

**ETHNOBOTANICAL PLANTS USED FOR MANAGEMENT OF MALARIA BY
PEOPLE OF SERERE DISTRICT, EASTERN UGANDA**

BY

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October, 2026

DECLARATION AND APPROVAL

DECLARATION

I, Agoro Agnes, hereby declare that the work presented in this dissertation is my original work and has not been presented for a degree or any award in any university or institution.

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DEDICATION

I dedicate this piece of work to my entire family, friends and mentors, most especially to my beloved father Mr. Olupot James Peter, who is so passionate about my education and loves seeing me reach greater heights in academia. Not forgetting my lovely son Ephraim Barack, for allowing me time to concentrate. I love you all and long lived.

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LIST OF ABBREVIATIONS AND ACRONYMS

ACTs	Artemisinin Combination therapies
AHO	African Health Organization
ANOVA	Analysis of Variance
DMSO	Dimethyl sulfoxide
IC ₅₀	50% Inhibitory concentration
ICF	Informant Consensus Factor
IRS	Indoor Residual Spraying
ITNS	Insecticide Treated Nets
MOH	Ministry of Health
NPHC	National Population and Housing Census
RDT	Rapid Diagnostic Tests
RPMI	Roswell Park Memorial Institute Medium
UBOS	Uganda Bureau of Statistics
WHO	World Health Organization

ABSTRACT

Malaria remains a significant public health burden worldwide despite the availability of control options recommended by the World Health Organization (WHO, 2023). WHO African Region accounted for 93.6% of global malaria cases and 95.4% of malaria deaths in 2022 (WHO, 2023), Uganda was one of the bigger contributors to the high number of cases. This high malaria burden coupled with Uganda's widespread reliance on traditional healthcare (60%) (WHO, 2017), underscores the need to evaluate medicinal plants for management of malaria. This study therefore surveyed and documented plant species used for management of malaria as well as the antiparasmodial activity of extracts from some of the commonly used medicinal plants in Serere district.

A cross-sectional survey (involving 362 participants) and a completely randomized experimental design (involving antiparasmodial in vitro tests) were used between January to June, 2025. Semi-structured questionnaires were administered to the participants. Later on, three species mostly cited were tested for some important phytochemicals and antiparasmodial activity. Analysis was done using IBM SPSS Statistics software version 26.0. Analysis of variance (ANOVA) was also used to compare the mean percentage parasitaemia between the different extract treatments and the controls (negative and positive) at each time point. Dose response curve fitting using Graph pad Prism software was done to determine the 50% inhibition concentration (IC₅₀) of the extracts.

55 plant species were documented to be used for management of malaria, the most commonly used species were *Zanthoxylum chalybeum* (18.09%) followed by *Dolichandra unguis-cati* (12.29%) and *Nauclea latifolia* (8.85%). The concoctions were prepared by; cleaning the harvested part, pounding then boiling and majorly taken orally. In terms of phytochemicals, alkaloids, phenolics, tannins and coumarins were found in the roots of the three plant species analysed. *Zanthoxylum chalybeum* exhibited the most promising antiparasmodial activity (P value).

This study has shown that many plant species are used for management of malaria in Serere district and have antiparasmodial potency. This calls for bioassay-guided fractionation of *Zanthoxylum chalybeum*, *Dolichandra unguis-cati* and *N. latifolia*, standardized preparation methods and further research studies on these plant species.

CHAPTER ONE: INTRODUCTION

1.1 Background

Malaria parasites were first discovered by a French military physician Charles Louis Alphonse Laveran on November, 6, 1880 in the blood of an infected patient (Tren, 2002). The disease is caused by the protozoan parasites of the *Plasmodium* genus and is spread through the bites of an infected female *Anopheles* mosquitoes (Varo et al., 2020). Malaria disproportionately affects children under five and pregnant women, who face higher risks of severe illness and death (Id et al., 2024). Majorly five of the 120 *Plasmodium* species known to exist do transmit malaria to humans, these include; *P. falciparum*, *P. vivax*, *P. ovale*, *P. malariae* and *P. knowlesi* (Varo et al., 2020). However, *P. falciparum* accounts for the majority of mortality, accounting for over 60% followed by *P. vivax* with about 40% of all malaria-associated deaths globally (Nigussie & Wale, 2022).

In sub-Saharan Africa, *Anopheles gambiae* and *An. funestus* are the primary mosquito species transmitting malaria in Africa (Mohammadi et al., 2020). When feeding, an infected mosquito injects saliva containing sporozoites beneath the skin, which then enter the bloodstream (Burton et al., 2012). The parasites first undergo development in the liver before releasing merozoites that invade red blood cells. This triggers repeated cycles of erythrocyte infection and destruction (Burton et al., 2012). The breakdown of red blood cells leads to symptoms such as fever, chills, vomiting, and joint pain. If untreated, malaria can progress to life-threatening complications including cerebral malaria, severe anemia due to massive red cell loss, and multi-organ damage (Varo et al., 2020).

The World Health Organization (WHO) reported approximately 249 million infections and 608,000 deaths worldwide (WHO, 2023). Areas where malaria is consistently present are often referred to as the “malaria belt.” These regions typically have tropical climates that favor mosquito breeding and facilitate parasite transmission to humans (WHO, 2023). WHO African Region accounted for 93.6% of global malaria cases and 95.4% of malaria deaths in 2022 (WHO, 2023). Most of the rise in malaria cases over the past five years has been concentrated in countries within the WHO African Region.

Between 2021 and 2022, significant increases were recorded in several nations: Pakistan (+2.1 million), Ethiopia (+1.3 million), Nigeria (+1.3 million), Uganda (+597,000), and Papua New Guinea (+423,000) (WHO, 2023). These figures highlight the continuing

challenge of malaria control in both Africa and parts of Asia-Pacific. In Nigeria, the rise in malaria cases was mainly linked to population growth, as the incidence rate itself remained stable. By contrast, other countries experienced genuine increases in incidence between 2021 and 2022. Pakistan recorded a fivefold surge, while Ethiopia and Papua New Guinea each saw a 32% rise. Uganda registered a smaller increase of about 2% in cases per 1,000 individuals at risk (WHO, 2023).

Malaria has remained a major public health challenge for decades, largely because the parasites and their mosquito vectors have developed resistance to many antimalarial drugs and insecticides (Mita & Ph, 2021) (Mbanefo & Kumar, 2020). This adaptability has undermined control strategies and sustained transmission in endemic regions (WHO, 2023). The persistent global burden of malaria particularly in endemic regions coupled with reliance on traditional medicine, has sustained the use of medicinal plants for malaria management, highlighting the need for scientific evaluation of their therapeutic potential (WHO, 2022).

The World Health Organization (WHO) defines traditional medicine as a broad set of practices, beliefs, and knowledge systems used to maintain health and treat disease. These methods include remedies derived from plants, animals, and minerals, as well as spiritual healing, manual therapies, and physical exercises (Kasilo & Nikiema, 2020). Such approaches may be applied individually or in combination to promote well-being, prevent illness, and manage both physical and psychological conditions (Kasilo & Nikiema, 2020).

Worldwide, large segments of the population continue to depend on traditional medicine as their primary source of healthcare (Noronha et al., 2020a). Within Africa, herbal decoctions prepared locally have been used for centuries in the management of malaria (Dogara & Labaran, 2020). These practices are often preserved through oral traditions or documented in herbal texts, ensuring their transmission across generations (Mohammadi et al., 2020). Despite their cultural importance, many communities administer herbal remedies based solely on indigenous knowledge, without formal pharmacological understanding. This lack of scientific validation can expose users to toxic effects from harmful compounds present in certain plants (Ssempijja et al., 2020).

Research in ethnobotany has highlighted the widespread reliance on medicinal plants for malaria management. In Cameroon's Menoua Division, investigators documented 46 species drawn from 32 botanical families, with *Asteraceae*, *Liliaceae*, and *Malvaceae* being the most prominent (Olivier et al., 2016). In Eastern Uganda, communities utilized 45 plant species

from 26 families and 44 genera in preparing herbal treatments for malaria and related symptoms. Frequently cited species included *Vernonia amygdalina*, *Aloe nobilis*, *Warburgia ugandensis*, *Abrus precatorius*, *Kedrostis foetidissima*, *Chamaecrista nigricans*, *Senna occidentalis*, *Azadirachta indica*, and *Mangifera indica* (Tabuti et al., 2023). Meanwhile, in Western Uganda, families such as Asteraceae, Fabaceae, Lamiaceae, and Poaceae were identified as key contributors to traditional antimalarial remedies (Gumisiriza et al., 2023).

The origins of drug-based malaria treatment are closely tied to traditional plant infusions used across cultures (Ceravolo et al., 2021). Since ancient times, many plants have been recognized for their healing properties. Their popularity as medicines grew because they were seen as effective, affordable, widely available, and often associated with fewer side effects compared to synthetic drugs (Budiarti et al., 2020). Knowledge from traditional practices has been instrumental in the discovery of two cornerstone antimalarial drugs. Quinine, an alkaloid extracted from *Cinchona* trees native to South American highland rainforests, became one of the earliest effective treatments. Centuries later, artemisinin, derived from *Artemisia annua* and rooted in ancient Chinese medicine, was developed and remains a critical therapy in modern malaria control (Ceravolo et al., 2021).

In Uganda, traditional plants with medicinal value remain one of the most important components for disease management particularly malaria, African tick-bite fever, cancer and others, by the indigenous people (Byamukama et al., 2011). In many communities, knowledge about ethnomedicinal plants used for malaria treatment is passed down through generations, often shared by parents, grandparents, and traditional healers (Byamukama et al., 2011). This oral transfer of expertise ensures continuity of cultural practices and sustains reliance on herbal remedies. People in Serere District have relied on herbal mixtures and plant-based remedies as alternatives to manage various illnesses, including malaria and its symptoms due to high costs and inaccessibility of modern medicine. Recording the medicinal plants employed in malaria therapy is crucial for safeguarding indigenous knowledge and biodiversity. Such documentation not only preserves cultural heritage but also strengthens community-based malaria interventions by providing a foundation for improved treatment strategies (Gumisiriza et al., 2023).

1.2 Statement of the Problem

The World Malaria Report 2023 highlights the persistent and complex challenges confronting the international malaria community. It documents the heavy toll of the disease, with an

estimated 249 million cases recorded in 2022 across 85 endemic countries. Of these endemic regions, 29 countries and one territory accounted for the overwhelming majority—approximately 95% of global malaria cases and 96% of malaria-related deaths in 2022 (WHO, 2023). Uganda was among the five nations that registered notable increases (2% incidence increase) in malaria cases between 2021 and 2022, underscoring its significant role in the regional and global malaria burden (WHO, 2023). Serere district reported test positive rates of about 63.7% malaria cases according to the MOH, (2023).

Currently, chemotherapeutic use of artemisinin derivatives, indoor residual spraying and use of insecticide-treated bed nets are the recommended methods of malaria control (WHO, 2023). However, limited access to medical facilities (Gumisiriza et al., 2023), high cost of treatment (Tabuti et al., 2023) and drug resistance (Budiarti et al., 2020) have been reported to frustrate these efforts. Other Barriers to holistic malaria prevention included inadequate knowledge of some methods such as improvements in housing conditions, hypersensitivity reactions to chemically insecticide treated nets, as well as the high cost and limited availability of insecticide sprays and body repellents (Id et al., 2024, Taremwa et al., 2022). This makes malaria to remain a big challenge, highlighting therefore the need for new innovative approaches to malaria prevention and treatment.

For generations, communities in Serere District have relied on herbal mixtures and plant-based remedies as alternatives to manage various illnesses, including malaria and its symptoms due to high costs and inaccessibility of modern medicine. Despite this long-standing practice, there has been little effort to record these treatments, identify their active compounds, or scientifically evaluate their effectiveness. This lack of evidence limits the potential of the district's rich plant biodiversity to contribute to the development of effective antimalarial drugs. The present study was therefore designed to document the medicinal plants used locally for malaria treatment and to assess their antiplasmodial activity in managing the disease in Serere district.

1.3. General Objective

The main aim of this study was to survey, document and asses the antiplasmodial activity of medicinal plants used for the management of malaria by the people of Serere district so as to bridge traditional knowledge with scientific evidence for improved malaria management.

1.3.1 Specific objectives

1. To document the plant species used by the local people in Serere district to manage malaria and its related symptoms.
2. To determine the methods of preparation, dosage form and routes of administration of the herbal remedies used by local communities in Serere District for malaria management.
3. To identify phytochemical constituents in the most frequently used medicinal plants with potential antiplasmodial activity.
4. To assess the in vitro antiplasmodial activity of the crude extracts from selected medicinal plants.

1.3.3 Research questions

1. Which plant species are used as traditional medicine for the management of malaria and related symptoms by the people of Serere district?
2. How is the concoction prepared and administered as herbal medicine to manage malaria by the people of Serere district?
3. Which phytochemicals are found in the plants commonly used as traditional medicine for the management of malaria in Serere district?
4. Can the crude extracts from the commonly used plant species by the people of Serere district inhibit the growth of the *plasmodium* parasite in vitro?

1.4 Justification of the study

This study would help in the preservation of traditional indigenous knowledge about medicinal plants and their uses in manage malaria hence safeguarding cultural heritage, promoting sustainable harvesting practices and ensuring biodiversity conservation.

This study would also help understand the efficacy of traditional plant remedies leading to future development of affordable and accessible herbal medicine formulations for the management of malaria where modern medicine may be expensive and scarce.

With increasing resistance to existing antimalarial drugs, this study explores the traditional remedies which can be used to offer alternative management or even provide insights into combating drug resistance.

Findings from this study would inform public health policies regarding the importance of integration of traditional medicine into healthcare systems, especially in regions where malaria is endemic like Uganda.

This research is anticipated to contribute to the discovery of novel drugs or the refinement of existing malaria control strategies, given that many modern medicines trace their origins to traditional remedies. Through detailed analysis of the chemical composition of medicinal plants, scientists can isolate bioactive compounds with antimalarial activity. Such findings hold promise for the development of new pharmaceutical agents.

1.5 Scope of the study

This study focused on surveying and documenting the plant species used for the management of malaria, establish the mode of preparation and administration of the concoctions and assess the efficacy of the traditional remedies in the management of malaria and the associated symptoms in Serere district, Eastern Uganda. Data collected included the socio-demographic characteristics of the people, their knowledge of malaria symptoms, medicinal plants used for treatment of malaria and the strategies used to manage the disease. Each informant would provide the local name of the plant used, the parts utilized to prepare the concoction and mode of preparation and administration.

The study identified the species of plants, tested crude extracts for secondary metabolites which are believed to be the bioactive ingredients with antiplasmodial activity of the roots of *Zanthoxylum chalybeum*, *Naulea laitfolia* and *Dolichandra unguis cati*, and tested for antplasmodial activity of the extracts in inhibiting the growth of plasmodium parasite under controlled laboratory conditions. This study was carried out between January 2025 and June 2026.

1.6 Limitations and delimitations

The traditional knowledge is usually orally transmitted from one individual to another, this led to inconsistency and incomplete information from the informants. This was handled by organizing structured interviews with focus groups to cross-check the information.

Informants had recall bias where they may forget details about plant used, dosage and preparation. This was resolved by using probing questions during interactions to elicit more detailed responses and also by triangulating data from different multiple informants and literature.

Some plants were not available all year round, this could affect collection and identification of plants used. However, the field visits were planned to cover both dry and rainy seasons following guidance from the informants.

Incorrect plant identification resulted in unreliable findings; however, this was catered for by the preparation of voucher specimens which was delivered to Makerere herbarium for proper taxonomic identification of plants.

Certain informants were reluctant to share this sensitive information due to cultural reasons and beliefs or fear of exploitation. This challenge was counteracted by building trust with community leaders, obtaining informed consent and ensuring that the community understands the purpose of the research and potential benefits.

CHAPTER TWO: LITERATURE REVIEW

2.1. Malaria as a public health concern

The word malaria originates from the Italian phrase *mal aria*, which translates to “bad air.” Historically, the miasma theory of humoral medicine suggested that infectious diseases were caused by exposure to polluted air filled with harmful vapors (Dagen, 2020). Today, malaria continues to be one of the most dangerous parasitic diseases (WHO, 2023). It remains widespread in tropical regions, particularly across Africa, where climatic conditions favor the survival and multiplication of mosquito vectors responsible for transmission (Mohammadi et al., 2020). The disease majorly affects children under five years, pregnant mothers and the elderly, however, all different age groups are equally susceptible to malaria infection (Waiganjo et al., 2020). This makes it very vital to uncover more effective measures to manage this disease problem.

On November 6, 1880, Charles Louis Alphonse Laveran, a French military physician, was the first to observe malaria parasites in the blood of an infected patient (Tren, 2002). His groundbreaking discovery laid the foundation for understanding the parasitic nature of malaria, and in recognition of this achievement, he was awarded the Nobel Prize in Medicine in 1907 (Tren, 2002). Plasmodium parasite belonging to apicomplexan group is a causative agent of malaria disease and over 120 different plasmodium species have been identified. However, *P. falciparum*, *P. vivax*, *P. ovale*, *P. malariae* and *P. knowlesi* are the major five species which cause the disease in humans (Varo et al., 2020). *P. falciparum* accounts for the majority of mortality, accounting for over 60% followed by *P. vivax* with about 40% of all malaria-associated deaths globally (Nigussie & Wale, 2022).

Globally reports indicate that malaria continues to claim over 600,000 lives annually, with children making up the majority of those affected (WHO, 2023). In 2022, malaria affected an estimated 249 million people across 85 endemic countries and territories. These infections resulted in approximately 608,000 deaths worldwide (World Malaria Report 2022, 2022). This is indicative that malaria is still a hurdle which requires vigorous confrontation for example by discovering new drugs that can effectively and efficiently clear the parasite.

In sub-Saharan Africa, more than 15% of admissions in hospitals and clinics are due to malaria (Robert et al., 2003). Uganda ranks eighth among sub-Saharan African countries with

the highest *Plasmodium falciparum* infections and is recognized globally as one of the nations with the most intense malaria transmission rates (Ibrahim Kasule).

