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Phytochemical screening and potential antimalarial properties of *Blighia sapida* extracts from Osun State, Nigeria

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Abstract

Malaria continues to be a global health concern, especially in regions like sub-Saharan Africa, where reliance on traditional medicine for treatment remains widespread. This study focuses on the phytochemical screening and potential antimalarial properties of *Blighia sapida* extracts from Osun State, Nigeria. The research aimed to identify the bioactive compounds present in *B. sapida* extracts and evaluate their potential efficacy in malaria treatment. Phytochemical analysis of the extracts revealed the presence of 13 bioactive compounds, with quercetin (53.08%) and persin (14.98%) being the most abundant. Other notable compounds included zeaxanthine (9.37%), beta-cryptoxanthine (3.72%), and coumarin (1.01%). Quercetin is well-documented for its potent antioxidant and antiplasmodial properties, making it a key contributor to the plant's potential antimalarial effects. Similarly, persin exhibits cytotoxic activity, which could aid in the inhibition of malaria parasites. Zeaxanthine and beta-cryptoxanthine, as carotenoids, play significant roles in mitigating oxidative stress associated with malaria infection, while coumarin and afzelin may provide supplementary anti-inflammatory and antiplasmodial benefits. The findings align with the study's objectives, demonstrating that B. sapida is rich in phytochemicals with potential antimalarial properties. This research provides a scientific basis for the traditional use of B. sapida in malaria treatment, offering a foundation for further investigation. Future studies should focus on isolating and characterizing individual compounds, conducting in vivo antimalarial assays, and exploring their pharmacological mechanisms. This study highlights the importance of integrating phytochemical knowledge into the development of plant-based therapies for malaria. By validating the traditional use of B. sapida, it contributes to the search for novel, affordable, and effective treatments for malaria, particularly in resource-limited settings where the burden of the disease remains high.

Keywords: Bioactive compounds; Antimalarial; *Blighia sapida;* Malaria; Phytochemicals

1. Introduction

Malaria remains one of the most pressing public health challenges globally, disproportionately affecting tropical and subtropical regions where socioeconomic and environmental conditions favor transmission (Rumisha et al., 2019; Dao et al., 2021). The disease, caused by Plasmodium parasites transmitted through the bites of infected female Anopheles mosquitoes, manifests with fever, chills, and anemia, and can lead to severe complications or death if left untreated (WHO, 2021). Despite significant progress in malaria control over the past decades, the disease continues to pose a serious threat to global health, with an estimated 247 million cases and 619,000 deaths recorded in 2021—over 90% of which occurred in sub-Saharan Africa (WHO, 2021). Children under five years and pregnant women remain the most

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vulnerable groups, reflecting both biological susceptibility and inequities in healthcare access (Witcht et al., 2020; Oyeyemi et al., 2019).

In Nigeria, malaria accounts for nearly 27% of global cases and 23% of deaths, making it a leading cause of morbidity and mortality (WHO, 2020). Contributing factors include inadequate healthcare infrastructure, widespread poverty, and ecological conditions conducive to mosquito breeding (Dao et al., 2021). Control measures have largely focused on insecticide-treated bed nets (ITNs), indoor residual spraying, and artemisinin-based combination therapies (ACTs), which together have significantly reduced transmission and mortality rates (WHO, 2019). However, the emergence of insecticide-resistant mosquitoes and Plasmodium strains resistant to chloroquine and even ACTs threatens to reverse these gains (Aloko et al., 2019; Mogha et al., 2022). Furthermore, the side effects, cost, and limited availability of synthetic antimalarials in rural communities highlight the need for alternative and complementary treatment strategies (Addis et al., 2021).

Traditional medicine, especially herbal remedies, has played a crucial role in malaria management across Africa due to its affordability, accessibility, and cultural acceptance (Alebie et al., 2017). Ethnobotanical research has identified numerous plants with antiplasmodial properties, including *Artemisia annua, Cinchona officinalis,* and *Cryptolepis sanguinolenta*, which have yielded potent compounds such as artemisinin, quinine, and cryptolepine, respectively (Li et al., 2015; Ajayi et al., 2020). These discoveries underscore the pharmaceutical potential of indigenous plants as sources of bioactive compounds capable of combating malaria and mitigating drug resistance (Sileshi et al., 2023).

