**NEPHROPROTECTIVE AND ANTIMALARIAL EFFECTS OF *AZADIRACHTA INDICA* AND *CYMBOPOGON CITRATUS* ETHANOLIC LEAF EXTRACTS IN *PLASMODIUM BERGHEI*-INFECTED MICE**

**Abstract**  
Malaria remains a major public health burden, especially in developing countries, with rising resistance to conventional antimalarial drugs. This study investigated the nephroprotective and antimalarial effects of ethanolic extracts of Azadirachta indica (EAI) and Cymbopogon citratus (ECC) in adult male Swiss albino mice infected with Plasmodium berghei. Forty mice were randomly assigned into eight groups (n = 5). All groups were induced with malaria except Group A, which served as the normal control. Group B was infected but untreated. Groups C and D received 100 mg/kg and 500 mg/kg of EAI, respectively. Groups E and F received 100 mg/kg and 500 mg/kg of ECC. Group G received 20 mg/kg/day of standard drug (Lonart®), while Group H received a combination of 500 mg/kg each of EAI and ECC. Treatments were administered orally for 14 days. Body weight increased significantly in Group A but showed no significant change in other groups. Relative kidney weights and urea levels varied insignificantly. Uric acid and creatinine levels significantly decreased in all treated groups compared to the untreated group. Parasitemia levels reduced significantly by days 7 and 14 in treated groups. Histological analysis showed preserved kidney structures with mild inflammation. Findings support the nephroprotective and antimalarial potential of EAI and ECC.

Keywords: ***Azadirachta indica***, ***Cymbopogon citratus***, ***Plasmodium berghei***, **Nephroprotection**

1. **INTRODUCTION**

Malaria remains a significant global health challenge, particularly in tropical and developing regions where it continues to cause substantial morbidity and mortality. It is a mosquito-borne infectious disease caused by protozoan parasites of the *Plasmodium* genus, transmitted through the bites of infected female *Anopheles* mosquitoes (WHO, 2018). Among the five *Plasmodium* species known to infect humans (*P. falciparum*, *P. vivax*, *P. ovale*, *P. malariae*, and *P. knowlesi*), *P. falciparum* is the most lethal and prevalent in sub-Saharan Africa (Weiss *et al.,* 2024; Singh, 2011). For experimental modeling in rodents, *Plasmodium berghei*, a rodent parasite with similar characteristics to *P. falciparum*, is widely used (Ploemen *et al.,* 2009).

Despite being both preventable and curable, malaria remains endemic in regions with limited healthcare access, poor socioeconomic conditions, and favorable climatic conditions for mosquito breeding. Nigeria alone accounts for more than a quarter of the global malaria burden, with 97% of its population at risk (NPC, 2014). The disease is responsible for approximately 60% of outpatient visits, 30% of hospital admissions, and 11% of maternal deaths (WHO, 2020). If not promptly treated, malaria can lead to complications such as anemia, jaundice, kidney failure, seizures, coma, and death (WHO, 2018).

The World Health Organization currently recommends artemisinin-based combination therapies (ACTs) such as artemether/lumefantrine and artesunate/amodiaquine for malaria treatment (WHO, 2018). However, emerging resistance to these drugs, along with high treatment costs and limited availability, continues to hinder effective malaria control (Zirihi *et al.,* 2005; Suresh & Haldar, 2018).

Given these challenges, there has been renewed interest in the use of medicinal plants with antimalarial properties, particularly in rural communities where traditional medicine is accessible and affordable. Several plants used in Nigerian ethnomedicine, including *Artemisia annua*, *Carica papaya*, *Azadirachta indica* (neem), *Cymbopogon citratus* (lemongrass) and Boerhaavia diffusa (commonly known as punarnava or spreading hogweed), have shown promising antiplasmodial activity in both in vitro and in vivo studies (Odugbemi *et al.,* 2007; Titanji *et al.,* 2008; Enenebeaku *et al.,* 2022; Anyasodor *et al.,* 2023; Adefokun *et al.,* 2015).

While many studies have assessed the individual efficacy of these plants, there remains a gap in understanding their synergistic effects when used in combination. This study seeks to evaluate the separate and combined effects of *Azadirachta indica* and *Cymbopogon citratus* leaf extracts on kidney function and histology in *Plasmodium berghei*-infected mice, providing scientific validation for traditional practices and contributing to the development of novel, plant-based antimalarial therapies.