Malaria commonly presents with symptoms such as fever, chills, muscle pain, profuse sweating, headaches, diarrhoea, vomiting, and general body weakness (Makanjuola & Taylor-robinson, 2020). The illness is marked by sudden, recurring febrile episodes. If left untreated, it can cause enlargement of the spleen, damage to vital organs such as the liver, lungs, and kidneys. In its cerebral form, the parasite can trigger coma, profound anemia, and ultimately death (Dagen, 2020). An individual experiencing these malaria symptoms will eventually become less productive and this affects family incomes as well as a country's economy. Therefore, it's paramount to continue sourcing for pivotal ways of suppressing malaria glitches.

2.2 *Plasmodium falciparum*

2.2.1 Life Cycle

Plasmodium species are part of the highly successful phylum *Apicomplexa*. Members of this group are obligate intracellular protozoan parasites, distinguished by their complex and multi-stage life cycles (Noronha et al., 2020a). The parasite has indirect life cycle which involves an intermediate host (vertebrate) and a definitive host (invertebrate) (Waiganjo et al., 2020). A female *Anopheles* mosquito while taking a blood meal injects plasmodium sporozoites into a susceptible host (human).

After entering the bloodstream, sporozoites quickly migrate to the liver typically within an hour where they invade hepatocytes (Suemizu et al., 2015). Inside these liver cells, they multiply and transform into schizonts, each containing thousands of hepatic merozoites (Suemizu et al., 2015).

Once released into circulation, these merozoites infect red blood cells, initiating the erythrocytic phase (Burton et al., 2012). The infected cells eventually rupture, releasing more merozoites that invade new erythrocytes. It is at this stage that clinical symptoms begin to manifest in the host (Burton et al., 2012). During repeated erythrocytic schizogony, some merozoites differentiate into male and female gametocytes. These sexual forms are later ingested by mosquitoes, continuing the transmission cycle (Waiganjo et al., 2020).

When gametocytes are ingested by mosquitoes, fertilization occurs, producing zygotes. These zygotes develop into ookinetes, which traverse the blood meal and peritrophic matrix,

penetrate the midgut epithelium, and lodge beneath the basal lamina where they form oocysts. The oocysts enlarge and undergo repeated mitotic divisions, creating a syncytial mass that generates sporozoites (Zollner et al., 2006). Sporozoites then move into the mosquito haemocoel and eventually colonize the salivary glands. This transformation from gametocytes to infective sporozoites typically takes 10–20 days, with the duration influenced by ambient temperature (Waiganjo et al., 2020).

The life cycle continues as the female anopheles mosquito containing sporozoites takes another blood meal. *Plasmodium vivax* and *Plasmodium ovale* show a slight difference in the life cycle within the mammalian host, characterized by some sporozoites once in the liver, do not develop immediately into schizonts but form hypnozoites. These remain dormant causing relapses weeks, months or even years after the primary infection (Mueller et al., 2013). This complex life cycle makes it difficult to manage and completely eradicate the parasite from the community, hence requiring to device measures to restrain the *plasmodium* parasite both in the invertebrate vector and the human host, and this can be done by developing new drugs, which starts by performing studies on herbal medicines that the indigenous people use for management of malaria in their local settings.

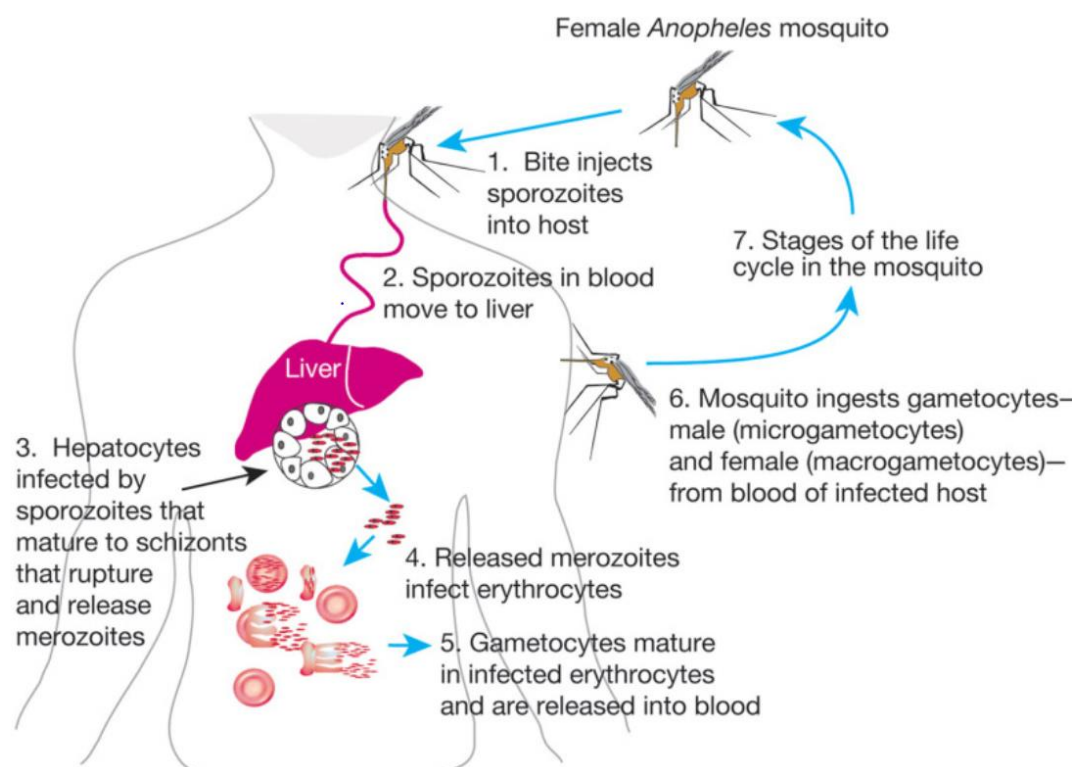


Figure 2. 1: *Plasmodium falciparum* life cycle

Source: <https://www.ncbi.nlm.nih.gov/books/NBK579956/figure/CSHLP5087CH43F1/>

2.3. Transmission of malaria parasite

Human infection occurs when female *Anopheles* mosquitoes carrying malaria parasites bite between dusk and dawn, depositing *Plasmodium* sporozoites into blood stream through the skin (Briquet et al., 2021). Among the parasite species, *P. falciparum* is the most prevalent and responsible for the majority of malaria cases in sub-Saharan Africa (Asua et al., 2017). Out of more than 400 *Anopheles* species, about 40 are recognized as significant malaria vectors worldwide (World Health Organization, 2021). In Uganda, the most common vectors include *An. funestus*, *An. gambiae sensu lato*, and *An. arabiensis* (Kasule, 2019).

The rate and intensity of malaria transmission depend on a number of factors like climate change which influences temperature, humidity and precipitation, and vector species which determines feeding, flight range and resting, biting, vectorial capacity, mortality and reproduction rate (Castro MC 2017). Human behavior, demographics, culture, socioeconomic characteristics, genetics and acquired immunity, all influence malaria transmission (Castro MC 2017). Agricultural development and increased populations in urban settlements, also facilitate the spread of infection (Dagen, 2020). Uganda being a developing country with a tropical climate and increasing urbanization makes transmission of malaria to be very high, hence it's notable that looking out for cheaper and available solutions to the malaria crisis is a vital call.

2.4 Malaria control strategies

For many decades, there have been global dialogues on malaria elimination and eradication, the World Health Organization (WHO) has established the Global Malaria Eradication Programme since the 1950s (Gimenez & Marques, 2021). These encompass many measures such as the innovation of diagnostics tools, the use of preventive chemotherapies, vector control approaches, vaccine discovery, and improved mechanisms for surveillance (WHO, 2021).

The development of antimalarial medicines has provided significant optimism for malaria elimination. Examples include quinolones, antifolates used in Intermittent Preventive Treatments for pregnant women (IPTPs) and Intermittent Preventive Treatments for infants (IPTIs), as well as Artemisinin-based Combination Therapies (ACTs), which are widely applied in endemic regions. These treatments have contributed to reductions in malaria-

related deaths. However, resistance to some of these drug combinations has been reported, often manifesting as delayed parasite clearance (Daskum et al., 2021).

Beyond drug therapy, the World Health Organization emphasizes insecticide-treated nets (ITNs) as a key intervention to protect communities from mosquito bites. In 2022, half of all ITNs distributed to malaria-endemic countries in sub-Saharan Africa were concentrated in six nations with the highest malaria burden: the Democratic Republic of the Congo, Nigeria, Ethiopia, Sudan, Uganda, and Mali (World Health Organization, 2023).

Indoor residuals spraying (IRS) using pyrethroids is another control strategy enrolled as recommended by WHO especially in malaria endemic regions and it has induced a beneficial impact on malaria infection worldwide. Expanding Indoor Residual Spraying (IRS) coverage and developing new, more effective insecticides are critical steps in addressing the growing challenge of insecticide resistance (Zhou et al., 2022). In Ugandan regions where IRS was consistently implemented, malaria incidence dropped dramatically by about 85% after four years. Conversely, areas where IRS programs were discontinued experienced a sharp rebound, with malaria cases increasing fivefold within just ten months (Namuganga et al., 2021).

At a workshop in Dakar, Senegal, the RTS,S/AS01 (Mosquirix, developed by GlaxoSmithKline) was recognized as the first malaria vaccine recommended by the World Health Organization (Merle et al., 2023). This decision followed pilot programs in Ghana, Kenya, and Malawi, which demonstrated the vaccine's effectiveness, including a 30% reduction in malaria-related hospital admissions (Merle et al., 2023). In October 2023, the WHO also endorsed the R21/Matrix-M vaccine. Both RTS, S and R21 are now prequalified by the organization as part of global malaria control strategies. Uganda is preparing for a phased rollout of RTS,S/AS01, reflecting its commitment to integrating vaccines into national malaria prevention efforts (Osoro et al., 2024).

2.5. Challenges facing malaria prevention and control

Malaria is actually a preventable and treatable disease however; it has continued to have devastating effects on people's health and livelihoods worldwide. Particularly in the tropical and subtropical regions where there's high poverty incidence in the population, with limited access to health facilities and barely being able to afford conventional treatment (Nwani & Osuji, 2020).

The COVID-19 pandemic presented a new threat to malaria service delivery. As the virus began to spread in malaria-endemic countries like in Sub-Saharan Africa, the fragile health systems became overwhelmed resulting to a substantial increase in morbidity and mortality from malaria and other diseases (WHO, Global Malaria Programme 2021). Another challenge is that the majority of commercially available Rapid Diagnostic Tools RDTs are designed to detect only *P. falciparum* which is just one of the five species that cause malaria to humans. This excludes the possibility of detecting infection with another parasite like *P. vivax*, *P. ovale*, *P. malariae*, and *P. knowlesi* or detection of mixed infections. Therefore, non-*P. falciparum* diagnosis is missed (Makanjuola & Taylor-robinson, 2020).

Cases of *Plasmodium vivax* malaria remain a major obstacle in control efforts because infections often produce very low levels of parasites in the blood, making them difficult to detect with standard diagnostic methods (Elliott et al., 2019). Another complication arises from dormant hypnozoites that persist in liver cells. These latent forms can reactivate after long incubation periods, leading to repeated relapses months after the initial infection (Elliott et al., 2019).

Resistance to currently available antimalarial medicines has emerged as a major obstacle, posing a serious threat to effective malaria treatment and control efforts. This makes it imperative to look for more effective mechanisms to combat this life threatening disease (Noronha et al., 2020b). The growing and widespread resistance of mosquitoes to insecticides has become a serious obstacle to effective malaria vector control. This resistance has contributed to rising disease incidence and has undermined, or even reversed, many of the significant achievements made in malaria control over the past decade (World Health Organization, 2021).

The challenges above clearly show that the hunt for substantial strategies towards malaria control is fundamental. Without a doubt chemotherapeutic drug developed from plants have been one of the key measures used to manage malaria, hence it's important to study the plants indigenous people have continued to use to manage malaria and this eventually will result to the discovery of effective medicines.

2.6. Use of traditional medicine

Traditional medicine encompasses the collective knowledge, skills, and practices rooted in cultural beliefs, theories, and experiences (Issel & Cook, 1993). It involves the use of plants,

animals, and mineral-based remedies, alongside spiritual therapies, manual techniques, and physical exercises (Issel & Cook, 1993). These practices may be applied individually or in combination to promote health, prevent disease, and support the diagnosis, management, or treatment of both physical and psychological conditions. It is estimated that nearly 80% of the world's population depends on traditional medicine to meet their healthcare needs (Noronha et al., 2020a), and 87% of WHO regions in Africa have reported the acceptable use of traditional medicine by their population (WHO, 2019).

Indigenous communities prefer using plants as medicine because they are more efficient, safe, and cost effective. Plants have been used to treat diseases like malaria for thousands of years. (Budiarti et al., 2020). The traditional medicines are also mostly used because of easy accessibility, not requiring any formal education to apply and due to inaccessibility to modern health services (Town et al., 2022).

Plants produce secondary metabolites such as phenolic compounds, anthraquinones, and alkaloids, often as defense mechanisms. These compounds have long been recognized for their potential therapeutic applications (Mohammadi et al., 2020). The development of two major classes of antimalarial medicines artemisinin derivatives and quinine-based drugs originated from plant innovations and remain central to first-line malaria treatment today (Town et al., 2022). The use of plants in drug development dates back centuries. In 1803, morphine was isolated from opium, followed by the extraction of digoxin from *Digitalis* and quinine from the *Cinchona* genus, laying the foundation for modern pharmacology (Mohammadi et al., 2020). Within medical circles, traditional practices are often criticized for lacking objectivity, standardization, and formal classification. Nonetheless, evidence suggests that many physical aspects of traditional medicine can be systematically studied, analyzed, and even recommended for clinical use (Abdullahi, 2011).

Across Africa, traditional healers and local communities use various plant species to manage malaria-related symptoms and infections. A systematic review by Willcox and Bodeker (2004) documented the importance of traditional herbal medicines in malaria-endemic regions, while a review by Chinsebu (2015) highlighted the diversity of medicinal plants used against malaria in sub-Saharan Africa. These studies indicate that medicinal plants are important sources of potential antiplasmodial compounds, although their traditional use does not, by itself, establish clinical efficacy or safety.

Some plant species with antiplasmodial potential include *Nauclea latifolia*, a member of the Rubiaceae family, which is widely used in traditional medicine in several African countries, including for the management of malaria (Haudecoeur et al. 2018). Different plant parts, including roots, stem bark and leaves, have been used in traditional preparations. A review on the ethno medicinal uses, photochemistry and pharmacological properties of *African Nauclea* species concluded that experimental studies supported several traditional applications, including antimalarial use. The review also identified indoloquinolizidine alkaloids as an important group of constituents in the genus.

In Uganda, 45 plant species have been documented from Tororo district as being used in the treatment and management of malaria and its associated symptoms. Among these, the most frequently reported species include *Vernonia amygdalina*, *Warburgia ugandensis*, *Chamaecrista nigricans*, *Senna occidentalis*, *Aloe nobilis*, *Azadirachta indica*, *Abrus precatorius*, *Kedrostis foetidissima*, and *Mangifera indica* (Tabuti et al., 2023). In this study, it was also reported that leaves (67.3%) were the most used parts and maceration (56%) was the commonest mode of preparation of concoctions, whereas oral route was the main way of administration (Tabuti et al., 2023). This study shows continued reliance on traditional remedies by the indigenous communities in management of malaria burden.

2.7 Phytochemicals of medicinal plants with potential antiplasmodial activity

Medicinal plants contain diverse secondary metabolites that contribute to their biological and pharmacological properties (Bero et al., 2009). Among the major classes of phytochemicals investigated in medicinal plants are alkaloids, flavonoids, phenolic compounds, tannins, terpenoids, anthraquinones, coumarins, quinones and saponins (Bero et al., 2009 and Koffi et al., 2020). Several of these phytochemical groups have been reported to possess antiplasmodial activity against *Plasmodium falciparum* and other *Plasmodium* species (Bero et al., 2009). Consequently, phytochemical investigations are commonly incorporated into ethnopharmacological studies to provide preliminary information on the chemical constituents that may contribute to the medicinal properties of traditionally used plants (Bero et al., 2009; Koffi et al., 2020; Mamede et al., 2020).

Alkaloids

Alkaloids are nitrogen-containing secondary metabolites that occur widely in medicinal plants and constitute one of the most pharmacologically important groups of natural products

(Bero et al., 2009). Their relevance to malaria treatment is historically demonstrated by quinine, an alkaloid obtained from *Cinchona* species, which became one of the earliest effective treatments for malaria (Bero et al., 2009). Numerous other plant-derived alkaloids have subsequently been investigated for antiparasmodial activity against *P. falciparum* (Schwikkard & van Heerden, 2002; Bero et al., 2009).

The antiparasmodial properties of alkaloids are associated with diverse mechanisms depending on their chemical structures (Bero et al., 2009). Some alkaloids interfere with parasite metabolic pathways, while others affect haemoglobin digestion, haem detoxification or essential parasite enzymes. Consequently, alkaloids represent an important chemical class in the search for new antimalarial compounds, particularly because of the structural diversity available within this group (Bero et al., 2009).

The importance of alkaloids has also been demonstrated in African medicinal plants. Koffi et al. (2020), in a review of antimalarial compounds obtained from African medicinal plants, identified alkaloids among the major groups of natural products investigated for antimalarial activity. In Uganda, Wamboga et al. (2016) reported alkaloids among the phytochemicals detected in selected medicinal plants traditionally used for malaria management, including *Zanthoxylum chalybeum*. Furthermore, *Nauclea latifolia* has received considerable phytochemical attention because of its abundance of biologically active indole alkaloids. Boucherle et al. (2016) reviewed the alkaloid chemistry and biological activities of *N. latifolia*, demonstrating its importance as a source of bioactive alkaloids. These findings indicate that alkaloids are an important phytochemical group to investigate in medicinal plants traditionally used against malaria.

Flavonoids

Flavonoids are polyphenolic secondary metabolites widely distributed throughout the plant kingdom (Mamede et al., 2020). They comprise several subclasses, including flavones, flavonols, flavanones, isoflavonoids and chalcones. Their biological activities include antioxidant, antimicrobial, anti-inflammatory and antiparasitic effects, making them important constituents of many medicinal plants (Mamede et al., 2020).

