accounted for about 99 percent of malaria cases in Sub-Saharan Africa in 2016, and responsible for most malaria deaths globally [2]. *P. vivax* is the most common parasite outside Sub-Saharan Africa, and in 2016, caused about 64 percent of malaria cases in WHO region of America and more than 30 percent of the cases in WHO South-East Asia region [1]. *P. knowlesi* infects monkey primarily and occurs rarely in human, was identified as a major parasite of malaria in human in some parts of Southeast Asia, and accounted for about 70 percent of malaria cases in these areas. *P. knowlesi* infection occurs when an *Anopheles* mosquito infected from monkey bites human [3]. Over the last 17 years, important measures have been put in place to prevent malaria, leading to 60 percent reduction of its worldwide death tolls [2]. ACTs, recommended by WHO, are currently used as the first-line antimalarial treatments worldwide. However, the current efforts to reduce the global burden of malaria are threatened by the rapid emergence and spread of *P. falciparum* resistance to ACTs including artemisinin derivatives and their partner drugs [4]. The possible source of malaria medicine appears in the traditional herbal medicine, because traditional herbal medicines have been the most available, affordable and cheap sources of malaria treatments for most communities [5].

The word *Eucalyptus* is a genus name from the Greek word “Eucalyptus” meaning “well-covered” and refers to its flowers that, in bud, are covered with cup-like membrane [6]. According to Rakholiya and Chanda [7], *Eucalyptus citriodora* Hook (family: Myrtaceae) is a tall, evergreen and graceful tree normally cultivated for essential oil, fuel, timbers and medicinal purpose. Husain and Ali [8], and Khanwar et al. [9], reported that the leaf of *E. citriodora* produce fragrant volatile oil with antibacterial, anti-inflammatory, antiseptic, analgesic, deodorant and diuretic activities. Also, the leaf contains numbers of phytochemicals like phenolic compounds, flavonoids, sesquiterpenes, aldehydes, ketones and tannins, and citronellol is found as the main constituent of the essential oil and is best known for aromatic property. In this study, the acute toxicity of the ethanolic leaf extract of *Eucalyptus citriodora* and effect of the extract on haematological factors of mice infected with *P. berghei* NK 65 were assessed.

2. **MATERIALS AND METHODS**

The leaf of *E. citriodora* was collected in the month of November, 2017 from Kogi State University, Anyigba, Nigeria. It was identified and authenticated by an expert in the Department of Biological Sciences of Kogi State University, Anyigba. The voucher specimen number of the plant Bio/ FUTA/ 70 was left in the herbarium of the Federal University of Technology, Akure, Ondo State, Nigeria.
2.1 Extraction of the Leaves
The leaf was washed, air dried at room temperature for three weeks and pulverized using mortar and pestle. Five hundred grams (500 g) of the pulverized leaf powder was macerated in 4500 ml of 75 percent ethanol for 72 hours and filtered using Millipore (pore size 0.7 μm) filter paper. By the use of rotary evaporator at reduced temperature of 40°C, the filtrate was concentrated to recover the extract for further use [10].

2.2 Determination of Phytochemicals
Phytochemical analysis of yielded ethanolic leaf extract of E. citriodora was carried out using standard procedures adopted by Dada and Oloruntola [10] and Dickson et al. [11].

2.3 Preparation of Leaf Extracts Dosages
The dosages of extract administered to mice were prepared by dissolving 0.4 g, 0.8 g and 1.6 g of the extract in 20 ml of distilled water each in sterile universal bottle based on the body weight and total numbers of mice per group to obtain 200, 400 and 800 mg/kg body weights respectively Momoh et al. [12].

2.4 Assemblage of Experimental Mice
A total of 44 swiss albino mice of body weights between 18-25 g were obtained from Animal House, Institute for Advance Medical Research and Training (IMRAT), University College Hospital, University of Ibadan, Nigeria. The animals were housed in cages with saw dust bedding at room temperature and were fed with standard diet (Grand cereal) and water ad libitum, acclimatized for 7 days prior to the study. Plasmodium berghei NK 65 donor mouse was obtained from IMRAT.

