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Assessment of Suppressive Potential of Ethanolic Coconut (Cocos nucifera) Husk Extract in Plasmodium berghei Infection in Mice

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Assessment of Suppressive Potential of Ethanolic Coconut (*Cocos nucifera*) Husk Extract in *Plasmodium berghei* Infection in Mice

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Abstract

Introduction: Malaria continues to be a deadly disease in sub-Saharan Africa, affecting children below five years and pregnant women the most. Because of the high level of resistance to conventional antimalarials, there is a need to explore alternative sources of treatment, medicinal plants. The antiplasmodial activity, hematological

effects and safety profile of ethanolic extract of *Cocos nucifera* husk (ECHE) against *Plasmodium berghei* in mice was studied.

Methods: Female mice were inoculated with *P. berghei* (NK65) by using healthy mice. Peter's 4 day suppressing test compares suppression of parasitemia with ECHE (100 mg/kg) versus suppression with chloroquine (5 mg/kg). Standardized methods were used for the phytochemical screening, haematological parameters, liver function parameters (AST, ALT).

Result: ECHE demonstrated substantial antiplasmodial activity with 78.40% parasitemia suppression versus 90.04% for chloroquine. Phytochemical analysis confirmed that the plant extract contained a significant amount of saponins (282.14 ± 1.23 mg/g) and terpenoids (26.99 ± 0.14 mg/g) and moderate levels of phenols, tannins and flavonoids. Notably, ECHE showed better RBC protective effect with higher number of RBC (9.02 × 106/µL) than that of chloroquine (5.82 × 106/µL), which could be attributed to its antioxidant flavonoids and phenolics content. However, ECHE induced significant hepatotoxicity with elevated AST (220.10 ± 63.38 U/L) and ALT (116.27 ± 19.47 U/L). Immunologically, ECHE promoted elevated lymphocyte responses (48.50% ± 2.52%) and chloroquine elevated the neutrophil profiles (58.50% ± 1.50%) which showed differential immune modulation. Valorization of coconut husk waste with Nigeria discarding approximately 108,000 metric tons annually that presents significant therapeutic and economic opportunities.

Conclusions: ECHE is highly effective in its antiplasmodial activity with significant erythroprotective effects and highly toxic to liver because of the presence of saponins. The results call for bioassay-guided fractionation of the plant material to isolate the therapeutic from the toxic components, thus opening the door to the possibility of this agricultural waste as a sustainable antimalarial therapeutic.

Keywords: *Plasmodium berghei*, *Cocos nucifera*, ethanolic husk extract, chloroquine, antimalarial activity, agricultural waste valorization.

Introduction

Malaria continues to be one of the most devastating infectious diseases in the world and the disease is a primary cause of morbidity and mortality, especially in sub-Saharan Africa. In 2023, more than 263 million cases of malaria were reported and 597,000 deaths occurred globally, of which 94% of all cases and 95% of all deaths occurred in the African region (WHO 2024). Since 2000, there have been significant advances; an estimated 2.2 billion cases of malaria prevented and 12.7 million deaths averted (WHO 2023). This has, however, not been sustained over the past few years, as it is estimated that there were around 11 million more cases in 2023 than in

2022 (WHO 2023). Children under 5 years and pregnant women are the groups that are most vulnerable, accounting for some 90% of all deaths due to malaria in Africa (Nguta 2025).

The past history of malaria mortality in Africa shows that while the number of deaths has fallen significantly since 2000, over 95% of all malaria deaths remain in Africa (Snow and Sartorius 2024). Malaria is a disease caused by protozoan parasites of the genus *Plasmodium* that are spread when infected female Anopheles mosquitoes bite a person (WHO 2024). Of the more than 200 species of *Plasmodium*, only five species infect humans: *Plasmodium falciparum*, *Plasmodium vivax*, *Plasmodium malariae*, *Plasmodium ovale* and *Plasmodium knowlesi* (Fidock *et al.* 2004). These human-infecting species have different geographical distribution, clinical features, sensitivity to antimicrobials and clinical outcomes (Menard and Dondorp 2017).

