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Physicochemical and Phytochemical Studies of Some Selected Antimalarial Herbal Drugs Used in Southwest Nigeria

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Abstract

Malaria is a major public health problem in developing countries and it is becoming more difficult to manage. This probably accounts for the current increase in use of herbal drugs in the prevention and treatment of malaria in Nigeria. The aim of this study was to determine the physicochemical properties and phytochemicals contents of some antimalarial herbal drugs produced in Nigeria. The herbal drugs were purchased from a local market in the Southwest Nigeria and were indicated to be manufactured in Nigeria. They were separately air-dried, the physicochemical properties and photochemicals in them were determined using standard methods. The ranges of pH, total ash, acid soluble ash and water insoluble ash are 4.20 - 8.10, 9.43 – 13.50%, 5.40 – 8.30% to 4.3 – 5.40% respectively. Metal analysis of the drugs showed five heavy metals and their concentrations ranges (mgkg-1) are: cobalt (4.5 – 1.0), cadmium (0.5-2.0), lead (0.5-4.5) manganese (35.0 - 115.0) and copper (3.0 – 8.5). The phytochemicals detected in the herbal drugs are: Tannin, flavonoid, alkaloid and phenol. Thus, the potency of these drugs may be attributed to some of the phytochemicals found in them. Concentrations of cobalt and cadmium are above WHO maximum permissible limit (0.48 and 0.3 $mgkg^{-1}$ respectively).

Keywords: Malaria, Herbal Drugs, Phytochemicals, heavy metals Physicochemical Parameters.

1. Introduction

Malaria has remained one of the five major life-threatening, childhood situations, resulting in an annual death toll of millions of African children. The persistence of malaria symptoms after treatment with modern antimalarial drugs has resulted in loss of faith in such drugs and yielded increased tendency towards the use of herbs as malaria treatment in Nigeria (Snow *et al*., 1999; Kamei *et al*., 2000).

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Herbal drugs are drugs made from medicinal plants with primary metabolites such as sugar, amino acid, proteins, purines, chlorophylls, and so on; secondary metabolites which include phenols, tannins, alkaloids, terpenoids, acetogenins, and so on (Amir *et al*., 2011). The biological activity of herbal drugs can be linked to the types of chemical compounds (phytochemical) found in the medicinal plants from which they are produced. Phytochemicals are secondary plant metabolites and they have biological properties such as stimulation of immune system, antioxidant activities, antimicrobial effect, decrease of platelet aggregation and modulation of hormone metabolism and anticancer property (Altiok, 2010).

WHO (2007) reported the increase in herbal drug usage, as 80% of the world population now uses herbal drug as primary care due to the effectiveness and perceived advantages of herbal drugs. In Nigeria, the use of herbal drug has increased rapidly because of easy access, low price and safety. Butler (2008) reported the following herbal drugs (*Elliptinium, galantamine* and huperzine) obtained from plants had been approved to cover therapeutic indications such as anti-cancer, anti-diabetic, anti-infective due to the phytochemicals present in them.

The general believe that herbal drugs are safe and harmless has been questioned due to the presence of high level of toxic substance such as heavy metals found in them Chan (2003). High level of toxic metals can be traced to metals containing agricultural expedient and contaminated irrigation water (Saeed *et al*., 2010). Chan (2003) also reported that the major source of contaminants (heavy metals) causing limitation to the use of herbal drugs are from the polluted environment where the herbal plants are grown, manufacturing processes and poor storage condition.

In recent years, many researchers have reported from their studies of herbal drugs, that concentration of heavy metals present in herbal drugs examined are higher than the maximum level recommended by WHO for herbs (Mihaljev *et al*., 2015). Apart from the worrisome levels of some heavy metals in herbal drugs, the WHO has established the fact that inappropriate use of plants and other materials in traditional medicine practices can have negative or damaging effects on human health. This assertion is based on the premise of the fact that a lot of contaminants such as PAHs are found in herbal plants and drugs. Thus, further research is required to ascertain the efficacy and the safety of several of the herbal drugs and medicinal plants used in traditional medicine system (WHO).Therefore, there is need for quality assessment of contaminants such as heavy metals in herbal drugs especially in developing countries so as to establish the probable toxicity that may be associated with consumption of

such drugs. In Nigeria, information on the quality and safety levels of herbal drugs that are produced locally is very scanty. As part of efforts to providing reliable base-line data for standardization of locally produced herbal drugs in Nigeria, it was decided to investigate the physico-chemical properties and photochemical in some anti-malaria drugs that are produced and used in Southwest, Nigeria.

