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ORIGINAL RESEARCH ARTICLE

In Vivo Safety Assessment of Aqueous Extracts of *Pterocarpus erinaceus*, *Boswellia dalzielii*, and *Cochlospermum tinctorium* Administered singly and as a Polyherbal Concoction, in Malaria-Infected Rats

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ABSTRACT

This study evaluated the acute and sub-chronic oral toxicity of aqueous extracts of *Pterocarpus erinaceus* leaves, *Boswellia dalzielii* stem bark, and *Cochlospermum tinctorium* roots, administered singly and as a combined formulation, in malaria-induced Wistar rats. Acute toxicity testing revealed no mortality up to 5000 mg/kg body weight, indicating an LD_{50} greater than 5000 mg/kg. The sub-chronic toxicity assessment showed that malaria infection significantly altered the hematological indices and the liver and kidney function biomarkers of the subjects. The results further shows that treatment of the infested rats with the therapeutic doses of 0.8, 1.1, 1.3 and 1.5 ml/kg of the individual plant extracts and the polyherbal concoction improved most of the altered parameters, with values largely remaining within normal physiological ranges. However, rats treated with single plant extracts exhibited better restoration of hematological and biochemical parameters compared to those treated with the combined extract. Overall, the results indicate that the individual extracts and their concoction are relatively safe at the administered doses, though polyherbal combinations may not necessarily confer enhanced therapeutic benefits as mostly perceived in the study location. These findings underscore the importance of safety evaluation and formulation optimization of traditional herbal medicines.

Introduction

Despite the availability of orthodox medicines, medicinal plants remain a cornerstone of traditional healthcare systems in Mubi, Adamawa State, Nigeria, where they continue to serve as primary therapeutic agents. This sustained reliance aligns with prevailing cultural perceptions and beliefs that traditional herbal remedies are inherently safe, largely due to their long-standing ethnomedicinal use (Uboko et al., 2020). The present study further revealed the widespread use of polyherbal formulations comprising *Pterocarpus erinaceus* leaves, *Boswellia dalzielii* stem bark, and *Cochlospermum tinctorium* roots, particularly for the treatment of malaria (Fig. 1). These formulations are commonly employed with the assumption that combining

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multiple plant species produces synergistic therapeutic effects and reduce the risk of parasite resistance (Adekunle, 2008; Ezeani et al., 2022).

In the study area and across Nigeria, *P. erinaceus*, *B. dalzielii*, and *C. tinctorium* are widely used in the treatment of malaria and febrile illnesses. Several studies have corroborated their antimalarial, anti-inflammatory, and antioxidant properties (Aliyu & Chedi, 2020; Bunnu et al., 2021; Jodi & Sani, 2022; Okoli et al., 2023; Ouedraogo et al., 2023; Peter et al., 2021). These plants are reported to exert antimalarial activity by disrupting multiple stages of the *Plasmodium* life cycle, including sporozoite invasion and schizont rupture (Sambou, 2021; Traore et al., 2022). Ouedraogo et al. (2023) reported improved bioavailability and therapeutic efficacy of polyherbal formulations due to interactions among diverse phytochemicals. These interactions may facilitate enhanced absorption of co-administered compounds such as flavonoids and alkaloids, as demonstrated by Zhang et al. (2018) and reviewed by Santos (2020). Additionally, certain phytochemicals have been shown to modulate or buffer the toxicity of complex polyphytochemical mixtures (Singh et al., 2019). Flavonoid-rich extracts have also been reported to reduce oxidative stress and tissue damage in malaria-infected rodent models (Li., 2020).

However, Hou et al. (2018) cautioned that some herbal combinations may exhibit antagonistic interactions or lead to unintended adverse effects. Mohanty and Pal (2016) further emphasized the risk of cumulative toxicity following repeated administration, with potential toxic effects on vital organs such as the liver, kidneys, and heart (De Jesus et al., 2021; Menghini & Massarelli, 2018). These toxic effects are thought to arise from metabolic activation of reactive metabolites and disruption of biochemical pathways, including elevated liver enzyme levels and altered lipid profiles (Diallo et al., 2019; Piozzi & Passannanti, 2017). Moreover, El-Desouky (2021) reported that long-term exposure to improperly dosed herbal mixtures may induce genotoxic effects, particularly in vulnerable populations such as children and pregnant women, underscoring the need for careful dosage and safety evaluation.

Previous toxicological studies have shown that aqueous and ethanolic extracts of *P. erinaceus* possess a high margin of safety, with LD_{50} values exceeding 5,000 mg/kg (Mohammed et al., 2021; Mohammed et al., 2023). Other studies reported no significant alterations in liver function markers (AST, ALT, and ALP) and no observable toxicity at doses up to 400 mg/kg following 14 days of administration (Mohammed et al., 2023; Umaru et al., 2024). In contrast, Johnson et al. (2023) reported that while the organic extract exhibited an LD_{50} greater than 5,000 mg/kg, sub-chronic toxicity studies revealed potential renal and hepatic toxicity following prolonged use. Similarly, the chloroform crude extract of *B. dalzielii* stem bark demonstrated high safety, with an LD_{50} greater than 5,000 mg/kg body weight (Bunnu et al., 2021), while aqueous extracts of *C. tinctorium* roots and leaves were also reported to have LD_{50} values exceeding 5,000 mg/kg (Adam et al., 2017).