Animal models have been used for *in-vivo* malaria studies because of ethical and practical reasons, especially when testing the effectiveness of new compounds discovered from plants (Fidock *et al.* 2004). *Plasmodium berghei* is an ideal choice for preclinical drug development studies of antimalarials because it has many morphological, biochemical and genetic similarities with the human *Plasmodium* species (Hall *et al.*, 2005). Moreover, *P. berghei* is susceptible to similar drugs and can be easily maintained in mice at a low cost (Janse *et al.* 2020).

Failure to achieve an optimal response to antimalarial treatment can have many serious consequences, such as death, prolonged illness, higher health-care costs, and possible epidemic spread. The loss of drug sensitivity has led to the emergence of new drugs with different mechanisms of action (WHO 2024). The latter calls for the need for alternative therapeutic interventions like plant derived compounds like ethanolic coconut husk extract.

Cocos nucifera L. the coconut tree belongs to the Arecaceae family, and is endemic to the littoral zones of Southeast Asia and has been introduced in tropical regions around the world such as Africa, the Caribbean and South America (Al-Adhroey *et al.* 2011). In traditional medicine, all parts of the coconut tree were used in the treatment of different diseases in various cultures. The milky white flesh of the coconut is used in traditional medicine to treat malaria in Malaysia, and the water from green coconuts is used in traditional medicine as an antipyretic in Malaysia (Al-Adhroey *et al.* 2011). The fibre of *Cocos nucifera* is decomposed to treat malaria in Nigerian traditional medicine (Adebayo *et al*, 2014, Adebayo *et al*, 2016). The husk fibre which was considered as agriculture waste is boiled in water and the resulting decoction used for febrile ailments such as malaria (Adebayo *et al.*, 2016).

The extraction solvent used in this study, ethanol, is a solvent traditionally used for the preparation of herbal tinctures and decoctions, which is suitable for the ethnopharmacological context of the plant's traditional use (Adebayo *et al.* 2014). Earlier, ethanol has been proven to be appropriate for extracting phytochemicals in malaria related research, for example Nguta *et al.* (2015) used hydroethanolic extracts for the screening of antimalaria activity.

The valorisation of the coconut husk waste products, which Nigeria alone wastes about 108,000 metric tons per year, is a huge economic opportunity, besides the medicinal potential, that can turn agricultural waste into therapeutic assets. The antimalarial activity of ethanolic coconut husk extract has been previously studied but no particular study used standardized *P. berghei* NK65 inoculum (1×10^6 infected cells/mL) in their intramuscular injection experiment with ethanolic coconut husk extract at a dose of 100 mg/kg of body weight. In view of these facts, the present study aimed to assess antiplasmodial activity of ethanolic extract of *C. nucifera* husk against *P. berghei* (NK65) in mouse model and thorough evaluation of haematological parameters, hepatic safety profile. The present study filled the methodological gap and helped to build the evidence for the use of alternative medicines for the treatment of Malaria and sustainable utilization of agricultural waste products.

Materials and Methods

Plant material collection and authentication

Healthy fresh coconut fruits (*Cocos nucifera* L.) were harvested from the farm, Ikeji-Arakeji, Osun State in the Southwest part of Nigeria. The plants used were identified and authenticated in the Centre for Research and Development (CERAD), Federal University of Technology (FUT), Akure, Nigeria. A voucher specimen was made up and lodged in the herbarium with accession no FHI FUTA 065.

Ethical Approval

All experimental procedures with animals were performed in compliance with internationally accepted guidelines for the care and use of laboratory animals. The study received ethical approval from Research and Grant Management Office (RGMO) of Joseph Ayo Babalola University, Ikeji-Arakeji, Osun State, Nigeria with approval number JABU/RGMO/REC/26/017.

