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PHYTOCHEMICAL ANALYSIS OF THE LEAF, STEM BARK AND ROOT OF SOME ANTIMALARIAL PLANTS USED IN SOUTH-WESTERN NIGERIA

[1]Chijindu, P.C.I., [2]Okpoma, M.O. and [3]Fasola, T.R.
[1]Department of Biological Sciences, University of Delta, Agbor, Delta State, Nigeria
[2]Department of Botany, University of Lagos, Lagos, Nigeria
[3]Department of Botany, University of Ibadan, Ibadan, Nigeria

Correspondence: pass.chijindu@unidel.edu.ng

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ABSTRACT

Quantitative phytochemical analysis of the leaf, stem bark and root of some antimalarial plants common in South-Western Nigeria was carried out. Results obtained showed the presence of tannins, alkaloids, flavonoids, terpenoids, saponins and phenolic acids in various concentrations in the different plant parts analysed. A high composition of phytochemicals was observed in the leaves, which confirms their frequency of usage in traditional medicine for the treatment of malaria. Of the various plants analysed, *Mangifera indica* leaves and stem bark had the highest tannin (176.3±1.5 mg/kg Garlic acid equivalents) and alkaloid (7350.3±2.5 mg/kg GAE) contents, respectively. Flavonoids were significantly highest ($p<0.05$) in the roots of *Vernonia amygdalina* (5055.0±3.0 mg/kg GAE). Terpenoid content was highest in the leaves of *Khaya senegalensis* and *Psidium guajava* (164.0±1.0 mg/kg GAE). Saponin content was generally low but was significantly highest ($p<0.05$) in the stem bark of *Tithonia diversifolia* (98,260.0±5.0 mg/kg GAE) while phenolic acid content was highest in the roots of *Citrus paradisi* (110.0±5.0 mg/kg GAE). All the plant parts analysed contained phytochemicals in various proportions, thus, justifying their use in traditional therapy and management of malaria disease.

Key words: *Phytochemicals; antimalarial; South-Western; plasmodium; malaria*
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INTRODUCTION

Traditional medicines have been used to treat malaria for thousands of years and are the source of the two main groups (artemisinin and quinine derivatives) of modern antimalarial drugs (Willcox and Bodeker, 2004). Malaria is caused by *Plasmodium* parasites and it is spread to people through the bites of infected female *Anopheles* mosquitoes. According to WHO, malaria is endemic in 91 countries predominantly in Africa, Asia and Latin America with an estimated 216 million cases of malaria and malaria deaths reaching 445, 000 in 2016 (WHO, 2017). The WHO African Region carries a high share of the global malarial burden as the region was home to 90% of malarial cases and 91% of malarial deaths.

Despite the efforts to provide and distribute anti-malarial drugs, people in rural communities are not able to access these drugs due to their high cost which has made them unaffordable and has led to widespread use of herbs for the treatment of malaria. In 2007, the traditional medicine policy (TMP) reported that plants/herbs remain the mainstay of healthcare systems in rural communities. Plants are a valuable source of various pharmacological active substances capable of dealing with health problems of humans. The attempt by mankind to use plants and plant products to cure diseases like malaria and relieve physical suffering is as old as creation (Mirutse *et al.,* 2003). WHO estimates that at least 80% of the populations in most developing countries of the world rely on traditional treatments for their primary healthcare needs (WHO, 1993; Ene *et al.,* 2009).

The medicinal value of plants has assumed a more important dimension in the past few decades owing largely to the discovery that extracts from plant samples contain not only minerals and primary metabolites but also a diverse array of secondary metabolites with antioxidant potential (Akinmoladun *et al.,* 2007).

Plants have limitless ability to synthesise aromatic substances, mainly secondary metabolites, used as defensive mechanisms against microorganisms, insects and herbivores. Close and McArthur (2002), Okwu, (2004), Okwu and Omodamiro (2005) and Okwu *et al.* (2007) have reported that woody plants and herbs synthesise and accumulate in their cells a great variety of phytochemicals including low molecular phenolics (hydroxybenzoic and hydroxycinnamic acids) as well as oligo or polymeric forms (hydrolysable and condensed tannins and lignins). These secondary metabolites have been shown to have a number of medicinal properties to improve human health (Lal *et al*., 2023).