**2.0 Material and methods**

**2.1 Plant Materials Collection and Extract Preparation**

Fresh leaves of *Azadirachta indica* (Neem) and *Cymbopogon citratus* (Lemongrass) were collected from authenticated botanical sources and identified at the Department of Botany, Nnamdi Azikiwe University. The leaves were thoroughly washed, shed-dried and then pulverized into fine powder using a mechanical grinder. Each powdered plant material (250g) was subjected to cold maceration in 70% ethanol for 72 hours with intermittent shaking. The resulting extracts were filtered using Whatman No. 1 filter paper and concentrated using a rotary evaporator under reduced pressure at 40°C. The crude extracts were stored in airtight containers at 4°C until further use.

**2.2 Toxicity Tests for Azadirachta indica (Neem) and Cymbopogon citratus (Lemongrass)**

The acute toxicity study of the ethanolic leaf extracts of Azadirachta indica and Cymbopogon citratus was conducted using the method described by Lorke (1983). No mortality or observable signs of toxicity were recorded in any of the test animals up to the maximum administered dose of 5000 mg/kg body weight for both extracts. This indicates that the LD₅₀ of each extract is greater than 5000 mg/kg, classifying them as practically non-toxic according to the Globally Harmonized System of Classification and Labelling of Chemicals (United Nations, 2019).

**2.3 Procurement and Housing of Experimental Animals**

Adult male Swiss albino mice weighing between 20 and 22 g were obtained from the Animal House of the College of Health Sciences and Technology, Nnamdi Azikiwe University. The mice were housed in standard laboratory cages under controlled conditions of 12-hour light and dark cycles and were allowed free access to standard pellet diet and water. Animals were acclimatized for two weeks before the commencement of the experiment. Ethical approval for this study was obtained from the Ethical Committee of the Department of Anatomy, Faculty of Basic Medical Sciences, Nnamdi Azikiwe University, Nnewi Campus (Ref No: ANA/EA/UG/AS/07/08/2024). All procedures involving animals were conducted in accordance with the Guide for the Care and Use of Laboratory Animals prepared by the National Academy of Sciences and published by the National Institutes of Health (NRC, 2011).

**2.4 Parasite Inoculation**

Chloroquine-sensitive strain of *Plasmodium berghei* (ANKA strain) was obtained from the Nigerian Institute for Medical Research (NIMR), Lagos. Blood containing approximately 30% parasitemia was collected from a donor mouse by cardiac puncture and diluted with normal saline to achieve a final concentration of 1 × 10⁷ parasitized erythrocytes in 0.2 mL. Each experimental mouse was inoculated intraperitoneally with this suspension (Fidock *et al.,* 2004).

**2.5 Experimental Design**

A total of forty adult Swiss albino male mice weighing between 20-22 grams were randomly assigned into eight groups (A–H), with five mice per group. Group A served as the normal (negative) control and received neither malaria infection nor treatment. All other groups (B–H) were infected with *Plasmodium berghei*. Group B served as the positive (malaria-infected untreated) control. Group C was treated with 100 mg/kg/day of *Azadirachta indica extract*. Group D received 500 mg/kg/day of *Azadirachta indica* extract. Group E was treated with 100 mg/kg/day of *Cymbopogon citratus* extract, while Group F received 500 mg/kg/day of *Cymbopogon citratus* extract. Group G was treated with a standard antimalarial drug (Lonart®), and Group H received a combined treatment of 500 mg/kg each of *Azadirachta indica* and *Cymbopogon citratus* extracts.

All treatments were administered orally once daily for 14 consecutive days, beginning 72 hours’ post-infection. Dose selections were based on prior toxicity and efficacy studies (WHO, 2022; CDC, 2023; Ofoego *et al.,* 2017). The standard drug, Lonart®—a fixed-dose combination of artemether and lumefantrine in a 1:6 ratio—was procured from Syleon-C Pharm. Nig. Ltd, Nnewi, and administered orally at 20 mg/kg/day of artemether and 120 mg/kg/day of lumefantrine, dissolved in distilled water.