Several flavonoids and flavonoid derivatives have demonstrated activity against *P. falciparum*. Proposed mechanisms include interference with parasite enzymes, disruption of parasite metabolic processes and effects on haem-related pathways (Mamede et al., 2020).

However, antiplasmodial activity differs considerably among individual flavonoids and depends on their molecular structures and concentrations (Mamede et al., 2020).

Flavonoids have been reported in several African medicinal plants investigated for malaria treatment. Koffi et al. (2020) identified flavonoids among the important classes of natural products associated with antimalarial activity in African medicinal plants. Wamboga et al. (2016) also detected flavonoids in *Z. chalybeum* and other Ugandan medicinal plants used traditionally against malaria. Their repeated identification in medicinal plants with antiplasmodial activity supports continued investigation of flavonoid-containing plants as potential sources of antimalarial compounds.

Phenolic compounds

Phenolic compounds constitute a broad group of plant secondary metabolites characterized by the presence of phenolic hydroxyl groups (Mamede et al. 2020). They include simple phenolic acids and more complex polyphenolic compounds. Phenolic compounds are widely distributed in medicinal plants and are associated with antioxidant, antimicrobial, anti-inflammatory and antiparasitic properties (Mamede et al. 2020).

Natural phenolic compounds have received considerable attention in antimalarial drug research. Mamede et al. (2020) reviewed natural phenolic compounds and derivatives with potential antimalarial activity and reported several chemical subclasses, including phenolic acids, flavonoids, coumarins and related compounds, with activity against *P. falciparum*. Their antiplasmodial effects have been associated with different mechanisms, including interference with parasite enzymes, oxidative processes and other cellular pathways (Mamede et al. 2020).

The occurrence of phenolic compounds in medicinal plants is therefore of interest when investigating plants traditionally used against malaria. However, the phenolic group encompasses chemically diverse compounds, and the presence of phenolics in a plant extract does not necessarily indicate antiplasmodial activity (Mamede et al. 2020). The biological activity depends on the specific compounds present, their concentrations and interactions with other constituents.

Tannins

Tannins are polyphenolic compounds that have a high capacity to bind proteins and other macromolecules (Koffi et al. 2020). They occur widely in plant tissues, particularly in bark,

leaves and roots, and are associated with a range of biological activities, including antimicrobial, antioxidant and anti-inflammatory effects (Koffi et al. 2020).

Although tannins have received less attention in antimalarial drug development than alkaloids and terpenoids, tannin-containing medicinal plant extracts have demonstrated biological activity against malaria parasites. Koffi et al. (2020) included tannins among phytochemical groups reported in African medicinal plants investigated for antimalarial activity.

The biological effects of tannins may be related to their ability to interact with proteins and enzymes and to modify cellular processes (Koffi et al. 2020). However, because tannins can bind proteins relatively non-specifically, their biological effects may vary considerably according to their structure and concentration. In Uganda, Wamboga et al. (2016) reported tannins among the phytochemical constituents of selected medicinal plants traditionally used against malaria, including *Z. chalybeum*. The occurrence of tannins in traditionally used antimalarial plants provides a basis for their inclusion in preliminary phytochemical investigations.

Terpenoids

Terpenoids constitute one of the largest and most structurally diverse groups of plant secondary metabolites (Koffi et al. 2020). They include monoterpenes, sesquiterpenes, diterpenes, triterpenes and related compounds. Terpenoids are of exceptional importance in malaria research because artemisinin, a sesquiterpene lactone obtained from *Artemisia annua*, is a major antimalarial compound and forms the basis of artemisinin-based combination therapies (Koffi et al. 2020).

The importance of terpenoids in antimalarial drug discovery extends beyond artemisinin. Koffi et al. (2020) identified terpenoids as one of the major groups of natural products associated with antimalarial activity among African medicinal plants. More recent reviews have similarly described numerous plant-derived terpenoids with antiplasmodial properties and highlighted their potential as sources of new antimalarial compounds (Wassie et al., 2025).

Terpenoids may affect malaria parasites through different mechanisms depending on their structures. Proposed mechanisms include interference with parasite membranes, oxidative processes and other metabolic pathways (Wassie et al., 2025). The wide structural diversity

of terpenoids therefore provides considerable potential for the discovery of new antiplasmodial agents.

Anthraquinones

Anthraquinones are aromatic quinone derivatives occurring naturally in a number of plant species (Koffi et al. 2020). They are recognized for various biological properties, including antimicrobial, antioxidant and antiparasitic activities. Quinones and related compounds have also been investigated for their antimalarial properties (Koffi et al. 2020). The potential antiplasmodial effects of quinone compounds have been associated with their redox properties and their ability to interfere with cellular and metabolic processes (Koffi et al. 2020). Anthraquinones have also been reported among the secondary metabolites identified in medicinal plants, including *N. latifolia*. Their occurrence in medicinal plants with traditional therapeutic applications provides a rationale for including anthraquinones in preliminary phytochemical screening. Nevertheless, the antiplasmodial activity of individual anthraquinones depends on their molecular structures, and their detection in a crude extract cannot by itself establish biological activity (Koffi et al. 2020).

Coumarins

Coumarins are benzopyrone derivatives widely distributed in plants (Mamede et al. 2020). They possess diverse biological activities, including antimicrobial, antioxidant, anti-inflammatory and antiparasitic properties (Mamede et al. 2020). Their chemical structures have attracted attention in medicinal chemistry because some naturally occurring coumarins and synthetic derivatives exhibit activity against *P. falciparum*. Mamede et al. (2020) reviewed several classes of natural phenolic compounds and derivatives and highlighted coumarins among plant-derived compounds investigated for antimalarial activity.

The reported antiplasmodial activity of coumarins varies considerably among compounds and proposed mechanisms include interference with parasite metabolic processes and essential cellular functions (Mamede et al. 2020). Therefore, the presence of coumarin-related compounds in medicinal plants may provide a basis for further chemical investigation, although individual compounds need to be isolated and characterized to establish their contribution to antiplasmodial activity.

Saponins

Saponins are glycosidic secondary metabolites consisting broadly of a hydrophilic sugar component linked to a steroidal or triterpenoid aglycone (Mamede et al. 2020). They are widely distributed among medicinal plants and are known for their surface-active properties, including the ability to produce persistent foam in aqueous solutions (Mamede et al. 2020).

Saponins have demonstrated several biological activities, including antimicrobial, anti-inflammatory and antiparasitic effects (Mamede et al. 2020). Saponins have been reported in African medicinal plants investigated for malaria treatment. Wamboga et al. (2016) detected saponins together with other phytochemical classes in selected Ugandan medicinal plants traditionally used against malaria. Saponins have also been reported in *N. latifolia*, together with other secondary metabolites associated with biological activity (Wamboga et al. (2016). The occurrence of saponins in medicinal plants therefore provides a basis for investigating their possible contribution to antiplasmodial activity.

Evidence from African and Ugandan medicinal plants further supports the relevance of these phytochemical groups to traditional malaria treatment. However, preliminary phytochemical screening provides information only about the presence or absence of broad classes of secondary metabolites. It does not identify individual compounds, determine their concentrations or establish which compounds are responsible for biological activity. Consequently, phytochemical screening is appropriately considered an initial step in the investigation of medicinal plants, while isolation, quantitative analysis and structural characterization are required to establish the compounds responsible for antiplasmodial activity.

2.8 Modern Medicines Used in the Treatment of Malaria

Modern medicine plays a central role in the prevention of malaria-related complications, reduction of mortality, and elimination of *Plasmodium* parasites from infected individuals (WHO, 2023). The development of antimalarial medicines has significantly improved malaria case management, particularly in malaria-endemic regions of sub-Saharan Africa, where *Plasmodium falciparum* is responsible for most severe infections and malaria-related deaths (WHO, 2018). The selection of antimalarial medicines depends on several factors, including the infecting *Plasmodium* species, severity of the disease, drug resistance patterns, patient age, body weight, and pregnancy status (WHO, 2025). The World Health Organization

(WHO) recommends prompt diagnosis and appropriate treatment to prevent uncomplicated malaria from progressing to severe disease and death (World Health Organization, 2025).

Sulfadoxine-Pyrimethamine

Sulfadoxine-pyrimethamine is a combination of two antimalarial medicines that act by interfering with folate metabolism in the parasite (George Hitchings et al., 1950). Sulfadoxine inhibits dihydropteroate synthase, whereas pyrimethamine inhibits dihydrofolate reductase (George Hitchings et al., 1950). Both enzymes are involved in pathways required for the synthesis of nucleotides and other compounds necessary for parasite growth and multiplication (George Hitchings et al., 1950). By targeting different steps in the folate pathway, the combination historically provided an effective treatment for susceptible malaria parasites.

However, resistance to sulfadoxine-pyrimethamine developed and spread in many malaria-endemic regions, reducing its effectiveness as a treatment for uncomplicated *P. falciparum* malaria (Ropa. C et al., 2004). Consequently, it is not the preferred routine treatment for uncomplicated *falciparum* malaria in most endemic countries where ACTs are recommended. Sulfadoxine-pyrimethamine continues to have an important role in specific malaria prevention programmes, particularly intermittent preventive treatment during pregnancy in eligible women living in areas where this intervention is recommended (WHO, 2025).

The experience with sulfadoxine-pyrimethamine reinforces the need to investigate additional sources of compounds that may inhibit malaria parasites. Phytochemical screening of the selected medicinal plants may provide preliminary information about the chemical groups present in their extracts, while in vitro testing can establish whether the extracts inhibit parasite growth under the experimental conditions employed. However, the presence of a particular phytochemical group does not establish that the extract acts through the same biochemical pathway as sulfadoxine-pyrimethamine.

Chloroquine

Chloroquine is a synthetic antimalarial medicine that was widely used for treating malaria because of its effectiveness against susceptible blood-stage Plasmodium parasites, relatively low cost, and established safety profile when appropriately administered (Coatney, 1963). Its antimalarial action involves interference with haemoglobin digestion within the parasite's acidic digestive vacuole (Coatney, 1963). During haemoglobin digestion, malaria parasites

release haem, which is toxic to them in its unprocessed form. Chloroquine interferes with the conversion of this toxic haem into a less harmful crystalline product known as haemozoin, resulting in the accumulation of toxic haem-related substances within the parasite (Coatney, 1963 & WHO 2018).

Despite its historical importance, the widespread emergence and spread of chloroquine-resistant *P. falciparum* substantially reduced the usefulness of chloroquine for treating *falciparum* malaria in most endemic regions (O'Neill & Bray 2012). Chloroquine nevertheless retains a role in treating infections caused by susceptible *Plasmodium* species, including *P. vivax* in locations where chloroquine resistance is not prevalent, and *P. malariae* under appropriate clinical guidance (Centers for Disease Control and Prevention CDC, 2024; WHO, 2025).

The emergence of chloroquine resistance demonstrates that the effectiveness of an antimalarial medicine cannot be assumed to remain constant over time. Parasites can develop and spread genetic changes that reduce their susceptibility to particular medicines, making continued monitoring of treatment effectiveness necessary (O'Neill & Bray 2012). This provides an important rationale for investigating additional sources of antiplasmodial compounds.

Mefloquine

Mefloquine was developed as an antimalarial drug to address the growing problem of resistance to existing medicines, particularly chloroquine (Wongsrichanalai et al., 1992). However, its effectiveness against *Plasmodium falciparum* was subsequently compromised by the emergence of drug resistance (White, N J 2004). Thailand introduced mefloquine for the treatment of *falciparum* malaria in the mid-1980s, but declining parasite sensitivity was documented in southeastern Thailand shortly thereafter. In vitro investigations demonstrated a progressive reduction in mefloquine sensitivity between 1984 and 1989, followed by an increase in the degree and prevalence of resistance in 1990 (Wongsrichanalai et al., 1992). By the late 1980s, mefloquine resistance had become prevalent in parts of Southeast Asia, particularly along the Thai–Cambodian and Thai–Myanmar borders, where multidrug-resistant malaria was a major public health concern (Wongsrichanalai et al., 2002). This history illustrates how the effectiveness of antimalarial medicines can diminish as resistant parasite populations emerge and spread, reinforcing the importance of investigating alternative antiplasmodial compounds, including those derived from medicinal plants.

Quinine

Quinine is a naturally occurring alkaloid obtained from the bark of *Cinchona* species (Achan et al., 2011). It has a long history of use in malaria treatment and represents an important example of a plant-derived compound that became an established modern antimalarial medicine (Achan et al., 2011). Its antimalarial activity is associated with interference with haem detoxification in the parasite's digestive vacuole. Quinine acts against the blood stages of malaria parasites, although its use is limited by tolerability concerns, potential adverse effects, and the availability of more convenient treatment regimens (WHO, 2011).

Historically, quinine was widely used for treating malaria, including infections caused by *P. falciparum* (WHO, 2011). However, its role has changed with the development of more effective and better-tolerated treatment options (WHO 2018). Quinine is no longer the preferred treatment for most uncomplicated *falciparum* malaria cases where effective ACTs are available (WHO, 2021). It can still be used in selected circumstances, generally in combination with another appropriate medicine, depending on clinical guidance and the availability of preferred treatments (CDC, 2026; WHO, 2025).

Quinine is particularly relevant to ethnobotanical research because it illustrates how the investigation of plants can contribute to the discovery and development of medicines. Its plant origin demonstrates that natural products can provide valuable starting points for pharmaceutical research. Nevertheless, the medicinal value of one plant-derived compound cannot be generalized to other plant species without experimental evidence

Artemisinin-Based Combination Therapies

Artemisinin-based combination therapies (ACTs) are the principal recommended medicines for treating uncomplicated *P. falciparum* malaria (WHO, 2025). These medicines combine an artemisinin derivative with a partner drug that has a different mechanism of action (WHO, 2023). Commonly recommended ACTs include artemether-lumefantrine, artesunate-amodiaquine, dihydroartemisinin-piperaquine, artesunate-mefloquine, and artesunate-pyronaridine (WHO, 2025). The combination of two antimalarial agents improves parasite clearance and reduces the likelihood that parasites surviving treatment with one component will develop into a resistant population (WHO, 2025). WHO recommends that ACT regimens provide three days of treatment with an artemisinin derivative (WHO, 2025).

Artemisinin derivatives act rapidly against blood-stage malaria parasites, substantially reducing parasite numbers during the initial phase of treatment (Makanga et al., 2006). The partner drug then eliminates the remaining parasites, increasing the likelihood of a complete parasitological cure (Makanga et al., 2006). This complementary action makes ACTs highly effective against uncomplicated *falciparum* malaria when the medicines are appropriately selected, correctly administered, and remain effective against circulating parasites (Makanga et al., 2006). However, their effectiveness can be compromised by incomplete treatment, poor-quality medicines, inadequate drug exposure, and the emergence of antimalarial drug resistance (WHO, 2025).

Artemisinin was developed from research on *Artemisia annua*, a plant used in traditional Chinese medicine (Makanga et al., 2006). Its subsequent development into an effective antimalarial compound illustrates the potential contribution of medicinal plants to modern drug discovery (WHO, 2010). Nevertheless, the effectiveness of purified artemisinin derivatives should not be taken as evidence that crude herbal preparations containing potentially related compounds will provide equivalent therapeutic benefits (WHO, 2010). WHO does not recommend using *Artemisia* plant material, including teas, tablets, or capsules, as a substitute for recommended antimalarial medicines (WHO, 2026). The development of artemisinin-based medicines is relevant to the present study because it demonstrates the scientific value of investigating plants with a history of medicinal use.

The continued importance of malaria in Uganda and antimalarial drug resistance to the modern medicines (WHO, 2023) coupled with reliance on traditional health care (WHO, 2017), provide a public health context for investigating traditional medicinal plants used by communities such as those in Serere District. Documenting these plants, the parts used, methods of preparation, and routes of administration helps establish an evidence base for understanding local malaria management practices. However, documenting traditional use and demonstrating laboratory antiparasmodial activity are distinct research activities. The former establishes ethnobotanical knowledge, whereas the latter provides preliminary experimental evidence of biological activity adding to plants pharmacological relevance.

CHAPTER THREE

MATERIALS AND METHODS

3.1 The study area

Serere District lies approximately between Latitude: 1° 29' 59.99" N and Longitude: 33° 32' 59.99" E and at an elevation of 1065.95 meters (3497.21 feet) above sea level (UBOS, 2014). It covers a total land area of 1,965.4 km² (758.8 sq. mi) and an estimated population of 285,903 according to the National Housing and Population Census 2014. It's found in Eastern Uganda and takes its name from Serere County, which also serves as the administrative headquarters. The district was created through an Act of Parliament and officially began operations on July 1, 2010. Originally part of Soroti District, Serere now belongs to the Teso sub-region as an independent administrative unit. It is bordered by Buyende to the south, Pallisa to the southeast, Soroti to the northeast, Kaberamaido to the north, and Ngora to the east.

The district is organized into two counties Kasilo and Serere alongside eight sub-counties, two town councils, 31 rural parishes, and 208 villages. Serere District was chosen as the focus area for this study because: (1) it is among the top 10 districts in Uganda with the highest malaria infection rate (63.7%) (MOH, 2023), indicating a high disease burden and potential reliance on traditional medicine; (2) the district has documented evidence of medicinal plant use (Okot et al., 2020), suggesting a rich and accessible ethnobotanical knowledge base; and (3) its proximity to Gulu University facilitated sample transportation and laboratory analysis.

The district's climate is influenced by extensive swamp areas surrounding it. Rainfall occurs mainly in two seasons March to July and September to November averaging between 1000 mm and 1500 mm annually. Peaks are observed in April–May and August–October, while June records a minimum. December and January are typically the driest months. Serere experiences a mean annual maximum temperature of about 31.3°C and a minimum of around 18°C. The district is also notable for its reliance on medicinal plant species, which local herbalists employ in treating conditions such as snakebite envenomation (Okot et al., 2020).

According to the 2014 National Housing and Population Census (NPHC), Serere District had 285,903 residents, comprising 139,493 males and 146,410 females (UBOS, 2014). Of the total households, 22.5% lived in dwellings with permanent roofing, 13.2% in semi-permanent

structures, while the majority—73.3%—occupied temporary housing units. About 15,627 households (32.7%) were located five kilometers or more from the nearest health facility, whether public or private. In contrast, 43,495 households (91.1%) reported owning at least one mosquito net. Agriculture dominates household livelihoods, with 93.9% of families engaged in crop cultivation or livestock farming (UBOS, 2014).

