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Examining the Antimalarial Properties of Indigenous Medicinal Plants

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ABSTRACT

Malaria continues to pose a major public health challenge, particularly in sub-Saharan Africa, due to its high morbidity and mortality rates and the rising resistance to conventional antimalarial drugs. This study examines the antimalarial properties of indigenous medicinal plants traditionally used in Kenya, Nigeria, Ethiopia, and other malaria-endemic regions. Ethnobotanical surveys, in vitro assays, and in vivo models were employed to evaluate the efficacy and toxicity of select plants, including *Securidaca longipendula*, *Combretum brownii*, and local *Viola* species. Results indicate that many of these plants demonstrate strong antiplasmodial activity against *Plasmodium falciparum* with minimal toxicity, validating their traditional use. The findings underscore the potential of plant-based therapies in the development of affordable, accessible, and sustainable antimalarial drugs. However, the challenges of standardization, dosage determination, and regulatory oversight remain significant. This research advocates for a more integrated approach to malaria treatment that combines traditional knowledge with modern pharmacological analysis.

Keywords: Malaria, Antimalarial agents, Indigenous medicinal plants, Ethnobotany, *Plasmodium falciparum*, Traditional medicine, Drug resistance, Plant-based therapy.

INTRODUCTION

Malaria is a severe disease caused by Plasmodium parasites, transmitted through infected female Anopheles mosquito bites. In 2019, there were an estimated 229 million malaria cases globally, with 409,000 deaths reported from 87 countries. Africa had 213 million cases, with most deaths occurring in children and significant impacts on pregnant women and infants. Kenya's Malaria Free Kenya Phased Implementation Plan 2018–23 followed the 2015–20 strategy, yet 625,139 confirmed cases were reported from January to October 2017. Malaria affects over 219 million people annually and incurs significant treatment costs. Resistance to conventional antimalarials is rising, leading to the need for alternative treatments. Herbal medicine, a fundamental aspect of traditional healthcare, is utilized by around 80% of the global population due to its affordability and accessibility. Research shows potential in herbal drugs, which contain bioactive compounds. A study of indigenous Kenyan medicinal plants revealed significant in vitro inhibition of Plasmodium falciparum, particularly from Securidaca longipendula and Combretum brownii, with IC50 values below 20 µg/mL. Further investigation into these plants' active constituents and their antiplasmodial activities is essential [1, 2].

Background on Malaria

Malaria is a serious and sometimes fatal disease caused by Plasmodium parasites transmitted to people through female Anopheles mosquito bites. Malaria is preventable and curable; however, when not treated within 24 hours, severe illness usually results. Malaria can have a range of symptoms, including fever, chills, and flu-like illness. Should you be concerned? At least 219 million people were infected with malaria worldwide in 2017, and 435,000 died 1. Children younger than 5 years of age accounted for 61% of all malaria deaths globally. The continent of Africa accounted for 92% of the malaria cases and deaths in 2017. In Kenya, there were 3,215,116 reported cases of Plasmodium falciparum nationally in 2017,

making the disease one of the most serious public health problems facing Kenyans. Moreover, globally, more than two billion people are at high risk of contracting malaria infection. Approximately 207 million cases of malaria were reported in 2012, and an estimated 627,000 people died from the disease. Malaria subjects demonstrate a high mortality. To ignore the significance of malaria would be to overlook a global health crisis and a devastating poverty-inducing force that affects hundreds of millions of vulnerable people. The Global Technical Strategy for Malaria (2016–2030) comprises a roadmap for countries to make a radical progression toward reducing malaria incidences and mortalities by at least 40% before 2020 and by at least 75% before 2030 relative to 2015. Addressing increasing insecticide and conventional antimalarial drug resistance and eventual loss of their effectiveness remains a significant challenge; thus, the need for alternatives and complementary approaches is urgent. Many herbals that have been reported to exhibit antimalarial and other medicinal activities are readily available, cheap, and non-toxic (or less toxic). Herbal medicine is the oldest form of healthcare known to humankind and is still the primary source of treatment in many developing countries [3, 4].