Nigeria is gifted with an immense floral diversity which is exploited as a source of food, medicine, raw materials for businesses and industry, and for other ecological services. Such a rich biodiversity implies that the country is blessed with plants with diverse secondary metabolites and unique phytochemicals which can serve as a source of medicine for the treatment of ailment in rural communities.

Ethnobotanical survey is an important step in the identification, selection and development of therapeutic agents from medicinal plants (Idowu *et al.,* 2010). In ethnobotany and natural products chemistry, the mode of preparation and administration of herbal preparations are often crucial variables in determining efficacy in pharmacological evaluations (Idowu *et al.,* 2010).

A review of the medicinal plants used in south-western Nigeria for the treatment of malaria indicates that a rich floral diversity exists in Nigeria (Odugbemi *et al.,* 2007). Ethnobotanical surveys carried out by several researchers have shown the use of a variety of plant species used, singly or in combination, for the treatment of malaria. Some of the mostly used plants in the Western part of Nigeria includes *Azadirachta indica* (Dogonyaro), *Khaya senegalensis* (Oganwo), *Alstonia boonei* (Ahun), *Mangifera indica* (Mangonro), *Morinda lucida (*Oruwo), *Carica papaya* (Ibepe), *Citrus species* (Osan wewe, *Osan gerepu*), *Anacardium occidentalis* (kashu), *Enantia chlorantha* (Awopa), *Chromolaena odorata* (Ewe Akintola), *Psidium guajava* (Gova), *Tithonia diversifolia* (Sepeleba) (Odugbemi *et al*., 2007; Idowu *et al.*, 2010; Ene *et al*., 2010). A research into the phytochemical contents of these plants may lead to the discovery of novel metabolites with great medicinal potentials against malaria.

MATERIALS AND METHODS

Plant Selection and Preparation

Plants were selected based on their high frequency of usage, as indicated in various ethnobotanical surveys carried out in the South-western part of Nigeria, on plants used in the treatment of malaria. All plant materials shown in Table 1 were collected around Ibadan, Oyo State in the South-western part of Nigeria and identified at the Department of Botany Herbarium, University of Ibadan, Oyo state, Nigeria. The different parts of the plant materials (leaves, bark, roots) were shade-dried. The dried samples were chopped into smaller pieces and pulverised using an electronic mill (commercial / generic disc attrition mill). The powdered samples were then stored in small plastic air-tight containers.

Phytochemical Screening

Determination of Tannin/Tannic acid using Harborne (1973) method

One gram (1g) of each sample was weighed and soaked in 25 ml solvent mixture (80 ml of acetone and 20 ml of 10% glacial acetic acid) for 5 hours to extract tannins. The samples were filtered through a double layer filter paper to obtain the filtrate. A standard solution of tannic acid was prepared ranging from 10 to 30. The absorbance of the standard solution as well as that of the filtrate were read at 500 nm on a spectrophotometer (Spectrum lab 23A).

Determination of Terpenoids using Harborne (1973) method

Extraction was done by weighing one gram (1g) each of the sample into 250 ml conical flask and soaked with 10 ml of petroleum ether. These were allowed to stay for 15 min and then filtered through double-layer filter paper. A standard solution 10, 20, 30, 40 and 50 ppm, standard solution was prepared and read in the spectrophotometer. The absorbance of the samples was measured on a spectrophotometer (Spectrum lab 23A) at 420 nm.

Determination of Alkaloids using Harborne (1973) method

One gram (1g) of each sample was weighed into 50 ml of 10% Acetic acid (HOAC) with Ethanol. It was mixed by shaking it and was allowed to stand for 4 hours, after which it was then filtered. The filterate was evaporated to 1/4 of its volume, after which concentrated ammonia was added in drops to precipitate the alkaloids. The precipitate was then filtered into a weighed filter paper and washed with 1% NH_4OH. The precipitate on the filter paper was dried in an oven at 60^0C for 30 min. The % alkaloid was calculated using the formula:

$$\% \text{ alkaloid} = \frac{W_2 - W_1}{W} \times \frac{100}{1}$$

Where,

W = Weight of sample

W_1= Weight of filter paper alone

W_2 = Weight of filter paper with precipitate

Determination of Flavonoids using the method of Boham and Kocipal-Abyaza (1974)