Although individual extracts of these plants have been shown to exhibit high safety margins (Adam et al., 2017; Bunnu et al., 2021; Mohammed et al., 2021; Mohammed et al., 2023; Umaru et al., 2024), there is limited information on their safety when administered as combined formulations. Furthermore, existing literature does not adequately report in vivo toxicity outcomes of polyherbal extracts consisting of *P. erinaceus* leaves, *B. dalzielii* stem bark, and *C. tinctorium* roots, which are commonly used in Mubi, Adamawa

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State, for malaria treatment. Therefore, the present study was undertaken to evaluate the in vivo safety of aqueous extracts of *P. erinaceus* leaves, *B. dalzielii* stem bark, and *C. tinctorium* roots, administered individually and as a polyherbal formulation, in malaria-induced rats.

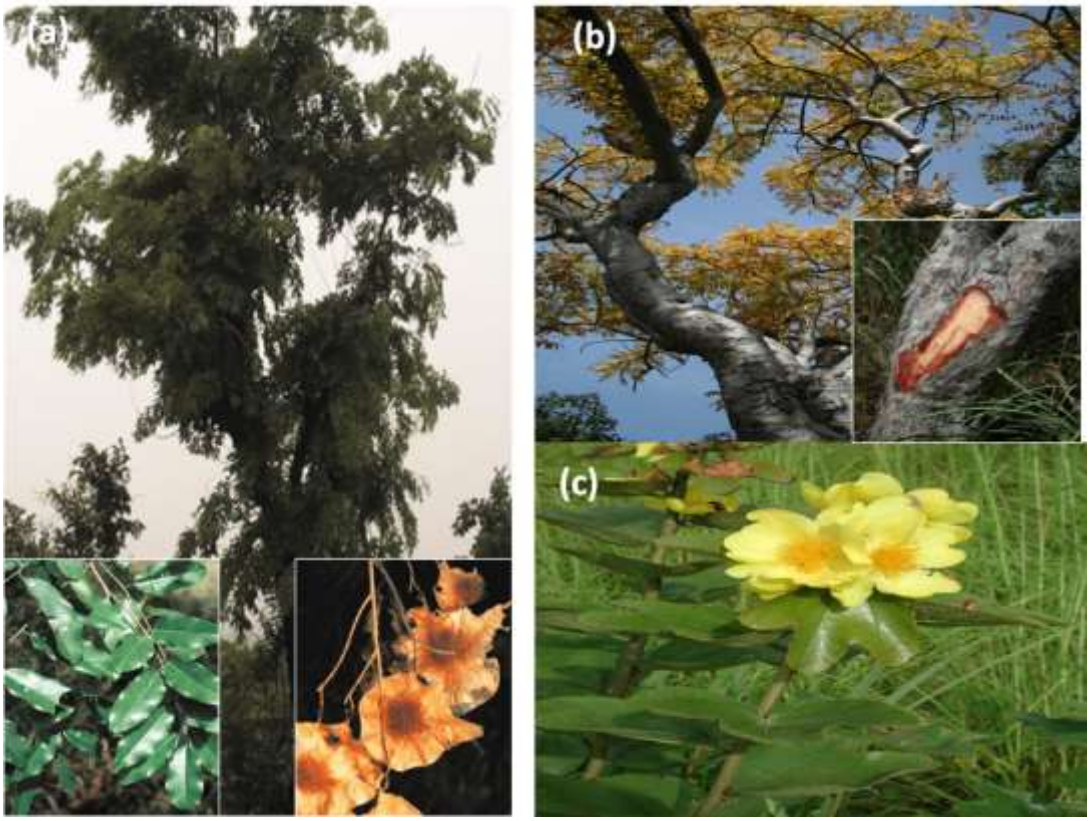

Figure 1: Showing (a) Pterocarpus erinaceus tree (insert, the leaves & flower), (b) Boswellia dalzielli tree (Insert the Stem back) and (c) Cochlospermum tinctorium

Materials and Methods

Study Area

Mubi senatorial zone is the largest town in Northern Adamawa state, Nigeria, consisting of Mubi North and Mubi South. The people are predominantly farmers with booming cattle farming operations as the major striving business (Adebayo, 2004). The area is geographically located between latitudes $10°11'30''N$ and $10°22'30''N$ of the Equator and between longitudes $13°13'00''E$ and $13°30'00''E$ of the Prime Meridian (Figure 2). The total land mass was estimated at 506.4 km^2 (Martins and Gadiga, 2015). The temperature reaches its maximum in April (40°C) and minimum between December and January (18°C) with the average values ranging from 26.7°C to 27.8°C. The annual rainfall falls between 998 mm and 1262 mm on average, spanning from April through October.

