ISSN: 2155-9597
Journal of Bacteriology & Parasitology

OPEN ACCESS Freely available online

Research Article

Therapeutic Potential of *Combretum mossambicense* Extracts Against *P. Falciparum* Parasite

Viness Milumbe Chikambwe[1], Patrick Mubambe[2], Kakoma K. Maseka[2], Lameck Banda[2*]

[1]Department of Sustainable Futures, Amrita Vishwa Vidhyapeetham, Amritapuri, India; [2]Department of Mathematics and Natural Sciences, Copperbelt University, Kitwe, Zambia

ABSTRACT

With the increase in the resistance of *P. Falciparum* (the deadliest malaria-causing Plasmodium) to antimalarial alkaloid-based drugs, there has been intense research on new drugs that can combat malaria. Plants provide an unlimited source of bioactive compounds that can be used to treat various diseases. In addition, plant host endophytes, such as bacteria and fungi, are regarded as ideal sources of bioactive constituents. The *Combretum mossambicense* plant is a medicinal plant traditionally used as an effective herbal remedy for malaria infection. However, very little research has been conducted to investigate the phytochemical composition of this plant. In this study, the phytochemistry of the extracts of this plant was investigated and referenced to the chemistry of the commercial drugs used to treat malaria.

The results showed that *Combretum mossambicense* extracts contained alkaloids. However, the alkaloids found in the plant extracts are not directly linked to those reported for the treatment of malaria. A literature review of other compounds found in the plant showed that other nonalkaloid compounds had a positive effect on *P. Falciparum*. According to the literature, antimicrobial compounds can be used to treat malaria. The profiles of all the plant parts revealed the presence of numerous compounds with reported biological importance, including antifungal, antibacterial, anti-inflammatory, anticancer, and antioxidant activities. Furthermore, some of these samples contained compounds like those reported for conventional nonalkaloid antimalarial drugs. It has been shown that *Combretum mossambicense* contains nonalkaloid but anti-plasmodial compounds such as 9,12-octadecadienoic acid methyl ester (linoleic acid), 17 octadecynoic acid, bis(2-ethylhexyl) phthalate, and beta-sitosterol. These compounds are present as modern non-alkaloid-based antimalarial drugs that fight *P. Falciparum* resistance. Given the reported increase in the resistance of *P. Falciparum* to alkaloid-based antimalaria drugs, the efficacy of this nonalkaloid herbal remedy for malaria treatment is important.

Keywords: Malaria, Anti-plasmodial compounds, Alkaloids, Bioactive, *P. Falciparum*

INTRODUCTION

Malaria is a life-threatening disease caused by *Plasmodium* parasites that are transmitted to people through bites of malaria vector-infected female mosquitoes. A vector is a living organism that transmits an infectious agent from an infected animal to a human or another animal. Vectors are usually arthropods such as mosquitoes, ticks, flies, fleas, and lice.

Malaria is the most lethal disease in Africa [1]. In Benin and Zambia, up to 40% of all outpatient visits are due to malaria [2]. In 2015, the World Bank provided funding worth US $ 470 million to African countries to fight malaria. The World Health Organization (WHO) estimates that more than one million people in Africa, including 3,000 children, die from malaria every year [3].

Most of the infected populations in endemic countries use antimalarial medicinal plants to treat malaria. However, very little scientific data exist to validate the antimalarial properties of most medicinal plants. Studies to establish the identity, purity, and quality of natural products include macroscopic and microscopic evaluations, physicochemical and chemical characteristics of crude

Correspondence to: Lameck Banda, Department of Mathematics and Natural Sciences, Copperbelt University, Kitwe, Zambia, E-mail: lameckbanda@cbu.ac.zm

Received: 18-Jun-2024, Manuscript No. JBP-24-26034; **Editor assigned:** 20-Jun-2024, PreQC No. JBP-24-26034 (PQ); **Reviewed:** 04-Jul-2024, QC No. JBP-24-26034; **Revised:** 11-Jul-2024, Manuscript No. JBP-24-26034 (R); **Published:** 18-Jul-2024, DOI: 10.35248/2155-9597.24.S27.099.

Citation: Chikambwe MV, Mubambe P, Maseka KK, Banda L (2024) Therapeutic Potential of *Combretum mossambicense* Extracts Against *P. Falciparum* Parasite. J Bacteriol Parasitol.S27:99.

plant extracts, and alkaloids contents [4].

Alkaloids are a class of naturally occurring organic compounds that contain at least one nitrogen atom. This group also includes compounds with neutral or weakly acidic properties. Some synthetic compounds with similar structures can also be termed alkaloids. Alkaloids in their pure form are usually colorless, odorless crystalline solids but can sometimes be yellowish liquids. They often have bitter tastes. More than 3,000 alkaloids are known to be present in more than 4,000 plants. All of these compounds are secondary compounds and are a collection of various elements and biomolecules derived from amino acids or transamination. There are three types of alkaloids: True alkaloids, protoalkaloids, and pseudoalkaloids. True alkaloids and protoalkaloids are produced from amino acids, whereas pseudoalkaloids are not derived from these compounds [5].

True alkaloids

This alkaloid is obtained from amino acids and contains a nitrogen-containing heterocyclic ring. They are highly reactive and exhibit potent biological activity. They form water-soluble salts, many of which are crystalline. They then conjugate with acids to form salts. Almost all true alkaloids are bitter in taste and solid, except nicotine, which is a brown liquid [6].

Their occurrence in plants occurs in three forms: (a) In the free state, (b) as N-oxides, or (c) as salts. Various amino acids, such as l-phenylalanine/l-tyrosine, l-ornithine, l-histidine, and l-lysine, are the main sources of alkaloids [7]. Cocaine, morphine, and quinine are common alkaloids found in nature (Figures 1-3).

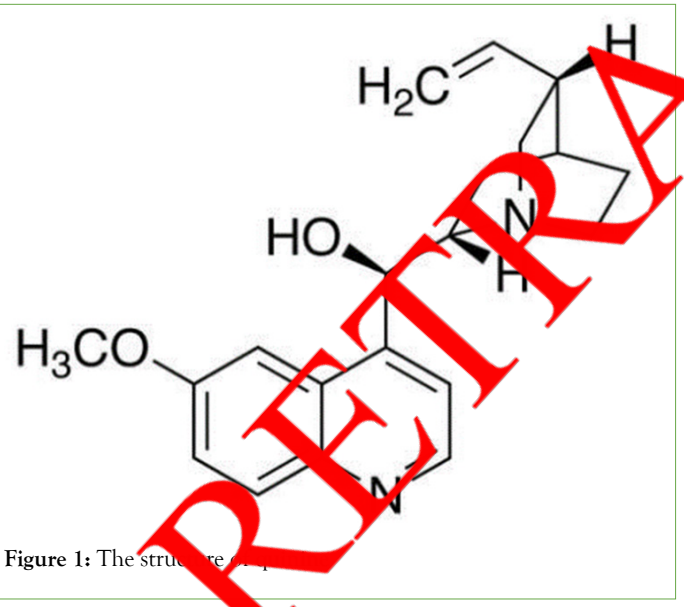

Figure 1: The structure of [illegible]