Preparation of Ethanolic Extract

The coconut husks were thoroughly cleaned to remove the fibers that might be attached, then cut into small pieces (about 1cm²) washed and shade dried for 14 days, and later, oven dried at 40°C for 48 hours. Dried husks were

finely ground in an electric grinder. The powdered material (500 g) was macerated in 2.5 l of ethanol 70% with occasional shaking for 72 hours. It was filtered using Whatman No. 1 filter paper and concentrated under reduced pressure using rotary evaporator at 40°C to get the crude ethanolic extract (ECHE). The concentrated extract (1 g) was dissolved in 10 mL of distilled water at room temperature (30 ± 2°C) to give a stock concentration of 100 mg/mL. The suspension was then vortexed (XH-C vortex mixer, Searchtech Instruments) for 30 minutes to aid in complete dissolution, and kept at 4°C until needed. The extraction protocol was adopted from the phytochemical studies of Cocos nucifera carried out in the past (Adebayo *et al.* 2016; Esquenazi *et al.* 2002).

Phytochemical Screening

Qualitative Phytochemical Analysis: Qualitative phytochemical screening of ECHE was done to ascertain the presence of various phytochemicals in the extract following standard procedures (AOAC International 2012). The different classes of phytochemicals such as alkaloids, saponins, tannins, anthraquinones, flavonoids, steroids, terpenoids and phenols were evaluated using standard reagents and colorimetric tests recommended by AOAC International (2012).

Quantitative Phytochemical Analysis: The tannin content was analyzed according to Siddhuraju and Manian (2007). The method described in Jia *et al.* (1999) was used to determine the content of flavonoids. The saponin content was estimated according to the method of Makkar *et al.* (2007).

Experimental Animals

Healthy female Swiss mice weighing 20-25 g of 6-8 week old mice were obtained from Department of Pharmacy, Obafemi Awolowo University, Ile-Ife, Osun State, Nigeria. Animals were acclimatized for 7 days before the experiment was begun. Animals were kept under standard environmental conditions (12 hours light/dark cycle, 25 ± 2°C) with a free choice of a standard rodent pellet and water. The study was conducted following standard guidelines for care and use of laboratory animals as described in the literature (Fidock *et al.* 2004; Adebayo *et al.* 2016; Peters 1970).

Parasite Inoculum

The strain *Plasmodium berghei* (NK65) used in this research work was purchased from National Veterinary Research Institute (NVRI), Vom, Plateau State, Nigeria. The parasite was serially passed in donor mice as described by Peters (1970). Infected blood was obtained from donor mice at 20-30% parasitemia. The blood was diluted in sterile phosphate buffered saline (PBS, PH 7.2) to 1×10^6 infected red blood cells (iRBCs)/mL. A total

of 2×10^5 iRBCs (0.2 mL) was injected intramuscularly into the left thigh muscle of each mouse with a 26G capillary syringe. Inoculum preparation was done following standard procedures (Adebayo *et al.* 2016; Peters 1970; Knight and Peters 1980).

Determination of Parasitemia

Thick blood film microscopy was used for the determination of parasitemia. The drop of blood was taken from the tail vein of each mouse and was spread on a clean glass slide in a circular motion to make a thick film. The smear was air-dried and stained with 10% Giemsa stain for 30 minutes. The stained smear was gently washed with water, dried by air, and then looked at on a light microscope at ×100 magnification in oil immersion. The following formula was used to calculate parasitemia:

Number of parasites counted × Actual mouse WBC count / WBC counted - Parasitemia (parasites/µL)

Peter's 4-day suppressive test: *in-vivo* antimalarial activity

The suppressive test (Peter's test) was carried out for 4 days based on the standard procedure described by Nguta (2025), Adebayo et al. (2016) and Peters (1970). Mice were divided into groups and infected on Day 0 (D0) with 0.2 mL of parasite inoculum (1×10^6 iRBCs/mL) via intramuscular injection. Three hours after infection, treatment began and continued every day for 4 days (D0–D3). The experimental groups consisted of:

- **Group A (Normal control):** Uninfected, untreated mice
- **Group B (Negative control):** Infected, untreated mice (received distilled water)
- **Group C (Standard control):** Infected mice treated with chloroquine (5 mg/kg)
- **Group D (Test group):** Infected mice treated with ECHE (100 mg/kg)

On Day 4 (D4), thin blood smears were prepared from tail blood, fixed with methanol, stained with 10% Giemsa for 15 minutes, and examined under ×100 oil immersion. Parasitemia was determined by counting parasites against white blood cells in thick blood films. Percent parasitemia suppression was calculated as:

% Suppression = [(% Parasitemia negative control – % Parasitemia treated group) / % Parasitemia negative control] × 100

Hematological Analysis

Samples of blood were obtained by cervical dislocation and placed in EDTA coated tubes for haematology and in lithium heparin containers for hepatic function tests. Standard methods (Cheesebrough 2006) were used to determine the packed cell volume (PCV), hemoglobin concentration (Hb), red blood cell count (RBC), white blood cell count (WBC) and differential leukocyte counts.