2.5 Grouping of Mice
A total of 24 mice were randomly divided into six groups; group 1 (negative control), group 2 (positive control), group 3 (normal control), groups 4, 5 and 6 (extract treated groups) of four mice per group for haematological analysis. While a total of 20 mice were randomized into five groups of four mice each for acute toxicity test [13].

2.6 Determination of Body Weight of Mice
The body weight of each mouse in all groups were measured before and after acute toxicity test at different doses, using sensitive digital weighing balance (Weight milk Water).

2.7 Acute Toxicity Test
A total of 20 healthy albino mice were randomized into 5 groups of 4 mice each. Each mouse in group 1 was treated with a single dose of 500 mg/kg b. wt. of the extract. Similarly, each mouse in groups 2, 3 and 4 were treated with 1000 mg/kg, 1500 mg/kg and 2000 mg/kg b. wt. of the extract respectively. Group 5 mice, the control group received normal saline. They were observed for signs of toxicity and general behaviour, such as reduced activity, licking paw, body weakness, convulsion, sleeping, salivation and mortality for 24 hours.

2.8 Preparation of Inoculum
The donor mouse of 20 percent parasitaemia was anaesthetized with chloroform and \(1 \times 10^7\) P. berghei infected erythrocytes was obtained using a standard procedure.

2.9 Administration of Extract and Drug
After 3 hours of infection with P. berghei, different concentrations (200, 400, 800 mg/kg body weight) of the extract were respectively prepared and administered orally as treatment doses to mice in groups 4, 5, and 6. Group 2 mice (positive control) received 0.2 mls of 5 mg/kg of chloroquine, mice in group 3 (normal control) received 0.2 mls of normal saline, mice in group 1 (negative control) were not treated. The treatments were administered for four consecutive days [14].

2.10 Haematological Analysis
This was carried out to know the effect of leaf extract and P. berghei on the haematological parameters: 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 were assessed. On the fifth day, 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 haematology analyzer [14].
2.11 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 (Duncan’s multiple range test).

3. RESULTS

3.1 Phytochemical Screening of the Ethanolic Leaf Extract of E. citriodora

Phytochemical screening of ethanolic leaf extract of E. citriodora revealed the presence of alkaloids, saponins, tannins, anthraquinone, flavonoid and cardiac glycosides (Table1).

3.2 Effect of the Leaf Extract of E. citriodora on Body Weight of Mice before and after Acute Toxicity Test

The body weight of mice before and after acute toxicity (Fig. 1) increase significantly at all concentrations (500, 1000, 1500 and 2000 mg/ml) tested.

3.3 Acute Toxicity Test of the Leaf Extract of E. citriodora

They were no noticeable signs of toxicities such as salivation, reduced activity, licking paw, body weakness, convulsion, jumping, hyperactivity in all mice and no death or mortality recorded for all doses tested (Table 2). It indicated that the LD50 is greater than 2000 mg/kg body weight.

3.4 Haematological Analysis

Haematological analysis (Tables 3 and 4) showed an increase value of PCV (pack cell volume), HB (haemoglobin), RBC (red Blood Cell) and PLT (platelet) in mice of groups 4, 5 and 6 (infected treated with 200, 400 and 800 mg/kg body weight extract). These values were significantly different (P < 0.05) from mice of group1 (infected not treated). Mice of group 3 (not infected and not treated) had the highest values of PCV, HB, RBC and least value of PLT. The MCV (Mean Corpuscular Volume) values in mice of groups 4, 5 and 6 increased after treatment with extract, compared with mice of group 1. However, MCV values in mice of groups 4, 5 and 6 is not significantly different (P > 0.05) from mice of groups 2 and 3. The values of MCHC (Mean Cell hemoglobin concentration) and MCH (Mean Cell haemoglobin) in mice of groups 4, 5 and 6 increased after treatment. These values were not significantly different (P > 0.05) from mice of groups 2 and 3, but significantly different (P< 0.05) from mice of group 1. Mice of group 1 showed lowest values of PCV, HG, RBC, PLT, MCV, MCHC and MCH. The WBCs count (white Blood Cell) in mice of groups 1, 2, 4, 5 and 6 increased significantly compared with groups 3, however group 1 had the highest WBCs counts. Lymphocyte count in mice of groups 1, 2, 5 and 6 decreased significantly compared with mice of groups 3 and 4. The mice in group 1 showed low count compared with mice of extract treated groups (groups 4, 5 and 6). However, there is no significant difference (P >0.05) between the lymphocyte counts of groups 5 and 6. The obtained monocyte and eosinophil counts showed no significant difference (P > 0.05) between mice of all groups (groups 1, 2, 3, 4, 5 and 6). However, neutrophil counts in mice of groups 1, 2, 5 and 6 increased, while that of group 4 decreased compared with group 3. There is no significant difference (P >0.05) between neutrophil counts of groups 4 and 5, and similar observation for groups 5 and 3.