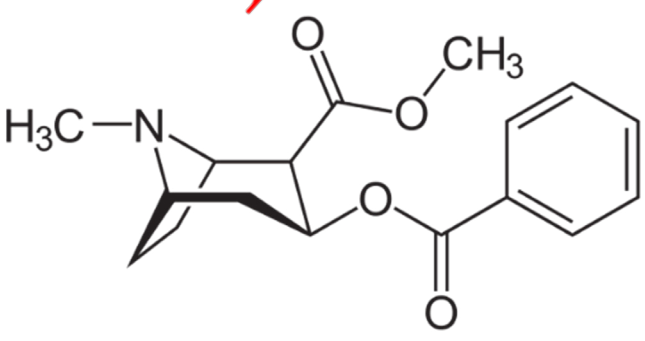

Figure 2: The structure of cocaine

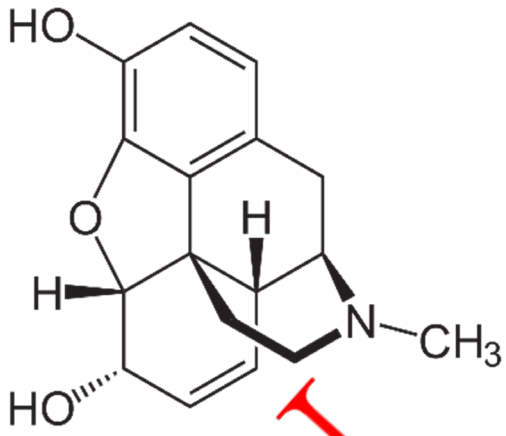

Figure 3: The structure of morphine

The malaria problem in Zambia

Zambia remains an endemic malaria country, with the entire population at risk of contracting malaria. The risk of contracting malaria is highest in the wetter, rural, and low-income provinces of Luapula, Northern, Muchinga, and North-Western, and lowest in Lusaka and Southern provinces. The increase in malaria cases in Zambia has led to a high demand for antimalarial drugs. In addition to side effects, most modern medicines are too expensive for poor rural people. Some possible side effects of antimalarial drugs include dizziness, headache, sleep disturbances (insomnia and vivid dreams), and psychiatric reactions (anxiety, depression, panic attacks, and hallucinations). For many years, local people have used herbs to treat malaria and other ailments. Despite recent efforts to study these herbal remedies, little is known about the medicinal contents of most herbs. Several studies have been conducted in Zambia on the treatment of malaria using herbal remedies, although very little literature is available. This study is intended to add to the body of knowledge on well-utilized antimalarial herbal remedies. This study aimed to determine the presence of alkaloids in selected plants from the Chikankata District, which are known to treat malaria and other malaria-related diseases in the local population for many generations.

Malaria Disease

Malaria is a disease caused by *Plasmodium* parasites, which are transmitted to humans through the bites of infected female Anopheles mosquitoes [8]. In biology, a vector is a living organism that transmits an infectious agent from an infected animal to a human or another animal. Vectors are frequently arthropods, such as mosquitoes, ticks, flies, fleas, and lice. These four parasitic species are known to cause malaria in humans. These include *Plasmodium falciparum*, *Plasmodium malariae*, *Plasmodium ovale*, and *Plasmodium vivax*, but the two most common pathogens are *P. Falciparum* and *P. vivax* [9].

Transmission of Malaria

Malaria is transmitted through the bites of female Anopheles mosquitoes [10]. There are more than 400 different species of Anopheles mosquitoes, of which only 30 are vectors of malaria. An important vector species bites between dusks and dawns [11]. The intensity of transmission depends on factors related to the parasite, namely, the vector, human host, and environment [12]. Anopheles mosquitoes lay eggs in water, hatch into larvae, and

eventually emerge as adult mosquitoes. The female mosquito uses the blood to nurture eggs. During a blood meal, the fungus sucks gametocytes, which develop into sporozoites in female mosquitoes. The sporozoites were injected into another human at the next blood meal [13].

Transmission is more intense in places where the mosquito lifespan is longer, as this increases the chance of the parasite fully developing inside the mosquito. These mosquitoes prefer to bite humans more than other animals. Approximately 90% of African malaria cases occur because of their long lifespan and human preferences [14]. Transmission also depends on climatic conditions, such as rainfall patterns, temperature, and humidity, which may affect the number of mosquitoes and their survival. Seasonal transmission peaks occur during and after the rainy season because of the large number of mosquito breeding sites [15]. Immunity is another factor that increases malaria transmission, especially in adults. Those with partial immunity, which develops over the years of exposure to the disease, provide partial protection [16].

Incubation of the parasite

P. Falciparum replicates repeatedly within erythrocytes over the course of 48 h, resulting in exponential growth and rapid disease progression. Following an infective bite by an Anopheles mosquito, the parasite grows and multiplies first in liver cells and then in red blood cells. The "incubation period" refers to the period before the first symptoms appear. The incubation period in most cases varies from seven to 30 days [17]. The incubation period of each parasite is nine to 14 days for *Plasmodium falciparum*, 12 to 17 days for *Plasmodium vivax*, and 18 to 40 days for *Plasmodium malariae*. Shorter periods were observed most frequently for *P. Falciparum*, and longer periods were observed for *P. malariae*.

Symptoms

Symptoms of malaria can develop as quickly as seven days after the infected mosquito is infected. Typically, the time between infection and symptom onset is 7-18 days, depending on the specific parasite that is infected. However, in some cases, symptoms can take up to a year to develop depending on the victim's immunity [18].

The initial symptoms of malaria are flu-like. These included a high temperature of 38°C or above, heat and shivering, headache, vomiting, muscle pain, diarrhoea, and generally feeling unwell, just to mention a few. These symptoms are often mild and can sometimes be difficult to associate with malaria infection. In some types of malaria, symptoms occur in 48-hour cycles. During these cycles, one feels cold at first, with shivering, and then develops a high temperature, accompanied by severe sweating and fatigue. These symptoms usually persist for between 6 hours and 12 hours (Centers for Disease Control and Prevention, 2010). Without prompt treatment, this type of pregnancy can lead to the rapid development of severe and life-threatening complications, such as breathing problems and organ failure. As the symptoms are similar to those of influenza, malaria infection can be confirmed using only a malaria test.

The fatality rate

Malaria is among the leading causes of mortality and morbidity in Zambia [19]. Efforts to control, prevent, and eliminate COVID-19 have intensified over the past two decades. These efforts have contributed to a reduction in the incidence of malaria and fewer than five deaths. However, the incidence of malaria increased by 21% between 2010 and 2015. According to the World Malaria Report, there were an estimated 241 million malaria cases and 627 000 malaria deaths worldwide in 2020. These numbers represent approximately 14 million more cases in 2020 than in 2019 and 69,000 more deaths. Approximately two-thirds of these additional deaths (47,000) were linked to disruptions in malaria prevention, diagnosis, and treatment during the pandemic [20-22].

Since 2015, 24 countries have registered an increase in malaria deaths, the baseline year for the WHO's global malaria strategy. Among the 11 countries that carry the highest burden of malaria worldwide, the number of cases increased from 150 million in 2015 to 163 million in 2020, and the number of malaria deaths increased from 390,000 to 444,600 over the same period.

Alkaloids

Classes of alkaloids: Alkaloids can be classified according to their biological system. The principal classes of alkaloids are pyrrolidines, pyridines, tropanes, pyrrolizidines, isoquinolines, indoles, quinolines, terpenoids, and steroids [23]. Alkaloids are natural plant compounds with basic characteristics that contain at least one nitrogen atom in a heterocyclic ring and exhibit biological activities. These compounds are mostly toxic and have strong physiological effects. The bioactive plant secondary metabolites include those with antimalarial, anticancer, anti-inflammatory, antimicrobial, and analgesic properties [24]. Uzor provides a very good review of the various types of alkaloids [25].

Other compounds that treat malaria: Owing to the resistance of *P. Falciparum* to alkaloid treatment, many compounds that treat malaria have been discovered. Some of these compounds are phenols, carboxylic acid esters, carboxylic acids, flavonoids, etc. Polyunsaturated fatty acids such as hexadecanoic acid, methyl ester, 9,12-octadecadienoic acid methyl ester (linoleic acid), 9,12,15-octadecatrienoic acid, methyl ester (linoleic acid), 9-octadecenoic acid (Z)-2-hydroxyethyl ester, eicosanoic acid, and 2-(acetyloxy)-1-((acetyloxy) methyl) ethyl ester have been found in active antiplasmodial fractions [26,27]. Butanedioic acid, mono ((3R,5aS,6R,8aS,9R,10S,12R,12aR)-decahydro-3,6,9-trimethyl-3,12-epoxy-12Hpyrano (4,3-j)-1,2-benzodioxepin-10-yl) ester, common name Artesunate, and Artemether, with the chemical formula $C_{16}H_{26}O_5$, are also used to treat malaria.