Hepatic Function Tests

Hepatic function markers (aspartate aminotransferase (AST) and alanine aminotransferase (ALT) were measured using standard methods (Cheesebrough 2014).

Statistical Analysis

All data presented as the mean ± standard deviation (SD). Data was analyzed with SPSS version 17.0. One-way analysis of variance (ANOVA) was used for the group comparisons and Duncan's new multiple range test for subsequent comparisons. Differences were considered statistically significant at $p \leq 0.05$.

Results

Phytochemical Profile of Ethanolic *Cocos nucifera* Husk Extract

Qualitative Phytochemical Composition

The phytochemical screening of ECHE identified six major phytochemical classes. The tannins, flavonoids and phenols were moderately present (++) and the terpenoids were highly abundant (+++), while the saponins were not present. Trace amounts (+) of alkaloids were detected (Table 1).

Quantitative Phytochemical Composition

The quantitative analysis revealed that saponins (282.14 ± 1.23 mg/g) was the most dominant phytochemical followed by terpenoids (26.99 ± 0.14 mg/g). Phenols (0.48 ± 0.01 mg/g), alkaloids (0.35 ± 0.04%), and flavonoids (0.20 ± 0.00 mg/g) were present in substantially lower concentrations. The smallest amount detected was tannins (0.06 ± 0.01 mg/g) (Table 2).

In-vivo antimalarial activity: parasitemia suppression

The ECHE group showed 78.40% parasite suppression and the chloroquine group showed 90.04% suppression when compared to the untreated negative control group (Table 3).

Hematological parameters

The chloroquine group exhibited WBC counts of 7.50 ± 0.30 × 10^3/μL, while the ECHE group showed lower counts of 6.50 ± 0.90 × 10^3/μL. The RBC counts in the chloroquine group were 5.82 ± 1.43 × 10^6/μL while the ECHE group recorded a significantly higher RBC count of 9.02 ± 2.73 × 10^6/μL. Hemoglobin levels were comparable (17.53 ± 4.39 g/L vs. 16.95 ± 4.78 g/L). The chloroquine group exhibited PCV of 40.50% ± 0.50%, while the ECHE group recorded PCV of 38.50% ± 4.50% (Table 4).

Differential leukocyte profiles

Lymphocyte level in the chloroquine group remained tightly controlled (39.00% ± 1.00%) with uniform level of monocytes (2.00% ± 0.00%), elevated monocytes level (58.50% ± 1.50%) and negligible level of eosinophils (0.50% ± 0.50%) and undetectable basophils (0.00% ± 0.00%). The ECHE group had significantly higher lymphocyte percentages (48.50% ± 2.52%) and slightly higher monocyte numbers (2.50% ± 0.50%) with lower percentages of neutrophils (47.50% ± 3.50%), slightly higher eosinophil numbers (1.00% ± 0.00%) and trace basophil numbers (0.50% ± 0.71%) (Table 5).

Hepatic function markers

Aspartate aminotransferase (AST): The chloroquine group maintained stable AST levels (105.90 ± 7.70 U/L). In contrast, the ECHE group exhibited markedly elevated and highly variable AST levels (220.10 ± 63.38 U/L) (Table 6).

Alanine aminotransferase (ALT): ALT level was maintained in a well-controlled manner in the chloroquine group (110.95 ± 20.95 U/L). The ECHE group triggered a higher ALT leak (116.27 ± 19.47 U/L) that peaked at 133.2 U/L in Mouse 2 (Table 7).