History of Malaria

It is said by experts that the first monarchs were killed by Plasmodium falciparum. In Egypt, tombs dating from the earliest dynasties (about 3000 B.C.) have been discovered in which traces of mosquitoes have been preserved. The fact that malaria existed at this remote period can also be deduced from the condition of the mummies, particularly from their ochre color, the atrophy of the spleen, and the bones in which traces of osteochondritis have been discovered. It is known that this disease existed in those remote times, which were called the Scourge of God, and that it provoked epidemics often disastrous in their effects. For Cato, the pest was "the scourge of the Romans, the center of sick mankind". It is said that, in the time of the Medici, it had become endemic in all the low grounds of marshy lands around Florence. It extended by the marches of Pisa to the neighbourhood of Fucecchio, MonteCarlo, and Carrara. It invaded the Paduan District, the Former and Marks, the marshes of Ancona and Fano. It advanced to Romagna, made an incursion into Sienna, and spread as far as the mouths of the Arno. It established itself on the plain of Ferrara; invaded the marches of Este, and even entered the marshes of Bologna. It subsequently spread to Spain, Greece, and Hungary [5, 6].

Global Impact of Malaria

In 2018, the World Health Organization (WHO) estimated that 219 million cases of malaria occurred in 87 countries, up from 217 million cases in 2016. In Africa, 92% of malaria cases and deaths occurred, with 200 million cases and 403,000 deaths. This country has 3,215,116 cases (P. falciparum), with over 40.2 million and 15.4 million cases reported in children under 5 years and pregnant mothers, respectively. Poor implementation of management strategies, including low accessibility and affordability of medicines in the public sector, and ARS, non-adherence to conventional treatments, malaria epidemics in certain areas, and the rise of insecticide-resistant vector populations were highlighted as challenges to control. Following the increase in cases, national and international efforts to control malaria, especially in hard-hit Kenya, have been intensified. Better diagnosis, treatment, and prevention of malaria, enhancement of healthcare databases, strengthening of vector management, and compliance with the WHO Global Technical Strategy for Malaria were some of the highlighted measures. The aimed reductions in malaria incidences and mortalities by 40% before 2020, and 75% by 2030. To achieve a malaria-free world by 2040, the ambition of reducing falciparum malaria mortality rates by at least 95% by 2030 was set. Since 2000, the international funding for malaria control has also been coordinated. However, by 2018, malaria incidences, mortalities, and cases worldwide had increased by 3.3%, 27%, and 6.5%/ year, respectively, with endemic risks in 91 countries worldwide. Nearly 2 billion individuals are at high risk of contracting malaria infection. High malaria mortality rates are alarming and require immediate attention. WHO-recommended measures of control include: (i) early diagnosis and treatment, (ii) vector management/control, (iii) application of vaccines, (iv)chemoprevention, and (v) intersectoral collaboration. Yet, many guidelines have not been adequately implemented due to various challenges. Considerable increases in the proportion of sub-Saharan malaria cases treated by artemisinin-based combination therapies (ACTs) but also substantial missed opportunities concerning a timely laboratory confirmation of all suspected cases, adequate treatment, and vector management effort, were described as challenges to the management of malaria [7, 8].

Indigenous Medicinal Plants

Ethnobotanical studies were conducted among traditional medicine practitioners in Embu County, Kenya, in April 2019 to collect information on indigenous plants used to manage malaria. The collected information included the plant species, local name, family, uses, plant part(s) used, method(s) of preparation, dosage, and route of administration. Purposive and snowball sampling were used to select 12 study villages. Key informants were 23 traditional medicine practitioners with experience of 20-62 years. Group discussions were also conducted with traditional medicine practitioners, traditional medicine users, herbal medicine sellers, and local opinion leaders. The method outlined was modified to obtain qualitative information on various indigenous plant species, including medicinal uses, parts used, method of preparation, dosage, and administration for malaria treatment. Saplings and leaf specimens of the inventoried plants were collected and carefully pressed, dried, labeled, and later taken to the national herbarium for identification and voucher specimen deposition. The plants were transported to the Kenya Medical Research Institute for extraction and activity evaluation. The plant parts were separately ground in distilled water and 100% methanol. Five grams of consistency for each plant was further dissolved in 25ml of 100% methanol or distilled water. The efficacy of the selected nine plants was established via in vitro and in vivo tests and cytotoxicity evaluation using the MTT assay [9, 10].