MATERIALS AND METHODS

Sample size

In this study, we evaluated *C. mossambicense* extracts from many parts of the plant. The plant was selected because it is commonly used by locals in the area. Three extractions were conducted for each sample. The roots, stems, and leaves of each plant were extracted. Traditionally, roots have been used to prepare antimalarial herbal remedies from these plants. In this study, leaves and stems were included to investigate whether they also contained antimalarial remedies.

Collection of samples

Samples were collected from the Chikankata District in June 2021. The roots were removed from the ground using a hoe. Leaves and stems were obtained from the plants. The samples were subsequently transported from the source to Kitwe in airtight plastic bags. An image of *Combretum mossambicense* is shown in Figure 4.

Figure 4: The *Combretum mossambicense* plant

Coding of *Combretum mossambicense* samples

Codes were developed and assigned for each part of the plant using the first letters of the names and sample numbers for easy identification of the samples. The sample codes used are listed in Tables 1 and 2.

Table 1: Sample Codes were developed and assigned for each part of the plant sample.

Code	Sample	Name
MZ	Plant	Botanical name: *Combretum mossambice*
MZR 02	Roots	
MZS 02	Stems	
MZL 02	Leaves	

Table 2: Codes used for samples below listed.

Reference samples codes	
Lum	Lumartem (Coaterm)
Quin	Quinine
Sulp	Sulphadar (Fansidar)

Sample preparation for extraction

The roots, leaves, and stems of *Combretum mossambicense* plants were dried under shade. After approximately one month of drying, the samples were ground to a relatively coarse powder using a mortar and pestle. The powder was sieved and extracted. The samples were weighed into 10 g packets using a balance. The samples were steeped in 6 g of calcium hydroxide and 15 ml of sodium hydroxide. A measuring cylinder was used to measure 200 ml of ethanol, which was then transferred to a round-bottomed flask following the procedure described by Nafiah [28,29].

Extraction of alkaloids using a Soxhlet apparatus

Many methods are used for the extraction of alkaloids from herbs, and Soxhlet extraction is more effective for herb extraction. A 10-gram sample was placed in a 33 mm × 100 mm cellulose thimble, which was subsequently placed in the extraction chamber of a 200 ml Soxhlet apparatus. To prevent the sample particles from being transported to the distillation flask, cotton wool was inserted into the cellulose thimble. The Soxhlet apparatus was set up in a 500 ml distillation flask containing 200 ml of solvent. The extraction was performed at 80°C for 8 h.

Extracted samples

The extracted samples were vacuum filtered. The samples were then concentrated using a rotary thin-film evaporator. Most alkaloids are sensitive to light; therefore, the samples were packed into amber bottles. Because the decomposition of alkaloids occurs only above 70°C, the samples were stored under ambient conditions [30].

Preparation of reference samples

The conventional anti-malaria medicines used as references were purchased from milestone pharmacy in Kabulonga, Lusaka, in tablet form. The samples were analyzed at the Zambia Agriculture Research Institute (ZARI) Chemistry Laboratories in Lusaka. The following drugs were purchased for reference: Lumartem, also known as Coaterm; Sulphadar, commonly known as Fansidar; and Quinine.

Preparation of quinine tablets for analysis by Gas Chromatography (GC) and High-Performance Liquid Chromatography (HPLC)

Using a crusher and pestle, a 300 mg quinine sulphate tablet was ground to powder. A 50 ml volumetric flask was filled with fifty milligrams (50 mg) of quinine sulphate. The powder was dissolved in methanol and used as a stock solution of quinine sulphate. Approximately 5 ml of the stock solution was transferred to a 50 ml volumetric flask and sonicated for 10 min before diluting with methanol to the desired concentration. Finally, the sample solution was filtered into a vial using a 0.45 mm membrane filter. As indicated in the packaging, the only active component in the tablet was quinine (248 mg), which contained 52 mg of sulphate. Using a micropipette, 1 ml of the filtered solution was transferred to and diluted in 2 ml of methanol for GC and HPLC analyses.

Preparation of Lumartem (Coartem) for GC and HPLC analysis

The lumarate pills were weighed and ground into a powder. A preparation comprising lumefantrine at a concentration of approximately 1.2 mg/ml (artemether at a concentration of approximately 0.2 mg/ml) was made using 0.2 g of powder. Methanol was acidified using acetic acid (0.5%) as a dilution solvent. Then, 2 ml of the stock solution was diluted to 10 ml. For the GC and HPLC analyses, using a micropipette, 1 µL (0.001 ml) of the sample was transferred and diluted to 2 ml. The active ingredients in the tablets were artemether (20 mg) and lumartem (120 mg), as indicated on the packet.

Preparation of Sulphadar (Fansidar) for GC and HPLC analysis

A 0.646 g tablet of Sulfadar was weighed and finely ground. The active ingredients in the tablets were sulfadoxine (500 mg) and pyrimethamine (25 mg). Approximately 0.100 g of tablet powder was transferred to a 50 ml volumetric flask and dissolved in methanol, followed by 0.002 ml of acetic acid. The mixture was sonicated for 15 min to disperse the contents completely. The volume was adjusted to the mark with acidified methanol. The sample was filtered through Whatman filter paper to obtain a stock solution. From this stock solution, 1 ml was transferred to a 10 ml

volumetric test tube and diluted to the mark as a working sample. From the working sample, 1 µL was transferred to 2 ml and diluted with methanol for GC and HPLC analyses.

Instrumentation for analysis

High-performance liquid chromatography: An AT-20 high-performance liquid chromatograph with a dual solvent pump high-pressure gradient system, an SPD-20A photodiode array detector, and an autosampler was used for the first-dimensional separation of alkaloids from the extract lid [31]. Chromatographic elution at pH 10.5 was conducted with a binary mobile phase gradient consisting of methanol (A) and water containing 0.2% phosphoric acid (B). The initial gradient conditions were set at 5% B at a flow rate of 1.0 ml/min before incorporating a linear gradient. HPLC was coupled with a UV and fluorescence detector. The parameters used for HPLC analysis of the samples are summarized in Table 3.

Table 3: Parameters used for HPLC for sample analysis.

Parameters	Values
Methanol	Mobile phase A
Acidified water	Mobile phase B
Injection volume	8 µL
Location	21
Pump limit	30
Flow rate	0.8 ml/min
Column	C18 (4.6 × 250 mm)
Column temperature	25°C
Wave length	190 to 400 nm
Gradient elution	From 10/90 100/0, 1
Retention time	30 min

All reagents were of analytical grade or similar grade, and the samples were prepared for HPLC analysis without further purification. The first sample was run for 30 min as a test sample once the apparatus was set.

Gas chromatography: Gas chromatography is an analytical technique used to separate the chemical components of a sample mixture to determine their presence or absence and how much is present. These chemical components are typically organic molecules or gases. For GC to be successful in analysis, these components need to be volatile, usually with a molecular weight less than 1250 Da, and thermally stable, so they do not degrade in the GC system [32].

GC-MS analysis: A Scion GC–MS SQ system with a gas chromatograph interfaced with a mass spectrometer (GC-MS) equipped with an Elite-I fused silica capillary column (30 mm × 0.25 mm 1D × 1Mdf, consisting of 100% dimethyl polysiloxane) was used to analyze leaf, root, and stem samples. An electron ionization device with 70 eV ionizing energy was used for GC-MS detection. The carrier gas was helium gas (99.999%) with a continuous flow rate of 1 mL/min and an injection volume of 2 L (split ratio of 10:1). The injector temperature was 25°C, and the ionization temperature was 280°C. Mass spectra were collected at 70 eV with a 0.5-second scan interval with fragments ranging from 45 to 450 Da. The GC run required 30 min to complete. A Turbo mass spectrometer was used to handle mass spectra and chromatograms, and the relative % amount of each component was computed by comparing its average peak area to the total area.

