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Anti-Malarial Bioactivity of *Garcinia kola* Aqueous Extracts in Treatment of *Plasmodium Berghei* Infected Mice

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ABSTRACT

Plasmodium parasites are the deadly cause of malaria, a disease spread by mosquitoes that still poses a threat to public health. The purpose of this study was to investigate antimalarial efficacy of the aqueous extracts of *Garcinia kola*'s leaf, root and nut, which is well-known for its medicinal components. The anti-malarial properties of aqueous extracts from *Garcinia kola*'s leaf, root, and nut were examined using a laboratory mouse model infected with *Plasmodium berghei*. The quantity of the phytochemical quantitative analysis was expressed as Mean ± Standard Error Mean of 3 replicates while the percentage (%) parasitaemia were analysed and expressed as Mean ± Standard Error mean of 5 replicates, also the Mean Survival Time (MST) was calculated and recorded. Mean values with the same alphabets were not significantly different while Mean values with different alphabets were significantly different. The quantitative study of parasitaemia percentage showed that all the doses of the crude extracts gave a parasitaemia reduction of >30% which implies being effective in the treatment of malaria. As the doses of all three extracts increased the parasitaemia suppression also increased with kola nut extract at 600mg/kg given the highest parasitaemia suppression rate of 54.70%. Additionally, in several therapy groups, MST was prolonged, which may have been advantageous for survival. The study highlights the significant anti-malarial potential of *Garcinia kola* extracts and recommends additional investigation, including clinical studies, to confirm their effectiveness and safety.

Key Words: Bioactive compounds, Malaria, Mean Survival Time (MST), Parasitaemia, Suppression

I. INTRODUCTION

One of the biggest threats to global health is still malaria, especially in tropical and subtropical areas. The disease, which is brought about by Plasmodium parasites and spread by infected mosquitoes, causes significant morbidity and mortality on a global scale. Drug resistance and restricted access to efficient therapies remain significant barriers to controlling and eradicating malaria. Consequently, it is crucial to find new and long-lasting anti-malarial treatments (Shibeshi *et al.*, 2020).

Due to its reputed therapeutic effects, the West and Central African native plant *Garcinia kola* occupies a significant position in traditional medicine. It is recognized for having a wide range of phytochemicals, including terpenoids, alkaloids, flavonoids, tannins, and saponins. These bioactive substances have been linked to a variety of health advantages, including anti-inflammatory, anti-oxidant, and antibacterial activities (Roy *et al.*, 2022).

Recent research has suggested that the leaves, roots, and nuts of the *Garcinia kola* plant, among other parts, have potential anti-malarial qualities. These sections contain substances that have been identified through phytochemical investigation as having the capacity to obstruct the growth and multiplication of parasites. Additionally, based on anecdotal evidence from traditional medical procedures, *Garcinia kola* may have historically been used to treat the symptoms of malaria (Dogara *et al.*, 2022).

There is need to explore locally available plants as alternative sources of therapeutic agents given the dearth of effective and affordable antimalarial medicines. The intriguing idea of using *Garcinia kola* in malaria treatment methods is raised by the bioactive substances it contains. Quantitative investigations and thorough scientific research are necessary to determine the plant's genuine anti-malarial capabilities, while qualitative analyses of the plant's extracts have given preliminary insights into its phytochemical makeup. The results of the study may aid in the creation of novel anti-malarial remedies, particularly in areas with restricted access to traditional medications. A viable and culturally appropriate answer to the ongoing problem of malaria management and treatment may be provided if *Garcinia kola* extracts show strong anti-malarial properties, which could lead to additional study, formulation, and clinical trials.

II. RESEARCH METHODOLOGY

Experimental Design

Randomized controlled animal study using a Laboratory mice model infected with *Plasmodium berghei* was adopted in this study. Fresh leaves, roots and nuts of *Garcinia kola* plant were collected from Kurmi LGA of Taraba State. The collected leaves were washed, aired dried and grinded into fine powder. The aqueous extracts of *Garcinia kola* leaf, root, and nut was conducted using maceration methods. The stock solution of the plants extract was used to constitute 200mg, 400mg and 600mg. This doses and a standard drug (200mg of chloroquine) were used in the treatments groups in this studies.