Sample Extraction

Aqueous extraction was carried out using method adopted by El- Desouky (2021). Five (5g) grams of the powdered samples were extracted in 100ml distilled water at room temperature for 24 hours, then centrifuged 3000rmp for 15 minutes and evaporated to near dryness, the remaining viscous powder was dissolved to obtain stock solution, with a concentration of 50mg/ml.

Experimental Animals

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Wistar rats used for the research were obtained from the animal housing unit of the department of Zoology, Adamawa State University Mubi. The rats weighed between 170 – 280g, were 8 – 12 weeks old. A maximum of five rats were housed in each cage. Animal use and care guidelines use was approved by the Adamawa State University institutional animal care and ethics committee (Approval No. ADSUIACEC/2022/25)

Parasite Inoculation

This was done by determining both the percentage parasitemia and erythrocyte count of the donor rat and diluting 0.2ml of the infected erythrocyte with 3.0 ml of phosphate buffer saline to give standard inoculums of 0.1×10^7. Each rat was inoculated with 0.2ml of the infected blood containing 0.1×10^7 of the malaria parasite. After 72 hrs. The rats were treated with the extracts for four days once daily.

Experimental Design for Induction of Malaria Parasite and Treatment of Malaria

Method adopted by Peter et al., (2021), and Temddie et al., (2022) was used for the Induction and treatment of malaria. A total of 35 Wistar rats were used for this study. The rats were divided randomly into seven groups of five rats per group. Each group was fed, induced with malaria and treated as follows:

Table 1: Experimental grouping and treatment procedure for treatment of malaria induced wistar rats

Group 1.	Normal Control: Neither inoculated with the parasite nor treated with the sample extracts
Group 2.	Inoculated with 0.2ml of 0.1 x 10^7 malaria infected erythrocyte. But were not treated with the extracts.
Group 3.	Inoculated with 0.2ml of 0.1 x 10^7 malaria infected erythrocyte and administered standard Artemita antimalaria drug on the fourth day for four days.
Group 4.	Inoculated with 0.2ml of 0.1 x 10^7 malaria infected erythrocyte and administered with 0.8ml/kg aqueous extract of Pterocarpus erinaceus leaves beginning on the fourth day after the induction of the parasite for four consecutive days.
Group 5.	Inoculated with 0.2ml of 0.1 x 10^7 malaria infected erythrocyte and administered with 1.1ml/kg aqueous extract of *Cochlospemum tinctorium* roots on the fourth day after the induction of the parasite for four consecutive days.
Group 6.	Inoculated with 0.2ml of 0.1 x 10^7 malaria infected erythrocyte and administered with 1.3ml/kg aqueous extract of *Boswellia dalzieli* stem bark on the fourth day after the induction of the parasite for four consecutive days.
Group 7.	Inoculated with 0.2ml of 0.1 x 10^7 malaria infected erythrocyte and administered with 1.5ml/kg aqueous cocktail extract of *Pterocarpus erinaceus leaves, Cochlospemum tinctorium root, Boswellia dalzieli* stem bark on the fourth day after the induction of the parasite for four consecutive days.

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Twenty-four hours after administration of the extracts, the rats were sacrificed and blood samples were collected. The blood samples were allowed to stand for 30 minutes, centrifuged at 2500 rmp for 10 minutes and the serum was collected for biochemical analysis. The livers and kidneys were carefully harvested, rinsed in 0.9% NaCl and weighed for assessment of organs relative weight.

In vivo Sub Chronic Oral Toxicity Test

The serum collected from the rats were analyzed for liver and kidney biomarkers such as Alanine aminotransferase (ALT), Aspartate aminotransferase (AST), total protein, bilirubin, creatinine and urea. Blood samples were tested for parameters such as Red blood cells (RBC), White blood cells (RBC) etc. This

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was carried out using an automatic analyzer (bio plus equipment) as described in Peter et al., (2021).

In vivo Acute Cytotoxicity test in malaria – induced rats

Method adopted by De Jesus et al., (2021) and Onwuliri et al., (2006) was used to determine the lethal dose with slight modification. Twenty (20) rats were divided into 4 groups of 5 rats. Each group was administered single doses of the cocktail intra-perioteneal y 500mg/kg, 1000mg/kg, 2000mg/kg and 5000mg/kg based on their body weights. The rats were observed for 15 days; physical signs and symptoms were recorded.

Statistical Analysis

Data collected were subjected to one-way analysis of variance ANOVA followed by Duncan multiple range test DMRT. P values will be considered statistically significant at $p < 0.05$.