The National Institute of Standards and Technology (NIST) database, which contains more than 62,000 patterns, was used to interpret the GC-MS mass spectra [33]. The spectra of the unknown components were compared with the spectra of the known components contained in the NIST collection. The components of the test materials were identified based on their name, molecular weight, and structure.

RESULTS

Three samples extracted from the *Combretum mossambicense* tree were analyzed using GC-MS and HPLC. The results and their interpretations are presented in the following sections.

Combretum mossambicense leaf

GC-MS analysis revealed 37 components in the ethanol extract of *Combretum mossambicense* leaves. Table 4 shows the active principles, Molecular Formula (MF), Molecular Weight (MW), and Retention Time (RT).

Combretum mossambicense root

GC-Ms analysis revealed 45 components in the ethanol extract of *Combretum mossambicense* roots. Table 5 shows the active principles, Molecular Formula (MF), Molecular Weight (MW), and Retention Time (RT).

Combretum mossambicense stem

GC-MS analysis revealed 39 components in the ethanol extract of *Combretum mossambicense* stems. Table 6 shows the active principle, Molecular Formula (MF), Molecular Weight (MW), and Retention Time (RT) of the TSLP.

GC-MS results for reference samples

Coartem: The ethanol extract of Coartem was analyzed by GC-MS, and eleven components were detected. Table 7 shows the active principle, Molecular Formula (MF), Molecular Weight (MW), and Retention Time (RT).

Sulphadar: By GC–MS analysis, 10 components in the Sulphadar ethanol extract were detected. Table 8 shows the active principle, Molecular Formula (MF), Molecular Weight (MW), and Retention Time (RT) of the TSLP.

Quinine: A GC–MS study of Quinine's ethanol extract revealed the presence of twelve components. Table 9 shows the active principle, Molecular Formula (MF), Molecular Weight (MW), and Retention Time (RT).

Analysis of Results

The data were organized into a Table 9, with color codes used to designate substances of interest. All common components were combined for analysis. Alkaloids are indicated in green, active chemicals for malaria treatment are indicated in yellow, and common molecules found in reference medications are indicated in red. Table 10 shows the results for the *Combretum mossambicense* plant.

Table 4: Compounds detected in the leaf ethanol extract of *Combretum mossambicense*.

Index	Retention time	Molecular weight	Name	Formula
1	5.147	120	Propanoicacid, 2-mercapto-methyl ester	$C_4H_8O_2S$
2	4.97	76	Propane, 2-fluoro-2-methyl-	C_4H_9F
3	6.329	130	2 (3H) Furanane, dihydro-3-hydroxy-4,4-di	$C_6H_{10}O_3$
4	6.251	130	2 (3H) Furanane, dihydro-3-hydroxy-4,4-di	$C_6H_{10}O_3$
5	8.744	170	Dodecane	$C_{12}H_{26}$
6	10.107	444	Cyclohexasiloxane, dodecamethyl-	$C_{12}H_{36}O_6Si_6$
7	10.241	604	Tetracontane,3,5,24-trimethyl-	$C_{43}H_{88}$
8	11.224	126	1,2,3-benzenetriol	$C_6H_6O_3$
9	11.618	212	Pentadecane	$C_{15}H_{32}$
10	12.332	576	3-isopropoxy-1,1,1,7,7,7-hexamet[illegible]3,5-	$C_{18}H_{52}O_7Si_7$
11	12.902	212	Pentade[illegible]ne	$C_{15}H_{32}$
12	13.527	240	[illegible]tadeca[illegible]	$C_{17}H_{36}$
13	13.765	282	[illegible]2-dimethyl[illegible]adecane	$C_{20}H_{42}$
14	14.111	282	Eicosane	$C_{20}H_{42}$
15	14.384	194	Methyl-be[illegible]D-thiogalactoside	$C_7H_{14}O_6$
16	15.175	198	Naphthalene,1,6-dimethyleth...	$C_{15}H_{18}$
17	15.954	88	[illegible]Silane, tetramethyl-	$C_4H_{12}Si$
18	16.024	436	Hentriacontane	$C_{31}H_{64}$
19	16.335	282	Eicosane	$C_{20}H_{42}$
20	16.49	350	Cyclohexane, nonadecyl-	$C_{25}H_{50}$
21	16.542	178	Phenanthrene	$C_{14}H_{10}$
22	17.044	278	1,2-benzenedicarboxylic acid, bis (2-methyl	$C_{16}H_{22}O_4$
23	17.441	[illegible]2	2-(2',4',4',6',6',8',8')-heptamethyltetrasiloxane	$C_{16}H_{48}O_{10}Si_9$
24	17.858	188	Dodecane, 1-fluoro-	$C_{12}H_{25}F$
25	17.958	256	n- Hexadecanoic acid	$C_{16}H_{32}O_2$
26	18.348	338	Tetracosane	$C_{24}H_{50}$
27	18.[illegible]2	350	Cyclohexane, nonadecyl-	$C_{25}H_{50}$
28	19.175	340	1-heneicosyl formate	$C_{22}H_{44}O_2$
29	19.647	254	Cis-7-hexadecenoic acid	$C_{16}H_{30}O_2$
30	19.846	282	Oleic acid	$C_{18}H_{34}O_2$
31	20.185	436	Hentriacontane	$C_{31}H_{64}$
32	20.414	350	Cyclohexane, nonadecyl-	$C_{25}H_{50}$
33	21.131	304	Malonic acid, bis (2-trimethylsilyethyl ester	$C_{13}H_{28}O_4Si_2$
34	22.188	676	1,4,10-trihydroxy-5-(hydroxyethyl)-8 methyl	$C_{30}H_{44}O_{10}Si_4$
35	22.983	502	Dodecyl phthalate	$C_{32}H_{54}O_4$
36	24.373	358	Octadecanoic acid,2,3-dihydroxypropropyl ester	$C_{21}H_{42}O_4$
37	27.484	490	17-pentatriacontene	$C_{35}H_{70}$

Table 5: Compounds detected in the root ethanol extract of *Combretum mossambisense*.

Index	Retention time	Molecular weight	Name	Formula
1	4.978	120	Propanoicacid, 2-mercapto-methyl ester	$C_4H_8O_2S$
2	6.252	130	2(3H)-Furanone, dihydro-3-hydroxy-4,4-di	$C_6H_{10}O_3$
3	6.741	219	4-Methyl-Piperidine-1-Carboxylic acid	$C_{13}H_{17}NO_2$
4	8.746	170	Dodecane	$C_{12}H_{26}$
5	8.962	184	(3H)-Furanane,5-heptydihydro	$C_{11}H_{20}O_2$
6	9.174	126	5-hydroxymethylfurfural	$C_6H_6O_3$
7	10.106	444	Cyclohexasiloxane, Dodecamethyl	$C_{12}H_{36}O_6Si_6$
8	11.233	126	1,2,3-benzenetriol	$C_6H_6O_3$
9	11.315	216	Nonane,1,1-dietl	$C_{13}H_{28}O_2$
10	11.618	212	Pentade ane	$C_{15}H_{32}$
11	12.329	576	3-isopropoxy-1,1,1,7,7,7-he methyl-3,5-dioxa-2-silabicyc (2,2,1)h ne	$C_{18}H_{52}O_7Si_7$
12	13.527	436	Hentricon ne	$C_{31}H_{64}$
13	14.108	240	Heptadecane	$C_{17}H_{36}$
14	14.211	168	Cyclopentane, 1-H 3-methylcyclopentane	$C_{12}H_{24}$
15	14.407	180	d-mannose	$C_6H_{12}O_6$
16	15.874	150	1,2 ,4,5-cyclopentanepentol	$C_5H_{10}O_5$
17	15.957	88	Silane, tetramethyl	$C_4H_{12}Si$
18	16.333	296	Heneicosane	$C_{21}H_{44}$
19	16.49	336	Cyclohexane, Octadecylcyclohexane	$C_{24}H_{48}$
20	16.541	178	Diphenylacetylene	$C_{14}H_{10}$
21	17.04	278	1,2-benzenedicarboxylic acid, bisdimethyl phthalate	$C_{16}H_{22}O_4$
22	17.857	436	Hentriacontane	$C_{31}H_{64}$
23	17.9 5	256	n-Hexadecanoic acid	$C_{16}H_{32}O_2$
24	8.28	340	Eicosanoic acid, ethyl ester	$C_{22}H_{44}O_2$
25	18.3	338	Tetracosane	$C_{24}H_{50}$
26	.541	182	Heptycyclohexane	$C_{13}H_{26}$
27	19.177	364	1-hexacosene	$C_{26}H_{52}$
28	19.601	280	9,12-octadecadienoic acid (Z, Z)-	$C_{18}H_{32}O_2$
29	19.653	280	17-octadecynoic acid	$C_{18}H_{32}O_2$
30	19.731	238	7- hexadecenal, (Z)-	$C_{16}H_{30}O$
31	19.848	284	Octadecanoic acid	$C_{18}H_{36}O_2$
32	19.913	282	Oleic acid	$C_{18}H_{34}O_2$
33	20.185	604	Tritetracontane	$C_{43}H_{88}$
34	21.133	652	2,2,4,4,6,6,8,8-heptamethyl-2,4,6,8-tetrasiloxane	$C_{16}H_{48}O_{10}Si_9$