| Table 1. Phytochemicals screening of the Ethanolic leaf extract of E. citriodora |
|-----------------------------------|-----------|
| Phytochemicals                   | Result    |
| Alkaloids                        | +         |
| Saponins                         | +         |
| Tannins                          | +         |
| Anthraquinones                   | +         |
| Flavonoids                       | +         |
| Cardiae glycoside                | +         |

Present = + and absent = -

4. DISCUSSION

The ethanolic leaf extract of E. citriodora contained alkaloids, saponins, cardiac glycosides, tannins, flavonoids and anthraquinone tested. This agreed with the similar findings of Yaya et al. [15].

The significant increase (P<0.05) in body weight in mice observed is expected, this might be attributed to the ability of mice to feed normal because they are healthy and with good feed conversion efficiency.
Fig. 1. Body weight of mice before and after acute toxicity test

Table 2. Acute toxicity test for the ethanolic leaf extract of *E. citriodora*

<table>
<thead>
<tr>
<th>Sign of toxicity</th>
<th>Doses of the ethanolic leaf extract</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>500 mg/kg</td>
</tr>
<tr>
<td>Sleeping</td>
<td>0</td>
</tr>
<tr>
<td>Salivation</td>
<td>0</td>
</tr>
<tr>
<td>Reduce Activity</td>
<td>0</td>
</tr>
<tr>
<td>Licking paw</td>
<td>0</td>
</tr>
<tr>
<td>Body weakness</td>
<td>0</td>
</tr>
<tr>
<td>Convulsion</td>
<td>0</td>
</tr>
<tr>
<td>Jumping</td>
<td>0</td>
</tr>
<tr>
<td>Death</td>
<td>0</td>
</tr>
<tr>
<td>Hyper activity</td>
<td>0</td>
</tr>
</tbody>
</table>

*Sign of Toxicity = +, Sign of no Toxicity = 0*

The observed acute toxicity test in mice with no death and general sign of toxicity is expected. This is in line with the findings of Bello et al. [16], who indicated that herbal extracts with LD$_{50}$ above 3000 mg/kg/oral may be considered safe and nontoxic.

The observed increase of RBCs and its indices (Hb, PCV, MCV, MCH and MCHC) and PLT in mice of groups 4, 5 and 6 (mice treated with extract at different concentrations) compared with group 1 (infected and not treated), disagrees with the report of Aglal et al. [17], which stated that administration of aqueous extract of *E. globulus* induced marked depression in Hb, PVC and RBC compared with controls mice and that administration of aqueous extract of *E. globulus* might induce sever type of anaemia. However, this finding agrees with Oungbé et al. [18], who advanced that extracts and fractions of *E. citriodora* did not cause any significant effect on RBC and its indices (Hb, MCV, MCH and MCHC). The increased values of RBCs and its indices in this study, agrees with Balogun et al. [19], who stated that some extract may have stimulatory effect on the production of red blood cells (erythropoiesis). The observed decrease in RBC, PCV, MCH, MHC and MCHC in group 1, is expected and this might be due to anaemia. This is in line with the report of Oungbé et al. [18], that the determination of blood indices such as MCV, MCH, MHC have a particular importance in anaemia diagnosis in most mice. Also, the observed decrease in Hb in mice of negative control (group 1) is expected and it agrees with reasons advanced by Balogun et al. [19], that the growing parasite consumes and degrades the intracellular proteins which are mainly
Table 3. Haematological parameter of the infected and treated mice