**2.6 Assessment of Antimalarial Activity**

Parasitemia levels were monitored daily using thin blood smears prepared from tail vein blood. The smears were air-dried, fixed with absolute methanol, stained with 10% Giemsa solution, and examined under a light microscope at 100× oil immersion magnification (Cheesbrough, 2006; Schmidt & Roberts, 2000). The percentage parasitemia was calculated according to the method described by Fidock *et al*., (2004), using the formula:

Percentage Parasitemia 100

To assess treatment efficacy, percentage chemosuppression—a standardized metric indicating the reduction in parasitemia relative to the untreated infected control—was determined using the following formula:

Percentage Chemosuppression =

**2.7 Termination of Experiment and Evaluation of Nephroprotective Effects**

On days 1, 7, and 14 post-inoculation, blood samples were collected via cardiac puncture, allowed to clot at room temperature, and subsequently centrifuged to obtain serum. These serum samples were used to determine percentage parasitemia levels. Twenty-four hours after the final treatment administration, animals were anesthetized using chloroform, and blood was collected immediately via cardiac puncture. The collected blood was allowed to clot, and serum was separated by centrifugation and stored under appropriate conditions for subsequent biochemical analysis. Serum levels of urea and creatinine were determined using commercially available diagnostic kits (Randox Laboratories, UK) following the manufacturer’s instructions. Kidneys were excised, rinsed in normal saline, and fixed in 10% buffered formalin for histopathological evaluation.

**2.8 Histopathological Examination**

Formalin-fixed kidney tissues were dehydrated in graded alcohol, cleared in xylene, and embedded in paraffin wax. Sections of 5 µm thickness were cut using a rotary microtome and stained with hematoxylin and eosin. Histological slides were examined under a light microscope for pathological changes such as glomerular distortion, tubular necrosis, and inflammatory cell infiltration.

**2.9 Statistical Analysis**

All data were expressed as mean ± standard error of the mean (SEM). Statistical analysis was carried out using one-way analysis of variance (ANOVA) followed by Tukey’s post hoc test for multiple comparisons. Differences were considered statistically significant at p < 0.05.

**3.0 RESULTS**

**3.1 Body weight Observation**

Table 1.0 summarizes body weight changes across eight experimental groups. Body weight changes across groups were generally not statistically significant, except in the positive control group (Group A), which showed a significant increase (P = 0.02). All other groups, including treated and malaria control groups, exhibited non-significant differences in body weight before and after treatment.

Table 1.0 Effect of ethanolic extract of *Cymbopogon citratus* and *Azadirachta indica* on body weight following *plasmodium berghei* induced toxicity.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **Initial weight (g)** | **Final weight (g)** | **BWC** | **P-value** | **T-value** |
|  | **MEAN±SEM** | **MEAN±SEM** |  |  |  |
| Group A (Negative control) | 22.46±0.96 | 28.56±0.31 | 6.10 | 0.02**a** | -6.77 |
| Group B (Malaria control) | 28.67±1.14 | 32.67±0.88 | 4.00 | 0.13**b** | -2.40 |
| Group C (Malaria + 100mg/kg of EAI) | 27.90±2.30 | 34.00±1.52 | 6.10 | 0.22**b** | -1.74 |
| Group D (Malaria + 500mg/kg of EAI) | 29.17±1.03 | 34.00±1.73 | 4.83 | 0.22**b** | -1.79 |
| Group E (Malaria + 100mg/kg of ECC) | 28.40±1.83 | 31.93±1.72 | 3.53 | 0.21**b** | -1.85 |
| Group F (malaria + 500mg/kg of ECC) | 28.70±1.47 | 28.87±2.00 | 0.17 | 0.91 **b** | -0.13 |
| Group G (malaria + Standard Drug) | 30.97±1.46 | 30.88±0.76 | -0.09 | 0.92 **b** | 0.11 |
| Group H (Malaria + 500mg/kg of EAI +ECC) | 29.83±1.02 | 28.31±2.04 | -1.53 | 0.52**b** | 0.78 |

Data was analyzed using T-test, and values considered significant at *p<0.05*. SEM: Standard error of mean. BWC: Bodyweight change, EAI: ethanolic leaf extract of *Azadirachta indica*, ECC: ethanolic leaf extract of *Cymbopogon citratus* (**a**= significant, **b**= not significant when initial weight was compared with final weight).