Two grams (2 g) of the plant samples was extracted with 20 ml of 80 % methanol at room temperature for 2 hr. The solution was filtered through Whatman filter paper No. 1 (110 mm). The filtrate was later transferred into a crucible, evaporated to dryness over a water-bath and weighed to constant weight. The total flavonoid content was computed using the formula:

$$\% \text{ Flavonoid} = \frac{W_2 - W_1}{W} \times \frac{100}{1}$$

Where,

W = Weight of sample

W_1 = Weight of crucible alone

W_2 = Weight of crucible + flavonoids

Determination fo Saponin using the method of Obadoni and Ochuko (2001)

One gram (1g) of each sample was weighed into bottles and 15 ml of 20% ethanol was added. These were heated in a water-bath at 55 ^{0}C for 4 hours and filtered. The residue was washed with 20 % ethanol twice and the extract was reduced to about 5 ml over the water-bath. Five (5) ml of petroleum ether was added in a separating funnel. The ether layer was discarded to the aqueous layer at the bottom, after which 3 ml butanol was added and washed with 5 ml of 5% NaCl in a separating funnel. The butanol layer was then poured into a weighed Petri dish and the saponin content was calculated using the formula:

$$\% \text{ Saponin} = \frac{W_2 - W_1}{W} \times \frac{100}{1}$$

Where,

W = Weight of sample

W_2 = Weight of Petri dish alone

W_1 = Weight of Petri dish + Saponin

Determination of Phenolic Content using the method of Singleton and Rossi (1965)

Two grams (2 g) of each sample was extracted with 20 ml of acetone (80%) and 0.2 % formic acid (20%) for 2 min. The extract was then filtered through Whatman filter paper 1. The supernatant was used for total phenolics analysis. Two (2) mls of the sample extract was measured into a test tube and 0.5 ml fohlin ciocalteau reagent was added. The mixture was allowed to stand for 30 mins and read in a spectrophotometer (Spectrum lab 23A) at a wavelength of 765 nm. Total phenolic content was expressed as tannic acid equivalents in mg/kg.

Statistical Analysis

The data were analysed using the two-way analysis of variance (ANOVA), using GLM procedure (Proc GLM) of SAS (Statistical Analysis System). The data were expressed as mean ± standard deviation (mean of 3 determinations) and differences between groups were considered significant at $p < 0.05$.

RESULTS

Medicinal plants used for the study

Medicinal plants with anti-malarial activity used in this study include *Morinda lucida* Benth., *Psidium guajava* L., *Mangifera indica* L., *Vernonia amygdalina* Delile., *Citrus paradisi* L., *Tithonia diversifolia* A. Grey. *Rauwolfia vomitoria* Afzel., *Khaya senegalensis.* Scientific, family, local and common names of the plant and parts used are presented in Table 1.

Plant parts used as anti-malarial

The number of parts for each plant used as anti- malarial in this study is presented in Table 2. Three (3) plant parts, namely leaf, bark and root, were recorded to be used as anti-malarial for *Citrus paradisi* L. and four (4) for *Rauwolfia vomitoria* Afze. Three (3) plant parts, namely, stem, bark and leaf were recorded for *Morinda lucida* Benth., *Psidium guajava* L., *Mangifera indica* L. while leaf and twig of *Tithonia diversifolia were* used and one (1) plant part was recorded for *Vernonia amygdalina* A. Grey. and *Khaya senegalensis* Desr (bark). Quantitative phytochemical analysis of the leaf, bark and root of anti-malarial plants in this study revealed the presence of medicinally active constituents in various quantities in the different plant parts analysed.

Quantitative phytochemical analysis of the leaf

The quantitative estimation of the crude phytochemical constituents in the leaf showed that the highest and the least amounts of tannins were recorded in *Mangifera indica* and *Citrus paradisi;* alkaloids-*Psidium guajava* and *Mangifera indica;* flavnoids - *Mangifera indica* and *Citrus paradisi;* terpenoids-*Psidium guajava, Khaya senegalensis* and *Citrus paradisi;* saponins- Tithonia diversifolia and *Vernonia amygdalina; p*henolic acids - *Vernonia amygdalina* and *Khaya senegalensis* (Table 3).