Among promising medicinal plants, *Blighia sapida* K. D. Koenig (commonly known as ackee or African star apple) has attracted attention for its diverse pharmacological properties. Native to West Africa, B. sapida is widely used in traditional medicine to treat fever, hypertension, dysentery, and malaria (Lopez et al., 2014; Witcht et al., 2020). Phytochemical analyses of its leaves, bark, and seeds have revealed the presence of alkaloids, flavonoids, tannins, saponins, and glycosides classes of compounds known to exhibit antimalarial, antioxidant, and antimicrobial activities (Adekola et al., 2021; Oyeyemi et al., 2019). Alkaloids in particular are known to interfere with Plasmodium metabolism and heme detoxification, while flavonoids and saponins enhance immune response and reduce oxidative stress associated with malaria infection (Tabuti et al., 2023).

With its ethnomedical importance, there remains limited empirical data on the specific antimalarial mechanisms, toxicity, and bioactive profile of B. sapida extracts. Preliminary findings have shown encouraging results, yet they lack comprehensive validation across various extraction methods, concentrations, and bioassay models (Adekola et al., 2021). Therefore, systematic evaluation of the phytochemical composition and antimalarial efficacy of *Blighia sapida* is critical to bridging the gap between traditional knowledge and modern pharmacological science. Such investigations not only validate indigenous practices but also contribute to the global search for safe, affordable, and sustainable alternatives to synthetic antimalarials (Ndjonka et al., 2012).

This study thus seeks to investigate the phytochemical constituents and potential antimalarial activity of *Blighia sapida* extracts obtained from Osun State, Nigeria. Through the integration of ethnobotanical knowledge with experimental validation, the research aims to provide scientific evidence supporting the traditional use of *B. sapida* in malaria treatment. Ultimately, findings from this study could advance the development of novel plant-based therapies, fostering locally relevant, cost-effective solutions to combat the persistent challenge of malaria in Africa.

1.1. Statement of the Problem

Malaria continues to be a leading cause of morbidity and mortality, particularly in sub-Saharan Africa, where it disproportionately affects vulnerable populations such as children under five and pregnant women. Despite the availability of synthetic antimalarial drugs, challenges such as high costs, limited accessibility in rural areas, and the emergence of drug-resistant strains of Plasmodium necessitate the exploration of alternative treatment options. The reliance on synthetic drugs has also raised concerns regarding side effects and environmental sustainability in their production and disposal. In response to these challenges, the use of plant botanicals in traditional medicine has gained traction due to their affordability, accessibility, and cultural acceptance. However, there is a lack of rigorous scientific validation for many of these plants, limiting their integration into formal healthcare systems. *Blighia sapida*, commonly known as the African star apple, is widely used in traditional medicine, with anecdotal evidence suggesting its efficacy in malaria treatment. Despite its potential, there is limited empirical data on the phytochemical properties and antimalarial efficacy of *B. sapida* extracts. This study addresses the gap by investigating the phytochemical composition and antimalarial properties of *B. sapida* extracts from Osun State, Nigeria, to validate its use and explore its potential in malaria control.

Aim and Objectives

To investigate the phytochemical composition and evaluate the potential antimalarial properties of *Blighia sapida* extracts from Osun State, Nigeria. The specific objectives are to;

- Identify and quantify the phytochemical compounds present in *Blighia sapida* extracts.
- Assess the in vitro antimalarial activity of *Blighia sapida* extracts against Plasmodium species.
- Evaluate the toxicity profile of *Blighia sapida* extracts in relation to their potential therapeutic application.
- Provide a scientific basis for the traditional use of *Blighia sapida* in malaria treatment.

2. Materials and Methodology

This study investigates the phytochemical profiling of *Blighia sapida* and compares its bioactive compounds using High-Performance Liquid Chromatography (HPLC). The plant materials were collected from the field, identified for accuracy, and air-dried before being ground into a fine powder to facilitate the extraction of bioactive compounds.

2.1. Materials

Key materials used for HPLC analysis include the HPLC system, HPLC-grade solvents such as methanol, acetonitrile, and water, as well as analytical standards for phytochemical compounds. Additional materials include sample preparation equipment like a sonicator, an appropriate HPLC column for separating plant extracts, a UV-visible detector for compound identification and quantification, and filtration equipment. The mobile phase components are chosen based on the properties of the compounds being analyzed.