Male and female (non-pregnant) mice of bodyweight 20g to 35g were purchased at Animal House, National Veterinary Research Institute Vom, Plateau State. The mice were allowed to acclimatize in the Laboratory, the acclimatization was done for fourteen days during which they will be fed with standard rodents' feed (Finisher) and tap water. Then, the mice were equally divided (5 mice/group) to formed seven groups. And the average weights of the mice in the test group were measured and used to calculate the dosage of plant extract to be administered to the mice. A total of 105 mice were used for all the different dosages of the three parts of the crude extracts that was used in the curative test. In all cases of the plant extract, administration was done by compulsory oral intubations with the aid of cannula and syringe (Turner *et al.*, 2011). The caring and experimental use of the Mice during this experiment was done using the guideline recommended by the Center for Drug Evaluation and Research (CDER, 2011).

Laboratory Examination

The parasitaemia levels of the infected mice was monitored using a blood smears stained with a Giemsa and was observed under the microscope. The percentage parasitaemia, percentage suppression, Mean Survival Time (MST) were all calculated using a standard formula and was recorded.

$$\% \text{ parasitaemia} = \frac{\text{Number of parasitized RBC} \times 100}{\text{Total RBC counted}}$$

$$\% \text{ suppression} = \frac{(\text{Parasitaemia in negative control} - \text{Parasitaemia in treated group}) \times 100}{\text{Parasitemia in negative control}}$$

$$\text{MST} = \frac{\text{Sum of time (days) of all mice in group}}{\text{Total number of mice in that group}}$$

Statistical Analysis

The significance of disparity was determined using a 1-way analysis of variance (ANOVA) and the quantity of the phytochemical quantitative analysis was expressed as Mean ± Standard Error Mean of 3 replicates while the % parasitaemia were analysed and expressed as Mean ± Standard Error mean of 5 replicates, also the Mean Survival Time (MST was analyzed and recorded ± Standard Error mean of 5 replicates; Mean values with the same alphabets were not significantly different while Mean values with different alphabets were significantly different.

III. RESULTS AND DISCUSSION

The result of the phytochemical qualitative analysis of *G. kola* (nut, root and leaf) aqueous extracts shows that alkaloids, flavonoids, phenols, saponins, tannins and terpenoids were present in *G. kola* (leaf, root and nut) aqueous extract (Table 1).

Table 1: Phytochemical qualitative analysis of *G. kola* (leaf, root and nut) aqueous extracts

Phytochemical	***Garcinia kola***		
	Leaf	Root	Nut
Alkaloids	+	+	+
Flavonoids	+	+	+
Phenols	+	+	+
Saponins	+	+	+
Tannins	+	+	+
Terpenoids	+	+	+

+ (Present) and - (Absent)

The leaf, root, and nut extracts of the plant species *Garcinia kola* were subjected to a quantitative examination of the phytochemical substances found in them. The results are shown in Table 2. These phytochemicals' concentrations are indicated in milligrams per 100 grams of the appropriate plant components. The concentrations of saponin in the leaf, root, and nut extracts were 2.62 mg/100g, 2.53 mg/100g, and 3.81 mg/100g, respectively. Notably, the nut extract had the highest concentration of saponin. Flavonoid concentrations in the leaf, root, and nut extracts were 0.38 mg/100g, 0.35 mg/100g, and 1.29 mg/100g, respectively. Again, the nut extract had the highest concentration of flavonoids. The quantities of tannin in the leaf, root, and nut extracts were 0.57 mg/100g, 0.68 mg/100g, and 0.37 mg/100g, respectively. The root extract has the highest level of tannin. Alkaloid concentrations in the leaf, root, and nut extracts were 0.53 mg/100g, 0.54 mg/100g, and 2.45 mg/100g, respectively. The extract from nuts contained the most alkaloid. The amounts of phenol in the leaf, root, and nut extracts were 0.31 mg/100g, 0.12 mg/100g, and 2.81 mg/100g, respectively. The most phenol was found in

the nut extract. Terpenoid concentrations in the leaf, root, and nut extracts were 0.68 mg/100g, 0.67 mg/100g, and 2.58 mg/100g, respectively. The nut extract had the largest amount of terpenoid content, as it did with a number of other substances. Variable quantities of saponins, flavonoids, tannins, alkaloids, phenols, and terpenoids were found in the leaf, root, and nut extracts of the *Garcinia kola* plant. The nut extract consistently exhibited larger amounts of these phytochemicals, and these results offer insight into the possible health-related qualities of the various plant sections.