Quantitative phytochemical analysis of the bark

Quantitative crude phytochemical constituents in the stem bark of plants used in this study revealed that the highest and the least amounts of tannins were recorded in *Tithonia diversifolia* and *Citrus paradisi / Vernonia amygdalina;* alkaloids - *Mangifera indica* and *Vernonia amygdalina;* flavonoids - *Mangifera indica* and *Rauwolfia vomitoria;* terpenoids - *Psidium guajava* and *Tithonia diversifolia; s*aponins- *Tithonia diversifolia* and *Psidium guajava;* phenolic acids; *Morinda lucida* and none was present in *Vernonia amygdalina* and *Citrus paradisi* (Table 4).

Quantitative phytochemical analysis of the root

In the roots of the plants used for this study, the highest and least amounts of quantitative phytochemical constituents recorded were as follows: tannins-*Psidium guajava* and *Tithonia diversifolia;* alkaloids - *Psidium guajava* and *Vernonia amygdalina;* flavonoids - *Vernonia amygdalina and Morinda lucida;* terpenoids – *Khaya senegalensis* and *Rauwolfia vomitoria /Tithonia diversifolia; s*aponins- *Mangifera indica* and *Tithonia diversifolia;* phenolic acids-*Citrus paradisi* and *Morinda lucida* (Table 5).

Table 1: Medicinal plants with anti-malarial activity employed in this study

S/No	SCIENTIFIC NAME	FAMILY NAME	LOCAL NAME	COMMON NAME	PARTS USED
1.	*Morinda lucida* Benth	Rubiaceae	Oruwo	Brimestone tree	Stem, Bark, leaves
2.	*Psidium guajava* L.	Myrtaceae	Gilofa	Guava	Stem, Bark, leaves
3.	*Mangifera indica* L	Anacardiaceae	Mangoro	Mango	Stem, Bark, leaves
4.	*Vernonia amygdalina* Del.cent	Asteraceae	Ewuro	Bitterleaf	Leaves
5.	*Citrus paradise*	Rutaceae	Osan-gerepu	Grape	Leaves, stem, roots
6.	*Tithonia diversifolia* A.Grey	Asteraceae	Jogbo, Agbale	Tree marigold	Leaves, twigs
7.	*Rauwolfia vomitoria* Afzel	Apocynaceae	Asofeyeje	Swizzle stick	Root, bark, leaves, seeds
8.	*Khaya senegalensis* Desr	Meliaceae	Oganwo	Mahogany	Bark

Table 2: Frequency of the parts used as anti- malarial

Family name	Frequency of part used
Morinda lucida Benth	3
Psidium guajava L.	3
Mangifera indica L	3
Vernonia amygdalina Del.cent	1
Citrus paradise	3
Tithonia diversifolia A.Grey	2
Rauwolfia vomitoria Afzel	4
Khaya senegalensis Desr	1

The frequency of plant part used, represented in percentage, showed that leaf recorded the highest fequency of use (54 %), followed by bark (31 %) while root had the least (15 %) (Figure 1).

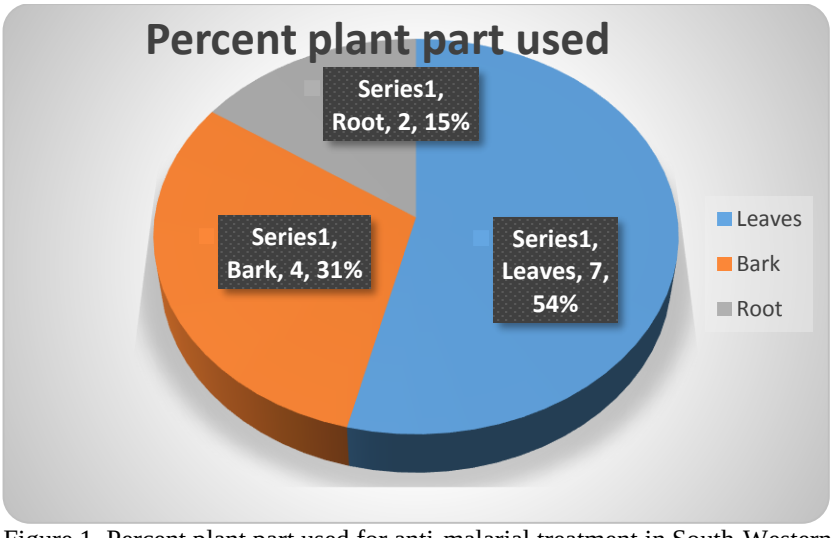

Figure 1. Percent plant part used for anti-malarial treatment in South-Western Nigeria