35	21.869	436	Hentriacontane	$C_{31}H_{64}$
36	22.462	322	Benzene, 1,1'-(1,2-ethanediyl) bis (1,1'-(1,2-Ethanediyl)bis(benzene)	$C_{24}H_{34}$
37	22.518	266	Conocarpan	$C_{18}H_{18}O_2$
38	22.816	358	Octadecanoic acid,2,3-dihydroxypropyl trioleate	$C_{21}H_{42}O_4$
39	22.985	390	Phthalic acid, di(2-proylpentyl) ester	$C_{24}H_{38}O_4$
40	24.186	266	Z, E-3,13-octadecadin-1-ol	$C_{18}H_{34}O$
41	24.373	358	Octadecanoic acid, 2,3-dihydroxypropyl.	$C_{21}H_{42}O_4$
42	24.975	236	Acetic acid, Bis (trimethylsilyl) sulfide oxide, trimethylsilyl ((trimethylsilyl) thio)acetate	$C_8H_{20}O_2SSi_2$
43	27.483	254	13-tetradecen-1-ol	$C_{16}H_{30}O_2$
44	30.023	410	Butyl tetracosyl ether	$C_{28}H_{58}O$
45	30.624	414	Beta-sitosterol	$C_{29}H_{50}O$

Table 6: Compounds detected in the stem ethanol extract of *Combretum mossambicense*.

Index	Retention time	Molecular weight	Name	Formula
1	8.746	170	Dodecane	$C_{12}H_{26}$
2	10.105	444	Cyclohexasiloxane, dodecamethyl	$C_{12}H_{36}O_6Si_6$
3	10.969	254	9-methylheptadecane	$C_{18}H_{38}$
4	11.619	212	Pentadecane	$C_{15}H_{32}$
5	12.33	576	3-isopropoxy-1,1,1,7,7,7-hexamethyl-3-	$C_{18}H_{52}O_7Si_7$
6	12.901	198	Tridecane, 6-methyl-	$C_{14}H_{30}$
7	13.529	436	Hentriacontane	$C_{31}H_{64}$
8	13.767	436	Hentriacontane	$C_{31}H_{64}$
9	14.11	0	Heptadecane	$C_{17}H_{36}$
10	14.212	182	Heptylclohexane	$C_{13}H_{26}$
11	14.6	150	1,2,3,4,5-cyclopentanepentol	$C_4H_{22}O_4$
12	15.176	198	Naphthalene,1,6-dimethyl-4-(1-methylet)	$C_{15}H_{18}$
13	15.7	436	Hentriacontane	$C_{31}H_{64}$
14	15.955	88	Silane, tetramethyl	$C_4H_{12}Si$
15	16.025	436	Hentriacontane	$C_{31}H_{64}$
16	16.333	282	Eicosane	$C_{20}H_{42}$
17	16.489	350	Cyclohexane, nonadecyl	$C_{25}H_{50}$
18	16.541	178	Phenanthrene	$C_{14}H_{10}$
19	17.043	278	1,2-benzenedicarboxylic acid, bis(2-met)	$C_{16}H_{22}O_4$
20	17.441	652	2-(2',4',4',6',6',8',8)-heptamethytetrasiloxane	$C_{16}H_{48}O_{10}Si_9$
21	17.856	436	Hentriacontane	$C_{31}H_{64}$
22	17.952	256	n-hexadecanoic acid	$C_{16}H_{32}O_2$

23	18.004	278	Dibutyl phthalates	$C_{16}H_{22}O_4$
24	18.073	436	Hentriacontane	$C_{31}H_{64}$
25	18.284	340	Eicosanoic acid, ethyl ester	$C_{22}H_{44}O_2$
26	18.349	338	Tetracosane	$C_{24}H_{50}$
27	18.544	242	1-hexadecanol	$C_{16}H_{34}O$
28	19.175	256	n-heptadecanol-1	$C_{17}H_{36}O$
29	19.591	280	9,12-octadecadienoic acid (Z, Z)-	$C_{18}H_{32}O_2$
30	19.643	310	9-Eicosenoic acid, (Z)-	$C_{20}H_{38}O_2$
31	19.73	310	Heneicosane,5-methyl-	C22H46
32	19.843	284	Octadecanoic acid	$C_{18}H_{36}O_2$
33	20.185	436	Hentriacontane	$C_{31}H_{64}$
34	20.411	350	Cyclohexane, nonadecyl	$C_{25}H_{50}$
35	21.133	234	Oxalic acid, 2TMS derivative	$C_8H_{20}O_2SSi_2$
36	22.981	390	bis (2-ethylhexyl) phthalate	$C_{24}H_{38}O_4$
37	24.978	236	Mercaptoacetic acid, 2TMS derivative	$C_8H_{20}O_2SSi_2$
38	24.978	236	Mercaptoacetic acid, 2TMS derivative	$C_8H_{20}O_2SSI_2$
39	25.598	436	Hentriacontane	$C_{31}H_{64}$

Table 7: Compounds detected in the ethanol extract of Coartem.

Index	Retention time	Molecular weight	Name	Formula
1	10.110	444	Cyclohexasiloxane, Dodecamethylcyclohexasiloxane	$C_{12}H_{36}O_6Si_6$
2	12.330	576	3-isopropoxyl-1,1,1,7,7,7-hexamethyl-3, 5-dioxatetrasilabicyclo(3.3.0)octane	$C_{18}H_{52}O_7Si_7$
3	13.039	206	2,4-Di-tert-butylphenol	$C_{14}H_{22}O$
4	15.170	238	1,4-Dihydroxy-1,2,3,3a,4,5,6,8a-octahydroazulene	$C_{15}H_{26}O_2$
5	16.300	180	3-(2,6,6-trimethyl-1-cyclohexen-1-yl)-2-propen-1-ol	$C_{12}H_{20}O$
6	17.[illegible]24	205	(5R, 8R,8aS)-8-Methyl-5- (pent-4-yn-1-yl) tetradecanamine	$C_{14}H_{23}N$
7	18.002	256	n-hexadecanoic acid	$C_{16}H_{32}O_2$
8	18.054	222	5-mthoxy-10,10-dimethyl-6-methylenebic	$C_{14}H_{22}O_2$
9	18.930	236	5-mthoxy-10,10-dimethyl-6-methylenebic	$C_{15}H_{24}O_2$
10	19.536	186	Methyl-8-methyl-nonaoate	$C_{11}H_{22}O_2$
11	19.901	264	Octadecanoic acid	$C_{18}H_{36}O_2$

Table 8: Compounds detected in the ethanol extract of Sulphadar.