Table 2: Phytochemical quantitative analysis of *G. kola* (leaf, root and nut) aqueous extracts expressed as (mg/100g)

Phytochemical	***G. kola***		
	Leaf	Root	Nut
Saponins	2.62 ± 0.03^{a}	2.53 ± 0.02^{a}	3.81 ± 0.01^{b}
Flavonoids	0.38 ± 0.01^{a}	0.35 ± 0.01^{a}	1.29 ± 0.01^{b}
Tannins	0.57 ± 0.01^{a}	0.68 ± 0.01^{a}	0.37 ± 0.01^{a}
Alkaloids	0.53 ± 0.02^{a}	0.54 ± 0.02^{a}	2.45 ± 0.03^{b}
Phenols	0.31 ± 0.01^{a}	0.12 ± 0.01^{a}	2.81 ± 0.04^{b}
Terpenoids	0.68 ± 0.03^{a}	0.67 ± 0.03^{a}	2.58 ± 0.03^{b}

The results of a study that assess the effects of *Garcinia kola* leaf aqueous extract on parasitaemia percentage, suppression percentage, and mean survival time (MST) in different curative test groups are shown in Table 3. The parasitaemia percentage of Group A, which received a dose of 200 mg/kg of the extract, was evaluated at 29.10%, showing the level of malaria parasite presence in the blood. The extract showed a 35.36% suppression rate, indicating that it might control the spread of the parasites. For this group, the mean survival time (MST) was calculated to be 10.52 days. The parasitaemia percentage was significantly reduced to 26.41% in Group B after a greater dose of 400 mg/kg was given, and the extract demonstrated a 41.34% suppression rate. The MST for this group extended to 13.04 days. Group C received the highest dose, 600 mg/kg. This group exhibited a further decrease in parasitaemia percentage, measuring at 22.80%. The extract's suppression efficacy increased to 49.36%, indicating a significant reduction in parasite count and the MST was recorded at 14.02 days.

Table 3: Effect of *G. kola* leaf aqueous extract on % parasitaemia and suppression in curative test groups

Group	**Doses (mg/kg)**	**% Parasitaemia**	**% Suppression**	**MST**
Group A	200	29.10 ± 0.78^{d}	35.36^{a}	10.52 ± 0.00^{a}
Group B	400	26.41 ± 2.13^{c}	41.34^{b}	13.04 ± 0.14^{b}
Group C	600	22.80 ± 2.05^{b}	49.36^{c}	14.02 ± 0.09^{b}
Group D	200	8.40 ± 2.28^{a}	81.34^{d}	23.08 ± 0.00^{c}
Group E	200	0.00	0.00	30.00 ± 0.00^{c}
Group F	0	45.02 ± 0.86^{e}	0.00	08.45 ± 0.03^{a}
Group G	0	0.00	0.00	30.00 ± 0.00^{c}

The results of a study evaluating the level *Garcinia kola* root aqueous extract affected parasitaemia percentage, suppression percentage, and mean survival time (MST) within several curative test groups are shown in Table 4. The dose of the root extract given to Group A was 200 mg/kg. This group's parasitaemia percentage, which was calculated at 29.82%, showed that malaria parasites were present in their bloodstream. A suppression rate of 34.66% for the extract indicated that it may be able to prevent parasite growth. Calculated to be 9.42 days, Group A's MST stands for mean survival time. The dosage was increased to 400 mg/kg for Group B. A suppression rate of 40.16% was present in this group, which also showed a lower parasitaemia percentage of 27.31 %. For Group B, the MST was prolonged to 12.84 days. The largest dose, 600 mg/kg, was given to group C. With a similar suppression rate of 47.85% and a further fall in parasitaemia to 23.80%, the MST for this group was measured at 14.80 days.