2. Materials and Methods

All reagents used were of analytical grade and were supplied by Labtrade, Ogbomoso, Nigeria. The reagents are nitric acid, perchloric acid, methanol, $FeCl_3$ solution, HCl, Meyer's reagent, KOH, $AlCl_3$ solution, acetic acid, ethanol, ammonia solution, diethyl ether, n-hexane, NaOH solution, distilled water.

Sample collection

Five most popularly used antimalarial herbal drugs (Nigeria products) sold in southwest Nigeria were purchased. The samples were separately oven dried, grounded and kept in separate air tight glass containers for the purpose of this study and they were labeled and coded as follows; *Jedi* malaria herbal drug (produced in Ibadan Oyo state) as sample 'A', Original malaria herbal drug (produced in Aromole, Ogbomoso, Oyo state) as sample 'B', *Ogun Iba* (by Alhaji Ekiti, Awo Ekiti, Ekiti state) as sample 'C', *Ogun Iba* (by Alhaji Raji, Osogbo, Osun state) as sample 'D' and *Ogun iba ati inurirun* (by Alhaji Ekiti, Oke Eso, Ilesa, Osun state) as sample 'E'.

Determination of total ash

Weighed amount (3) grams of each of the selected herbal drugs (already in powdered form) were transferred into porcelain crucibles. The samples were charred with muffle furnace at temperature of 450 ºC for about 2 hours, cooled in a desiccator and accurately weighed. This procedure was repeated until a constant weight was obtained for each sample. The percentage of ash was calculated in relation to the dried drug. The acid insoluble ash was obtained by boiling the total ash with dilute hydrochloric acid and filtered to remove soluble ash. The water insoluble ash was determined by boiling the total ash with 15 ml of distilled water and filtration was carried out to remove the water soluble ash.

Determination of pH

Weighed amount (10 g) of each sample was quantitatively transferred into a beaker and 20 ml distilled water was added. The suspension was stirred for 15 minutes using a glass rod and was allowed to settle for 20 minutes. The pH meter was standardized using buffer solutions (pH 4

and pH 7). The pHs of the samples were measured to the nearest 0.10. The electrode of the pH meter was rinsed with distilled water before and after each reading. The pH of the various suspensions was recorded digitally by the pH meter.

Sample digestion for heavy metal analysis

A known weight of each sample (0.5 g) was added into a flask, 25 ml of nitric acid was added to the weighed sample in the flask, 10 ml of perchloric acid was added to the solution in the flask and heated using a heating mantle in a fume cupboard until a colorless solution was observed. The digested samples were then analyzed quantitatively using Atomic absorption spectrophotometer (AAS).

Phytochemical Screening

Method of extraction for qualitative determination of phytochemicals in the herbal drugs

A known weight (15 g) of each of the five malaria herbal drugs samples was extracted by 150 ml of methanol for 24 hours at room temperature. The extract was filtered. The filtrate was collected and concentrated on rotary evaporator. The concentrated methanolic extract was subsequently used for qualitative analyses of different phytochemicals present in the herbal drugs under this study.

Determination of tannins

Distilled water (10 ml) was added to 0.3 g of the concentrated methanolic extract and filtered. Then 5 ml of the filtrate was treated with freshly prepared $FeCl_3$ solution. A greenish dark coloration was observed which confirmed the presence of tannins (Sofowora, 1999).

Determination of alkaloids

Concentrated extract (0.5 g) was stirred with 5 ml of 1% HCl on water bath and filtered; 1 ml of the filtrate was then treated with few drops of Meyer's reagent. Occurrence of turbidity confirmed alkaloid (Sofowora, 1999).

Determination of flavonoids

Concentrated extract (0.5 g) was dissolved in 5 ml of $AlCl_3$, 2 ml methanol, 2 ml of concentrated HCl, 2 ml of KOH solutions were added in succession followed by a few drop of magnesium turning. Observation of pink coloration confirmed the presence of flavonoid (Sofowora, 1999).

Determination of phenols

Concentrated extract (0.5 g) was treated with $FeCl_3$ solution and intense coloration was observed which confirmed the presence of phenol (Sofowora, 1999).

Quantitative determination of phytochemicals in the herbal drugs

Determination of alkaloids

Weighed (5 g) of each of the sample was transferred into 250 ml beaker, 200 ml of 20% acetic acid ethanol was added and allowed to stand for 4 hours, the solution was filtered and the filtrate was concentrated on a water bath to evaporate to about a quarter of the initial volume. Concentrated ammonia solution was added drop wise until precipitation was completed. The entire solution was allowed to settle and the precipitate was filtered, air dried and weighed (Okwu *et al.,* 2004).