Index	Retention time	Molecular weight	Name	Formula
1	5.839	93	Aniline	C_6H_7N
2	8.674	182	6-tridecane, Z)-	$C_{13}H_{36}$
3	12.384	152	Benzoic acid, 4- hydroxyl- hydrazide	$C_7H_8N_2O_2$

4	12.604	328	Carbonic acid, ethyl heptedecyl ester	$C_{20}H_{40}O_3$
5	14.197	228	Lauryl acetate	$C_{14}H_{28}O_2$
6	15.041	260	Hexadecane,1- chlorohexadecane.	$C_{16}H_{33}Cl$
7	17.970	256	n-Hexadecanoic acid	$C_{16}H_{32}O_2$
8	19.965	284	Octadecanoic acid	$C_{18}H_{36}O_2$
9	20.328	248	Pyrimethamine	$C_{12}H_{13}ClN_4$
10	25.742	310	Sulfadoxine	$C_{12}H_{14}N_{44}O_4S$

Table 9: Compounds detected in the ethanol extract of quinine.

Index	Retention time	Molecular weight	Name	Formula
1	10.110	444	Cyclohexasiloxane, Dodecamethylcyclohexasiloxane.	$C_{12}H_{36}O_6Si_6$
2	4.032	151	Oxime, methoxy-phenyl-oxime	$C_8H_9NO_2$
3	12.374	152	Benzoic acid,4-hydroxy-hydra	$C_7H_8N_2O_2$
4	12.374	152	Benzoic acid, 4-hydroxy-hydraide	$C_7H_8N_2O_2$
5	14.066	222	Diethyl phthalate	$C_{12}H_{14}O_4$
6	17.625	228	Methyl 11-methyl-dodecanoate	$C_{14}H_{28}O_2$
7	17.963	256	n-hexadecanoic acid	$C_{16}H_{32}O_2$
8	19.848	284	Octadecanoic acid	$C_{18}H_{36}O_2$
9	20.246	248	Pyrimethamine	$C_{12}H_{13}C_1N_4$
10	25.580	356	Quinine 1,1'-dioxide, (9S)- ibogaine	$C_{20}H_{24}N_2O_2$
11	25.874	324	Quinine	$C_{20}H_{24}N_2O_2$
12	26.286	324	1- (5-ethylquinulidine-2-carbonyl)-6- ergotamine	$C_{20}H_24N_2O_2$

Table 10: The results for the *Combretum molle Combisense* plant.

Compounds	Formula	Retention time	Molecular weight	Activity
Propanoic acid, 2-mecapto- methyl ester	$C_4H_8O_2S$	5.147	120	Used as a solvent in pharmaceuticals
Propane-2-fluoro-2-methyl	C_4H_9F	4.970	76	insecticide
2(3H)-Furanone, dihydro-4-di	$C_4H_{10}O_3$	6.329	130	Causing relaxation. Increasing mental clarity Relieving depression and stress.
Dodecane	$C_{12}H_{26}$	8.744	170	Antibacterial activity and antifungal activity.
Cyclohexasiloxane, dodecamethyl	$C_{12}H_{36}O_6Si_6$	10.107	444	Medical devices, blood-handling equipment, as a blood defoaming agents, protective barriers, lubricants, and surface treatment of wound dressings
Tetracontane,3,5,24-trimethyl	$C4_3H_{88}$	10.241	604	Anti-inflammatory
1,2,3- Benzenetriol	$C_6H_6O_3$	11.224	126	Antimicrobial, Anti-inflammatory, antioxidant, Analysis, insecticide, anticancer, cytoxic
Pentadecane	$C_{15}H_{32}$	11.618	212	Used in organic synthesis and as a solvent.

3-isopropoxyl-1,1,1,7,7,7-hexamethyl-3-5	$C_{18}H_52O_7Si_7$	12.332	576	Antimicrobial
Heptadecane	$C_{17}H_{36}$	12.902	212	Antifungal
2,2-dimethyoctadecane	$C_{20}H_{42}$	13.527	282	Antimicrobial
Eicosane	$C_{20}H_{42}$	13.765	282	Antibacterial, antifungal, antitumor, antimicrobial, larvicidal Methyl-beta-d-thiogalactoside
(maaliol)	$C_7H_{14}O_6$	14.111	194	Antinociceptive, Anticancer
Naphthalene,1,6-dimethyl-4-(1-methyllethane	$C_{15}H_{18}$	14.384	198	Antioxidant, Antibacterial
Silane, tetramethyl	$C_4H_{12}Si$	15.175	88	used as a starting material for synthesizing more silanes,
Hentriacontane	$C_{31}H6_4$	15.954	436	treat diseases such as skin diseases, ulcers, betes, piles, dysentery, asthma, gonorrhea gleets, leucorrhoea, and urinary diseases.
Cyclohexane, nonadecyl	$C_{25}H_{50}$	16.024	350	
Phenanthrene	$C_{14}H_{10}$	16.335		Used to make dyes, plastic, pesticides, explosives and drugs
1,2-benzenedicarboxylic acid, bis (2-methyl propyl ester)	$C_{16}H_{22}O_4$	17.044	278	antibacterial
2-(2',4',4',6',6',8',8', -heptamethyltetrasiloxane	$C_{16}H_{48}O_{10}Si_9$	17,441	652	Antifungal
Dodecane, 1-fluoro-dodecane	$C_{12}H_{25}F$	17.854	188	
n-Hexadecanoic acid	$C_{16}H_{32}O_2$	17.958	256	Antioxidant, anti-inflammatory, hypochglestero lenic, nematicide, pesticide, lubricant, antiandrogenic, flavor
Tetracosane	$C_{24}H_{50}$	18.384	338	Treatment of nervous debility, insomnia, fatigue, low energy level, and brain tonic for memory functions.
Cyclohexane, nonadecyl	$C_{25}H_{50}$	18.542	350	
Hexanedioic, bis (2-ethylhexyl) est	$C_{22}H_{44}O_2$			Antifungal
Cis-7-hexadecenoic acid	$C_{16}H_{30}O_2$	19.647	254	Antibacterial
Oleic acid	$C_{18}H_{34}O_2$	19.846	282	Anti-inflammatory, anti-androgenetic cancer preventive
Malonic acid, bis (2-trimethy silyl ethyl ester)	$C_{13}H_{38}O4Si_2$	21.131	304	anti-inflammatory effect, bactericidal
1,4,10-trihydroxy-5-(hydroxymethyl) -8-methyl	$C_{30}H_{44}O_{10}Si_4$	22.188	676	antimicrobial
Didode cyl phthalate	$C_{32}H_{54}O_4$	22.983	502	Used as a solvent and vehicle for fragrance and cosmetic ingredients, as well as an alcohol denaturant – that is, an additive to alcohol to make it unfit to drink.
Octadecanoic acid,2,3-dihydroxypropyl	$C_{21}H_{42}O_4$	24.373	358	Anticancer, antimicrobial