<table>
<thead>
<tr>
<th>Groups</th>
<th>PCV (%)</th>
<th>Hb (g/dl)</th>
<th>Rbc (x10^6 µl)</th>
<th>Wbc (x10^6 µl)</th>
<th>Platelet</th>
<th>Lymphocyte (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>21.66±0.33&lt;sup&gt;a&lt;/sup&gt;</td>
<td>7.26±0.03&lt;sup&gt;a&lt;/sup&gt;</td>
<td>3.19±0.01&lt;sup&gt;a&lt;/sup&gt;</td>
<td>20402.66±1.33&lt;sup&gt;a&lt;/sup&gt;</td>
<td>77010.00±5.77&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>63.66±0.88&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>2</td>
<td>48.33±0.33&lt;sup&gt;c&lt;/sup&gt;</td>
<td>15.70±0.05&lt;sup&gt;d&lt;/sup&gt;</td>
<td>8.12±0.01&lt;sup&gt;e&lt;/sup&gt;</td>
<td>10303.33±3.33&lt;sup&gt;c&lt;/sup&gt;</td>
<td>96010.00±5.77&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>67.00±0.57&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>3</td>
<td>54.66±0.57&lt;sup&gt;e&lt;/sup&gt;</td>
<td>18.40±0.05&lt;sup&gt;f&lt;/sup&gt;</td>
<td>8.62±0.01&lt;sup&gt;f&lt;/sup&gt;</td>
<td>9253.33±3.33&lt;sup&gt;e&lt;/sup&gt;</td>
<td>69003.33±3.33&lt;sup&gt;e&lt;/sup&gt;</td>
<td>74.66±0.66&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td>4</td>
<td>40.00±0.57&lt;sup&gt;b&lt;/sup&gt;</td>
<td>12.76±0.03&lt;sup&gt;b&lt;/sup&gt;</td>
<td>6.32±0.01&lt;sup&gt;b&lt;/sup&gt;</td>
<td>11103.33±3.33&lt;sup&gt;e&lt;/sup&gt;</td>
<td>82023.33±14.52&lt;sup&gt;c&lt;/sup&gt;</td>
<td>76.66±0.66&lt;sup&gt;g&lt;/sup&gt;</td>
</tr>
<tr>
<td>5</td>
<td>51.66±0.66&lt;sup&gt;d&lt;/sup&gt;</td>
<td>13.33±0.03&lt;sup&gt;c&lt;/sup&gt;</td>
<td>6.78±0.01&lt;sup&gt;bc&lt;/sup&gt;</td>
<td>10660.00±5.77&lt;sup&gt;d&lt;/sup&gt;</td>
<td>86006.66±3.33&lt;sup&gt;d&lt;/sup&gt;</td>
<td>70.66±0.33&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>6</td>
<td>54.00±0.57&lt;sup&gt;e&lt;/sup&gt;</td>
<td>17.46±0.03&lt;sup&gt;e&lt;/sup&gt;</td>
<td>7.64±0.00&lt;sup&gt;e&lt;/sup&gt;</td>
<td>9633.33±16.67&lt;sup&gt;b&lt;/sup&gt;</td>
<td>88006.66±6.66&lt;sup&gt;e&lt;/sup&gt;</td>
<td>69.33±0.33&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Data are presented as Mean ±S.E. (n=3). Values with the same superscript letter(s) along the same column are not significantly different (P<0.05).

Group 1: P. berghei + 0.2 ml normal saline, group 2: P. berghei + 5 mg/kg body weight Chloroquine, group 3: 0.2 ml normal saline, group 4: P. berghei + 200 mg/kg body weight leaf extract, group 5: P. berghei + 400 mg/kg body weight leaf extract and group 6: P. berghei + 800 mg/kg body weight leaf extract.