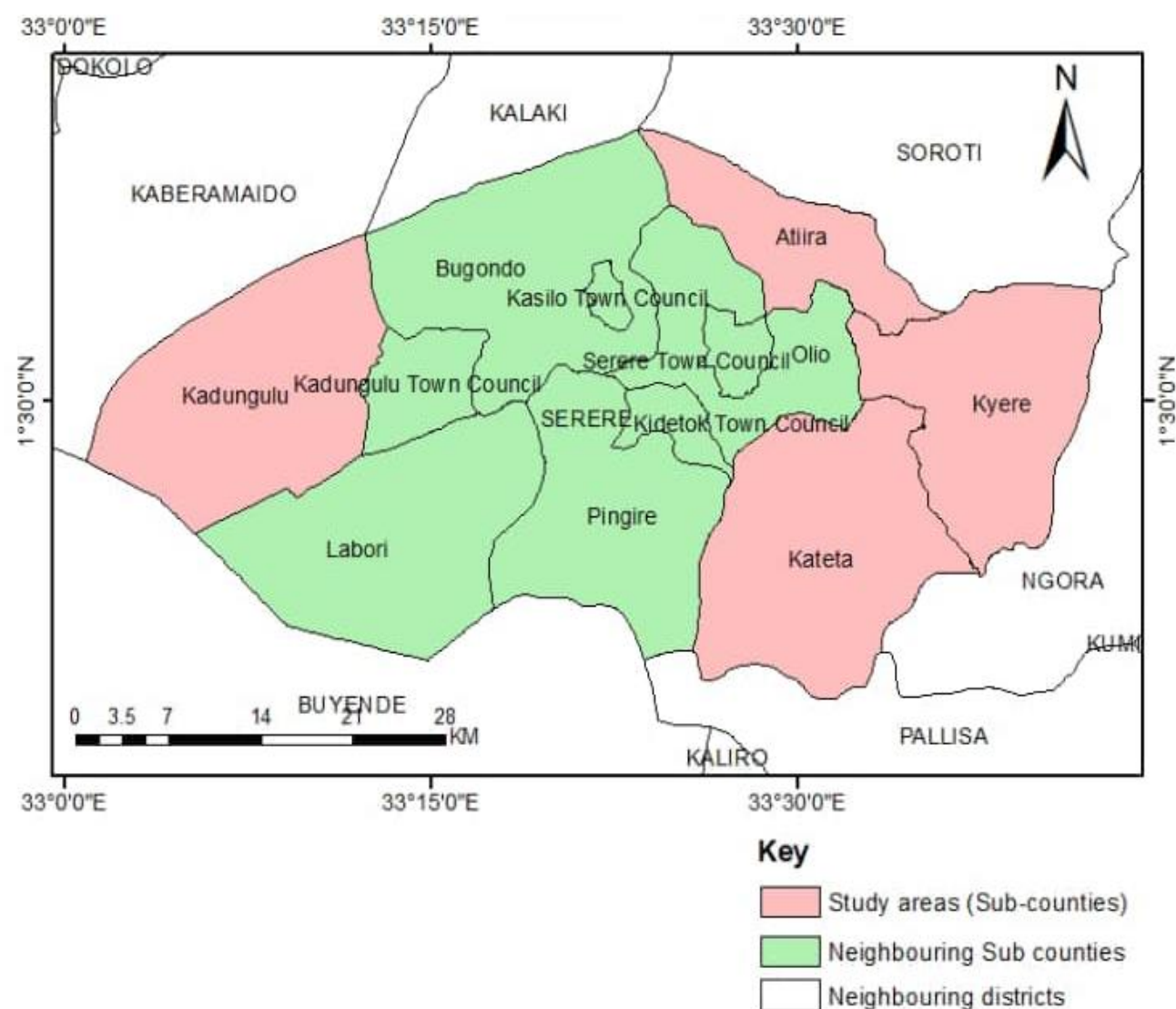


Figure 3. 1: Map of Serere district showing the study area

3.2. The study population

The study population was made up of the target and accessible population. The target population was all adults residing in Serere district, while the accessible population was adults residing in Serere district who use or deal in traditional medicines for managing malaria.

3.3 The Research design and sampling

The study used cross-sectional and experimental study designs, which aided in the collection of both quantitative and qualitative data. Cross-sectional study design has previously been used in ethnobotanical study of antimalarial herbs (Tabuti et al., 2023), where data on plant species used for management of malaria, parts used as well as the mode of preparation and administration was gathered. A semi-structured questionnaire translated into the local language (Ateso) was given to the accessible population. A completely randomized experimental design (CRD) was used in the assessment of the extracts and phytochemicals in the identified plant species with the highest citation, as well as the potency of the extracts in the management of malarial parasites, as previously done in Kenya (Waiganjo et al., 2020). It involved administration of diluted crude extracts, positive and negative controls into the culture wells containing 1% parasitemia and 2% hematocrit to test for antiparasitic activity, this was carried out in Gulu University Multifunctional Research Laboratories.

The study population was selected using a multistage sampling technique. First, four sub-counties were randomly selected from the list of 8 sub-counties and 2 town councils found in Serere district. In each of the four sub-counties/town councils, three parishes and/or wards were selected randomly making a total of 12 parishes and/or wards. From each parish or ward, 3 villages or cells were picked totaling 36 villages or cells. Informants were persons of 18 years and above who are legally adults according to the law of Uganda. This implied about 12 participants were interviewed per village or cell. The participants were sampled using the snowball sampling method which involved referral so that only the rightful respondents are interviewed. Snowball sampling was chosen because traditional healers and knowledgeable elders are not readily identifiable through random household sampling. This method relies on peer referral to access individuals with specialized knowledge, ensuring the information collected is from credible and experienced informants.

3.4 Inclusion and exclusion criteria

The inclusion criteria were an adult who had experience with the use of herbal medicine for treating malaria. Long-term residence of the informants in the study area of about 10 years and above, consent and voluntary participation. However, whoever had knowledge of herbal medicine for treating malaria but is unwilling to consent were left out.

3.5 Sample size determination

The sample size in this study was determined using formula according to Kish Leslie (1965):

$$n = \frac{Z^2 p(1-p)}{e^2}$$

n = sample size required

Z = 1.96 parameter standard at = 0.05 and 95% confidence interval for a normal distribution curve.

p = prevalence of users of herbs for treating malaria in Serere district. Since this is not known, a prevalence rate of 50% was assumed to be used in sample size calculation

e = precision at 5 % (standard value of 0.05)

$$n = \frac{1.96 \times 1.96 \times 0.5}{0.05 \times 0.05}$$

$$n = \frac{1.96 \times 1.96 \times 0.25}{0.0025}$$

$$n = \frac{0.9604}{0.0025}$$

$$n = 384$$

To account for a possible 10% non-response rate, the initially calculated sample size was increased by 10%, resulting in a final total of 422 participants. A prevalence value (*p*) of 50% was applied, following the recommendation of Kish and Leslie (1965) for studies where the actual proportion of the population with the characteristic of interest—such as expert knowledge of antimalarial herbs is unknown. This approach ensures the largest and most conservative sample size estimate.

3.6. Ethical considerations

- i. The study protocol was approved by the Research and Ethics Committee of Gulu University (GUREC -2024-991) before the commencement of data collection.
- ii. Permission from the district local government that is, the chief administrative officer of Serere district, District Health Officer and Sub-county chiefs of Serere district to carry out this study in the community was obtained, and meetings with the local authorities were held prior to the survey.

- iii. Permission was sought from the In-charge Multi-purpose Science Laboratory at Gulu University to use the laboratory.
- iv. Before the questionnaires were administered, all eligible participants were briefed in the local language (Ateso) about the study's objectives, procedures, potential risks, and expected benefits. This ensured that informed consent was properly obtained.
- v. Throughout data collection, participants' privacy was safeguarded, and confidentiality of their information was strictly maintained. To reinforce confidentiality, personal identifiers such as names and telephone numbers were deliberately excluded from the records.
- vi. Prior Informed Consent (PIC) was obtained from knowledge holders for the publication of this data. In accordance with the Nagoya Protocol on Access and Benefit-Sharing, the researcher committed to collaborating with the herbalists and the local community in the event that any patentable product or commercial application arises from this knowledge, ensuring fair and equitable sharing of benefits.

3.7 Data collection

The semi-structured questionnaire was used to collect the data for the ethnobotanical survey. Both quantitative and qualitative data were collected. Qualitative data about screening for phytochemicals with known antiplasmodial activity was recorded. Pertaining to the assessment of the efficacy of the most commonly used medicinal plants for malaria treatment, only quantitative data was collected. All the data collected was recorded in the data sheets.

3.7.1 Survey of medicinal plants used for treatment of malaria and assessment of knowledge of malaria

A Semi-structured questionnaire expressed in Ateso, the primary or main language spoken in Serere district, was used to collect ethnobotanical data, socio-demographic characteristics of the people which also included people's knowledge about malaria symptoms. The questionnaire included questions on the respondent's personal information, knowledge of the symptoms of malaria, plant species used, harvested part, preparation of the herbal concoction, route of administration and dosage of malaria traditional medicines, habitat and availability of the mentioned plant species. Questions on the control and treatment measures for malaria in Serere district were also included. Prior to the survey, meetings with the local leaders were conducted at every study site to inform them about the aim and objective of the study and to request for their permission to conduct the study in their communities. The respondents were

selected using snowballing techniques such that only rightful people are given the questionnaire.

Plants reported by respondents were identified during guided field walks conducted together with the informants and species nomenclature were verified using the Plants of the World Online (POWO) database (<https://powo.science.kew.org>). Voucher specimens of each plant species were prepared and deposited at the Makerere University Herbarium.

3.8 Analysis for phytochemicals with known antiplasmodial activity

3.8.1 Collection and preparation of plant materials

The plant materials were collected from their natural habitat in the area of study. Plant parts used for remedy preparation were harvested and gently cleaned to remove soil or debris. They were then air-dried under shade at room temperature in the laboratory for ten days. Once dried, materials such as bark and roots were ground into fine powder using an electric grinder. The resulting powder was sieved to ensure uniform texture. Prepared samples were packed in plastic bags, wrapped in aluminum foil, and stored for later use.

3.8.2 Extraction method

Crude extracts were obtained using a method adapted from Waiganjo et al. (2020). For aqueous extraction, 100 grams of powdered plant material were placed into clean, labeled beakers with a capacity of 1000 ml. This hot aqueous extraction method was chosen to simulate the traditional preparation of herbal remedies (decoctions) as reported by informants during the ethnobotanical survey, thereby increasing the ethnopharmacological relevance of the subsequent *in vitro* assays (Waiganjo et al., 2020). The mixtures were first passed through Whatman No. 1 filter paper to remove solid residues. They were then subjected to freeze-drying for a period of 48 hours. After drying, the extracts were placed into clean, dry, pre-weighed universal bottles. The percentage yield of each extract was subsequently calculated using the appropriate formula: $W_1 \div W_0 \times 100\%$ where W_1 is the weight of the extract after extraction, W_0 is the weight of the sample after drying. Samples were stored at -20° C in a freezer until use.

3.8.3 Screening for Phytochemicals

Screening for phytochemicals was done for small aqueous proportions of each plant extract as per the standard method (Shaikh & Patil, 2020).

Test for alkaloids (Wagner's test)

Two milliliters of extract were treated with two drops of Wagner's reagent along the sides of the test tube. The formation of a brown or reddish precipitate confirmed the presence of alkaloids.

Test for Flavonoids (Alkaline Reagent Test)

One milliliter of extract was mixed with 2 ml of 2% NaOH solution. The appearance of an intense yellow color that disappeared upon addition of dilute HCl indicated flavonoids.

Test for Phenolic Compounds (Ferric Chloride Test)

To 1 ml of the aqueous extract, three drops of 5% ferric chloride solution were added. A dark green to black coloration signified the presence of phenolic compounds.

Test for Tannins (Braymer's Test)

One milliliter of extract was combined with 3 ml of distilled water and three drops of 10% ferric chloride solution. A blue-green color confirmed tannins.

Test for Terpenoids

Two milliliters of chloroform were mixed with 5 ml of plant extract and evaporated on a water bath. The residue was treated with 3 ml of concentrated H₂SO₄ and heated further. A grey solution indicated terpenoids.

Test for Anthraquinones (Borntrager's Test)

Two milliliters of extract were shaken vigorously with 10 ml of 10% ammonia solution for 30 seconds. A pink, violet, or red coloration revealed anthraquinones

Test for Coumarins (NaOH test)

To 2mL of Plant extract, 10% NaOH and 2mL of Chloroform was added, appearance of yellow color indicated the presence of Coumarins.

Test for Saponins

One gram of each extract was dissolved in 5 ml of distilled water, boiled, and filtered. The filtrate was then mixed with 3 ml of distilled water and shaken vigorously. Persistent frothing after boiling indicated the presence of saponins.

3.9. In vitro antiplasmodial activity

3.9.1 Preparation of extract stock solutions

Stock solutions of crude extracts were prepared following Waiganjo et al. (2020), with slight modifications. 60mg of concentrated crude extract was dissolved in sterile deionized water to make a 200ml final volume at a concentration of 300µg/ml and passed through 0.22µm membrane filters under aseptic conditions in a laminar flow hood. This was repeated for every crude extract from each plant species. Stock solutions of coartem (as positive controls) was also prepared by dissolving in 0.02% Dimethyl sulfoxide (DMSO). Stock solutions were diluted in the culture medium RPMI 1640 to the required concentrations of 5, 15 and 50µg/ml for use. Briefly, a 1:6 dilution of the stock solution yielded 50µg/ml solution, subsequently, a 1:3.33 dilution of the 50µg/ml solution produced 15µg/ml, which was further diluted at 1:3 to obtain 5µg/ml. This serial dilution approach was employed to enhance pipetting accuracy and ensure consistency across experimental replicates. All the stock drugs were stored at -20° C and retrieved only during use.

3.9.2 *Plasmodium falciparum* parasite culture

The culturing process followed protocol according to Methods in Malaria Research document (Kristen et al., 2013), with slight modifications. This was divided into two stages that is thawing of Parasites and the maintenance of the plasmodium culture. All the reagents were sterilized since the culture process is very sensitive to contamination and the whole process was done in a biosafety level II cabinet (hood). The parasite for culturing was obtained from Gulu University multifunctional laboratory.

3.9.2.1 The process of thawing

The cryopreserved tube containing the parasite was picked from -80°C, placed in ice and transferred quickly to 37°C incubator to thaw for 2 minutes. The content which was in the cryotube was then transferred into a 15ml falcon tube and then followed by the addition of 0.2ml of 12% NaCl dropwise to each 1ml of material while swirling and then left to sit for 5 minutes at 37°C. Furthermore, 9 ml of 1.6% NaCl was added slowly down the side of the tube and mixed 1-2 times using a sterilized pipette then left to stand for 2 minutes at 37°C. Centrifuging at 800 rcf for 5 minutes was done to remove supernatant leaving behind the entire pellet. 9 ml of 0.9% NaCl / 0.2% Dextrose was added slowly down the side of the tube and mixed gently with a pipette to resuspend followed by centrifuging at 800 rcf for 5 minutes at room temperature. The supernatant was then aspirated and pellet suspended with 9

ml of complete medium RPMI 1640 (RPMI containing half albumax- half AB serum, and sodium bicarbonate). The solution was added to a standard 75ml tissue culture flask and followed by 0.3 ml of fresh-washed packed red blood cells. The contents in the tissue culture dish were gassed with 1% O₂, 5% CO₂, and balanced nitrogen for 1 minute and swiftly tightly closed and incubated at 37°C.

3.9.2.2 Maintenance of *plasmodium falciparum* tissue culture

The parasite cell culture was maintained every other day by adding RPMI 1640 complete medium and fresh red blood cells (group O⁺). Parasitaemia and hematocrit of the culture was monitored daily to determine the rate of growth of the parasite by making a smear of the culture with Giemsa.

The detailed method was as follows;

The culture was transferred into a 15 ml conical tube, and a 0.1 ml aliquot was set aside for thin smear preparation. The remaining culture was centrifuged at 400 g for five minutes, after which the supernatant was removed, leaving the pellet. The pellet volume was measured to determine the amount of red blood cells required. For instance, if the culture volume was 5 ml, the RBC volume to be added was calculated as 0.1 ml – pellet volume = RBC × 2 ml. The appropriate amount of RPMI complete medium was added, and to synchronize parasites at the ring stage, 5% sorbitol (w/v) was introduced. The mixture was gassed with a special gas blend for one minute and incubated at 37°C.

Giemsa staining of thin blood film from culture

The 0.1ml of *plasmodium* culture which was kept was centrifuged for 30 seconds, supernatant was aspirated and a drop of the pellet was placed on a clean pre-labelled slide. The thin film was air dried then fixed in methanol for about 5 seconds and left to air dry. Freshly prepared Giemsa solution was used to stain for 15-20 minutes. The slide was then rinsed thoroughly under running tap water and then left to air dry at an upright position until ready for viewing. The film was observed using a microscope with immersion oil and objective 100x.

3.9.3 In vitro antiplasmodial bioassay

The assay was conducted following Nafuka (2014) with minor modifications. Experiments were performed in triplicate using 96-well plates, with incubation periods of 24 and 48 hours. Three concentrations of the selected plant extracts—5, 15, and 50 µg/ml—were tested. A

solution containing 0.5% DMSO in RPMI 1640 medium served as the negative control, while Coartem was used as the positive control. *Plasmodium falciparum* cultures were adjusted to 1% parasitaemia and 2% hematocrit, then thoroughly mixed under biosafety level II conditions. From this suspension, 100 μ l was dispensed into pre-labelled 1 ml centrifuge tubes, followed by the addition of the required extract concentrations from working solutions: 20 μ l of 30 μ g/ml working solution for 5 μ g/ml concentration, 20 μ l of 90 μ g/ml working solution for 15 μ g/ml concentration, and 20 μ l of 200 μ g/ml working solution for 50 μ g/ml concentration. The prepared 96-well plates were placed in a gas chamber, flushed with a specialized gas mixture for five minutes, and subsequently incubated at 37°C for 24 and 48 hours. Observation was done after 24 hours to assess for early antiplasmodial effect and after 48 hours to assess antiplasmodial effect where the parasite would have completed asexual erythrocytic development cycle (Tuteja, 2007).