Results and Discussion

The findings of the acute cytotoxicity test are summarized in Table 2. No mortality was observed, indicating an LD_{50} exceeding 5000 mg/kg. This suggests that both the individual doses and the combined extract are relatively safe at concentrations up to 5000 mg/kg. However, animals in the group administered 5000 mg/kg exhibited reduced activity on the second day post-administration, accompanied by loss of appetite. These signs improved by the third day and continued to resolve throughout the observation period. This observation implies that the plant extract combination may produce mild side effects at higher doses and under repeated administration.

Table 2: In vivo acute Cytotoxicity Test

Group	No of Rats	Average weight	Dose of cocktail mg/kg	No of deaths	Observed physical signs
1	5	176g	500	0	Nil
2	5	206g	1000	0	Nil
3	5	252g	2000	0	Nil
4	5	308g	5000	0	Decreased activity and loss of appetite

The results of the hematological parameters following the administration of the aqueous extracts of the samples are presented on Table 3. The experimental rats were treated with the respective sample extracts according to the groupings once daily for four days. From the results, malaria infection was observed to markedly disrupted the hematological parameters, as evidenced by significant reductions in WBC, RBC, PCV, and hemoglobin levels in the malaria control group. These alterations reflect malaria-induced hemolysis, bone marrow suppression, and immune dysregulation, which are well-established pathological consequences of *Plasmodium* infection (Adebayo et al., 2020; Tajbakhsh et al., 2021 Dkhil et al., 2020). Malaria parasites destroy RB cells, leading to reduced oxygen transport and overall hematological decline (Adebayo et al., 2020). This could be due to several reasons including immune suppression and dysregulation and the migration of lymphocytes to the lymphoid to fight the infection, (Lars and kare 2001). The elevated level of neutrophils indicates infection or inflammation since neutrophil granules contains anti-microbial proteins that effectively kill pathogens, they are inflammatory and cytotoxic to the host tissues (Amulik et al., 2020).

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Treatment with the standard antimalarial drug (artemether) significantly restored hematological indices toward normal values, validating the experimental model. Administration of individual plant extracts (*P. erinaceus*, *C. tinctorium*, and *B. dalzielii*) also resulted in notable improvements in RBC count, PCV, and hemoglobin concentration, suggesting that these plants may support erythropoiesis and mitigate malaria-associated anemia. The extracts exhibit protective effects against malaria-induced hematological dysfunctions and influences recovery in the infected rats' models. Similar hematological recovery has been reported for plant-derived antimalarial therapies rich in flavonoids and phenolic compounds, which enhance antioxidant defense and reduce erythrocyte destruction (Okoli et al., 2023; Ouedraogo et al., 2023).

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Table 3: Blood Chemistry Study

	Group	WBC	NEU	LYM	MON	RBC	PCV	HB
1.	**Control**	9.17±0.25^{e}	19.00 ± 2.00^{a}	86.33±1.53^{e}	4.67±0.58^{ab}	5.30 ± 0.10^{f}	46.00 ±2.00^{d}	16.50±0.20^{f}
2.	**Malaria Control**	4.53±0.15^{a}	46.00 ± 1.00^{f}	47.33±2.08^{a}	8.67±0.50^{d}	2.30 ± 0.10^{a}	23.00 ±1.00^{a}	8.50±0.10^{a}
3.	**Mal D**	8.53±0.25^{d}	22.67 ± 0.58^{b}	82.33±1.53^{d}	3.67±0.58^{a}	4.80 ± 0.10^{e}	43.00±3.00^{cd}	15.50±0.20^{e}
4.	**PE**	6.90±0.10^{c}	29.33 ± 0.58^{d}	73.67±1.53^{c}	5.33±0.58^{b}	4.40 ± 0.10^{c}	42.00± 1.00^{c}	14.50±0.20^{c}
5	**CT**	6.70±0.10b^{c}	26.33± 1.53^{c}	71.33±1.15^{bc}	4.33±0.58^{ab}	4.60 ± 0.10^{d}	43.33±1.53^{cd}	15.10±0.10^{d}
6.	**BD**	6.77±0.15^{bc}	26.67± 0.58^{c}	72.33±1.53^{bc}	5.00±1.00^{b}	4.70 ± 0.10^{de}	46.00± 1.00^{d}	15.30±0.10^{de}
7.	**COMB**	6.50±0.10^{b}	31.67± 0.58^{e}	69.67± 0.58^{b}	7.33±0.58^{c}	3.90 ± 0.10^{b}	39.00 ±1.00^{b}	13.83±0.42^{b}
	Normal range	**5-15**	**10-50**	**70-90**	**2-10**	**7.5-10.5**	**36-54**	**13.5-17.5**

Mean on the same column with different superscript are statistically different ($p< 0.05$).
Malaria Control= Malaria parasite without extract, Mal D = Malaria parasite with standard arthemeter drug, PE= Malaria parasite with Pterocarpus erinaceus, BD= Malaria parasite with Boswellia dalzielli, CT= Malaria parasite with Coclospermum tinctorium, COMB= Malaria parasite with combination of three plants extracts.