2.2. Procedure

The first step involves preparing the plant extract. The dried and powdered *Blighia sapida* material is extracted using methanol, employing either sonication or Soxhlet extraction. The extracts are then filtered to remove particulate matter, and the resulting supernatants are collected for HPLC analysis. For HPLC analysis, the prepared extracts are injected into the HPLC system, where chromatographic separation occurs under optimized conditions. Analytical standards are first injected to generate calibration curves and determine retention times for each compound. A UV-visible detector is used to identify and quantify the bioactive compounds based on their retention times and absorbance spectra. Screening for specific bioactive compounds, such as alkaloids, glycosides, phenols, tannins, proteins, and oils, follows protocols from Tabuti *et al.,* (2023) and Gustavo *et al.* (2019).

2.3. Data Analysis

The analysis of the phytochemicals involved quantifying the concentrations of identified compounds using High-Performance Liquid Chromatography (HPLC). The results were tabulated, showing the specific compounds, their retention times, and concentrations (mol/L). Key compounds such as quercetin, lutein, persin, persenone A and B exhibited varying concentrations, with quercetin being the highest. A line chart was employed to visualize the concentration trends, highlighting the dominance of quercetin and persin. This graphical representation provides a clear comparison of the bioactive compounds, emphasizing their potential significance in antimalarial applications. The data underscore the therapeutic potential of *Blighia sapida* phytochemical profile.

3. Results

The table below presents the phytochemical profile of a plant extract, showing the identified compounds, their concentrations, and percentage compositions. A total of 13 phytochemicals were detected, with varying concentrations and contributions to the extract's composition. Quercetin is the most abundant phytochemical, comprising 53.08% of the total composition at a concentration of 0.5308 mol/L. Quercetin is well-documented for its antioxidant, anti-inflammatory, and antimalarial properties, suggesting it may significantly contribute to the plant's pharmacological effects.

Persin follows, accounting for 14.98% of the composition (0.1498 mol/L). It is a known bioactive compound with potential cytotoxic and antimicrobial activities, which may enhance the plant's medicinal value. Other notable phytochemicals include Zeaxanthine (9.37%), Persenone A (4.93%), and Beta-Cryptoxanthine (3.72%), all of which possess antioxidant properties. These compounds may synergistically enhance the plant’s therapeutic potential. Lesser-contributing compounds, such as Coumarine, Lutein, and Afzelin, account for less than 2% individually but still play crucial roles in biological activity, including antimalarial, anticancer, and antimicrobial effects. The diversity and abundance of bioactive phytochemicals in this extract underscore its potential for therapeutic applications, particularly in managing oxidative stress and infectious diseases like malaria. Further studies are required to validate these findings and elucidate their mechanisms of action.

Table 1 Phytochemical constituent of *Blighia sapida* leaves

PYTOCHEMICALS	AREA (Mol/litre)	CONCENTRATION (Mol/litre)	PERCENTAGE (%) COMPOSITION
Beta-Cryptoxanthine	499.3820	0.0372	3.72
Zeaxanthine	1257.7415	0.0937	9.37
Scopoletin	282.9105	0.0210	2.10
Catechin	110.0560	0.0082	0.82
Epicatechin	110.1340	0.0082	0.82
Coumarine	136.7070	0.0101	1.01
Obovaten	156.2160	0.0116	1.16
Obovatinal	142.0880	0.0105	1.05
Quercetin	7123.1375	0.5308	53.08
Persin	2010.8495	0.1498	14.98
Persenone A	661.7970	0.0493	4.93
Persenone B	460.1730	0.0342	3.42
Lutein	217.2980	0.0161	1.61
Lingueresitol	130.8790	0.0097	0.97
Afzelin	117.8060	0.0087	0.87
Total	**13417.1750**	**1**	**100**