**3.2 Relative Organ (Kidney) weight Observation**

The relative kidney weights across all groups showed no statistically significant differences, as indicated by the F-ratio of 0.32. Values remained comparable among treated and control groups as shown in table 2.0.

Table 2.0 Effect of ethanolic extract of *Cymbopogon citratus* and *Azadirachta indica* on relative kidney weight following *plasmodium berghei* induced toxicity.

|  |  |
| --- | --- |
|  | **Relative kidney weight (g)** |
|  | **MEAN±SEM** |
| Group A (Negative control) | 0.72±0.14 **b** |
| Group B (Malaria control) | 0.77±0.01 |
| Group C (Malaria + 100mg/kg of EAI) | 0.79±0.07 **b** |
| Group D (Malaria + 500mg/kg of EAI) | 0.71±0.04 **b** |
| Group E (Malaria + 100mg/kg of ECC) | 0.82±0.01 **b** |
| Group F (malaria + 500mg/kg of ECC) | 0.72±0.02 **b** |
| Group G (malaria + Standard Drug) | 0.74±0.02 **b** |
| Group H (Malaria + 500mg/kg of EAI +ECC) | 0.75±0.05 **b** |
| **F-ratio** | 0.32 |

Data was analyzed using ANOVA followed by post Hoc LSD, and values considered significant at *p<0.05*. SEM: Standard error of mean. EAI: ethanolic leaf extract of *Azadirachta indica*, ECC: ethanolic leaf extract of *Cymbopogon citratus* (**a**= significant, **b**= not significant when compared with the positive control – Group B).

**3.3 Effect of Ethanolic Extracts of Cymbopogon citratus and Azadirachta indica on Urea, Creatinine, and Uric Acid Levels in Plasmodium berghei-Infected Mice**

Table 3.0 shows the levels of urea, uric acid, and creatinine varied across treatment groups following Plasmodium berghei infection. The F-ratios for urea (4.34), uric acid (5.90), and creatinine (4.96) indicate intergroup differences, with statistical significance observed in certain treatment comparisons as denoted by superscripts.

Table 3.0 effect of ethanolic extract of *Cymbopogon citratus* and *Azadirachta indica* on urea, creatinine, and uric acid level following *plasmodium berghei* induced toxicity.

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Urea level (mg/dl)** | **Uric acid level (mg/dl)** | **Creatinine level (mg/dl)** |
|  | **MEAN±SEM** | **MEAN±SEM** | **MEAN±SEM** |
| Group A (Negative control) | 45.55±16.35 **b** | 2.74±1.26 **a** | 2.94±0.01**b** |
| Group B (Malaria control) | 61.86±4.32 | 8.33±0.47 | 2.83±1.26 |
| Group C (Malaria + 100mg/kg of EAI) | 47.42±4.62 **b** | 3.40±1.61 **a** | 0.83±0.49 **a** |
| Group D (Malaria + 500mg/kg of EAI) | 46.30±4.27 **b** | 1.52±0.47 **a** | 0.34±0.04 **a** |
| Group E (Malaria + 100mg/kg of ECC) | 48.63±6.95 **b** | 1.36±0.10 **a** | 0.77±0.04 **a** |
| Group F (malaria + 500mg/kg of ECC) | 45.76±14.67 **b** | 1.15±0.53 **a** | 0.67±0.08 **a** |
| Group G (malaria + Standard Drug) | 32.65±5.68 **a** | 2.33±0.91 **a** | 0.69±0.07 **a** |
| Group H (Malaria + 500mg/kg of EAI +ECC) | 99.07±10.92 **a** | 2.68±1.22 **a** | 0.33±0.04 **a** |
| **F-ratio** | 4.34 | 5.90 | 4.96 |

Data was analyzed using ANOVA followed by post Hoc LSD, and values considered significant at *p<0.05*. SEM: Standard error of mean. EAI: ethanolic leaf extract of *Azadirachta indica*, ECC: ethanolic leaf extract of *Cymbopogon citratus* (**a**= significant, **b**= not significant when compared with the positive control – Group B).