In contrast, rats treated with the polyherbal concoction (COMB) exhibited comparatively lower RBC, PCV, and hemoglobin values relative to the single-extract groups. Although still improved compared to the malaria control, this reduced restorative effect suggests possible phytochemical interactions within the combination that may attenuate hematological recovery. Lila and Raskin (2005) and Ekor (2021) have previously reported that polyherbal formulations may exhibit antagonistic interactions that impair bioavailability or alter pharmacodynamics, leading to diminished therapeutic performance.

The elevated neutrophil counts observed in the malaria control and polyherbal-treated groups further indicate persistent inflammatory or immune activation. Neutrophilia is a common response to infection and tissue injury, reflecting host defence mechanisms (Amulik et al., 2020). The relatively higher neutrophil levels in the combination group may therefore suggest prolonged inflammatory stimulation compared to single-extract treatments.

On Table 4, renal biomarkers were observed to significantly alter in malaria-infected untreated rats, with elevated urea and creatinine levels indicating compromised glomerular filtration and renal stress. Malaria-associated acute kidney injury is a recognized complication, often resulting from hemoglobinuria, oxidative stress, and inflammatory damage to renal tissues (Olatunji et al., 2020).

Treatment with the standard drug and individual plant extracts significantly reduced urea and creatinine levels, restoring them toward normal physiological ranges. This improvement suggests that the extracts exerted nephroprotective effects, possibly through antioxidant and anti-inflammatory mechanisms. Similar renoprotective effects have been reported for *C. tinctorium* and *P. erinaceus*, attributed to their phenolic and terpenoid constituents (Peter et al., 2021; Jodi & Sani, 2022).

However, rats treated with the polyherbal concoction showed comparatively higher urea levels and mild electrolyte disturbances, particularly in sodium and chloride concentrations. Although these values remained within normal reference ranges, they suggest a reduced capacity of the combination to fully restore renal homeostasis. Prolonged exposure or higher doses could therefore pose a risk of mild nephrotoxicity, consistent with

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earlier reports that polyherbal formulations may unpredictably affect renal handling of electrolytes (Ekor, 2021).

Table 4: Renal Function Tests

GROUP		UREA	CREATININE	CALCIUM	SODIUM	POTASSIUM	CHLORINE
1.	**Control**	2.90 ± 0.10^{b}	1.30 ± 0.10^{a}	10.30 ± 0.20^{a}	152.00 ± 1.00^{d}	3.73 ± 0.06^{b}	106.60 ± 0.70^{e}
2.	**Malaria Control**	5.87 ± 0.15^{f}	1.50 ± 0.10^{d}	8.20 ± 0.20^{d}	136.67 ± 1.53^{a}	5.73 ± 0.15^{d}	90.70 ±0.20^{a}
3.	**Mal D**	2.50 ± 0.10^{a}	1.00 ± 0.10^{c}	9.30 ± 0.20^{c}	150.00 ± 0.00^{d}	3.90 ± 0.10b	102.87 ± 0.52^{d}
4.	**PE**	4.30 ± 0.10^{c}	0.90 ± 0.10^{c}	9.70 ± 0.20^{b}	146.00 ± 1.00^{c}	4.40 ± 0.20^{c}	99.80 ± 0.26^{c}
5	**CT**	4.33 ± 0.49^{c}	0.60 ± 0.10^{b}	9.57 ± 0.15^{bc}	147.67 ± 0.15^{c}	4.37 ± 0.15^{c}	102.40 ± 2.05^{d}
6.	**BD**	4.90 ± 0.10^{d}	0.50 ± 0.10^{ab}	9.57 ± 0.25^{bc}	145.67 ± 0.58^{bc}	4.37 ± 0.12^{c}	106.83± 0.31^{e}
7.	**COMB**	5.47 ± 0.58^{e}	0.37 ± 0.58^{a}	9.00 ± 0.10^{c}	143.6 ± 1.53^{b}	3.50 ± 0.10^{a}	96.67 ± 0.71^{b}
	Normal range	2.5-5.5mg/dL	0.3-1.5mg/dL	8.5-11.5 mg/dL	140-155mmol/L	3.5-5.5 mmol/L	95-110mmol/L

Mean on the same column with different superscript are statistically different (p< 0.05).
Malaria Control= Malaria parasite without extract, **Mal D** = Malaria parasite with standard arthemeter drud, PE= Malaria parasite with *Pterocarpus erinaceus*, **BD**= Malaria parasite with *Boswellia dalzielli*, **CT**= M alaria parasite with *Coclospermum tinctorium*, **COMB**= Malaria parasite withcombination of three plants

In Table 5, Liver function enzymes (ALT, AST, and ALP) were significantly elevated in malaria-infected untreated rats, reflecting hepatocellular injury and cholestatic stress induced by *Plasmodium* infection. Malaria-associated liver dysfunction is commonly linked to oxidative stress, inflammatory cytokine release, and parasite sequestration within hepatic sinusoids (Adeyemi et al., 2020).