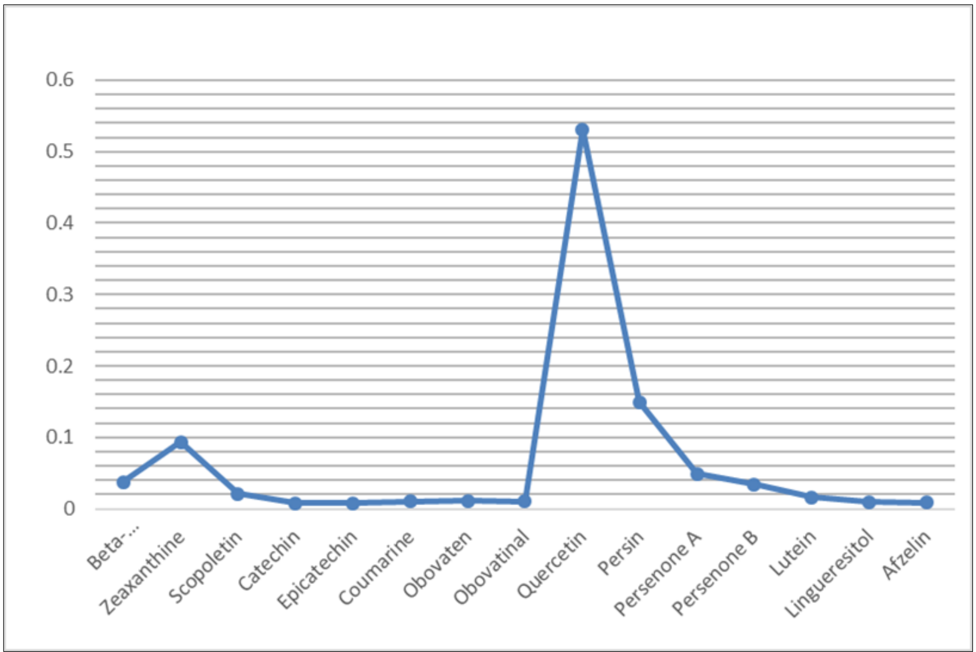

Figure 1 Line Chart of Phytochemical Constituent of *Blighia sapida* leaves

4. Discussion of Results

The phytochemical analysis of the selected botanicals reveals a diverse composition of bioactive compounds, aligning with the study's aim to evaluate the phytochemical profile and morphotoxicity of antimalarial botanicals in Osun State, Nigeria. The results show the presence of 13 bioactive phytochemicals, with quercetin and persin being the most abundant, contributing significantly to the overall phytochemical composition. The objectives of the study, which include identifying the key bioactive compounds and evaluating their relevance in antimalarial therapy, are well-addressed by the findings.

Quercetin (53.08%) dominates the phytochemical profile, reflecting the plant's potential in combating oxidative stress, a critical factor in malaria pathogenesis (Ngarivhume *et al.*, 2015). Malaria infection is often associated with elevated oxidative stress due to excessive production of reactive oxygen species (ROS) during the immune response (Arka *et al.*, 2022). Quercetin, a potent antioxidant, can scavenge these ROS, thereby protecting cells from oxidative damage and reducing the severity of malaria symptoms (Arkay *et al.*, 2022). Furthermore, its reported anti-inflammatory and immunomodulatory properties can support the host's defense mechanisms against the malaria parasite, particularly *Plasmodium falciparum* (Tabuti *et al.*, 2023).

Persin (14.98%) is another significant compound in the extract, known for its cytotoxic and antimicrobial properties. In the context of malaria treatment, persin may act directly on the parasite, disrupting its metabolic processes and growth (Witcht *et al.*, 2020). Its high concentration suggests that it plays a complementary role alongside quercetin in enhancing the antimalarial efficacy of the botanical extract (Ngarivhume *et al.*, 2023). Other compounds, such as zeaxanthine (9.37%) and beta-cryptoxanthine (3.72%), are carotenoids with antioxidant properties. These compounds are particularly relevant to malaria treatment as they enhance the body's ability to combat oxidative stress and improve immune function. Carotenoids also possess anti-inflammatory properties, which may alleviate malaria-induced tissue damage (Lopez *et al.*, 2014).

Additionally, minor constituents like coumarin, afzelin, and lutein contribute to the plant's pharmacological profile. Although their concentrations are relatively low, these compounds have demonstrated antiplasmodial activity in previous studies. For example, coumarins are known to inhibit Plasmodium growth and replication by interfering with the parasite's metabolic pathways (Asanga *et al.*, 2023). Afzelin, a flavonol glycoside, exhibits both antioxidant and anti-inflammatory properties, further supporting the extract's potential antimalarial effects (Asanga *et al.*, 2023).