**3.4 Percentage parasitemia (%) at Day 0**, **Day 7**, and **Day 14 Following Treatment with Ethanolic Extracts of Cymbopogon citratus and Azadirachta indica**

At Day 0, all malaria-infected groups (Groups B to H) exhibited significantly elevated Plasmodium counts compared to the uninfected positive control group (Group A). By Day 7, all treatment groups, including those receiving ethanolic extracts of Azadirachta indica (EAI), Cymbopogon citratus (ECC), and their combination, showed marked reductions in parasite counts relative to the malaria control group (Group B). This downward trend continued by Day 14, with all treatment groups demonstrating further suppression of parasitemia, comparable to the standard drug treatment (Group G). The positive control group maintained the lowest parasite load throughout the study as shown in table 4.0.

Table 4.0 effect of ethanolic extract of *Cymbopogon citratus* and *Azadirachta indica* on plasmodium count at day 0, 7, and 14 following *plasmodium berghei* induced toxicity.

|  |  |  |  |
| --- | --- | --- | --- |
| **Group** | **Plasmodium Count Day 0** | **Plasmodium Count Day 7** | **Plasmodium Count Day 14** |
| **Group A (Negative Control)** | 0.00 ± 0.00a | 0.00 ± 0.00ᵃ | 0.00 ± 0.00ᵃ |
| **Group B (Malaria Control)** | 37.33 ± 1.45 | 60.00 ± 3.00 | 78.00 ± 4.03 |
| **Group C (Malaria + 100 mg/kg EAI)** | 43.00 ± 1.52b | 8.67 ± 0.88ᵃ | 4.67 ± 0.88ᵃ |
| **Group D (Malaria + 500 mg/kg EAI)** | 40.33 ± 0.88b | 10.67 ± 0.88ᵃ | 3.33 ± 0.33ᵃ |
| **Group E (Malaria + 100 mg/kg ECC)** | 44.33 ± 2.64b | 7.00 ± 1.52ᵃ | 4.33 ± 0.33ᵃ |
| **Group F (Malaria + 500 mg/kg ECC)** | 42.33 ± 1.76b | 5.00 ± 0.57ᵃ | 3.00 ± 0.00ᵃ |
| **Group G (Malaria + Standard Drug)** | 41.33 ± 1.20b | 3.67 ± 0.88ᵃ | 3.00 ± 0.57ᵃ |
| **Group H (Malaria + 500 mg/kg EAI+ECC)** | 44.00 ± 2.08b | 5.00 ± 0.00ᵃ | 2.33 ± 0.33ᵃ |

Data was analyzed using ANOVA followed by post Hoc LSD, and values considered significant at *p<0.05*. SEM: Standard error of mean. EAI: ethanolic leaf extract of *Azadirachta indica*, ECC: ethanolic leaf extract of *Cymbopogon citratus* (**a**= significant, **b**= not significant when compared to the Positive Control – Group B).

**3.5 Percentage Chemosuppression of Parasitemia**

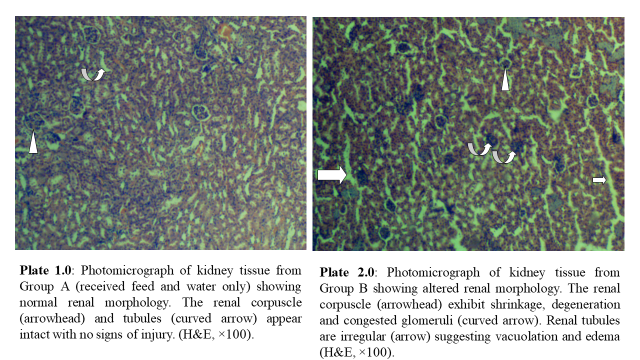
Table 5.0 presents the percentage chemosuppression of parasitemia on days 7 and 14 in all treated groups. On day 7, the lowest chemosuppression was observed in Group D (500 mg/kg EAI) with 82.22%, while the highest was in Group G (standard drug) at 93.89%. By day 14, all treatment groups showed increased chemosuppression, ranging from 94.01% in Group C (100 mg/kg EAI) to 97.01% in Group H (500 mg/kg EAI + ECC). The standard drug (Group G) showed 96.15% suppression on day 14. No parasitemia was observed in the negative control group (Group A).