Administration of individual plant extracts significantly reduced liver enzyme levels compared to the malaria control, indicating hepatoprotective effects. Restoration of albumin and total protein levels further suggests improved hepatic synthetic function. These findings align with previous studies reporting antioxidant-mediated hepatoprotection by *Boswellia* and *Pterocarpus* species (Ouedraogo et al., 2023; Okoli et al., 2023).

Conversely, rats treated with the polyherbal concoction exhibited higher ALT, AST, and ALP levels relative to the single-extract groups, though still lower than the malaria control. This pattern suggests that the combined formulation may impose a greater metabolic burden on hepatic detoxification pathways, possibly due to increased phytochemical complexity. Such findings corroborate earlier observations that polyherbal mixtures can alter hepatic enzyme activity through competitive metabolism or enzyme induction (Ekor, 2021).

Table 5: Liver Function Tests

GROUP		ALT	ALP	AST	ALB	TP	BLB
1.	**Control**	32.67 ± 1.53^{a}	47.00 ± 2.00^{a}	56.33 ± 1.53^{a}	47.57 ± 0.25^{a}	63.63± 0.47^{e}	0.23 ± 0.06^{a}
2.	**Malaria Control**	45.67 ± 1.15^{d}	76.00 ± 2.00^{f}	87.33 ± 1.15^{e}	35.43 ± 0.21^{a}	55.70 ± 0.44^{a}	0.70 ±0.10^{c}
3.	**Mal D**	37.33 ± 2.08^{b}	56.67 ± 0.58^{b}	66.33 ± 1.53^{b}	45.83 ± 0.42^{f}	69.50 ± 0.20^{d}	0.27 ± 0.06^{a}
4.	**PE**	40.00 ± 1.00^{c}	63.33 ± 1.53^{c}	71.67 ± 1.53^{c}	42.07 ± 1.35^{d}	64.50 ± 0.28^{a}	0.56 ± 0.06^{b}
5	**CT**	40.67 ± 0.58^{c}	69.00 ± 2.00^{d}	71.33 ± 1.53^{c}	41.33 ± 0.15^{c}	64.03 ± 2.71^{c}	0.46 ± 0.06^{ab}
6.	**BD**	41.00 ± 1.00^{c}	71.67 ± 0.58^{e}	71.67 ± 1.53^{c}	42.87 ± 0.15^{e}	63.97 ± 0.47^{c}	0.30 ± 0.10^{a}
7.	**COMB**	46.67 ± 1.53^{d}	76.00 ± 1.00^{f}	76.00 ± 1.00^{d}	39.70 ± 0.20^{b}	61.10 ± 0.20^{b}	0.43 ± 0.06^{b}
	Normal range	20-50IU/L	30-150IU/L	50-150IU/L	30-55g/dL	60-80g/gL	0.10-5mg/dL

Mean values on the same column with different superscripts are statistically different (P < 0.05).

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Malaria control= Malaria parasite without any extract**, Mal D** = Malaria parasite with standard athemether drug**, PE** = Malaria parasite with *Pterocarpus erinaceus*, **CT** = Malaria parasite with *Cochlospermum tinctorium*, **BD** = Malaria parasite with *Boswellia dalzielli*, **COMB** = Malaria parasite with combination of three plants

Conclusion

The aqueous extracts of *Pterocarpus erinaceus* leaves, *Boswellia dalzielli* stem bark and *Cochlospermum tinctorium* root are relatively safe and exhibit protective effects against malaria-induced hematological, renal, and hepatic dysfunctions in rats. However, polyherbal combinations did not consistently enhance therapeutic outcomes compared to single extracts. Furthermore, on administering of 5000mg/kg of the cocktail extracts to the rats, the decreased activity and loss of appetite observed in the rats shows that the plants could trigger side effects at higher doses and longer period of administration. Therefore, these findings highlight the necessity for careful formulation and scientific validation of herbal cocktails prior to widespread use. Recommending future studies should focus on evaluating the compatibility and interactions of various plant metabolites presents in poly herbal formulations and investing in long term effects to ensure their safe use in traditional medicine practice.

Conflict of Interest

The authors declare that there was no conflict of interest with regards to this publication

References

Adam, A.A., Nafiu, M.O., Garba, M.H., (2017). Effect of Root extract of *Cochlospermum tinctorium* on Liver Function Makers of Albino Rats. *Comparative Clinical pathology*. Vol 4(1). 59-67

Adebayo, A. T., Balogun, O. P., Okon, E. J., & Ibrahim, M. Y. (2020). Hematological alterations in malaria infection: A review of pathophysiological mechanisms and therapeutic interventions. *African Journal of Medical Sciences, 14*(2), 67-79.

Adebayo, A.A. (2004), "Soil and vegetation", In: Adebayo, A. A (ed). Mubi Region: A Geographical Synthesis. A Division of Paraclete and Sons, Yola-Nigeria, 38-43.