3.9.4 Assessment of the antiplasmodial assay by microscopy

The average percentage of parasitaemia after 24 and 48 hours of incubation at 37°C with plant extracts and control treatment was analyzed by microscopy as previously done by Nafuka (2014) with slight modifications. To minimize observer bias, all slides were coded by a second individual before microscopy. The microscopist was therefore blinded to the treatment group (extract type, concentration, or control) during counting. Parasitaemia was determined by counting the number of infected erythrocytes per 1,000 erythrocytes in at least 5 random microscopic fields on each slide. The average parasitaemia for the three technical replicates was calculated. Parasitaemia was expressed as the percentage of the total number of infected erythrocytes over the total number of erythrocytes for each smear. The average parasitaemia of the three replicates was calculated and recorded. This was repeated for all three different plant extracts and the controls. To estimate the half maximal inhibitory concentration (IC_{50}) of the plant extracts after 48 hours of exposure, the interpolation method was used. Percentage inhibition values obtained at different extract concentrations were examined to identify two concentrations that produced inhibition responses immediately below and above 50%. The IC_{50} value was then estimated by determining the concentration corresponding to 50% inhibition between these two adjacent response points, assuming a linear relationship within that interval (Irwanto et al., 2025; Joseph, 2026).

3.10 Data analysis

Data obtained was fed into Microsoft Excel, sorted, and exported into SPSS software version 20 for further analysis. Ethnobotanical information of plant species used, part of plant harvested, preparation method, mode of administration, dosage and the respondents' socio-demographic characteristics were summarized using descriptive statistical measures, including percentages and frequencies and data was presented in the form of tables and figures. One-way analysis of variance (ANOVA) was used to compare the mean percentage parasitaemia between the different extract treatments and the controls (negative and positive) at each time point (24 and 48 hours). Where significant differences were found ($p < 0.05$), Dunnett-t post-hoc test was done for multiple pairwise comparisons. The 50% inhibition concentration (IC₅₀) of the extracts was as well determined to estimate the potency of the crude extract a fifty percent inhibition level.

CHAPTER FOUR: PRESENTATION AND INTERPRETATION OF RESULTS

4.1 Socio-demographic characteristics of the study participants

Table 4.1 shows the background characteristics of the respondents. Slightly more than half of the participants were male (n = 193, 53.3%), while females constituted (n = 169, 46.7%), indicating a fairly balanced gender distribution. Regarding age, the largest proportion of respondents were aged 18–30 years (n = 94, 26.0%), followed by those aged 31–40 years (n = 82, 22.7%) and 41–50 years (n = 79, 21.8%), suggesting that most participants were in their economically active age groups; however, a notable proportion were aged above 60 years (n = 57, 15.7%). In terms of education level, the majority of respondents had attained primary education (n = 226, 62.4%), while some had secondary education (n = 79, 21.8%); only a small fraction had tertiary education (n = 14, 3.9%), and a notable proportion had never attended school (n = 43, 11.9%). Overall, these findings indicate a predominantly adult population with low to moderate levels of formal education, which may influence access to information and utilization of health services.

Table 4. 1: Background characteristics of study participants (n=362)

Variable	Number	Percent
Gender of the respondents		
Male	193	53.3
Female	169	46.7
Age of the respondents		
18-30	94	26.0
31-40	82	22.7
41-50	79	21.8
51-60	50	13.8
Above 60	57	15.7
Education level of the respondents		
Never went to school	43	11.9
Primary	226	62.4
Secondary	79	21.8
Tertiary	14	3.9

The predominance of respondents with primary education (62.4%) and those never attending school (11.9%) may explain the heavy reliance on oral tradition and indigenous knowledge for malaria management among the respondents, rather than formal health education channels.

4.1.1 Knowledge of malaria symptoms among the respondents

As shown in Figure 4.3, headache was the most commonly reported malaria symptom (n = 322, 89.69%), followed by fever (n = 261, 72.70%) and vomiting (n = 251, 69.92%). A considerable proportion of respondents also reported muscle pain (n = 235, 65.46%) and shivering (n = 221, 61.56%), while more than half experienced diarrhoea (n = 198, 55.15%). In contrast, relatively fewer respondents reported symptoms associated with more severe manifestations of malaria, including fatigue (n = 68, 18.94%), organ failure (n = 65, 18.11%), confusion (n = 57, 15.88%), anaemia (n = 54, 15.04%), and jaundice (n = 45, 12.53%). The findings suggest that while common acute symptoms of malaria were widely experienced, severe or complicated symptoms were reported by a smaller proportion of respondents. Overall knowledge of malaria and its symptoms is well spread among the community.

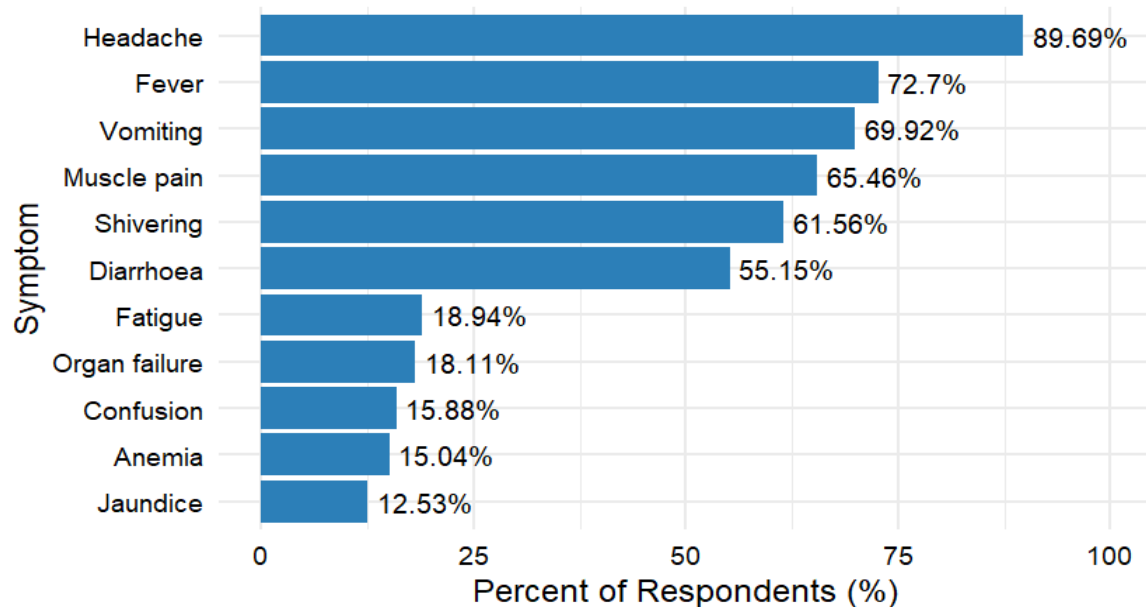


Figure 4. 1: Reported Malaria symptoms

Symptoms reporting by sociodemographic

Basing on the findings, there were no statistically significant sociodemographic factors associated with symptom reporting among the respondents, ($p > 0.05$).

Table 4. 2: Symptom reporting by sociodemographic characteristics

Variable	Category	Symptom reporting		χ^2 (p-value)
		No n (%)	Yes n (%)	
Gender of the respondents	Male	106 (55.8)	87 (50.6)	0.98(0.321)
	Female	84 (44.2)	85 (49.4)	
Age of the respondents	18–30	55 (28.9)	39 (22.7)	4.98(0.288)
	31–40	43 (22.6)	39 (22.7)	
	41–50	34 (17.9)	45 (26.2)	
	51–60	25 (13.2)	25 (14.5)	
	Above 60	33 (17.4)	24 (14.0)	
Education level of the respondents	Never went to school	25 (13.2)	18 (10.5)	3.17(0.366)
	Primary	111 (58.4)	115 (66.9)	
	Secondary	47 (24.7)	32 (18.6)	
	Tertiary	7 (3.7)	7 (4.1)	

4.2 Ethnobotanical inventory of medicinal plants used by local people for the management of malaria in Serere district, and their method of preparation and route of administration

A total of 55 malaria treatment plant species that belong to 31 families were documented and botanically identified with their common and scientific names (Table 4.3). The most commonly used plant species documented were Knob wood (*Zanthoxylum chalybeum*), 18.09% followed by Golden-shower (*Dolichandra unguis-cati*), 12.29% and African red peach (*Nauclea latifolia*), 8.85% (Table 4.3, image 1, 2 and 3). The parts processed for treatment were either leaves or roots although trunks, seeds and barks were used in the cases of knob wood and shea nut tree. Common method of preparation involved cleaning the plant part, pounding, drying and boiling in water or mixing with hot/warm water. The mode of administration was mainly oral, although steaming was used for *Lantana camara* and *Ocimum gratissimum*, then bathing with for *Annona muricata* and *Psidium guajava*. The dosage differed, starting from one tea spoonful, to ¼ a cup, ½ a cup to one cup which were taken mainly twice a day for two to three days.

Table 4. 3: Plant species used by the local people for the management of malaria, their method of preparation and route of administration in Serere district

Voucher number	Common name	Local Name	Botanical name	Family name	Tall y	%	Parts used	Method of preparation	Route of administration	Dosage
MMP001	Tick berry	Elatana	<i>Lantana camara</i> L.	Verbenaceae	4	0.25	Leaves	Boiling leaves	Steaming	Twice a day
MMP002	Conker berry or bush plum	Emuriei	<i>Carissa spinarum</i> L.	Apocynaceae	131	8.34	Roots, leaves	Pound, soak with hot water	Drink	½ a cup - adult, Spoon -child, 3 days+ 1/4 cup
MMP003	Clove basil or African basil	Emoping	<i>Ocimum gratissimum</i> L.	Lamiaceae	82	5.22	Roots, leaves	Wash and pound, then mix with boiled water, boiling	Drink, steaming	½ a cup - adult, Spoon -child 3 times a day
MMP004	Camel's foot tree/monkey bread	Epapai/ Ebwolo	<i>Piliostigma thonningii</i> (Schumach)	Fabaceae	13	0.83	Root	Peel, wash and pound then mix with hot water	Drink	½ a cup- adult, 2 spoons - child, 3 times a day
MMP005	Paperback thorn	Etirir	<i>Vachellia sieberiana</i> (DC.) Kyal. And Boatwr	Fabaceae	53	3.38	Roots	Clean, pound, mix with hot water	Drink	1 time a day
MMP006	Sickle bush tree	Ekisim	<i>Dichrostachys cinerea</i> (L.) Wight & Arn.	Fabaceae	68	4.33	Roots, leaves	Pound, dry, soak in hot water, boiling	Drinking, steaming	1 cup -adult, spoonful - child, 2 times a day for 3 days

Voucher number	Common name	Local Name	Botanical name	Family name	Tall y	%	Parts used	Method of preparation	Route of administration	Dosage
MMP007	Porknut or longspine acacia	Egirigiro roi	<i>Vachellia macracantha</i> (Humb. & Bonpl. Ex Wild.) Seigler & Ebinga	Fabaceae	2	0.13	Roots	Peel the bark, pound and mix with warm water	Drink	½ a cup, three times a day for two days
MMP008	Tropical almond	Ekaka	<i>Terminalia catappa</i> L.	Combretaceae	3	0.19	Roots	Wash, pond and boil	Drink	1 cup, 3 times a day
MMP009	Soursop	Epenesi	<i>Annona muricata</i> L.	Annonaceae	3	0.19	Leaves	Pound and soak with hot water	Use for bathing	1 tea spoonful
MMP010	Lemon	Enimu	<i>Citrus x limon</i> (Christm) Swingle	Rutaceae	25	1.59	Roots	Dry, pound, soak with water	Drink	1 tea spoonful-child, 1cup-adult, 3 days +
MMP011	Rough blue grass	Edinyo	<i>Poa trivialis</i> L.	Poaceae	1	0.06	Roots	Pound and mix with hot water	drink	2 cups per day
MMP012	Mango	Emyebe	<i>Mangifera indica</i> L.	Anacardiaceae	7	0.45	Roots	Boiling	Oral	2 cups per day
MMP013	Blackjack	Enyikim ony	<i>Bidens pilosa</i> L.	Asteraceae	3	0.19	Leaves	Boiling	Oral	½ a cup
MMP014	Barbados nut	Ejumula	<i>Jatropha curcas</i> L.	Euphorbiaceae	1	0.06	Roots	Pound, mix with hot water	Drink	¼ a cup three times a day
MMP015	Avocado	Evakedo	<i>Persea Americana</i> Mill.	Lauraceae	26	1.66	Roots, leaves	Pound and use warm water	Drink	½ cup/1 cup, 3 times a day

Voucher number	Common name	Local Name	Botanical name	Family name	Tall y	%	Parts used	Method of preparation	Route of administration	Dosage
MMP016	Weeping bushwillow	Ekulony	<i>Combretum collinum</i> Fresen.	Combretaceae	6	0.38	Roots	Dig and pound then mix with hot water	Drink	½ a cup twice a day
MMP017	Jackal jujube	Ekodoko doi	<i>Ziziphus oenopolia</i> (L.) Mill.	Rhamnaceae	1	0.06	Roots	Pound and boil	Drink	½ a cup mls twice a day
MMP018	Persian silk tree	Eteka	<i>Albizia julibrissin</i> Durazz.	Fabaceae	12	0.76	Roots	Wash, pound, mix with hot water then dry	Drink	¼ cup, 3 times a day
MMP019	Apple leaf tree	Ekuworo	<i>Philenoptera violacea</i> (Klotzsch) Schri..	Fabaceae	3	0.19	Roots	Dig, clean, pound and boil with water	Drink	¼ cup, 3 times a day
MMP020	Coral tree	Engosor ot	<i>Erythrina abyssinica</i> Lam.	Fabaceae	10	0.64	Root	Pound and soak with hot water	Drink	¼ a cup, twice a day
MMP021	Lemon grass	Enyait	<i>Cymbopogon citratus</i> (DC.) Stapf	Poaceae	31	1.97	Leaves	Pound and soak with hot water, boil	Drink	1 cup, Twice a day
MMP022	Smutgrass	Ejanit	<i>Sporobolus indicus</i> (L.) R. Br	Poaceae	23	1.46	Roots	Pound, mix with hot water	Oral	1½ spoons three times/day
MMP023	Kassod tree	Egasiya	<i>Senna siamea</i> (Lam.) H.S. Irwinand Barn.	Fabaceae	10	0.64	Roots	Peel, clean, wash with hot water	Drink	¼ a cup ,3 times a day

Voucher number	Common name	Local Name	Botanical name	Family name	Tally	%	Parts used	Method of preparation	Route of administration	Dosage
MMP024	Sickle pod	Elakumare	<i>Senna obtusifolia</i> (L.) H.S. Irwin and Barn.	Fabaceae	1	0.06	Roots	Clean, peel and pound	Drink	1 Spoon-child, 1/4 a cup -adult, twice a day for 3 days
MMP025	Devil's fig	Etulelut	<i>Solanum torvum</i> Sw.	Solanaceae	8	0.51	Roots	Peel, wash, pound and mix with hot water	Drink	1 Spoon-child, 1/4 a cup -adult, twice a day for 3 days
MMP026	Chinaberry tree	Elira	<i>Melia azedarach</i> L.	Mliaceae	10	0.64	Leaves	Pound and boil with hot water, boil	Drink	¼ a cup 3 times a day
MMP027	Neem tree	Enimuturi	<i>Azadirachta indica</i> A. juss.	Mliaceae	65	4.14	Roots, leaves	Wash, pound, boil with water; pound and soak with hot water, boil	Drink	¼ a cup, 2-3 times a day
MMP028	Swamp mahogany	Ekalutusi	<i>Eucalyptus robusta</i> Sm.	Myrtaceae	31	1.97	Roots, leaves	Pound, dry, soak in hot water; pound and soak with hot water, boil	Drink and steaming	½ cup - adult, spoonful child -1/4 cup

Voucher number	Common name	Local Name	Botanical name	Family name	Tall y	%	Parts used	Method of preparation	Route of administration	Dosage
MMP029	Nile tulip or nile trumpet	Emiti	<i>Markhamia lutea</i> (bnth.) K. Schum.	Bignoniaceae	29	1.85	Roots	Wash, pound and mix with hot water in a container	Drink	½ a cup, 3 times a day
MMP030	Pawpaw	Epapali	<i>Carica papaya</i> L.	Caricaceae	4	0.25	Roots	Pound and Boiling	Oral	2 caps per day
MMP031	Guava	Emopera	<i>Psidium guajava</i> L.	Myrtaceae	19	1.21	Roots, leaves	Pound and mix with hot water Pound and soak with hot water, boil	Drink, Bath with, cover body with	¼ cup, 3 times a day.
MMP032	Chili pepper	Emulalu	<i>Capsicum annum</i> L.	Solanaceae	1	0.06	Roots	Pound and mix with hot water	Drink	¼ cup , 2 times a day
MMP033	Knobwood	Eusuk	<i>Zanthoxylum chalybeum</i> Engl.	Rutaceae	284	18.09	Roots, bark, trunk	Pound and mix with warm water, Pound, soak with warm water	Drink	½ cup-adult, 1 spoon - child, for 3 days
MMP034	Blue butterfly	Ekweru/ Ekueru	<i>Rothea myricoides</i> (Hochst.) Steane.	Lamiaceae	47	2.99	Roots, leaves	Clean, pound and mix with warm water; Pound and soak with hot water, boil	Drink, steaming	1-2 times a day, 1 spoon -child or 1/4 cup adult