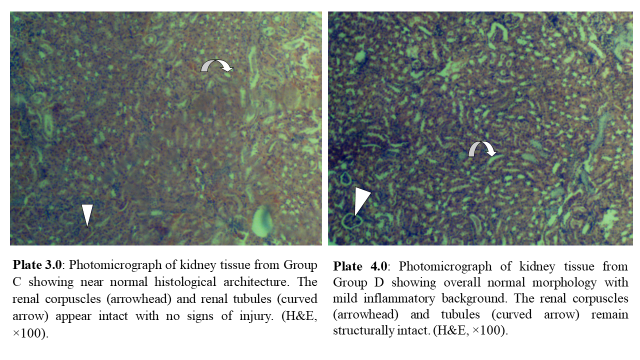
Table 5.0: Chemosuppression of parasitemia

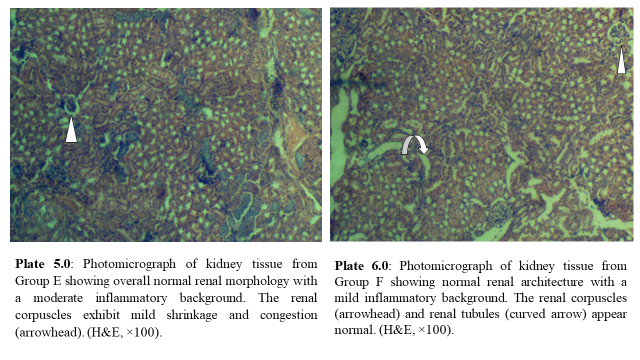
|  |  |  |
| --- | --- | --- |
| **Group** | **Day 7 Suppression (%)** | **Day 14 Suppression (%)** |
| Group B | - | - |
| Group C | 85.55% | 94.01% |
| Group D | 82.22% | 95.73% |
| Group E | 88.33% | 94.45% |
| Group F | 91.67% | 96.15% |
| Group G | 93.89% | 96.15% |
| Group H | 91.67% | 97.01% |

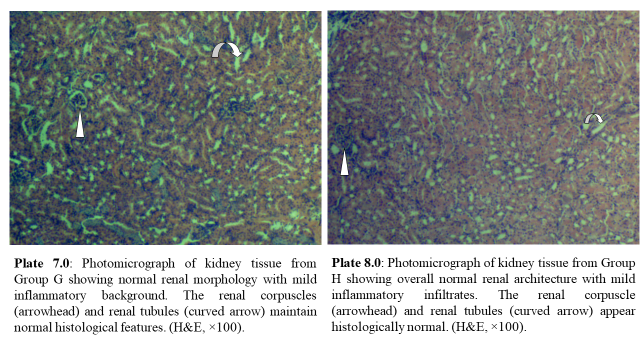
**3.6 Histological Findings**

In this study, kidney sections from treated and untreated mice were microscopically evaluated to assess morphological alterations caused by Plasmodium berghei infection and the effects of plant extract interventions. The results revealed significant histopathological changes in the kidneys of untreated infected mice, including glomerular shrinkage, tubular vacuolation, and interstitial edema—hallmarks of malaria-associated renal damage. In contrast, kidney sections from mice treated with Azadirachta indica and Cymbopogon citratus extracts showed markedly reduced tissue damage, with near-normal renal architecture and fewer inflammatory signs, as shown in Plates 1.0-8.0.









**4.0 DISCUSSION**

Malaria remains one of the most significant infectious diseases worldwide, caused by Plasmodium species and transmitted through the bite of infected *Anopheles* mosquitoes. Among the five species that infect humans—*P. falciparum*, *P. malariae*, *P. vivax*, *P. ovale*, and *P. knowlesi*—*P. falciparum* is the most virulent and predominant in sub-Saharan Africa (Babatunde *et al.,* 2018; Weiss *et al.,* 2024).

This study evaluated the effects of ethanolic extracts of *Cymbopogon citratus* (lemongrass) and *Azadirachta indica* (neem) on kidney function in mice infected with *Plasmodium berghei*. Both plants are well known for their rich phytochemical profiles and ethnomedicinal use. *C. citratus* contains compounds such as alkaloids, saponins, tannins, anthraquinones, steroids, phenols, and flavonoids (Asaolu *et al.,* 2009), while *A. indica* is endowed with antibacterial, antifungal, and antimalarial properties due to active constituents like azadirachtin and nimbolide (Subapriya & Nagini, 2005; Afolabi *et al.*, 2021).