Table 4. Haematological parameter of the infected and treated mice

<table>
<thead>
<tr>
<th>Groups</th>
<th>Neutrophil (%)</th>
<th>Monocyte (%)</th>
<th>EOS (%)</th>
<th>MCV</th>
<th>MCHC</th>
<th>MCH</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>36.00±1.00&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.00±0.00&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.00±0.00&lt;sup&gt;a&lt;/sup&gt;</td>
<td>48.97±0.01&lt;sup&gt;a&lt;/sup&gt;</td>
<td>27.83±0.00&lt;sup&gt;a&lt;/sup&gt;</td>
<td>17.93±0.01&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>2</td>
<td>30.33±0.33&lt;sup&gt;d&lt;/sup&gt;</td>
<td>1.00±0.00&lt;sup&gt;d&lt;/sup&gt;</td>
<td>3.00±0.00&lt;sup&gt;d&lt;/sup&gt;</td>
<td>59.06±0.02&lt;sup&gt;bc&lt;/sup&gt;</td>
<td>32.93±0.00&lt;sup&gt;d&lt;/sup&gt;</td>
<td>19.44±0.01&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>3</td>
<td>24.33±0.33&lt;sup&gt;d&lt;/sup&gt;</td>
<td>1.00±0.00&lt;sup&gt;d&lt;/sup&gt;</td>
<td>1.00±0.00&lt;sup&gt;d&lt;/sup&gt;</td>
<td>60.32±0.01&lt;sup&gt;c&lt;/sup&gt;</td>
<td>32.68±0.01&lt;sup&gt;c&lt;/sup&gt;</td>
<td>19.74±0.01&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td>4</td>
<td>20.66±0.66&lt;sup&gt;d&lt;/sup&gt;</td>
<td>3.00±0.00&lt;sup&gt;d&lt;/sup&gt;</td>
<td>1.00±0.00&lt;sup&gt;d&lt;/sup&gt;</td>
<td>61.82±0.02&lt;sup&gt;d&lt;/sup&gt;</td>
<td>32.43±0.00&lt;sup&gt;d&lt;/sup&gt;</td>
<td>20.31±0.01&lt;sup&gt;c&lt;/sup&gt;</td>
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<tr>
<td>5</td>
<td>26.00±1.00&lt;sup&gt;bc&lt;/sup&gt;</td>
<td>2.00±0.00&lt;sup&gt;c&lt;/sup&gt;</td>
<td>2.00±0.00&lt;sup&gt;c&lt;/sup&gt;</td>
<td>60.48±0.01&lt;sup&gt;d&lt;/sup&gt;</td>
<td>32.44±0.00&lt;sup&gt;d&lt;/sup&gt;</td>
<td>19.64±0.01&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>6</td>
<td>27.33±0.33&lt;sup&gt;c&lt;/sup&gt;</td>
<td>1.00±0.00&lt;sup&gt;c&lt;/sup&gt;</td>
<td>3.00±0.00&lt;sup&gt;c&lt;/sup&gt;</td>
<td>61.33±0.01&lt;sup&gt;c&lt;/sup&gt;</td>
<td>32.83±0.00&lt;sup&gt;c&lt;/sup&gt;</td>
<td>20.14±0.00&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Data are presented as Mean ±S.E. (n=3). Values with the same superscript letter(s) along the same column are not significantly different (P<0.05).

Group 1: P. berghei + 0.2 ml normal saline, group 2: P. berghei + 5 mg/kg body weight Chloroquine, group 3: 0.2 ml normal saline, group 4: P. berghei + 200 mg/kg body weight leaf extract, group 5: P. berghei + 400 mg/kg body weight leaf extract and group 6: P. berghei + 800 mg/kg body weight leaf extract.
haemoglobin. The observed increase in MCV in extract treated groups compared with control groups is in line with the findings of Asangha et al. [20], which stated that is a pointer to a possible macrocytic anaemia. The observed increase in MCH and MCHC are expected, as these two parameters were not measure directly, but calculated from RBC, HB and MCV, this is in consistent with the report of Asangha et al. [20]. The observed increase in WBCs counts in extract treated groups and chloroquine treated group are expected and might be due to immune boosting of the extract to fight the parasite, this corroborates with the report of Balogun et al. [19]. Also, the observed increase in platelet counts for extract treated groups compared with normal control, agrees with Balogun et al. [19], that the extract have stimulatory effect on platelet production, probably by enhancing thrombopoietin’s secretion.

5. CONCLUSION

Conclusively, the results of this study revealed that, the ethanolic leaf extract of *E. citriodora* demonstrated the properties that can enhance and boost the haematological parameters of infected treated mice. Further investigation should be carried out on the pure active components of the leaf extract of the *E. citriodora* responsible for these actions and the effect on long term administration is recommended for further studies.

CONSENT

It is not applicable.

ETHICAL APPROVAL

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

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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