Table 3: Phytochemical composition of leaves of some plant species

Plant	Part	Tannins (mg/kg GAE)	Alkaloids (mg/kg GAE)	Flavonoids (mg/kg GAE)	Terpenoids (mg/kg GAE)	Saponins (mg/kg GAE)	Phenolic acids (mg/kg GAE)
Citrus paradisi	Leaf	83.7±0.6d	1350.0±2.0e	120.0±0.0f	7.7±2.5e	480.0±2.0e	11.3±0.6d
Khaya senegalensis	Leaf	168.3±1.5ab	4440.0±5.0b	1234.7±0.6b	164.0±1.0a	2060.0±5.0b	3.0±0.0e
Mangifera indica	Leaf	176.3±1.5a	790.0±2.0f	4520.0±10.0a	162.7±2.5a	397.0±5.2f	65.0±1.0a
Morinda lucida	Leaf	159.0±2.0c	3060.3±2.5cd	1060.3±2.5c	148.7±1.5b	1190.0±10.0c	64.0±1.0ab
Psidium guajava	Leaf	152.0±1.0c	7140.0±2.0a	320.0±2.0e	164.0±1.0a	300.0±5.0g	46.0±2.0c
Rauwolfia vomitoria	Leaf	174.7±1.5a	3290.3±2.5c	150.0±0.0f	157.3±2.5a	560.0±10.0d	63.0±3.0ab
Tithonia diversifolia	Leaf	159.0±1.5c	2860.0±3.0d	700.0±2.0d	40.0±2.0d	8220.0±5.0a	61.0±1.0b
Vernonia amygdalina	Leaf	174.0±1.0a	2710.0±0.0d	1215.0±3.0b	97.7±2.5Ac	300.0±5.0C	71.0±1.0a

Figures are expressed as mean ±SD. Means followed by the same letter(s) within the same column are not significantly different at 5% level of probability

Table 4: Phytochemical composition of stem bark of some plant species

Plant	Part	Tannins (mg/kg GAE)	Alkaloids (mg/kg GAE)	Flavonoids (mg/kg GAE)	Terpenoids (mg/kg GAE)	Saponins (mg/kg GAE)	Phenolic acids (mg/kg GAE)
Citrus paradisi	Bark	12.0±2.0d	3020.3±2.5c	974.7±2.5e	85.0±5.0d	570.3±2.5e	0.0±0.0d*
Khaya senegalensis	Bark	125.7±3.5b	2589.7±0,6d	3035.0±5.0b	90.0±0.0d	28840.0±10.0a	51.0±1.0b
Mangifera indica	Bark	24.0±2,0c	7350.3±2.5a	4290.3±2.5a	116.3±1.5c	4529.7±4.5c	61.0±1.0a
Morinda lucida	Bark	159.0±2.0a	3060.3±2.5c	1060.3±2.5d	148.7±1.5b	1190.0±10.0d	64.0±1.0a
Psidium guajava	bark	152.0±1.0a	7140.0±2.0b	320.0±2.0C	164.0±1.0a	300.0±5.0f	46.0±2.0c
Rauwolfia vomitoria	Bark	13.0±2.0d	1300.0±5.0e	150.0±0.0C	157.3±2.5ab	560.0±10.0e	63.0±3.0a.
Tithonia diversifolia	Bark	159.0±1.5a	2860.0±3.0cd	700.0±2.0f	40.0±2.0e	8220.0±5.0b	61.0±1.0a
Vernonia amygdalina	bark	12.0±2.0d	729.7±4.5f	1515.3±4.5c	80.0±2.0df	1100.0±5.0d	0.0±0.0c*

Figures are expressed as mean ±SD. Means followed by the same letter(s) within the same column are not significantly different at 5% level of probability