Weight changes during the study reflected underlying physiological or pathological processes. Group A (uninfected control) showed a significant weight gain, likely reflecting normal growth under optimal conditions. In contrast, Group B (malaria control) had a marginal, non-significant increase, indicating that *P. berghei* infection may have impaired normal metabolism. This finding partially contradicts Atkinson *et al.,* (2000), who reported marked weight loss and reduced food intake in infected birds. Interestingly, mice in Groups C to F (treated with plant extracts) showed varied weight responses. Increases observed in some groups may be due to the nutritional and metabolic benefits of bioactive compounds in the extracts, in line with findings by Ubua *et al.,* (2019). However, this contrasts with Agbafor and Akubugwo (2007), who reported weight loss in rats treated with *C. citratus* extract.

Relative kidney weights across groups remained largely unchanged, indicating limited gross morphological alterations. The slight decrease observed in Group D (500 mg/kg *A. indica*) may reflect diuretic or detoxifying actions of certain phytochemicals. These findings correspond with reports by Ofoego *et al.,* (2019) and Abdel Moneim *et al.,* (2014), who observed protective effects on renal morphology and mass with neem extract, and with Ogbuewu *et al.,* (2015), who noted lower kidney weights in rabbits fed neem-supplemented diets.

Biochemical parameters further highlighted the extracts' protective roles. Urea levels generally decreased across treatment groups, except in Group H, where a significant increase may suggest dose-related synergistic effects. Notably, creatinine and uric acid levels decreased significantly in extract-treated groups, suggesting improved renal function. This nephroprotective effect is likely due to the antioxidant and enzyme-inhibitory actions of flavonoids and alkaloids. These compounds disrupt parasite metabolism by inhibiting glycolytic enzymes and ATP production, leading to parasite death. Flavonoids also block hemozoin formation, resulting in toxic free heme accumulation and oxidative stress within the parasite (Tasdemir *et al.*, 2006; Oluwadare *et al.,* 2025). These mechanisms contribute to organ protection during infection.

Parasitemia evaluation revealed high parasite loads at baseline (Day 0) in all infected groups. However, by Days 7 and 14, groups treated with either extracts or standard antimalarial drugs showed significant reductions in parasite counts, confirming the antiplasmodial efficacy of both *C. citratus* and *A. indica*. The observed reductions in parasitemia in the extract-treated groups, particularly those receiving higher doses of Azadirachta indica and Cymbopogon citratus, demonstrated marked chemosuppressive effects when compared to the untreated malaria control group. This aligns with earlier findings by Okeke *et al.,* (2014) and Anyasodor *et al.,* (2023), who reported similar parasite suppression using these plants. The bioactive phytochemicals likely exert their effects through DNA intercalation, inhibition of topoisomerases, disruption of ribosomal function, and mitochondrial depolarization thus disrupting parasite growth and replication (Cimanga *et al.,* 2004; Slater & Cerami, 1992).

Histological analyses supported these observations. Group B (untreated malaria) exhibited marked renal damage, including glomerular congestion, tubular degeneration, vacuolation, and interstitial edema. These lesions are typical of malaria-associated kidney injury, often driven by red blood cell sequestration, rosette formation, and vascular occlusion, which impair renal microcirculation and provoke ischemia, tubular necrosis, and inflammatory infiltration (Naqvi, 2015; Silva *et al.,* 2017). In contrast, kidney tissues from treated groups (C to H) showed relatively preserved architecture, with mild or absent structural lesions, comparable to the negative control group. These findings reinforce the nephroprotective properties of the plant extracts, though mild inflammatory signs in some groups may suggest dose- or duration-related tissue responses.

**5.0 Conclusion**

This study demonstrates that ethanolic extracts of *Cymbopogon citratus* and *Azadirachta indica* possess antimalarial and nephroprotective properties in *Plasmodium berghei*-infected mice. The extracts significantly reduced parasitemia and improved renal biomarkers, especially at individual doses. However, combined high doses may induce mild kidney inflammation, indicating a need for dose optimization.

**Disclaimer** (Artificial intelligence)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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