Determination of flavonoids

Each of the sample (10 g) was quantitatively transferred into a 250 ml flat bottom flask; 100 ml of 80% aqueous methanol was added repeatedly at room temperature until a colorless extract was obtained. The solution was filtered and filtrate was transferred into 200 ml beaker and evaporated to dryness over a water bath. The weight of the flavonoids was determined accurately (Boham and Kocipai, 1994).

Determination of tannins

Each sample (5 g) was weighed into a conical flask and 100 ml of 2 M HCl was added. The content was boiled on a water bath for 30 minutes. The extract was cooled and filtered, 40 ml of diethyl ether was added to the filtrate, and the ether extract was heated to dryness and weighed (Okwu *et al.,* 2004).

Determination of total phenolics

A fat free sample of each of the samples was prepared by adding 2 g of each sample to 100 ml n- hexane and shaken for 4 hours. The filtrate was discarded and the residue extracted with 50 ml di-methyl ether, filtered into a separating funnel and about 50 ml of 10% NaOH solution added. The mixture was properly agitated and a phase separation was observed. 25 ml distilled water was added to separate the aqueous layer from organic layer,; the total aqueous layer was acidified into pH 4.0 by adding 10% HCl solution and 50 ml dichloromethane. The organic layer was collected, dried and weighed (Boham and Kocipai, 1994).

3. Results and Discussion

Physico-chemical parameters of selected antimalarial herbal drug samples.

The physico-chemical properties of the anti-malaria herbal drug samples are as shown in Table 1.

Table 1: Physico-chemical properties of the selected anti malaria herbal drugs

	Physico-chemical properties			
Sample	**pH**	**total ash (%)**	**acid insoluble ash (%)**	**Water insoluble ash (%)**
A	4.52±0.26	13.500±0.13	7.100±0.24	5.400±0.26
B	5.20±0.42	12.283±0.17	8.300±0.18	4.300±0.32
C	6.40±0.37	9.433±0.24	5.400±0.67	4.200±0.43
D	8.10±0.12	11.300±0.28	6.133±0.32	5.200±0.28
E	4.20±0.32	13.000±0.34	6.800±0.35	5.000±0.32

Means ± standard deviations of triplicate determinations.

pH of the selected anti malaria herbal drugs

The pH of a drug is an important factor to determine the basicity and acidity of it and most drugs are either weak acids or weak alkalis. The pH of the selected antimalarial herbal drug pH ranges from 4.20 to 8.10 as seen in table 1. The studied herbal drugs are slightly acidic and slightly alkaline (pH of sample A, B, C and E are slightly acidic and the pH of sample D shows slightly basic). The important part of the body has pH range of slightly acidic and slightly basic, the buccal cavity (6.2 - 7.2), duodenum (7.0-8.5), Plasma (7.35 - 7.45), small and large intestines (4.0-7.0). The results of pH values obtained from this study are in agreement with results of pH of some herbal drugs in India (Uma and Sekar, 2014).

Percentage of Total Ash, Water insoluble and acid insoluble ash of the selected anti malaria herbal drugs

Paramjyothi and Syed (2010) reported that ash values are used to determine quality, authenticity and purity of unsophisticated drug and also these values are important quantitative standards. Ashes represent the inorganic matter component of the drug. It measures the amount

of non-volatile residue or items present in drug and identify its level or purity. The acid-insoluble ash measures the level of silica (sand and siliceous earth) available in the drug AOAC, (2005). In this study, results showed that total ash was highest in sample A (13.500±0.13 %) and lowest in sample D (11.300±0.28) as given in table 1. The total ash content in this study agrees with findings of Kunle *et al.*, (2011), who analysed some herbal drugs in which were collected from drug vendors in Agege, Nigeria.

Concentration of manganese in the selected antimalarial herbal drugs

The concentration of manganese in this study varied from 115.00 to 35.00 $mgkg^{-1}$. The highest concentration of manganese in this study was found in sample E (115.00 $mgkg^{-1}$) and least concentration in sample A (35.00 $mgkg^{-1}$) as shown in (Table 2). The lowest limit of manganese established by WHO in medicinal herbs was (200 $mgkg^{-1}$) (WHO, 1998), which points out that the concentration of manganese in all selected antimalarial herbal drugs fell within the WHO limit. The concentration of manganese in this study agrees with the result from Manzoor and Mahmood (2011) (25.3 $mgkg^{-1}$ to 90.6 $mgkg^{-1}$), and was higher than that of (Moses *et al.*, 2012) (3.25 $mgkg^{-1}$ to 17.13 $mgkg^{-1}$). According to (Jabeen *et al.*, 2010) the concentration of manganese in some herbal drugs of Egypt ranged from 44.6 to 339 ($mgkg^{-1}$).