Adekunle, M. F (2008). Indigenos Indigenous uses of plant leaves to treat malaria fever at Omo forest reserve (OFR) Ogun state Nigeria. *Ethiopian journal of environmental studies.* 1(1): 31-35

Adeyemi, O. S., Akanji, M. A., & Rotimi, D. (2020). Flavonoid-rich medicinal plants and their therapeutic effects on malaria: A review. *African Journal of Traditional, Complementary and Alternative Medicines, 17*(4), 56-68.

Adeyemi, R. A., Bello, M. S., Okonkwo, C. J., & Ibrahim, T. O. (2020). Malaria-induced liver dysfunction and the role of antioxidant therapy. *Nigerian Journal of Hepatic Studies, 18*(3), 45-61.

Aliyu, M & Chedi, B. M. Z (2020). Effects of Ethanolic stem bark Extract of Pterocarpus erinaceusus (FABACEAE) on some isolated smooth muscles. *Bayero journal of pure and applied science.* 3(1): 34-38.

Amulik. B., Moxon. C. A., & Cunnington, A. J (2020). A more Granular review of Nutrophils in malaria. *Trends in parasitology.* Vol. 3, issue 6. Https; //doi.org/10.101./j.pt.2020.03.003

Bunnu, M.I., Ikhile, I., Matheri, A.N., Charlotte, M.I., Fosting, M.C D & Ndiriiteh, D (2021). Evaluation of secondary Metabolites, Anti-bacterial, Antiplasmodial and AcuteToxicity Potential of Chloroform crude extract of *Boswellia dalzielli* Stem bark. *Pharmacogn. J.* 2021: 13(2): 393-400.

De-Jesus, R., Fernandez, N. V., Osorto, A., Gracia, C. A & Jimenez, W. (2021). Determination of medium lethal dose

(LD50) and acute toxicity of formulation Cytoreg, an ionic mixture of strong and weak acids. *Latin and American journal of Development, Curitiba* 3(3), p.

Diallo, M. S., (2019). Ethnobotanical survey of medicinal plants used for malaria therapy in Kedougou region (Senegal). *Journal of Ethnopharmacology*, 241, 111984.

Dkhil, M., Al-Quraishy, S., Al-Shaebi, E., Abdel-Gaber, R., Thagfan, F., & Qasem, M. (2020). Medicinal plants as a fight against murine blood-stage malaria. *Saudi Journal of Biological Sciences*, 28, 1723 - 1738. https://doi.org/10.1016/j.sjbs.2020.12.014

Ekor, M. (2021). The regulatory challenges of herbal medicines in developing nations. *Journal of Herbal Pharmacotherapy*, *21*(2), 105–116. https://doi.org/10.1080/15228835.2021.188902

El-Desouky Tarek, A. (2021). Evaluation of effectiveness of aqueous extract of some leaves of wild edible plants in Egypt as anti-fungal and anti-toxigenic. J. Heliyon 7(2) 2021.

Ezeani, C., Ezeanyi, I., Erhunse, N., Sahal, D., Akune, T., & Okoli C. (2022). Assesment of anti-malarial medicinal plants used in Nigarian ethnomedicine reveals anti-malarial potential of Cucurbits pepo leaf extracts. *J. Heliyon* 8 (2022). Https: //Doi. Org/10.1016/j. heliyon 2020. e09916

Hou, D. X. (2018). Potential mechanisms of cancer chemoprevention by anthocyanins. *Current Molecular Medicine,* 18(1), 1-25.

Jodi, M. & Sani, N. A (2022). Phytochemical and anti-microbial activity of Cochlospermum tinctonium root powder against food borne pathogens. *FUDMA journal of science.* 6(5), October 2022. 146-153. doi.org/10.33003/Fjs-2022-0605-1118.

Johnson, A. O. R., Olusayo, A. S. & Onyezuna, E. C. (2023). Acute Toxicity, synchronic toxicity and identification of anti-inflammatory compounds in Pterocarpus Osun heart wood. *Internal Medicine Research journal.* 8(2.) 1-10.

Lars, H & Kare, K. 2001. What is the cause of lymphopheria in malaria? *Infection and immuinity*. Doi 10.1128/iai.8.10.6087-6089.2001.

Li, X. (2020). Triterpenoids as potential agents for the prevention and treatment of liver diseases. *Frontiers in Pharmacology*, 11, 1-16.

Lila, M. A., & Raskin, I. (2005). Health – Related Interactions of Phytochemicals. *J. of food science.* 7(1). 2005.

Martins, A. K., & Gadiga, B. L. (2015). Hydrological and Morphometric Analysis of Upper Yedzaram Catchment of Mubi in Adamawa State, Nigeria. Using Geographic Information System (GIS). *World Environment*, 5(2), 63–69. https://doi.org/10.5923/j.env.20150502.03

Menghini, L., & Massarelli, P. (2018). Acute and subchronic toxicity of an aqueous extract of Tanacetum parthenium L. enriched with the sesquiterpene lactone parthenolide. *Journal of Ethnopharmacology,* 224, 248-253.