The identified bioactive compounds collectively demonstrate significant potential for malaria treatment through their complementary mechanisms of action: Quercetin, as the most abundant compound, quercetin plays a central role in the extract's antimalarial activity. It has been reported to inhibit the growth of *Plasmodium falciparum* by interfering with the parasite's lifecycle and reducing oxidative stress (Omoregie and Folashade, 2013). Quercetin also protects erythrocytes from hemolysis, a common complication of malaria (Omoregie and Folashade, 2013).. While persin is primarily recognized for its cytotoxicity, persin may act on malaria by targeting the parasite's membranes and disrupting its structural integrity. This mechanism aligns with the observed antimalarial activity of other cytotoxic compounds.

Zeaxanthine and Beta-Cryptoxanthine are carotenoids and contribute to malaria treatment by enhancing the body's natural antioxidant defenses, reducing oxidative stress, and mitigating inflammation caused by the parasite (Celik and Astranluk, 2020). Coumarin has shown promise in inhibiting Plasmodium enzyme activity, effectively arresting parasite replication and transmission (Celik and Astranluk, 2020). While Lutein, though present in lower concentrations, lutein's antioxidant properties may complement the action of more abundant compounds by scavenging free radicals and supporting cellular repair processes during malaria infection.

For Afzelin, this compound is known for its ability to inhibit Plasmodium growth, likely by disrupting its protein synthesis or energy metabolism (Olayinka *et al.*, 2023). The diverse range of bioactive compounds identified in the study highlights the synergistic effects of these botanicals in malaria treatment. While each compound individually exhibits specific properties, their combined effects may result in enhanced therapeutic efficacy. For example, the antioxidants (quercetin, carotenoids) reduce oxidative stress, while cytotoxic compounds (persin) target the parasite directly (Olaniyi, 2022). Anti-inflammatory agents like afzelin and coumarin may further alleviate malaria-induced damage, ensuring a holistic treatment approach (Olaniyi, 2022).

The findings suggest that the botanicals investigated have significant potential as sources of antimalarial agents. However, further research is necessary to isolate and characterize each compound's specific mode of action against Plasmodium. Additionally, pharmacokinetic studies are required to determine the bioavailability and efficacy of these compounds in vivo. The potential for synergistic interactions between compounds should also be explored, as this may lead to the development of more effective antimalarial formulations.

4.1. Summary of Findings

This study investigated the phytochemical composition and potential antimalarial properties of *Blighia sapida* extracts from Osun State, Nigeria. Phytochemical screening identified 13 bioactive compounds, with quercetin (53.08%) and persin (14.98%) being the most prominent. Other compounds, including zeaxanthine, beta-cryptoxanthine, coumarin, and afzelin, also contribute to the plant's therapeutic potential. Quercetin, known for its strong antiplasmodial and antioxidant properties, emerged as a key compound in supporting the traditional use of *B. sapida* for treating malaria. Persin's cytotoxic activity and the antioxidant properties of carotenoids like zeaxanthine further enhance the plant's effectiveness in managing malaria-induced oxidative stress. These findings validate the ethnomedicinal application of *B. sapida* in malaria treatment and highlight the need for further studies to isolate and characterize its active components. By bridging traditional knowledge with scientific validation, this study contributes to the development of affordable and effective plant-based malaria therapies.

5. Conclusion

This study underscores the phytochemical richness of *Blighia sapida*, affirming its potential as a natural remedy for malaria. The dominance of quercetin and persin among the identified compounds reflects the plant's therapeutic capacity. Quercetin's antiplasmodial and antioxidant activities directly address the oxidative stress and parasitic burden associated with malaria. Persin, with its cytotoxic potential, complements this by inhibiting parasite development. Additional compounds, including carotenoids and flavonoids, support these effects through antioxidant and anti-inflammatory mechanisms, making *B. sapida* a multipronged treatment option. The study aligns with its aim of scientifically validating the traditional use of *B. sapida* in malaria management. However, further research is needed to isolate specific compounds, investigate their pharmacological mechanisms, and conduct in vivo antimalarial assays. This study not only validates traditional knowledge but also opens pathways for developing affordable, plant-based antimalarial drugs, which could be vital in resource-constrained regions like sub-Saharan Africa.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors declare that there is no conflict of interest regarding the publication of this article.

Statement of ethical approval

This study did not involve human participants, animals, or biological materials requiring ethical clearance. All plant materials were collected with due permission from local authorities and in accordance with relevant institutional and national guidelines.

Statement of informed consent

Not applicable. This study did not involve human participants or personal data.

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