Voucher number	Common name	Local Name	Botanical name	Family name	Tall y	%	Parts used	Method of preparation	Route of administration	Dosage
MMP035	Shear nut tree	Ekunguru	<i>Vitellaria paradoxa</i> C.F. Gaertn.	Sapotaceae	1	0.06	Trunk	Wash, peel and boil	Oral	½ cup, 3 times a day
MMP036	Green wattle	Egirigiroi	<i>Acacia decurrens</i> (J. C. Wendl.) Willd.	Fabaceae	1	0.06	Roots	Pound	Drink	¼ cup 3 times a day
MMP037	African red peach	Eutdolei	<i>Nauclea latifolia</i> Sm.	Rubiaceae	129	8.85	Roots, leaves	Pound, dry, soak in hot water, boiling	Drink, steaming	½ cup - adult, spoonful - child, 2 times a day
MMP038	Tobacco	Etaaba	<i>Nicotiana tabacum</i> L.	Solanaceae	2	0.13	Roots, leaves	Pound, boil	Drink, steaming	½ cup - adult, spoonful - child 2 times a day
MMP039	Ugandan greenheart or pepper back tree	Emus	<i>Warburgia ugandensis</i> Heirn	Canellaceae	1	0.06	Roots, buck	Clean, Pound and boil	Drink, chew	½ cup - adult, spoonful - child, 3 times a day
MMP040	Carrot tree	Ebusibus i	<i>Steganotaenia araliacea</i> Hochst	Apiaceae	1	0.06	Roots	Pound and soak with hot water	Drink	½ a cup 3 times a day
MMP041	Bois benjion	Ekubui	<i>Terminalia bentzoe</i> (L.) L.f.	Combretaceae	1	0.06	Roots		Oral	½ a cup three times a day
MMP042	Bitter melon	Ebomo	<i>Momordica charantia</i> L.	Cucurbitaceae	5	0.32	Roots	Pound, soak in hot water	Drink	¼ cup Twice a day for 5 days

Voucher number	Common name	Local Name	Botanical name	Family name	Tall y	%	Parts used	Method of preparation	Route of administration	Dosage
MMP043	Yellow plum or sour plum	Elamai	<i>Ximenia Americana</i> L.	Olacaceae	2	0.13	Roots	Pound, soak	Drink, Bath with, Cover body with	½ cup, 2 times a day
MMP044	Java plum	Ejumbul a	<i>Szygium cumini</i> (L.) Skeels	Myrtaceae	2	0.13	Roots	Wash, pound, dry and mix with hot water	Drink with hot water	½ a cup and a child 1 spoon
MMP045	Octopus cabbage tree	Eyileyile	<i>Cussonia arborea</i> Hochst. ex A.Rich.	Araliaceae	3	0.19	Roots	Peel and pound and mix with water	Drink	1 cup, two times a day
MMP046	Moringa tree	Emoring a	<i>Moringa oleifera</i> Lam.	Moringaceae	11	0.7	Leaves	Clean, pound and boil	Drink	½ cup, twice a day
MMP047	Giant granadilla	Emulodo	<i>Passiflora quadrangularis</i> L.	Passifloraceae	131	8.34	Roots	Clean, pound, boil	Drink	½ cup - child, 1 cup adult, 2 times a day
MMP048	Tropical crabgrass	Etangawusi	<i>Digitaria ciliaris</i> (Retz.) Koeler	Poaceae	20	1.27	Roots	Pound and mix with hot water	Drink	½ cup, twice a day
MMP049	gripeweed	Epeduru Lo Didi	<i>Phyllanthus urinaria</i> L.	Phyllanthaceae	4	0.25	Roots	Pound and mix with water	Drink	Half a cup, 2 times a day
MMP050	Aloe vera	Ecucukia	<i>Aloe vera</i>	Asphodelaceae	17	1.08	Leaves	Clean, pound and boil	Drink	½ cup- adult, spoonful – child, twice a day

Voucher number	Common name	Local Name	Botanical name	Family name	Tall y	%	Parts used	Method of preparation	Route of administration	Dosage
MMP051	Elegant dutch man's pipe	Enambawan	<i>Aristolochia littoralis Parodi</i>	Aristolochiaceae	4	0.25	Roots, seeds	Wash, pound and mix with warm water	Drink	1-2 spoons twice a day
MMP052	Bee-bee tree	Etit	<i>Tetradium daniellii</i> (Benn)T.G.Hartley	Rutaceae	2	0.13	Roots	Pound and boil with water	Drink	½ a cup twice a day
MMP053	Heartleaf noseburn	Ekenep	<i>Tragia cordata Michx.</i>	Euphorbiaceae	2	0.13	Roots, leaves	Pound, dry, soak in hot water	Drink	½ cup - adult, spoonful - child, 3 times a day
MMP054	Golden-shower	Asimirri	<i>Dolichandra unguis-cati</i> (L) L.G. Lohmann	Bignoniaceae	193	12.29	Roots	Sun drying, pound and mix with hot water	Drink	1spoon-child, ¼ cup-adult - 2-3 times a day
MMP055	Curious-weed	Omwana kuwan	<i>Schkuhria pinnata</i> (Lam.) Kuntze ex Thell.	Asteraceae	11	0.7	Leaves, seeds	Pound and soak with warm water	Drink	1 spoon, three times a day

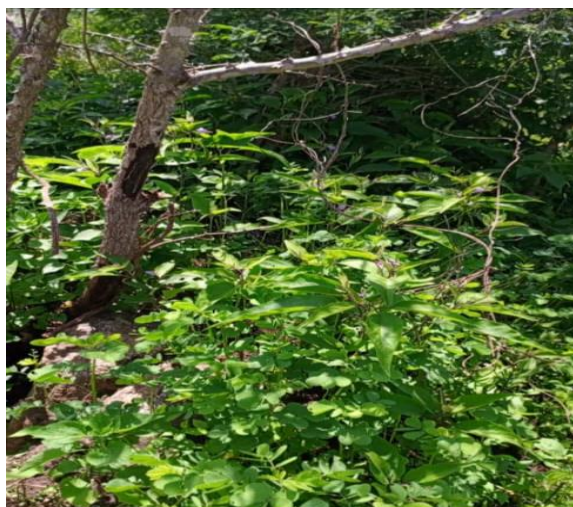


Image 1: Zanthoxylum chalybeum tree drying up



Image 2: Dolichandra unguis cati leaf and roots



Image3: Nauclea Latifolia tree whose root has been harvested and hole not covered

4.2.1 Sources of traditional medicine

The figure 4.2 illustrates the sources of traditional medicine used by respondents for malaria management. The majority of respondents obtained their traditional medicines from semi-wild sources (73.52%), followed by those grown in gardens (58.59%). Medicines harvested from completely wild sources were the least commonly reported, cited by 53.8% of respondents.

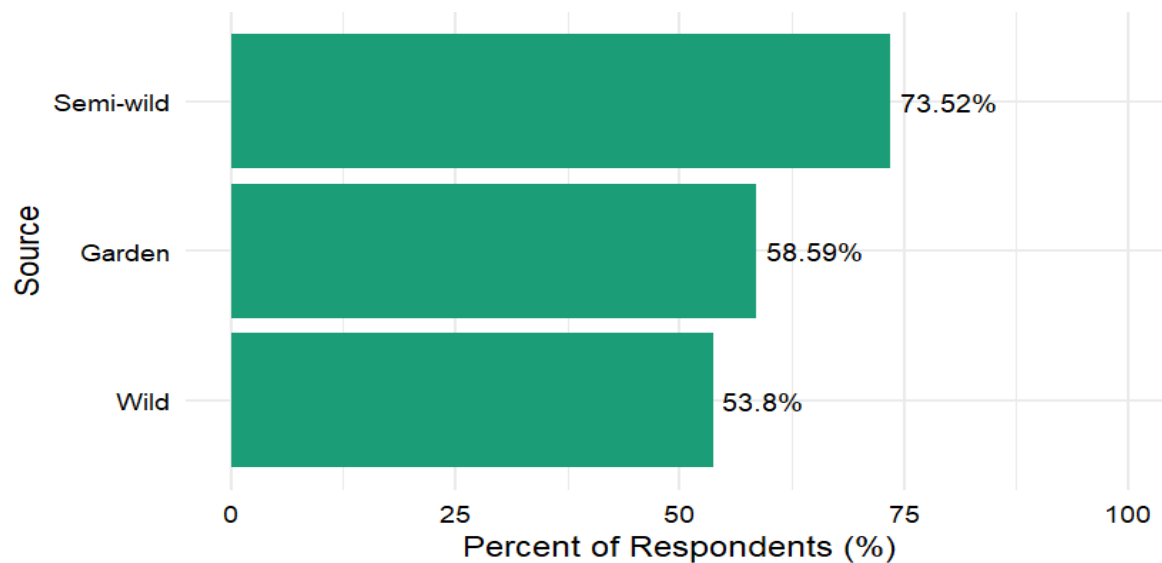


Figure 4. 2: Sources of traditional medicine

4.2.2 Reasons for preferring traditional medicines

The Figure 4.3 shows the reasons respondents preferred traditional medicines for treating malaria. The most commonly reported reason was accessibility, cited by 76.62% of respondents, followed closely by affordability at 72.11%. Effectiveness was also an important consideration, reported by 65.63% of respondents. In contrast, the absence of side effects was less frequently mentioned, with only 35.77% of respondents indicating it as a reason for their preference. Respondents could select more than one reason, so percentages do not sum to 100%.

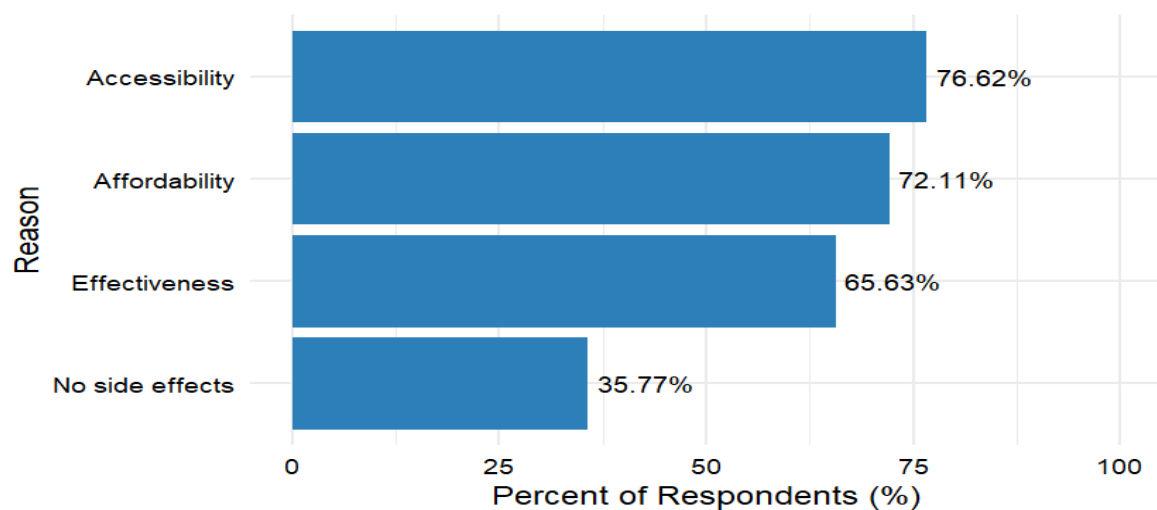


Figure 4. 3: Reasons for preferring traditional medicines

4.2.3 Utilization and reported side effects of traditional medicine among respondents

Table 4.5 has shown that most respondents reported use traditional medicine in combination with other remedies rather than singly (n = 293, 82.3% vs. n = 63, 17.7%). Regarding side effects, a small proportion of respondents experienced adverse effects from traditional medicine (n = 49, 13.8%), with the majority reporting no side effects (n = 306, 86.2%). The duration was typically short for the symptoms experienced to disappear, lasting 3–5 days for most (n = 194, 54.3%), less than 2 days for 43.1% (n = 154), and more than 5 days in very few cases (n = 9, 2.5%).

Table 4. 4: Utilization and reported outcomes among respondents using traditional medicine for malaria

Variable	Number	Percent
Utilization of the medicine		
Singly	63	17.7
Mixed	293	82.3
Side effects of traditional medicine		
Yes	49	13.8
No	306	86.2
Duration it takes for symptoms to disappear		
<2 days	154	43.1
3-5 days	194	54.3
More than 5 days	9	2.5

4.3 Phytochemicals with antiplasmodial activity in the crude extracts of mostly used plant species

Phytochemical classes, alkaloids, phenolics, tannins and coumarins were found in the root bark of all the three plant species analysed, although the level of concentration differed. In addition, flavonoids and saponins were only found in *Zanthoxylum chalybeum* roots and *Nauclea latifolia* roots. Furthermore, terpenoids was only found in *Zanthoxylum chalybeum*. However, Anthraquinones were not found in any of the three plant species analysed (Table 4.5).

Table 4. 5: Phytochemical composition of aqueous extracts of the three most cited antimalarial plants from Serere district

Phytochemical class	Test performed	<i>Zanthoxylum chalybeum</i>	<i>Dolichandra unguis-cati</i>	<i>Nauclea latifolia</i>
Alkaloids	Wagner's test	+++	++	++
Flavonoids	Alkaline reagent test	-	+	+
Phenolics	Ferric chloride test	+++	++	+++
Tannins	Braymer's test	+++	+++	+++
Terpenoids	Salkowski test	+++	-	-
Anthraquinones	Borntrager's test	-	-	-
Coumarins	NaOH test	+	+++	+
Saponins	Froth test	-	++	++

Key: +++ = strong presence; ++ = moderate presence; + = trace presence; - = absent

4.4 In vitro antiplasmodial activity tests of the plant crude extracts

The study analyzed the three extracts, and each extract was compared to the two controls, CO+ve and DMSO-ve, while using the varied dilutions (5, 15 and 50µg/ml) and times (24 and 48 hours).

Figure 4.4 shows the analysis of the in vitro antiplasmodial activity of plant extracts by illustrating mean parasitaemia across varying concentrations and exposure times. Ex MMP033 demonstrates consistently low and stable parasitaemia levels at both 24 and 48 hours, indicating modest potency with minimal concentration-dependent variation. In contrast, Ex MMP037 exhibits pronounced fluctuations, with higher parasitaemia at lower concentrations at 24 hours followed by a marked reduction at higher concentrations and longer exposure, suggesting a clear dose- and time-dependent inhibitory effect. Ex MMP054 shows relatively higher parasitaemia at 48 hours compared to 24 hours across most concentrations, implying weaker or delayed antiplasmodial activity. Overall, the results indicate that Ex MMP033 has the strongest in vitro potency, particularly at low concentrations at all incubation times, compared to Ex MMP037 and Ex MMP054.

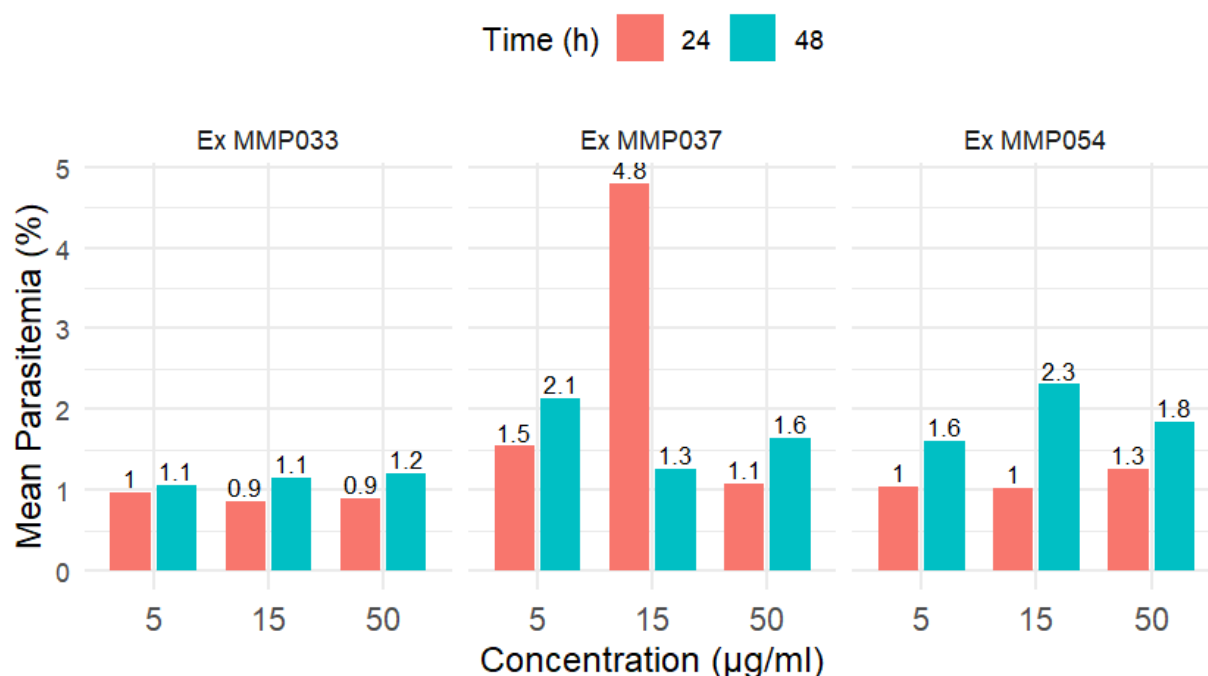


Figure 4. 4: Mean *parasitaemia* across concentrations and times

Table 4.6 indicates that between negative controls (DMSO –ve) and three plant extracts as well as positive control (CO +ve), the findings show that there was statically significant effect on percentage parasitaemia ($p < 0.001$) between DMSO -ve and each treatment (column I). This seems to indicate that the set assays were valid, since negative controls were set without administering any drug treatments.

In addition, the findings show no statistically significant difference between the extracts (MMP033, MMP054, and MMP037) and the positive control ($p > 0.05$) (Table 4.7). These data suggest that the extracts suppressed the growth of the *P.falciparum* parasite, similarly to Coartem. It should be noted that positive controls contained Coartem, the drug used for treatment of uncomplicated malaria caused by *Plasmodium falciparum*.

Table 4. 6: Post Hoc tests using Dunnett-t-tests

(I) Treatments	Control	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
MMP033	DMSO –ve	-3.8096	.17828	p<0.001	-4.2537	-3.3654
MMP054	DMSO –ve	-3.7996	.17828	p<0.001	-4.2437	-3.3554
MMP037	DMSO –ve	-3.8207	.17828	p<0.001	-4.2648	-3.3766
CO+ve	DMSO –ve	-3.8508	.13288	p<0.001	-4.1818	-3.5197
DMSO-ve	CO+ve	3.9057	.23774	p<0.001	3.2899	4.5215
MMP033	CO+ve	.0586	.30072	.999	-0.7203	0.8375
MMP054	CO+ve	.0986	.30072	.995	-0.6803	0.8775
MMP037	CO+ve	-.1097	.30072	.992	-0.8886	0.6692

4.4.1 Interaction of Extract and Concentration over time and setup

Figure 4.5 shows the analysis of the interaction between extract type and concentration across time and experimental setup. Under the positive control and experimental conditions, mean parasitaemia remains consistently low at both 24 and 48 hours across all concentrations, confirming assay validity and indicating effective parasite suppression. In contrast, the DMSO control exhibits markedly higher parasitaemia, particularly at 24 hours. Ex MMP037 showed a pronounced peak at the mid concentration, highlighting the absence of inhibitory activity in the solvent control and a clear concentration–extract interaction. At 48 hours, parasitaemia levels in the DMSO control decrease but remain substantially higher than in the experimental setup, suggesting time-dependent moderation without true antiparasmodial effect.