Mohammed, I., Mohammed, H., & Abubakar, M. (2021). Effect of Pterocarpus erinaceus Stem Bark Extracts on Haematological Parameters in Malaria Induced Anaemic Mice. *American Journal of Chemical and Biochemical Engineering*. https://doi.org/10.11648/j.ajcbe.20210501.13

Mohammed, U., Mohammed, A., Mhya, D., Gabriel, S., & Dahiru, D. (2023). Protective Efficiency of Pterocarpus erinaceus Leaves Extract in Carbon-tetrachloride-induced Hepatic and Hematological Injuries in Rats. *Journal of Applied Life Sciences International*. https://doi.org/10.9734/jalsi/2023/v26i3606

Mohanty, B., & Pal, S. (2016). Biochemical, histopathological and ultrastructural studies on the hepatoprotective effects of an ayurvedic formulation lasuna extract against experimental hepatocellular carcinoma in rats. *Biomedicine & Pharmacotherapy,* 81, 482-495.

Okoli, C. E., Umar, J. I. & Olawale, O. (2023). Determination of Phytochemical constituents, anti-microbial and antioxidant activities of ethanolic extracts of Pterocarpus erinaceusus. *Biodiversitas*. Vol 24 (4), Doi 10.3057/biodiv/ d240440.

Olatunji, A. T., Ibrahim, Y. M., Chukwu, O. P., & Balogun, F. L. (2020). Malaria-induced kidney dysfunction: Mechanisms, clinical implications, and potential therapeutic interventions. *West African Journal of Clinical Research, 15*(4), 56-72.

Onwuliri, F. C, Mawak, J. D, Worang, D. L & Onwuliri, E. A. (2006). Phytochemical, Toxicological and Histopathological studies of some medicinal plants in Nigeria. *Int. J. of natural and applied sciences,* 2(3), 225-229.

Ouedraogo, N. Traore, K. T., Belemnaba. L, & Guissou, P. I. (2023). Anti- inflammatory potential of glycosidic flavonoids from Pterocarpus erinaceusus poor. (Fabaceae) leaves. *Pharmacogn. J.* 2023 15(4): 593- 598. Doi 10.55 30/pj 2023.

Peter, S., Modobbo, A.A & Musa, M. G (2021) Effects of Pterocarpus erinaceusus stem bark Extract on liver in malaria induced mice. *European journal of biomedical and* pharmaceutical science. 8(9) 63-66. Iso 9001: 2015

Piozzi, F., & Passannanti, S. (2017). Acute oral toxicity and effects of ethanolic extract of Ocimum basilicum L. leaves in mice. *Natural Product Research*, 31(3), 365-369.

Sambou, S. (2021). Evaluation of the anti-inflammatory and anti-nociceptive activities of the aqueous extract of the leaves of Pterocarpus erinaceus (Poir.) in rodents. International *Journal of Biological and Chemical Sciences,* 15(1), 1-9.

Singh, N., Das, A., & Sharma, V. (2019). Synergistic interactions of plant extracts in treatment of malaria: An emerging approach. *Journal of Tropical Medicine*, 2019, 1–7.

Tajbakhsh, E., Kwenti, T., Kheyri, P., Nezaratizade, S., Lindsay, D., & Khamesipour, F. (2021). Antiplasmodial, antimalarial activities and toxicity of African medicinal plants: a systematic review of literature. *Malaria Journal*, 20.

Temddie Apichaya N., Chatgat, W., Chatawatee. B., Keereekoch. T., Issuriya. A. Chusri. S & Kunworarath. N (2022). Safety Evaluation of the polyherb Formu lation Nawatab: Acute and subacute Oral Toxicity Studies in Rats. *National Library of medicine.* 24; 2023: 9413458 Doi:10/1155/2023/9413458.

Uboko, H. U., Nwinyi, O. C., Oranusi, Solomon. U, Fatoki Toluwase. H, & Omohinmin, C. A. (2020). Anti-microbial importance of medicinal plants in Nigeria. *Hindawi The science world journal.* Article ID 7059323 https: //Doi.ogr/10.1155/2020/7059323.

Umaru, I., Olawale, O., Okoli, E., Tensaba, A., Umaru, K., Istifanus, D., & Umahi, D. (2024). Ameliorative Effects of Stem

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bark Extract of Pterocarpus erinaceus on Indomethacin-induced Ulcer. *African Journal of Biochemistry and Molecular Biology Research*. https://doi.org/10.58578/ajbmbr.v1i1.3487

Zhang, Y., & Yi, L. (2018). Xanthones from Mangosteen Extracts as Natural Chemopreventive Agents: Potential Anticancer Drugs. Current Molecular Medicine, 18(3), 180-190.