Table 5: Phytochemical composition of the roots of plants analysed

Plant	Part	Tannins (mg/kg GAE)	Alkaloids (mg/kg GAE)	Flavonoids (mg/kg GAE)	Terpenoids (mg/kg GAE)	Saponins (mg/kg GAE)	Phenolic acids (mg/kg GAE)
Citrus paradise	Root	17.7±1.5b	4210.0±2.0a	3190.3±2.5b	19.3±1.5c	1509.7±2.5d	110.0±5.0a
Khaya senegalensis	Root	32.0±1.0a	1600.3±2.5d	2880.3 ±2.5c	34.0±1.0b	322.0±2.0e	58.0±2.0d
Mangifera indica	Root	21.0±1.0b	4400.3±3.a	1530.0±5.0d	19.3±2.5c	3299.7±2.5a	27.0±3.0e
Morinda lucida	Root	7.0±0.0c	2839.7±4.5b	25.0±0.6g	78.7±1.5a	210.0±2.0f	0.0±0.0g*
Psidium guajava	Root	34.0±0.0a	4970.3±1.5a	2679.7±2.5c	30.0±0.0b	2628.3±5.7b	90.7±1.2b
Rauwolfia vomitoria	Root	6.0±0.0c	2720.0±2.0bc	470.0±5.0e	5.0±0.0d	70.0±0.0g	6.0±0.0f
Tithonia diversifolia	Root	5.0±0.0c	2240.3±2.5c	284.7±2.5f	5.0±0.0d	40.0±0.0g	25.0±0.0e
Vernonia amygdalina	Root	10.0±1.0c	240.0±2.0e	5055.0±3.0a	33.7±1.5b	1620.0±4.0c	76.3±1.5c

Figures are expressed as mean ±SD. Means followed by the same letter(s) within the same column are not significantly different at 5% level of probability

DISCUSSION

Medicinal plants with anti-malarial activity used in this study include *Morinda lucida* Benth., *Psidium guajava* L., *Mangifera indica* L., *Vernonia amygdalina* Delile., *Citrus paradisi*, *Mangifera indica L.; Tithonia diversifolia* A. Grey., *Rauwolfia vomitoria* Afzel. and *Khaya senegalensis* Desr. Similar studies by Okello and Kang (2019) reported *Mangifera indica, Psidium guajava*, *Tithonia diversifolia* and *Vernonia amygdalina*. Silva *et al*. (2011) reported *Vernonia amygdalina*, *Tithonia diversifolia* and *Morinda lucida* while do Céu de Madureira *et al*. (2002) reported *Vernonia amygdalina*, *Tithonia diversifolia* and *Morinda lucida* as having anti-malarial properties.

The use of leaves, stem and roots of plants as a potential source of malarial treatment has also been reported by Ungogo *et al*. (2020), Adebayo and Kretti (2011) and Bankole *et al*. (2016). The leaf is the most common plant part used as anti-malarial. The use of leaves of plants for medicinal purposes ensures that the plant is conserved. The phytochemical analysis of the leaf in this study revealed the presence of tannins, alkaloids, flavonoids and terpenoids. The presence of tannins which are polyphenolic compounds could also mean that it is an astringent with wound-healing and anti-parasitic properties (Okhale *et al.,* 2010). Tannins have also been reported to have anti-diarrhoeal activity (Enzo, 2007). The presence of tannins is likely to be responsible for the free radical scavenging effects (Ayoola *et al.,* 2008). Tannins have also been reported to demonstrate significant activity against chloroquine-sensitive strain of *Plasmodium berghei* in mice (Jigam *et al.,* 2010).