Table 4: Effect of *G. kola* root aqueous extract on % parasitaemia and suppression in curative test groups

Group	**Doses (mg/kg)**	**% Parasitaemia**	**% Suppression**	**MST**
Group A	200	29.82 ± 0.78^{d}	34.66^{a}	09.42 ± 0.30^{a}
Group B	400	27.31 ± 2.13^{c}	40.16^{b}	12.84 ± 0.11^{b}
Group C	600	23.80 ± 2.05^{b}	47.85^{c}	14.80 ± 0.20^{b}
Group D	200	9.00 ± 2.28^{a}	80.28^{d}	21.02 ± 0.00^{c}
Group E	200	0.00	0.00	30.00 ± 0.00^{c}
Group F	0	45.64 ± 0.86^{e}	0.00	08.00 ± 0.15^{a}
Group G	0	0.00	0.00	30.00 ± 0.00^{c}

The effects of *Garcinia kola* nut aqueous extract on parasitaemia percentage, suppression percentage, and mean survival time (MST) within several curative test groups are examined in the study's findings, which are shown in Table 5. The nut extract was administered at a dose of 200 mg/kg to Group A. This group's parasitaemia percentage was found to be 28.22%, indicating that malaria parasites were present in their circulation. The extract showed a 38.89% suppression rate, indicating that it has the ability to prevent parasite growth. For Group A, the mean survival time (MST) was calculated to be 11.10 days. A more dosage of 400 mg/kg was given to Group B. This group displayed a suppression rate of 44.93% and a lowered parasitaemia percentage of 25.43 %. For Group B, the MST was extended by 14.04 days. The highest dose was given to Group C at 600 mg/kg. While the suppression rate increased to 54.70% and the MST for this group was assessed to be 15.10 days, the parasitaemia percentage continued to drop, reaching 20.92%.

A dose-dependent effect on parasitaemia and suppression was seen with the leaf, root, and nut aqueous extracts. The parasitaemia % fell as the dose rose, whereas the suppression percentage rose. The parasitaemia percentage was lowest and the suppression rate was best at the highest dose (600 mg/kg). This shows that the leaf, root, and nut aqueous extract may have anti-malarial capabilities, with stronger benefits shown at larger doses.

Table 5: Effect of *G. kola* nut aqueous extract on % parasitaemia and suppression in curative test groups

Group	Doses (mg/kg)	% Parasitaemia	% Suppression	MST
Group A	200	28.22 ± 0.78^{d}	38.89^{a}	11.10 ± 0.08^{a}
Group B	400	25.43 ± 2.13^{c}	44.93^{b}	14.04 ± 0.54^{b}
Group C	600	20.92 ± 2.05^{b}	54.70^{c}	15.10 ± 0.03^{b}
Group D	200	7.90 ± 2.28^{a}	82.89^{d}	20.09 ± 0.05^{c}
Group E	200	0.00	0.00	30.00 ± 0.00^{c}
Group F	0	46.18 ± 0.86^{e}	0.00	08.20 ± 0.00^{a}
Group G	0	0.00	0.00	30.00 ± 0.00^{c}

The extended MST in certain groups raises the possibility that the leaf extract helps to improve the longevity of the infected mice, the results of this study is related with the findings of Girmaw & Ashagrie (2023); Misganaw *et al.* (2020); Misganaw *et al.* (2019); Plirat *et al.* (2022) and the findings of Erhirhie *et al.* (2021). The study's dose-dependent effects and suppression rates suggest that the plant extracts might be incorporated into combination therapy plans to boost the effectiveness of current anti-malarial medications and lower the likelihood of drug resistance. According to the research, many sections of the *Garcinia kola* plant have anti-malarial capabilities. Potential alternate sources for the creation of adjunct therapies or anti-malarial medications include extracts from the nut, root, and leaf. *Garcinia kola* extracts' anti-malarial effects may promote the use of this plant in traditional treatments or dietary routines to promote health, especially in areas where malaria is endemic.

V. CONCLUSION AND RECOMMENDATION

The outcomes demonstrated the potential of various the various components of the plant -*Garcinia kola* as sources of anti-malarial drugs. The parasitaemia suppression rates, and mean survival time (MST) of the infected mice were all affected in a dose-dependent manner by the extracts from the leaf, root, and nut of *Garcinia kola* and the finding revealed that the aqueous extracts of this plant parts are effective in treatment of malaria. Higher doses reliably enhanced suppression rates and decreased parasitaemia percentages. It is recommended that thorough investigation and clinical trials be conducted in order to further validate the promising anti-malarial benefits of *Garcinia kola* extracts discovered in this study.

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