Overall, the figure demonstrates that the observed reductions in parasitaemia under the experimental condition are attributable to the plant extracts rather than the solvent, with Ex MMP037 showing the greatest variability and concentration sensitivity over time.

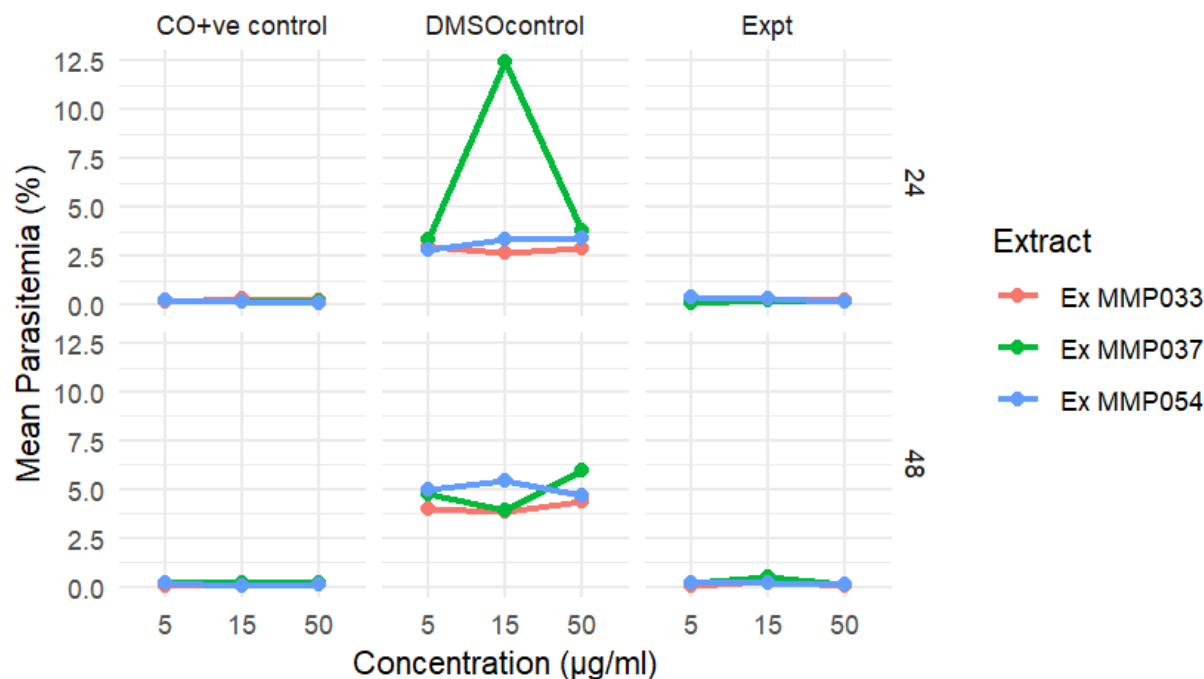


Figure 4. 5: Interaction of Extract and Concentration over time and setup

4.4.2: Factorial ANOVA Analysis for Mean Parasitaemia (%)

A factorial analysis of variance (ANOVA) was employed to examine the effects of experimental setup, extract type, concentration, and exposure time on mean parasitaemia (Table 4.8). Specifically, a four-way factorial ANOVA was used to assess the main effects of each factor as well as their two-way and three-way interaction effects on parasitaemia levels. This analytical approach allowed simultaneous evaluation of individual and combined influences of the study factors while controlling for error variance, with statistical significance assessed at the 5% level ($\alpha = 0.05$).

Table 4.7 shows the analysis of the factorial ANOVA results for mean parasitaemia, indicating that setup had a statistically significant effect on mean parasitaemia ($F(2,118) = 47.33$, $p < 0.001$), implying that differences in experimental conditions strongly influenced parasite levels. In contrast, extract type, concentration, and exposure time were not statistically significant ($p > 0.05$), nor were any of the two-way or three-way interaction effects, suggesting that variations in parasitaemia did not differ significantly across extracts, concentrations, or incubation periods within the experimental context. Although residuals significantly deviated from normality, the consistent non-significance of main and interaction effects indicates that the overall conclusions

regarding extract efficacy remain robust, with observed differences in parasitaemia largely attributable to the experimental setup rather than treatment-related factors.

Table 4. 7: Factorial ANOVA Results for Mean Parasitaemia (%)

Source	df	SS	MS	F	P
Setup	2	554.20	277.12	47.33	< 0.001
Extract	2	14.00	7.00	1.20	0.306
Concentration	2	9.80	4.88	0.83	0.437
Time (h)	1	0.05	0.05	0.01	0.929
Extract × Concentration	4	15.80	3.95	0.67	0.611
Extract × Time	2	8.70	4.33	0.74	0.480
Concentration × Time	2	10.40	5.19	0.89	0.415
Extract × Concentration × Time	4	23.40	5.85	1.00	0.411
Error	118	690.90	5.86	—	—

Note. SS = Sum of Squares; MS = Mean Square. Significance level set at $\alpha = 0.05$. Residuals deviated significantly from normality (Shapiro–Wilk test: $W = 0.36$, $p < 0.001$).

Table 4.8, shows that the in vitro antiplasmodial activity of the tested plant extracts against *Plasmodium falciparum* after 48 hours of exposure varied in both potency and consistency. *Z. chalybeum* exhibited strong and consistent activity across all concentrations, with parasitaemia around 1% and inhibition of approximately 77–78%, corresponding to a low IC_{50} of 3.18 $\mu\text{g/mL}$, indicating high antiplasmodial potency. *D. unguis-cati* showed moderate but relatively consistent activity, with parasitaemia ranging from 1.33–1.53%, inhibition between 66.9–71.3%, and an IC_{50} of 4.07 $\mu\text{g/mL}$. *N. latifolia* demonstrated more variable efficacy, with parasitaemia and inhibition fluctuating across concentrations (34.5–70.7% inhibition) and a higher IC_{50} of 8.41 $\mu\text{g/mL}$, reflecting moderate antiplasmodial activity. The positive control, Coartem, showed the highest inhibition (95–96%) and the lowest IC_{50} (0.62 $\mu\text{g/mL}$), validating the assay, while the negative control (DMSO) exhibited no inhibition (0%) as expected. The experimental extract labeled “Expt” demonstrated very strong activity with IC_{50} (0.91 $\mu\text{g/mL}$), achieving 92–96% inhibition and an IC_{50} of 0.91 $\mu\text{g/mL}$, suggesting it is highly effective against *P. falciparum*. Overall, *Z. chalybeum* and the Expt extract are the most promising for further antimalarial investigation, whereas *N. latifolia* shows moderate and less consistent activity.

Table 4. 8: In vitro antiplasmodial activity of plant extracts against *P. falciparum* after 48 hours exposure

Extract	Concentration (µg/mL)	Parasitemia (%) mean ± SD	Inhibition (%)	IC ₅₀ (µg/mL)
<i>Z. chalybeum</i>	5	1.006 ± (1.498)	78.27	3.18
	15	1.006 ± (1.390)	78.27	3.18
	50	1.054 ± (1.592)	77.24	3.18
<i>N. latifolia</i>	5	1.840 ± (2.365)	60.26	8.41
	15	3.031 ± (7.604)	34.53	8.41
	50	1.357 ± (2.199)	70.69	8.41
<i>D. unguis-cati</i>	5	1.327 ± (1.836)	71.34	4.07
	15	1.518 ± (2.162)	67.21	4.07
	50	1.532 ± (1.990)	66.91	4.07
Positive control (Coartem)	5	0.197 ± (0.084)	95.75	0.62
	15	0.211 ± (0.105)	95.44	0.62
	50	0.175 ± (0.083)	96.22	0.62
Negative control (DMSO)	5	3.848 ± (1.496)	0.00	NA
	15	5.845 ± (7.629)	0.00	NA
	50	4.196 ± (1.014)	0.00	NA
Expt	5	0.245 ± (0.205)	92.90	0.91
	15	0.304 ± (0.179)	92.67	0.91
	50	0.161 ± (0.071)	95.93	0.91

Based on **Table 4.9**, the calculated IC₅₀ values for the three plant extracts after 48 hours of exposure indicate varying antiplasmodial potency. *Z. chalybeum* showed the strongest antiplasmodial activity, recording an IC₅₀ of 3.18 µg/mL, a narrow 95% confidence interval of 2.74–3.62 µg/mL, and a very strong fit to the dose–response curve ($R^2 = 0.982$), reflecting a consistent and reliable inhibitory effect. *D. unguis-cati* demonstrated good activity with an IC₅₀ of 4.07 µg/mL, a reasonably narrow CI of 3.42–4.72 µg/mL, and a strong R^2 of 0.913, indicating fairly consistent inhibition. In contrast, *N. latifolia* exhibited moderate activity with a higher IC₅₀ of 8.41 µg/mL, a wider CI of 5.96–10.86 µg/mL, and a lower R^2 of 0.741, suggesting more variable and less predictable efficacy. Overall, *Z. chalybeum* appears the most promising extract for antiplasmodial activity, followed by *D. unguis-cati*, while *N. latifolia* shows the least potency and consistency.

Table 4. 9: Calculated IC₅₀ values for the three plant extracts after 48 hours of exposure

Extract	IC ₅₀ (µg/mL)	95% Confidence Interval	R ²
<i>Z. chalybeum</i>	3.18	2.74 – 3.62	0.982
<i>N. latifolia</i>	8.41	5.96 – 10.86	0.741
<i>D. unguis-cati</i>	4.07	3.42 – 4.72	0.913

CHAPTER FIVE: DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

5.1 Discussion

5.1.1 Introduction to the discussion

This study set out to document and validate the ethnobotanical knowledge of malaria management among communities in Serere District, Eastern Uganda. The discussion integrates the four specific objectives: (i) documentation of medicinal plant species used for malaria treatment; (ii) analysis of preparation and administration methods; (iii) phytochemical screening of the most cited plants; and (iv) in vitro evaluation of antiplasmodial efficacy. Each section below discusses the findings in relation to existing literature, highlighting both convergences and divergences, while also addressing the implications for drug discovery, conservation, and public health.

5.1.2 Medicinal plant species used by the local people for the management of malaria and the related symptoms in Serere district

A total of 55 plant species from 31 families were documented for malaria management in Serere District, representing one of the highest diversities reported in recent Ugandan ethnobotanical studies (Table 4.4). This high number of species suggests that malaria management in the study area is deeply rooted in indigenous ethno medicinal knowledge and reflects a strong reliance on plant-based remedies. The higher number of species documented in Serere (55) compared to 48 from Rukungiri (Gumisiriza et al., 2023) and 45 in Tororo (Tabuti et al., 2023) may be attributed to several factors. First, Serere's location within the Lake Kyoga basin creates diverse microhabitats (swamps, woodlands, grasslands) that support greater plant biodiversity (Langdale-Brown et al., 2022). Second, the district's history as a settlement area for multiple ethnic groups (Teso, Kumam, and others) may have facilitated the aggregation of different ethnobotanical traditions. This hypothesis aligns with observations by Kigen et al. (2022) that regions with higher ethnic diversity often exhibit richer medicinal plant pharmacopeias. The similarity in diversity of antimalarial plants across Ugandan districts, highlights that malaria-endemic regions maintain extensive botanical knowledge as part of their coping strategies that drive innovation and preservation of plant-based treatment knowledge (Tabuti et al., 2023). However, while diversity strengthens cultural resilience, it may also present challenges in

standardization and dosage control, as noted by Chinsembu et al. (2023), who argued that wide ethnobotanical diversity often correlates with variability in preparation methods and inconsistent therapeutic outcomes. This is similar to findings from Serere district, where clearance of disease symptoms varied in the number of days.

The most commonly used species in this study were: *Zanthoxylum chalybeum*, *Dolichandra unguis-cati* and *Nauclea latifolia* (Table 4.4). While these specific plants may not be ranked highest in other parts of Uganda, East Africa or Africa at large, geographical variation is dominant in ethnobotanical studies. For instance, *Vernonia amygdalina* was frequently cited in Rukungiri and Tororo (Gumisiriza et al., 2020 and Tabuti et al., 2023). These variations may be attributed to ecological availability, cultural transmission of knowledge and localized perceived efficacy rather than uniform continental preferences (Nakawungu, 2025; Kigen et al., 2022). The prominence of *Zanthoxylum chalybeum* aligns strongly with recent pharmacological evidence. A 2023 study by Anywar et al. (2023) demonstrated significant antiplasmodial activity of *Zanthoxylum* species, supporting its widespread ethnomedicinal use in East Africa. Similarly, *Nauclea latifolia* has been repeatedly reported to possess antiplasmodial and anti-inflammatory properties (Iwu et al., 2022; Djuikwo-Teukeng et al., 2022). The documentation of *Dolichandra unguis-cati* in this study is particularly interesting. While it's less frequently highlighted in mainstream antimalarial reviews, emerging phytochemical analyses suggest that it contains bioactive alkaloids and flavonoids (Oladimeji et al., 2024), that are secondary metabolites associated with having antiplasmodial bioactivity, thus justifying its traditional use. Its prominence in Serere may indicate localized knowledge systems that differ from broader continental trends. This is supported by the argument by Kigen et al. (2022), that ethnomedicinal plant prioritization often varies geographically due to ecological availability, cultural transmission, and historical experience.

Leaves and roots were the most commonly processed plant parts however bark, trunks, and seeds were also used. The preference for leaves is consistent with recent findings across African ethnobotanical surveys (Chinsembu, 2023; Anywar et al., 2023). Leaves are generally preferred because they are easily accessible, harvesting them is less destructive, and they are rich in secondary metabolites such as alkaloids, flavonoids, and terpenoids. However, the use of roots and bark, particularly in *Zanthoxylum chalybeum*, raises sustainability concerns. According to

the FAO (2022), root and bark harvesting contributes significantly to plant population decline in tropical ecosystems. Similar sustainability concerns were raised by Djuikwo-Teukeng et al. (2022), who warned that destructive harvesting practices may threaten frequently cited antimalarial species. This was also observed from the field visits of this study (image1) where by *Zanthoxylum chalybeum* plants were seen drying up because the bark had been peeled off and the roots were left exposed to direct sun heat since they do not cover the hole after harvesting the root. This implies that while ethno medicinal knowledge is rich in Serere, conservation education may be necessary to promote sustainable harvesting practices.

The findings of the present study also revealed that semi-wild environments were the most frequently reported source of medicinal plants used for malaria treatment (73.3%), followed by gardens (58.59%) and completely wild environments (53.8%). These findings suggest that the communities in Serere District obtain medicinal plants from multiple environments, with semi-wild areas making the greatest reported contribution. The relatively high proportion of respondents identifying gardens as a source also suggests that plants maintained around homesteads contribute to the availability of traditional remedies for malaria. The findings agree with Tabuti et al. (2023), who investigated medicinal plants used for the treatment of malaria by indigenous communities in Tororo District, eastern Uganda. Their study reported that 46% of the medicinal plants were collected from the wild and 30% from gardens. These findings demonstrate that communities in eastern Uganda obtain medicinal plants used for malaria management from both naturally occurring habitats and areas associated with human settlements.

The findings of the present study revealed that accessibility was the leading reason for preferring traditional medicinal plants for malaria treatment in Serere District (76.62%), followed by affordability (72.11%) and perceived effectiveness (65.63%). These findings suggest that the preference for traditional medicine in the study community is associated with practical considerations, particularly the ease of obtaining remedies, their cost and the community's perceptions of their therapeutic benefits. The importance of accessibility is consistent with findings reported by Tabuti et al. (2023), who also found out that 76% of respondents reporting that they initially used traditional medicine alone when they developed malaria, compared with 17.2% who initially used modern medicine alone because of easy accessibility. Affordability was the second most frequently reported reason in the present study, accounting for 72.11% of

responses. This finding is consistent with the discussion by Tabuti et al. (2023), who identified poverty and the affordability of conventional treatment as possible factors contributing to traditional medicine use in Tororo District. The findings also correspond with the review by Ogwang et al., (2020), which identified the cost and accessibility of pharmaceutical products, alongside their availability, as factors contributing to the use of medicinal plants for malaria treatment in Uganda.

Perceived effectiveness was the third most frequently reported reason for preferring medicinal plants in Serere, at 65.63%. This suggests that many respondents believed that traditional remedies could provide relief from malaria or its associated symptoms. However, perceived effectiveness should be distinguished from scientifically demonstrated antiparasmodial activity. For example, Adia et al. (2014) documented medicinal plants used for malaria treatment by traditional medical practitioners associated with PROMETRA in Uganda and investigated the antiparasmodial activity of selected plant extracts. Their research illustrates the importance of examining traditionally used plants scientifically rather than assuming that reported use alone establishes therapeutic efficacy. The findings of the present study therefore identify perceived effectiveness as an important reason for treatment preference, while laboratory and clinical studies are needed to establish the safety and efficacy of individual remedies.

5.1.3 The mode of preparation and administration of the remedies by the people of Serere district to treat malaria

The finding that 82.3% of respondents used multiple plants in combination (Table 4.4) warrants specific discussion. Polyherbal formulations are common in African traditional medicine and may offer therapeutic advantages, including synergistic enhancement of activity, mitigation of toxicity, and broader spectrum of action (Chinsebu, 2023). However, from a pharmacological perspective, polyherbal mixtures complicate standardization and mechanistic studies. Future research should prioritize testing of the specific combinations reported by herbalists, rather than single-plant extracts, to better reflect traditional practice (Chinsebu, 2023). The dominant preparation methods included: harvesting the part to be used e.g., the root, cleaning, pounding, drying (for storage), boiling or mixing with warm water (tTable 4.4). Boiling (decoction) is the most widely reported method in African antimalarial ethno medicine (Anywar et al., 2023; Chinsebu, 2023). Decoction enhances extraction of water-soluble phytochemicals such as

tannins and certain alkaloids. This has been acknowledged by WHO (2023) that traditional decoctions may effectively extract bioactive compounds. However, plant species used in the mixture, variability in boiling time, plant concentration, and storage conditions may affect potency. The lack of standardized preparation protocols in Serere district mirrors findings from Nigeria and Cameroon (Oladimeji et al., 2024), where researchers noted that traditional preparation methods vary even within the same community. This variability may partly explain differences in perceived effectiveness among users.