Alkaloids are the most efficient therapeutically significant plant substances (Ayoola and Adeyeye, 2010). Alkaloids are amino acid derivatives and their pharmacological effects could be associated with the inhibition of nucleic acid, protein and membrane phospholipid biosynthesis (Shelton, 1991). Pure isolated alkaloids and their synthetic derivatives are used as basic medicinal agents because of their analgesic, anti-spasmodic and anti-bacterial properties (Stray, 1998). Many alkaloids have pharmacological effects and have been used to treat diseases like malaria and in managing heart diseases (Oomah, 2003). It has been reported that isolated alkaloid, 9 – methoxycanthin – 6 – one had higher anti-malarial activity against *Plasmodium falciparum* Gombak A isolate, when compared with chloroquine (Chan *et al.,* 2004). The anti-oxidant effect of plant alkaloids may represent another mechanism that contributes to its anti-malarial activity. Flavonoids belong to a group of polyphenolic compounds found in fruits and vegetables (Walad-Kahni and Clemens, 2001). The group includes flavonols, flavanones, rutin, etc. The biological functions of flavonoids include protection against +llergies, inflammation, platelets aggregration, microbes, ulcers, hepatoxins, viruses and tumours (Okwu and Omodamiro, 2005; Okwu and Emenike, 2006). Flavonoids also act against oxidative stress- related diseases such as diabetes, cancer and

coronary heart disease (Burits and Bucar, 2002; Ayoola *et al.*, 2008). In addition to their free-radical scavenging activity, flavonoids have anti-bacterial, anti-fungal and anti-viral effects.

Certain common dietary flavonoids have been reported to inhibit the intra-erythrocytic growth of the chloroquine-sensitive and chloroquine-resistant strain of *Plasmodium falciparum* (Lehane and Saliba, 2008). The antimalarial activity of flavonoid derivatives has also been reported (Ferreira *et al.*, 2010). Terpenoids have been reported to possess anti-bacterial, anti-fungal and anti-parasitic activities (Cowan, 1999) as well as anti-tumour activities (Guang-Zhong *et al.*, 2007). Terpenes have also been reported to arrest the parasite development and inhibit biosynthesis of Isoprenoids in *Plasmodium falciparum* (Goulart *et al.*, 2004). The inhibitory effects of terpenes on the intra-erythrocytic stages of *Plasmodium species* have been shown to appear specific (Goulart *et al.*, 2004; Su *et al.*, 2008); for example, monoterpenes like limonene arrests development at the ring stage while Nerolidol prevents parasites from developing past the trophozoite stage. Also, the monoterpene 1, 8 cineole present in Eucalyptus oil has been reported to inhibit the growth and development of chloroquine-sensitive and chloroqune-resistant *Plasmodium falciparum* at their trophozoite stage and the minute concentrations required for these effects make it suitable for drug development (Su *et al.*, 2008).

Saponins are naturally occurring surface-active glycosides, with a distinctive foaming characteristic. The use of saponins as dietary supplements, expectorants and anti-inflammatory agents has been reported (Xu *et al.*, 1996; Marjan *et al.*, 2008). Saponins are also used to control human cardiovascular diseases and to reduce blood cholesterol (Aletor, 1993). The hypoglycaemic, anti-fungal, anti-microbial, anti-cancer, anti-bacterial, analgesic, immunomodulatory, anti-oxidant and anti-malarial activities of saponins have been reported by Desai *et al.*, (2009). Phenolic acids are widely distributed in plants and their quantities vary among the different plant parts and with temperature during the development stage (Singh *et al.*, 2010). It has been reported that the antioxidant activity of phenolic acids is mainly due to their redox properties, hydrogen donors and singlet oxygen quenchers (Nagulendran *et al.*, 2007). The presence of phenolic acids has been reported to confer anti-bacterial and anti-viral effects (Okhale *et al.*, 2010). They are also considered to be bacteriostatic and fungistatic (Okwu and Iroabuchi, 2001; Okwu and Morah, 2007). In addition, phenolics, which are also known to possess anti-parasitic, anti-carcinogenic, anti-inflammatory and immunomodulatory effects, may also play a significant role in the anti-malarial activity of plant extracts (Abdulelah and Zainal-Abidin, 2007)

CONCLUSION AND RECOMMENDATION

Results from this study have shown that these plants are rich in phytochemicals which occur in various quantities in the different parts analysed. The high concentration of phytochemicals observed in the leaves confirms their frequent use in traditional medicine for the treatment of malaria. It is, therefore, concluded that phytochemical composition is fundamental to understanding modes and mechanisms of action of medicinal plants in general. Since different parts of some plants have different clinical indications or therapeutic applications, it is important to establish quantitatively the plant raw materials for its constituent plant part composition. This study, therefore, serves as an important step towards intensifying research in the areas of development of new antimalarial drugs especially from medicinal plants in Nigeria.

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