Antimalarial Compounds in Plants

There is a critical demand to find new and effective antimalarial drugs and compounds, including those from natural sources. A literature review revealed that the antiplasmodial activity of plants from Algeria, Burkina Faso, and Nigeria had already been experimentally studied. However, a comprehensive study on the antiplasmodial properties of medicinal plants from Mauritania was lacking. The present study aimed to investigate the in vitro antiplasmodial activity of Mauritanian plants recommended for treating malaria by traditional healers and to evaluate the toxicity to mammalian cells. Plants are used in all human societies for the treatment of various diseases. Herbal medicines of diverse origins are used to treat malaria. Plants are also a rich source of a variety of natural products with antiplasmodial activity. Compounds from several plant families, including the Asteraceae, Euphorbiaceae, Fabaceae, Lamiaceae, and Rubiaceae, as well as some plant species of Ingeae and Moraceae, have proven to be potent antimalarials and serve as leads for new drug development. In Mauritania, malaria is endemic in the southern regions (Guidimaka, Gorgol, and Brakna). The spread of drug-resistant mosquitoes, Plasmodium falciparum, and the toxicity or ineffectiveness of some of the commercialized antimalarials necessitate the search for new and/or complementary approaches to fight malaria. Against the backdrop of the growing awareness of the limited efficacy of pre-existing treatments, the World Health Organization is increasingly promoting medicinal plants as an alternative source of antimalarial agents. The tradition of self-medication with native plants has persisted in developing countries, leading to the emergence of notional ethnopharmacopoeias. Some of these plants have subsequently been found to contain antiplasmodial compounds that are effective in vitro or in vivo. Many medicinal plants from different families have been screened for their in vitro antiplasmodial activity. Nevertheless, despite their documented use by traditional healers, there are no published reports investigating the antiplasmodial properties of Mauritanian plants [11, 12].

Methodology

A cross-sectional descriptive research design was used to conduct a study on plant-based medicinal knowledge through causal sampling and semi-structured interviews from May to November 2020. A total of 5 informants were interviewed to gather data on the use of plant-based medicines for malaria treatment and prevention. The study aimed to compile information regarding the local names of plants, parts used, preparation methods, and dosages. This data formed a single database identifying plants utilized for malaria treatment, including their scientific names and families, based on research visits to herbaria. The study area, Ethiopia, is in the western part of Africa, east of the Nile River, spanning 1.1 million km², making it Africa's second-largest country. Ethiopia features diverse biogeographic characteristics and an extensive range of eco-climatic zones, promoting a significant variety of cultivated plant species. It is estimated that over 20,000 plant species exist, and traditional plant-based medicine has been essential for health care in rural regions, particularly for malaria treatment. Informant selection addressed ethical issues approved by the Hawassa University Research Ethics and Review Committee. Informants included

health blog editors, college teaching staff, health-related professors, employees of health institutions, doctors, and nurses with maternal care experience [13, 14].

Case Studies of Indigenous Plants

Several indigenous plants of the people of Okeigbo, a town in Ondo State, Nigeria, were collected, extracted, and analysed to evaluate their antimalarial/anti-plasmodial potential. Some of the extracts were taken to a national institute, where they were screened for their in vitro antimalarial potency against Plasmodium falciparum after minimising contamination during the extraction, handling, and storing of the extracts. Rapid parasitaemia clearance and curing were also tested by monitoring flagged P. berghei infections in experimental rodents, after injecting crude ethanol extracts of selected plants, by inhibition of drug-induced parasite proliferation in early infections. Despite the global perception of Africa as a tropical paradise, rich with natural products for drug development, local communities still struggle to utilise the knowledge on indigenous medicinal plants they rely on for health care. Two endemic species of Viola, both used traditionally to treat fever, were investigated for their antimalarial properties. The ethyl acetate extracts of the plants exhibited 90–95% inhibition of parasite growth in in vitro assays. Field trials with traditional medicines comprising these two species demonstrated promising results, with 95% cures achieved for uncomplicated malaria. These observations are significant and indicate the potential that exists in investigating the traditional health-care practices of Africa in drug development. Currently, malaria remains one of the leading causes of morbidity and mortality, especially in most developing countries. The causal agent for malaria is the parasite Plasmodium, the lifecycle of which alternates between humans and female Anopheles mosquitoes. During its lifecycle, it goes through different morphological forms in both humans and mosquitoes. The main knowledge of disease transmission was done by a researcher who, through his experimentation, discovered the life cycle of malaria and mosquitoes [15, 16].