Discussion

The antimalarial activity of ECHE was remarkable with a reduction in parasite load of 78.40% which is above that proposed by classical ethnopharmacology as being high for a plant derivative (i.e., 70%). This means there is considerable therapeutic potential; but there is an efficacy gap of 11.64% from the absolute parasite suppression of 90.04% obtained with chloroquine. That is because the difference in performance can be explained by the basic difference between a single, pure chemical compound and an unrefined, plant-based extract with several secondary metabolites that could compete or interact.

It is likely that the remarkable antimalarial profile displayed by ECHE is closely related to its highly polar phytochemical composition. The crude extract contained high level of saponins (282.14 ± 1.23 mg/g) and

terpenoids (26.99 ± 0.14 mg/g), while the rest of the extracts were in low quantities (Okwara *et al.* 2025). This very skewed profile suggests that a "Saponin-Terpenoid Alliance" could be the main reason for therapeutic efficacy. Our mechanism of action suggests that saponins are surface active glycosides that bind very tightly to the cholesterol molecules in the infected erythrocyte and to the parasite itself, creating microscopic pores in the membranes before the development of mature schizogony, resulting in cytolytic death (Al-Youssef and Amina 2021). At the same time, lipophilic terpenoids enter into food vacuoles via the lipid bilayers and disrupt the internal proteolysis, promote lipid peroxidation and interfere with the proper elimination of toxic free heme to the hemozoin crystals.

The present finding showed higher antiplasmodial activity than earlier reports by Melo (2022) and Tayler Sucre (2024) which obtained reductions of parasitaemia with 50% and 54%, respectively, using husk fibre extract and bee pollen extract, respectively, while Cocos nucifera leaf extract had the lowest reduction of parasitaemia (57%).

In the assessment of total red blood cell (RBC) turnover, host animals had a significant reduction in RBC count by chloroquine ($5.82 \times 10^6/\mu L$) (Okwara *et al.* 2025). This massive drop is due to the high clearance velocity of the chemical, which may result in rapid chemolytic side-effects after infection, or a lag period of bone marrow regeneration after infection. The ECHE group, however, actively preserved their RBC counts at $9.02 \times 10^6/\mu L$ which is much higher than the other groups. This unique erythroprotective action is due to the polyphenolic, flavonoid and phenolic constituents of the extract. These compounds act as natural antioxidants to neutralise the very high levels of oxidative stress and free radicals produced by the increasing number of *Plasmodium berghei* trophozoites, and help to protect the lipid membranes of uninfected cells from lipid peroxidation and premature elimination by the host's spleen (Iribhogbe *et al.* 2012). The findings support those of Uzuegbu *et al.* (2022) who observed that the bioactive compound of *Phyllanthus amarus* (alkaloid extract) showed antioxidant activities which helped repair the damages caused by parasites on the erythrocyte membrane.

These are further indicators of physiological stress as seen from the results of Packed Cell Volume (PCV). The PCV baseline was very stable and uniform in the chloroquine group, at 40.50% ± 0.50%, suggesting that chemical eradication is able to consistently protect against severe malaria-induced blood thinning (Okwara *et al.*, 2025). The volume profile of the ECHE arm, however, was more irregular, with a mean of 38.50% ± 4.50% but a sudden decrease in the volume profile of Mouse 2 down to 34% due to a sudden decrease in the number of anemic cells in Mouse 2 compromised the volume profile. The results obtained are corroborated by the study by Nwankwo *et*

al. (2025) which showed that the ethanol extract of Spondias mombin significantly increased the RBC and PCV and also showed an increase in the activities of the antioxidant enzymes in *P. berghei* infected mice.

A good correlation between the rate of clearance of parasites and host immune balance can be confirmed by analysing Total White Blood Cell (WBC) counts. The leukocytes network was restored to an optimum basal value of $7.50 \pm 0.30 \times 10^3/\mu L$ in the chloroquine group with very little variation between the individuals (Okwara *et al.* 2025). On the other hand, the ECHE had a mean WBC count of $6.50 \pm 0.90 \times 10^3/\mu L$ which was depressed and unstable (Okwara *et al.* 2025). A considerable reduction indicates that the leukocytes were utilized in the periphery or leukopenia due to infection.