17-pentatriacontene	$C_{35}H_{70}$	27.484	490	anti-inflammatory, anticancer, antibacterial, and ant-arthritic properties
4-methylpiperidine-1-carboxylic acid,	$C_{13}H_{17}NO_2$	6.741	219	Anti-inflammatory, and rheumatic disorders used in ophthalmological eyedrops to enlarge pupils.
2(2H)-Furanone,5-heptydihydro	$C_{11}H_{20}O_2$	8.962	184	Antifungal, antibacterial
5-hydroxymethylfurfural	$C_6H_6O_3$	9.174	128	antioxidants
Nonane,1,1-dethoxy	$C_{13}H_{28}O_2$	11.315	216	Give a strong fruity aroma
Cyclopentane,1-hexyl-3-methyl	$C_{12}H_{24}$	14.211	168	It has a role [illegible] a human metabolite and a mammalian metabolite.
d-mannose	$C_6H_{12}O_6$	14.407	180	Use to [illegible] called carbohydrate-deficient glycol protein syndrome type 1b
1,2,3,4,5- cyclopentol	$C_5H_{10}O_5$	15.874	150	Used for pharmaceuticals, dyes, and spices production, it is also used as a solvent for drugs and spices.
Cyclohexane, octadecyl	$C_{24}H_{48}$	16.490	336	Used for organic synthesis
biphenyl acetylene	$C_{24}H_{10}$	16.541	298	It is used as a building block in organic synthesis and as a ligand in organometallic chemistry.
1,2-benzenedicarboxylic acid, bis (2-methyl ester)	$C_{16}H_{22}O_4$	17.040	278	Antimicrobial, antifouling
Eisosanoic acid, ethyl ester	$C_{22}H_{44}O_2$	18.280	340	Helps to store the skin's natural oils
Tetracosane	$C_{24}H_{50}$	18.345	338	Used for organic synthesis
heptylcyclohexane	$C_{13}H_{26}$	18.541	182	
1-hexacosane	$C_{26}H_{54}$	19.174	364	antimicrobial activity
9,12-octadecadienoic acid (z, z) methyl ester	$C_{18}H_{32}O_2$	19.601	280	Antibacterial, antiplasmodial activity
17-octaecynoic acid	$C_{18}H_{32}O_2$	19.653	280	Antibacterial, anti-inflammatory, Antiplasmodial
7-hexadecenal, (z)	$C_{16}H_{30}O$	19.731	238	
Octadecanoic acid	$C_{16}H_{36}O_2$	19.848	284	Antibacterial
Benezene,1,1-(1,2-ethanediyl) bis (2,3,[illegible]	$C_{24}H_{34}$	22.462	322	Antinociceptive anti-Inflammatory
Conocarpan	$C_{18}H_{18}O_2$	22.518	266	Anticancer, antimicrobial
Octadecanoic acid, 2,3-dihydroxy propxyl	$C_{21}H_{42}O_4$	22.816	358	Antimicrobial antifouling, antibacterial activity
Phthalic acid, di(2-propylpentyl) ester	$C_{24}H_{38}O_4$	22.985	390	Antibacterial used to treat TB, anti-malarial
Z, E-3,13-octadecadien-1-ol	$C_{18}H_{34}O$	24.186	266	Helps to lose weight
13-tetradecen-1-ol acetate	$C_{16}H_{30}O_2$	27.483	254	Used for treatment of Parkinson's disease
Butyl tetra cosyl ether	$C_{28}H_{58}O$	30.023	410	Used to lower the level of lipids in the blood
Beta-sitosterol	$C_{29}H_{50}O$	30.624	414	Anti-inflammatory, antipyretic, anti-ulcer, and arthritic antiplasmodial

DISCUSSION

The samples collected from the leaf stems and roots presented in Table 7 show the results for the *Combretum mossambicense* plant used in this study. Due to space constraints, some of the GC MS data did not provide a complete name, but the chemical formula helped identify what they were.

Results for an extract of parts of *Combretum mossambisense*

Leaf extract results and analysis (MZL02): Table 7 shows the results of the GC–MS investigation, which revealed a total of 37 chemicals. The peaks were visible in the GC–MS chromatogram. Some of the chemicals found were propanoic acid, 2-mercapto-methyl ester, 3-isopropoxyl-1, 1, 1, 7, 7,7-xxamethyl-3, 5-, malonic acid, bis(2-trimethylsilyyl ester), Octadecanoic acid, and 2,3-dihydroxypropropyl ester. There were no alkaloids found. Table 3 shows the results of the leaf extracts of *Combretum mossambisense*, and none of the substances found had antiplasmodial activity according to the available literature.

Root extract results and analysis (MZR02): GC–MS analysis revealed 45 compounds (Table 4). Only one alkaloid was detected, and it is used to treat anti-inflammatory and rheumatic illnesses, as well as to widen pupils in ophthalmological eye drops.

MZR02 contained many compounds, including n-hexadecanoic acid, eicosanoic acid, ethyl ester, 9,12-octadecadienoic acid (z,z), 17-octadecynoic acid, octadecanoic acid, and beta-sitosterol. The roots contained the greatest number of antimalarial chemicals, four of which were identified: 9,12-octadecadienoic acid (Z,Z)-methyl ester, 17-octadecynoic acid, phthalic acid, di (2-propyl pentyl) ester (also known as bis (2-ethylhexyl) phthalate), and beta-sitoste[34-36].

Stem extract results and analysis (MZS02): The ethanol extract of MZS02 (Table 5) yielded a total of 39 compounds. Some of the detected compounds were heptade[illegible]ane, [illegible]clopentane, 1-hexyl-3-methyl, hentriacontane, tetradecane[illegible]ane, tetramethyl, 1,2-benzenedicarboxylic acid, bis (2-[illegible]et., eicosane, 2-(2',4',4',6',6',8',8)-heptamethyletrasi[illegible]ne, phthalic acid, and 2-chloropropyl isobutyl ester.

No alkaloids were found, but two antiplasmodial or antimalarial compounds were detected. These include 9,12-octadecadienoic acid (Z,Z)-methyl ester, , phthalic acid, and di (2-propyl pentyl) ester, also known as bis (2-ethylhexyl) phthalate.

Analysis of conventional malaria drugs

Many diseases, including malaria, have been treated using single-component medications in recent decades. Combination therapy, a new technique that is effective against other multidrug-resistant illnesses, such as Human Immunodeficiency Virus (HIV) and tuberculosis, is now widely suggested for malaria treatment [37]. As a result of the rapid increase in drug resistance among *Plasmodium* parasites worldwide, combination therapy has gradually supplanted single-drug treatment of malaria [38]. Combination therapy, particularly quinine, which has been linked to *Plasmodium* parasite resistance, was used in combination with traditional drugs [39]. Researchers are working on novel medications to combat malaria, in addition to combination therapy with alkaloid drugs.

Use of other compounds to treat malaria

There is advanced research on other compounds in the treatment of malaria, apart from alkaloids, as the resistance of the parasite to drugs increases. Esters, ethers, and phenols are some of these compounds. Stigmasterol, p-hydroxycinnamic acid ethyl ester, docosanoic acid ethyl ester, octadecanoic acid methyl ester, and 9-octadecenoic acid (Z)-ethyl ester were obtained. Hexadecanoic acid, methyl ester, 9,12-octadecadienoic acid, methyl ester (linoleic acid), 9,12,15-octadecatrienoic acid, methyl ester (linoleic acid), 9-octadecenoic acid (Z) eicosanoic acid, 2-(acetyloxy)-1-((acetyloxy) methyl) ethyl ester and 2-hydroxyethyl ester are polyunsaturated fatty acids that exhibit anti-plasmodial action. This activity is said to increase as the degree of unsaturation increases. According to previous research on bis(2-ethylhexyl) phthalate, it has a similar effect on malaria parasites as artesunate, scientifically called ((3R,5aS,6R,8aS,9R,10S,12R,12aR)-decahydro-3,6,9-trimethyl-3,12-epoxy-12 Hpyrano ((4,3-j)-1,2-benzodioxepin-10-yl) ester, an effective conventional malaria [illegible]

CONCLUSION

In this work, a phytochemical investigation of *Combretum mossambisense*, a plant whose herbal extract is utilized as a potent herbal anti-malaria remedy, was performed to establish whether the plant contains alkaloids found in anti-malaria drugs. However, it was established that the plant does not contain any antimalarial alkaloids. However, it was observed that the plant contains chemicals similar to those found in conventional malaria medicines. Compounds such as octadecanoic acid, n-hexadecanoic acid, cyclohexasiloxane, tetrasiloxane 3-isopropoxyl-1, 1, 1, 7, 7, and 7-xamethyl-3, 5, and 5 TIS (trimethylsiloxyl) were detected in the herb, as were conventional medications. *Combretum mossambisense*, as well as Coartem and quinine, contains n-hexadecanoic acid. Quinine and *Combretum mossambicense* contain cyclohexasiloxane. The tetrasiloxane 3-isopropoxyl-1, 1, 1, 7, 7,7-hexamethyl-3, 5, 5 TIS (trimethylsiloxyl) was discovered in *Combretum mossambicense* and Coartem. Several comparable chemicals were also observed.