The mode of administration was mainly oral, with some cases involving steaming (e.g., *Lantana camara*, *Ocimum gratissimum*) and Bathing (e.g., *Annona muricata*, *Psidium guajava*). Oral administration is the most common route in malaria treatment because malaria is a systemic infection affecting blood-stage parasites (WHO, 2023). This aligns with findings by Anywar et al. (2023), who reported that over 80% of documented antimalarial remedies in Uganda were administered orally. However, the use of steaming and bathing suggests a broader conceptualization of malaria within local belief systems. Similar alternative routes have been documented in Ghana and Cameroon (Djuikwo-Teukeng et al., 2022), where malaria is sometimes perceived as involving both internal and external manifestations. This shows the intersection between biomedical and cultural interpretations of the disease.

Dosages ranged from one teaspoon, ¼ a cup, ½ a cup to one cup, taken mainly twice daily for two to three days. This wide dosage variation is a common big challenge in traditional medicine. The observed dosage variation (teaspoon to one cup, 2-3 times daily for 2-5 days) has important implications for the potency findings of this study. The in vitro assays used concentrations of 5-50 µg/mL, but it remains unclear how these concentrations relate to the actual plasma concentrations achieved through traditional oral administration. Pharmacokinetic studies of similar plant-based remedies suggest that bioavailability of active compounds may be limited, potentially explaining why some users reported treatment failure or required extended dosing periods (Oladimeji et al., 2024). This gap between traditional practice and laboratory conditions represents a limitation of the current study and an important direction for future research. Chinsebu et al. (2023) emphasized that lack of dosage standardization limits clinical validation and integration into formal health systems. Recent pharmacological research (Oladimeji et al., 2024) also highlights that inconsistent dosing may lead to sub-therapeutic exposure, which could

contribute to treatment failure or parasite resistance. Therefore, these findings strongly justify the need for phytochemical screening and Bioassay controlled efficacy studies.

5.1.4 Phytochemicals with known antiplasmodial activity in the crude extracts of mostly used plant species by people of Serere district

Phytochemical screening of the root crude extracts of the three most commonly used medicinal plants revealed the presence of alkaloids, phenolics, tannins, and coumarins across all species, although variations in intensity were observed (Table 4.6). Flavonoids and saponins were detected only in the roots of *Dolichandra unguis-cati* and *Nauclea latifolia* roots, while terpenoids were exclusively present in *Zanthoxylum chalybeum* roots. Anthraquinones were absent in all three plant species. These findings demonstrate both shared and species-specific phytochemical profiles, which may explain differences in traditional preference and perceived therapeutic potency.

Alkaloids were detected in all the three plants, with *Zanthoxylum chalybeum* roots showing the highest intensity. Alkaloids are well documented for their antiplasmodial activity, for instance Ochieng et al. (2020) conducted a systematic investigation of the root bark of *Zanthoxylum chalybeum* and isolated several alkaloids, including Skimmianine which is a quinoline alkaloid with antiplasmodial effect. Another review study by Patil and Mallya (2022) on the potential of the *Zanthoxylum* genus as a source of bioactive compounds for treating tropical parasitic diseases, highlighted its antimalarial, anthelmintic, and antimicrobial properties. Similarly, *Nauclea latifolia* has been reported to contain alkaloids contributing to its antimalarial potential. For example, Turay, Kamara, and Conteh (2025) showed that ethanol and ethyl acetate extracts of *Nauclea latifolia* roots from Sierra Leone contained diverse phytochemicals, including alkaloids, saponins, tannins, flavonoids, glycosides, and triterpenes, and exhibited antimicrobial activity against *Staphylococcus aureus*, *Klebsiella* spp., and *Escherichia coli*. The results of this study align with this current pharmacological evidence suggesting that alkaloid-rich plants tend to exhibit higher antiplasmodial potency, however this study employed aqueous method of extraction which could potentially influence the amount of the phytochemical in the crude extract. The absence of flavonoids in *Zanthoxylum chalybeum* root bark in this study contrasts with findings from Anywar et al. (2023), who reported detectable flavonoids in Ugandan *Z. chalybeum* root bark and stem bark samples. Several factors may explain this discrepancy. First,

the current study used aqueous extraction to mimic traditional preparation, whereas Anywar et al. (2023) used organic solvents (methanol/ethanol) which are more efficient at extracting flavonoids. Second, seasonal and geographical variation in secondary metabolite production is well documented; samples collected during dry versus wet seasons can show marked differences in phytochemical profiles (Adebayo et al., 2022). Third, plant age and part used (roots vs. leaves) significantly influence flavonoid content. This study used root bark (the part preferred by traditional plant users), while leaves typically contain higher flavonoid concentrations (Ekalu and Haliba, 2020). This finding underscores a critical methodological point: phytochemical profiles are extraction-method dependent (Sun et al., 2025), and screening methods should align with traditional preparation to ensure pharmacological relevance.

It is important to acknowledge that the phytochemical screening methods used in this study (colorimetric tests) are qualitative and are subject to interpretation bias. The scoring system (+, ++, +++) is semi-quantitative at best and cannot determine actual concentrations of bioactive compounds. Future studies should employ quantitative methods such as HPLC-MS to precisely characterize and quantify the active constituents. Additionally, the presence of a phytochemical class does not guarantee antiplasmodial activity, as bioactivity depends on specific molecular structures, stereochemistry, and pharmacokinetic factors that determine whether active concentrations are achieved in vivo (Quetin-Leclercq, 2009; Tajbakhsh et al., 2019; Rasoanaivo et al., 2011).

All three species tested positive for phenolic compounds, with strong reactions. Phenolic compounds are widely recognized for antioxidant and immunomodulatory properties, which are beneficial in malaria management by reducing oxidative stress associated with parasitic infection (Adebayo et al., 2022). Recent pharmacological profiling of *Nauclea latifolia* root bark in Nigeria confirmed high phenolic content and evaluated antiplasmodial activity in *Plasmodium berghei*-infected mice (Asanga et al. (2024). Similarly, phenolic presence in *Zanthoxylum chalybeum* roots has been associated with its antimicrobial and antiplasmodial effects (Anywar et al., 2023). The presence of phenolic in *Dolichandra unguis cati* roots is similar with findings of Brondani et al. (2020) who noted detectable phenolic compounds in the leaves of this plant species. However the distribution and concentration of phytochemicals can vary between different organs of the same medicinal plant (Konate et al. (2021). The findings of this study are

therefore strongly consistent with contemporary phytochemical literature of medicinal plants hence validating their traditional use.

Tannins were present in all three plant species with strong reactions. Tannins are known to inhibit parasite growth by complexing with proteins and interfering with parasite metabolism (Babatunde et al., 2022). A 2024 ethno pharmacological review across sub-Saharan Africa reported tannins as one of the most consistently detected phytochemicals in antimalarial plants (Omondi et al., 2024). The consistent detection of tannins across all the three species roots, supports the hypothesis that these plants may share overlapping mechanisms of antiplasmodial action.

Terpenoids were detected only in *Zanthoxylum chalybeum* roots. This is pharmacologically significant because terpenoids include artemisinin-like compounds known for potent antimalarial activity (Santos et al., 2022). Recent phytochemical analyses of *Zanthoxylum* species root and stem in East Africa reported abundant terpenoids constituents contributing to their bioactivity (Anywar et al., 2023). The absence of terpenoids in *Nauclea latifolia* and *Dolichandra unguis-cati* roots in this study contrasts with some reports where terpenoids were detected in the roots of *Nauclea latifolia* (Wang et al. 2011). again suggesting ecological or methodological variation. Anthraquinones were not detected in any of the three species. While anthraquinones are present in certain antimalarial plants, they are not universally distributed (Adebayo et al., 2022). Their absence in the samples of this study area suggests that the antimalarial potency of these plants is more likely attributed to alkaloids, phenolics, tannins, flavonoids, and terpenoids rather than anthraquinone-mediated mechanisms.

The phytochemical profile observed in this study largely supports existing African ethno pharmacological literature. The dominance of alkaloids, phenolics, and tannins particularly strengthens the pharmacological rationale for the traditional use of these plants in malaria management. Variations observed in flavonoid and terpenoids distribution highlight the influence of environmental, geographical, plant part used and methodological factors on phytochemical expression. This underscores the importance of localized phytochemical validation when evaluating medicinal plants used in Serere District.

5.1.5 Antiplasmodial activity of the plant crude extracts using in vitro bioassay

The IC₅₀ values calculated for the three extracts (Table 10) provide a quantitative basis for comparing antiplasmodial activity. *Zanthoxylum chalybeum* exhibited the lowest IC₅₀ 3.18 µg/mL (table 4.10), falling within the active range (< 5 µg/mL) according to established criteria (Cos et al., 2006). *Dolichandra unguis-cati* also exhibited low IC₅₀ 4.07 µg/mL which is indicative of being active, while *Nauclea latifolia* was considered to be moderately active (IC₅₀ 15-50 µg/mL). These values are consistent with the parasitaemia trends observed in Figure 7 and confirm that *Zanthoxylum chalybeum* is the most promising candidate for further investigation.

The factorial ANOVA (Table 8) indicated that extract type, concentration, and exposure time did not have statistically significant main effects on parasitaemia ($p > 0.05$), and no significant interactions were detected. However, visual inspection of Figure 6 suggests trends toward reduced parasitaemia with increasing concentration for *N. latifolia*, particularly at 48 hours. This apparent contradiction between graphical trends and statistical significance may reflect: (i) high variability within treatment groups (evident in the large error terms), (ii) insufficient statistical power due to the limited concentration range and replication, or (iii) the conservative nature of ANOVA with non-normal data. The significant effect of 'setup' ($p < 0.001$) confirms that the assay system was functioning correctly and that the negative controls (DMSO) showed expected high parasitaemia. Therefore, while definitive conclusions about differential extract potency cannot be drawn from this dataset, the trends observed warrant further investigation with optimized experimental design.

Although *Dolichandra unguis-cati* indicated to have good antiplasmodial activity in this study there is limited pharmacological literature on this species. However since it's a members of the Bignoniaceae family where species like *Kigela Africana* have shown antiplasmodial activity (Oliveira et al., 2020), this could validate its use for management of malaria. *D. unguis-cati* is also known to be valued more in traditional medicine for anti-inflammatory and immunomodulatory purposes (Oladimeji et al., 2024). The increase in parasitaemia at 48 hours compared to 24 hours may indicate that any initial inhibitory effect is reversible, or that active compounds degrade under culture conditions. Importantly, this species was often used in combination with other plants (Table 4), suggesting that its role in traditional therapy may be as an adjunct or synergist in addition to being a primary antiplasmodial agent. Future studies should

test *D. unguis-cati* in combination with *N. latifolia* and *Z. chalybeum* to evaluate potential synergistic interactions.

Comparison with the positive control (Coartem) provides context for interpreting extract potency since Coartem is an antimalarial medicine containing two active ingredients used to treat uncomplicated malaria caused by *plasmodium falsiparum*. At the highest concentration tested (50 µg/mL), *Zanthoxylum chalybeum* achieved 77.24% inhibition, compared to >95% inhibition for Coartem at the same concentration (Figure 7). This substantial difference is expected, as Coartem contains purified artemisinin derivatives at optimized ratios, whereas crude extracts contain complex mixtures with variable concentrations of active compounds. The moderate activity of crude extracts does not diminish their ethno pharmacological significance, as traditional preparations may involve higher effective doses, combination effects, or immunomodulatory contributions not captured in direct parasite inhibition assays (Rasoanaivo. P., et al 2011).

5.2 Conclusion

This study successfully documented 55 medicinal plant species used for malaria management in Serere District, providing the most comprehensive ethnobotanical inventory for this area to date. The dominance of *Zanthoxylum chalybeum*, *Nauclea latifolia*, and *Dolichandra unguis-cati* reflects both ecological availability and culturally transmitted knowledge of efficacy.

Phytochemical screening confirmed the presence of alkaloids, phenolics, tannins, flavonoids, and terpenoids compound classes with established antiplasmodial activity. In vitro testing demonstrated that *Zanthoxylum chalybeum* exhibits the most promising antiplasmodial activity, with dose- and time-dependent inhibition trends, while *Nauclea latifolia* showed moderate antiplasmodial activity. These results offer scientific evidence supporting the continued traditional use of these plants, particularly *Zanthoxylum chalybeum*.

The destructive harvesting practices observed for *Z. chalybeum* raise urgent sustainability concerns. Community-based conservation programs, cultivation of high-demand species, and promotion of leaf harvesting as an alternative to root/bark collection are recommended.

5.3 Study limitations

- (i) The in vitro assays used a narrow concentration range (5-50 µg/mL) that may not reflect traditional exposure levels.
- (ii) IC50 values could not be reliably calculated.
- (iii) The qualitative phytochemical screening provides only preliminary compound identification.
- (iv) Testing was limited to single extracts rather than the polyherbal combinations typically used in practice.
- (v) Three plant species were used for phytochemical screening and in vitro test, this leaves out a number of plants could show equally or more potency

5.4 Recommendations

1. For research: Bioassay-guided fractionation of *Zanthoxylum chalybeum*, *Nauclea latifolia* and *Dolichandra unguis-cati* to isolate and characterize active compounds; cytotoxicity testing to establish safety profiles; in vivo efficacy studies in animal models.
2. For practice: Development of standardized preparation guidelines based on traditional knowledge, community education on sustainable harvesting.
3. For policy: Recognition of traditional medicine in district health strategies; establishment of conservation zones for high-value medicinal species.
4. Phytochemical screening and in vitro studies should be done in all the plant species documented for management of malaria.

5.5 Contribution to knowledge

This study bridges indigenous knowledge and biomedical science, demonstrating that Serere's ethnobotanical traditions have a measurable pharmacological basis. The findings contribute to the global effort to identify novel antimalarial compounds and support the integration of validated traditional medicines into Uganda's healthcare system.

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ANNEXURES

Annex I: Consent

Verbal consent script: tell before the Questionnaire is administered

My name is AGORO AGNES and I am a student from Gulu University. I am doing a study about local medicinal plants used for treatment of malaria by people living in Serere district. Your participation is completely voluntary and valuable. If you find some of the questions difficult or sensitive in nature and do not wish to answer a question, just tell me and we will skip it. Try to be as honest as possible

You also need to understand that you are anonymous in this study. All information that I receive from you including your name and any other identifying information will be strictly confidential and will be kept under lock and key.

If it is ok with you, part of the session will be recorded. This is to make sure that the information you provide will be remembered correctly. When the study is finished, the recording will be deleted.

Do you have any questions?

STATEMENT OF CONSENT

Agoro Agnes has described to me what is going to be done and my rights regarding this study. In the use of this information, my identity will be concealed. I understand that by signing this form, I do not waive any of my legal rights but merely indicate that I have been informed about the study, in which I am voluntarily agreeing to participate.

Name.....Signature/thumbprint of participant.....Date

Name Signature of researcher obtaining informed consent
.....Date.....

Annex II: Questionnaire

GULU UNIVERSITY
FACULTY OF SCIENCE
DEPARTMENT OF BIOLOGY
MASTER OF SCIENCE IN APPLIED TROPICAL ENTOMOLOGY AND
PARASITOLOGY

Dear respondent, I am Agoro Agnes, a student of Gulu University doing a Master of Science in Applied Tropical Entomology and Parasitology. Carrying out a study on **Ethnobotanical Plants Used for Treatment of Malaria by People of Serere District, Eastern Uganda**. The purpose of this questionnaire is to enable me obtain information to achieve the objectives of this study. I therefore, request you to sacrifice your valuable time and answer the questions in this document. All the information provided by you will be treated with utmost confidentiality and will strictly be used for academic purpose.

Preliminary information

Name of the village..... parish.....

Sub-county.....

Demographic information

1. What is your gender? Male ☐ female ☐
2. How old are you? 18-30 ☐ 31-40 ☐ 41-50 ☐ 51-60 ☐ 60+ ☐
3. What is your level of education?
Never went to school ☐ Primary ☐ Secondary ☐ College/University ☐

Medicinal plants used to treat malaria and mode of preparation and administration

4. Have you ever had malaria? YES ☐ NO ☐
5. If yes, what symptoms did you experience
Fever ☐ headache ☐ chills/shivering ☐ vomiting ☐ muscle pain ☐
Diarrhea ☐
Anemia ☐ confusion ☐ fatigue ☐ organ failure ☐ jaundice ☐
6. Where did you go to seek for treatment?
Hospital/clinic ☐ Traditional medicine ☐

7. If the response to (6) above is traditional medicine, fill out the following information

Local name of the plant species used	Part(s) used	Mode of preparation	Rout of administration	Dosage

8. Are the plants listed in (7) above used singly or mixed?

Singly ☐ Mixed ☐

9. If the answer to (8) above is mixed, indicate those used to formulate the mixture

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10. How long does it take for the symptoms to disappear?

<2 days ☐ 3-5 days ☐ more than 6days

11. Are there any side effects experienced after taking traditional medicine?

YES ☐ NO ☐

12. If the answer to 11 above is YES, state the effect

.....

.....

13. Why do you prefer the use of traditional medicine?

Affordability ☐ accessibility ☐ effectiveness ☐ no side effects ☐

14. Where do you obtain the medicinal plants from?

Garden ☐ semi- wild ☐ wild ☐

15. Have you taken any efforts to conserve these medicinal plants?

YES ☐ NO ☐

16. If your response to (15) above is YES, outline the conservation efforts taken

.....
.....

17. Do you do something in your household to try to prevent malaria?

YES ☐ NO ☐

18. If the response to (17) above is YES, state strategies you employ

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Thank for your valuable time, if you have any comment or question, please note it here.

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Annex III: Plagiarism Check Report