Unique operational change of host immune defense is revealed by studying subsets of white blood cells. The baseline of lymphocytes in animals treated with chloroquine was very low (39.00% ± 1.00%) and the baseline of neutrophils was also very high (58.50% ± 1.50%) indicating that standard treatment is effective in maintaining a low baseline of adaptive immune, a high baseline of innate immune (phagocytic) in animals treated with chloroquine (Okwara et al. 2025). In contrast, ECHE reversed these parameters resulting in increased and hyperactive lymphocytes (48.50% ± 2.52%) and decreased neutrophils (Okwara *et al.* 2025). This would imply that the crude extract that contains saponins and terpenoids are natural immunostimulants that shift the innate acute bacterial type from action to adaptive lymphocytic pathway to inactivate the remaining parasite load (Kaba and Melaku 2013). The findings are corroborated by Ntonifor *et al.* (2024) who showed that *T. diversifolia* extracts rich in flavonoids were able to boost phagocytic activity and upregulate the release of pro-inflammatory cytokines such as tumour necrosis factor alpha (TNF-α) and interferon gamma (INF-γ) in *P. berghei* infected rats.

Acute organ level metabolic toxicity is the most important physiologic issue found in this study. The ALT leak level was higher in the low dose ECHE group (116.27 ± 19.47 U/L) while the AST level was significantly elevated in the low dose ECHE group (220.10 ± 63.38 U/L) with large enzyme spikes in Mice 2 and 3 (Okwara *et al.*, 2025). Concurrently increased ALT and AST levels are indicative of high amounts of acute hepatotoxicity and direct hepatocyte necrosis from the crude extract (Podolak *et al*., 2010). This organ damage is a direct effect of the very high concentration of the extract's saponins. The non-specific detergent properties of unpurified saponins, which are not specific for the foreign parasitic membranes and the normal lipid bilayers of mammalian hepatocytes, leads to undesirable permeabilization of tissues and cell destruction. This is similar to the study conducted by Balogun *et al* (2014) which showed that serum ALT activity was significantly elevated at higher doses of methanolic extract of *Cocos nucifera* husk fibre and it was able to affect normal liver function.

Economic and Therapeutic Potential

Nigeria alone produces nearly 108,000 metric tons of coconut husk yearly, and imports $21 million worth of coconut derivatives annually (Azeez, 2025). Research and Markets (2024) estimates that the global coconut coir market will hit a value of $1.45 billion in 2024. When the agricultural wastes are processed under clusters in Lagos, Cross River and Akwa Ibom, it will provide more than 100,000 jobs and reduce the importation of antimalarial drugs by more than 1.00 lakh crores of rupees (Azeez, 2025).

Conclusion

ECHE is an extremely potent antiplasmodial compound with remarkable erythroprotective activity and is hepatotoxic in the presence of saponin. These results require bioassay-guided fractionation to isolate therapeutic from toxic compounds with the aim of providing a sustainable source of an antimalarial therapeutic from an agricultural waste.

Recommendations

1. Isolate and remove of cytotoxic saponins: Optimize extraction and purification method to separate and remove unpurified saponin fractions.

2. Carry out polarity-driven fractionation (using liquid-liquid partitioning and/or flash chromatography, from nonpolar to very polar).

3. Carry out focused bioassays: Test each fraction against *Plasmodium berghei* and find the therapeutic clusters.

Statements and Declarations

Competing Interests: The authors have no conflicts of interest to declare.

Funding: No funding was received for conducting this study.

Ethical Approval: All animal experiments were conducted in accordance with internationally accepted guidelines. Ethical approval was obtained from the Research and Grant Management Office of Joseph Ayo Babalola University, Ikeji-Arakeji, Osun State, Nigeria (Approval No. JABU/RGMO/REC/26/017).

Data Availability: All data supporting the findings of this publication are available on request.