Other forms of alkaloids were found, but the data indicated that they could be useful for treating other conditions but not malaria. Norepinephrine (R), a 4TMS derivative, is an example of such an alkaloid. It is used to treat life-threatening low blood pressure (hypotension), which can arise because of certain medical conditions or surgical procedures.

It was observed from the data gathered in this study that malaria is treated by more than just alkaloids. Other chemicals are also effective. The following compounds are reported to have favorable effects on the malaria parasite *P. Falciparum*: 9,12-octadecadienoic acid (Z, Z), methyl ester, and bis (2-ethylhexyl) phthalate, which were found in the *Combretum mossambicense* extract. The *Combretum mossambicense* also contained 17-octadecynoic acid and beta-sitosterol. According to the literature, 17-octadecynoic acid inhibits both *Plasmodium* infections and plasmodial FAS-II enzymes, while beta-sitosterol in combination with other compounds shows potential antiplasmodial activity. Because of these properties, it would be safe to conclude that the *Combretum mossambicense* extract is an effective non-alkaloid-based antimalarial herbal remedy. These results are important because of the observed resistance of *P. Falciparum* to alkaloid-based antimalaria drugs. This could also help to explain why some modern conventional anti-malaria drugs are nonalkaloid based. Further studies on *Combretum mossambicense* investigating the efficacy and toxicity of this herbal remedy will be reported in a subsequent publication.

REFERENCES

1. CDC-Centers for disease control and prevention. 2010.
2. Intensifying the fight against malaria. 2008.
3. Bank W. Bioactive alkaloids from medicinal plants of Lombok.2002.
4. Vivekraj A, Vijayan A, Anandgideon V, Muthuselvam D. Phytochemical Profiling of Abutilon hirtum (lam.) Sweet. Leaf Extracts Using GC-MS analysis. World J Pharm Res. 2015; 4(3):1270-12755 .
5. Dey P, Kundu A, Kumar A, Gupta M, Lee BM, Bhakta T, et al. Analysis of alkaloids (indole alkaloids, isoquinoline alkaloids, tropane alkaloids). Rec Adv in Nat Prod Anal 2020; 505-567
6. Aniszewski T. Alkaloids-secrets of life: Aklaloid chemistry, biological significance, applications and ecological role. Elsevier. 2007.
7. Alamgir AN. Therapeutic use of medicinal plants and their extracts: Volume 1. Springer Int Pub AG. 2017.
8. Hermans M, Akoègninou A, van der Maesen J. Medicinal plants used to treat malaria in southern Benin. Econ Bot. 2004; 58(1):239-252.
9. Bikash D, Jashim U, Prasenjit P, Manik D, Debasish MC, Kuntal. Estimation of alkaloids and phenolics of five edible cucurbitaceous plants and their antibacterial activity'. Int J Pharm Sci. 2005; 7(12): 223-227.
10. World Health Organization. (2020). World malaria report: 20 years of global progress and challenges.
11. Ross I.A. Medicinal plants of the world. 2001.
12. Kabula B, Tungu P, Matowo J, Kitau J, Mweya C, Emidi B, et al. Susceptibility status of malaria vectors to insecticides commonly used for malaria control in Tanzania. Trop Med Int. Health 2012;17(6):742-750.
13. Mosquito Life Cycle | US EPA. 2021.
14. Rasmussen C, Alonso P, Ringwald P. Current and emerging strategies to combat antimalarial resistance. Expert Rev Anti Infect Ther. 2022; 20(3):353-372.
15. Bilia AR, Lapenna S, Bergonzi MC, Vincieri F. NPC Natural product communications 2008. NPC Nat Prod Co. 2008.
16. World Malaria Report: 20 years of global progress and challenges. 2020.
17. CDC - Malaria - malaria worldwide - Impact of malaria. 2015.
18. Blenkinsopp A, Duerden M, Blenkinsopp J. Symptoms in the pharmacy: A guide to the management of common illnesses. John Wiley Sons. 2022.
19. Nawa M, Hangoma J, Morse A, Michelo C. Investigating the upsurge of malaria prevalence in Zambia between 2010 and 2015: A decomposition of [illegible]. Malaria J. 2019;18:1-0.
20. World Malaria Report: 20 years of global progress and challenges. 2020.
21. World Malaria Report. 2021.
22. World Malaria Report 2015-World Health organization-google books. In WHO Press, World Health Organization, 20 Avenue Appia, 1211 Geneva 27, Switzerland. 2015.
23. Kurek J. Alkaloids: Their importance in nature and human life. BoD–Books on Demand. 2019.
24. Nchabeleng EK. Determination of biological activity of Celtis africana extracts and its endophytic microflora and mycoflora.2017.
25. Uzor PF. Alkaloids from plants with antimalarial activity: A review of recent studies. Evid Based Complement Alternat Med. 2020; 2020(1):8749083.
26. Mustofa SE, Wahyuono S. In vitro and in vivo antiplasmodial activity and cytotoxicity of extracts of Phyllanthus niruri L. herbs traditionally used to treat malaria in Indonesia. Southeast Asian J Trop Med Public Health. 2007;38(4):609-15.
27. Okokon JE, Augustine NB, Mohanakrishnan D. Antimalarial, antiplasmodial and analgesic activities of root extract of Alchornea laxiflora. Pharm Biol. 2017; 55(1):1022-3[illegible]
28. Okokon JE, Antia BS, Mohanakrishnan D, Sahal D. Antimalarial and antiplasmodial activity of husk extract and fractions of Zea mays. Pharm Biol. 2017 ;55(1):1394-400.
29. Nafiah MA, Khoo J, Chen H, Muhammad SN, Awang K, Hadi AH, et al. Extraction and isolation of alkaloids from the leaves of Alseodaphne corneri Kosterm. Malaysian J Chem. 2013;15(1):27-32.
30. Rotary Evaporator-an [illegible].2020.
31. Li L, Long W, Wan J, Ding Q, Zhang F, Wan D. Studies on quantitative determination of total alkaloids and berberine in five origins of crude medicine "Sankezhen". J Chrom Sci. 2015 ;53(2):307-11.
32. Banakar P, Jeraj M. GC-MS analysis of bioactive compounds from ethanolic leaf extract of Waltheria indica Linn. and their pharmacological activities. Int J Pharm Sci Res. 2018;9(5):2005-10.
33. Rajaduraai MV, Maithili RA, Yogesh V. Phytochemical profiling of medically significant crude extract using GC-MS analysis. Int J Curr Pharm. Res. 2021;10:16-20.
34. Tajuddeen N, Van Heerden FR. Antiplasmodial natural products: An update. Malaria J. 2019;18:1-62.
35. Enenebeaku UE, Duru CE, Mgbemena IC, Ukwandu NC, Nwigwe HC, Enenebeaku CK, et al. Phytochemical evaluation and molecular docking of bioactive compounds from the roots of Dictyandra arborescens (Welw.) against Plasmodium berghei protein targets. CABI Database. 2021; 5(2): 370-381.
36. Gakunju DM, Mberu EK, Dossaji SF, Gray AI, Waigh RD, Waterman PG, et al. Potent antimalarial activity of the alkaloid nitidine, isolated from a Kenyan herbal remedy. Antimicrob Agents Chemother. 1995;39(12):2606-9.
37. Marimani M. Combination therapy against multidrug resistance. Comb Ther Ag Multid Res. 2020; 39-64.
38. Hunt P, Martinelli A, Modrzynska K, Borges S, Creasey A, Rodrigues L, et al. Experimental evolution, genetic analysis and genome re-sequencing reveal the mutation conferring artemisinin resistance in an isogenic lineage of malaria parasites. BMC Genomics. 2010;11:1-3.
39. Yeung S, Pongtavornpinyo W, Hastings IM, Mills AJ, White NJ. Antimalarial drug resistance, artemisinin-based combination therapy, and the contribution of modeling to elucidating policy choices. Am J Trop Med Hyg. 2004;71(2):179-86.