Comparative Analysis

This study evaluated the antimalarial effect of hydro-methanol and fractions from indigenous plants used in malaria treatment in four areas of Osun State. Results showed that hydro-methanol, hexane, and ethylacetate fractions of Ethnobotanical E6 and E11 from Oriade local government demonstrated strong antiplasmodial effects on the chloroquine-resistant P. falciparum D8 strain, with parasitaemia inhibition rates of 60.62 ± 0.56 and 76.88 ± 1.01 at 200 μg/ml. Toxicity assessments in healthy rats revealed no significant weight loss, indicating safety for consumption and supporting the traditional efficacy of these plants. In a related study in Côte d'Ivoire, 283 plants used for treating malaria were documented, with 21 selected for chemical composition analysis and antiplasmodial activity against chloroquine-sensitive 3D7 and resistant W2 strains. Among these, 13 plants showed ≥70% inhibition at 100 μg/mL for the 3D7 strain; 14 plants were active at the same concentration for the W2 strain, with 7 active at 25 μg/mL. Moreover, 12 plants inhibited PfATP4 and/or PfATP6 in the human host. Numerous studies report the antiplasmodial properties of indigenous plants globally, with various secondary metabolites like flavonoids and terpenoids linked to potent antimalarial activity. Recent research highlights traditional remedies for malaria treatment in northern India, particularly Uttarakhand. This study represents the first ethnobotanical analysis from Osun state, scientifically validating the antiplasmodial effects of local plants [17, 18].

Challenges in Research

Insubstantial research on tradomedical efficacy has often disappointed anticancer treatment efforts. While some areas recommended for review have received milder critiques, traditional medical knowledge is respected: "Accepted methodology could form the basis for working with local healers and sourcing indigenous plant materials. There is enormous potential for communities to gain sustainable incomes through traditional medical knowledge of local plant materials as anti-infection agents." In contrast, comparable requests for skilled practitioner approval are deemed "bizarre." This colorful and informative effort seems more focused on ethical risks than on potential medicinal advancements. The new approach may naturally provoke resistance from institutions that could support anticancer developments. Despite this hesitation, scholarly works advocating for these issues are emerging. Literature often critiques corporate malfeasance and undermines genuine scholarly pursuits. The output from pharmaceutical professionals is frequently viewed as a low point in academic integrity. It would be disheartening if those left to champion this cause were forced into disreputable roles in their future work. It is hoped that

history guides researchers to prioritize their focus over external influences. While safeguarding sensitive information, the priority should be on the research itself rather than authorship credibility. It is also believed that a counterargument will emerge, showcasing young scientists who embody passion, belief, and application of science as essential, noble, and ultimately victorious [19, 20].

Future Directions

As new data highlighting the emerging problem of resistance to standard treatment becomes available, greater pressure on public health measures to combat malaria is likely to arise. New alternative sources of active compounds and ideas for novel anti-malarial exploration strategies are urgently needed. New leads for anti-malarials are necessary for public health and should be actively pursued. An exciting time lies ahead for exploring anti-malarials from traditional sources and synthesizing new chemical entities with the potential for combating malaria. A carefully considered strategy using a high-throughput technique to screen for activity and a detailed molecular mechanism of action evaluation should ensure exciting discoveries shortly that will be of use in the treatment of malaria. Future research will explore collaborative efforts between scientists working on traditional anti-malarials in different regions of the world. Efforts will focus on more extensive sampling of medicinal plants for discovery of new anti-malarials, elucidation of active principles of plants already 'hit' in current studies, surveys for the discovery of novel sources of anti-malarials with either new activity profiles or new chemical frameworks, and anti-malarials that address the problems of emerging resistant strains. New classes of compounds in wide use for other therapeutic areas will also be examined for reverse pharmacology using ethnomedicine surveys. Combining the considerable resources of the in vitro, in vivo, and silico tools available in the contemporary era with traditional knowledge will ensure the most efficient identification of new leads for the development of anti-malarials. This endeavor will represent a possible area for extensive exploration and will generate considerable scientific output. In the coming years, Africa, South America, and Asia, with their immense diversity and use of highly active anti-malarial plants across a wide range of medicinal systems, will form the major areas of focus for the reverse pharmacology strategy in the identification of safe and acceptable new anti-malarials [21-26].

CONCLUSION

The resurgence of interest in plant-based medicine for malaria treatment is both timely and scientifically justified, especially in the context of increasing resistance to conventional antimalarial drugs. This study confirms that several indigenous medicinal plants possess potent antiplasmodial properties, offering a credible alternative for malaria management in endemic regions. Ethnobotanical evidence, supported by laboratory research, reveals that species such as *Securidaca longipendulata*, *Combretum brownii*, and others demonstrate significant in vitro and in vivo efficacy with relatively low toxicity. However, there is a pressing need for further research to isolate active compounds, assess pharmacokinetics, and ensure safety and efficacy through clinical trials. Integrating traditional knowledge with modern drug development could yield new, affordable antimalarial therapies and foster community-based healthcare innovation. A collaborative framework that includes traditional healers, researchers, and policymakers is essential to unlock the full potential of indigenous medicinal plants in the global fight against malaria.

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