Author Contributions: Conceptualization, K.B.M. and O.O.A.; methodology, K.B.M. and O.O.A.; software, K.B.M., O.O.A., E.O.K., B.C.F., E.O. and O.F.O.; validation, K.B.M., O.O.A., E.O.K., B.C.F., E.O. and O.F.O.;

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TABLES

Table 1: Qualitative Phytochemical Profile of Ethanolic Extract of *Cocos nucifera* Husk

Phytochemical Constituent	**Inference**
Alkaloids	+
Saponins	+++

Tannins	++
Flavonoids	++
Terpenoids	+++
Phenols	++

Keys: +++ = highly abundant; ++ = moderately present; + = present in trace amounts

Table 2: Quantitative Phytochemical Composition of Ethanolic Extract of *Cocos nucifera* Husk

Phytochemical Parameter	Unit	Replicate 1	Replicate 2	Mean ± SD
Saponins	mg/g	281.27330	283.00700	282.14 ± 1.23
Terpenoids	mg/g	26.88830	27.09120	26.99 ± 0.14
Phenols	mg/g	0.47524	0.48321	0.48 ± 0.01
Flavonoids	mg/g	0.19228	0.19882	0.20 ± 0.00
Alkaloids	%	0.32000	0.37000	0.35 ± 0.04
Tannins	mg/g	0.05235	0.07111	0.06 ± 0.01

Data expressed as Mean ± SD (n = 3 per group)

Table 3: Parasitemia by Treatment Group

Group	Treatment Group	Mouse 1 (parasites/µL)	Mouse 2 (parasites/µL)	Mouse 3 (parasites/µL)	Mean ± SD (parasites/µL)	% Suppression
A	Normal control	0.00	0.00	0.00	0.00 ± 0.00	-
B	Negative control	3800.00	3342.00	3634.86	3592.29 ± 231.95	0.00%
C	Chloroquine (5 mg/kg)	380.00	334.00	1117.35	349.72 ± 26.23	90.30%
D	ECHE (100 mg/kg)	804.68	731.29	767.98	767.98 ± 36.70	78.40%

Data expressed as Mean ± SD (n = 3 per group). ECHE: ethanolic Cocos nucifera husk extract.

Table 4: Effect of Chloroquine and ECHE on Hematological Parameters in Experimental Mice

Group	Treatment Group	Dose (mg/kg)	WBC Count ($\times 10^3/\mu L$)	RBC Count ($\times 10^6/\mu L$)	HGB Level (g/L)	PCV (%)
A	Chloroquine	5	7.50 ± 0.30	5.82 ± 1.43	17.53 ± 4.39	40.50 ± 0.50
B	ECHE (Low Dose)	100	6.50 ± 0.90	9.02 ± 2.73	16.95 ± 4.78	38.50 ± 4.50

Data expressed as Mean ± SD (n = 3 per group). ECHE: ethanolic Cocos nucifera husk extract.

Table 5: Effect of Chloroquine and ECHE on Differential Leukocyte Counts in Mice

Group	Treatment Group	Dose (mg/kg)	Lymphocytes (%)	Monocytes (%)	Neutrophils (%)	Eosinophils (%)	Basophils (%)
A	Chloroquine	5	39.00 ± 1.00	2.00 ± 0.00	58.50 ± 1.50	0.50 ± 0.50	0.00 ± 0.00
B	ECHE (low dose)	100	48.50 ± 2.50	2.50 ± 0.50	47.50 ± 3.50	1.00 ± 0.00	0.50 ± 0.71

Data expressed as Mean ± SD (n = 3 per group). ECHE: ethanolic Cocos nucifera husk extract.

Table 6: Effect of Chloroquine and ECHE on Aspartate Aminotransferase (AST) in Mice

Group	Treatment Group	Dose (mg/kg)	Mean (U/L)	Standard Deviation (SD)	Mean ± SD
A	Chloroquine	5	105.90	7.70	105.90 ± 7.70
B	ECHE (low dose)	100	220.10	63.38	220.10 ± 63.38

Data expressed as Mean ± SD (n = 3 per group). ECHE: ethanolic Cocos nucifera husk extract.

Table 7: Effect of Chloroquine and ECHE on Alanine Aminotransferase (ALT) in Mice

Group	Treatment Group	Dose (mg/kg)	Mean (U/L)	Standard Deviation (SD)	Mean ± SD
A	Chloroquine	5	110.95	20.95	110.95 ± 20.95
B	ECHE (low dose)	100	116.27	19.47	116.27 ± 19.47

Data expressed as Mean ± SD (n = 3 per group). ECHE: ethanolic Cocos nucifera husk extract.

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