Khan *et al.* (2008) reported that manganese is essential in normal reproductive functions and normal functioning of the central nervous system while its deficiency causes myocardial infection, cardiovascular diseases, disorder of bony cartilaginous growth in children and rheumatic arthritis in adults. This indicates that the use of these antimalarial herbal drugs might may reduce degree of myocardial infections in human.

Concentration of copper in the selected anti-malarial herbal drugs

The concentration of copper in the anti-malarial herbal drugs analyzed in this study ranged from 3.0 to 8.5 $mgkg^{-1}$, the concentration of copper was maximum in sample A (8.5 $mgkg^{-1}$) and minimum in sample C (3.0 $mgkg^{-1}$), (Table 2). (WHO, 1998) The maximum permissible limit for copper in medicinal herbs set by WHO is 10 $mgkg^{-1}$ showing that the average concentration of copper in this study is below WHO maximum permissible limit.

On comparison, the concentration of copper from this study is lower than the results (2.98 $mgkg^{-1}$ to 9.12 $mgkg^{-1}$) reported by Manzoor and Mahmood, (2011) and higher than (0.31 $mgkg^{-1}$ to 1.44 $mgkg^{-1}$) obtained by Moses *et al.* (2012). The high concentration of copper in this study might be from the soil contamination with copper from the medicinal plants used for

the production of these herbal drugs, as plants have high tendency of absorbing copper from the soil on which they grow (Sarpong & Boateng, 2013).The high levels of copper may cause metal fumes fever with flue like symptoms, hair and skin decolouration, dermatitis, irritation of the upper respiratory tract, metallic taste in the mouth and nausea (Ullah *et al.,* 2012). Moses *et al.* (2012) reported that high intake of copper may result in hair and skin discoloration, irritation of the upper respiratory tract and liver damage among others. Gautam and Irfan (2011) stated in their study that high dosage and accumulation of copper causes liver and brain damage which results in a disease called Wilson's disease. Despite the low concentrations of copper in these drugs users need to be cautious as excessive consumption of any of the drugs may make them prone to some of the diseases associated with excessive consumption of copper as earlier reported in literatures.

Concentration of lead in the selected anti-malarial herbal drugs

The concentration of lead was between 0.5 $mgkg^{-1}$ and 4.5 $mgk^{-1}g$ (Table 2). The highest concentration of lead was recorded as in sample C and lowest was in sample D (0.5 $mgkg^{-1}$) as shown in Table 3. According to (WHO, 1998) the maximum permissible limit for lead contents in herbal drug is 10 $mgkg^{-1}$. Therefore lead concentrations in this study were below the maximum permissible limit set by WHO. Lead concentrations in this study except sample D, were above the concentration obtained from (Manzoor and Mahmood, 2011) (0.7 $mgkg^{-1}$ to 0.78 $mgkg^{-1}$) and Moses *et al.* (2012) (0.15 $mgkg^{-1}$ to 0.41 $mgkg^{-1}$) in comparison.

Sarpong and Boateng (2013) attributed the high concentration of lead above WHO in his study to the soil from which the medicinal plant was planted due to the fact that plants are particularly efficient at absorbing lead from the soil, significantly higher in rocky (igneous) soils and are reported to retain up to 7%. Annan *et al.* (2013) attributed the observed levels of lead beyond WHO maximum permissible limit to vehicular deposition of the mineral into the soil because medicinal plants are usually transported to the markets from farms where they are grown. This suggests that the concentration of lead from this study might be from the deposition of lead in soil where the herbal plant was harvested.

Khan *et al.* (2008) reported the damages of liver and kidney immune system due to excessive intake of lead. Singh *et al.* (2014) reported that high dosage and bioaccumulation of lead cause severe illness leading to permanent difficulties with cerebral problems leading to stomach pain, nuisance, anemia, peripheral neuropathy and irritability. Consumers of any

of the selected anti-malarial herbal drugs may be free from risk of chronic lead toxicity, but excessive intake of any of the drugs should be avoided to prevent bioaccumulation.

Concentration of cadmium in the selected anti-malarial herbal drugs

The concentrations of cadmium in the selected anti-malarial herbal drugs ranged from (0.5 $mgkg^{-1}$ to 2.0 $mgkg^{-1}$), see Table 2. The highest concentration of cadmium in this study was found in sample A (2.0 $mgkg^{-1}$) and a minimum concentration (0.5 $mgkg^{-1}$) was observed in samples B and C (Table 3).The maximum permissible cadmium limit set by WHO for medicinal herbs is 0.3 $mgkg^{-1}$ (Soylak *et al*., 2004) Hence, the result indicates that the concentrations of cadmium in this herbal drugs were above maximum permissible limit set by WHO. The probable source of cadium in the analysed samples of antimalarial herbal drugs might be from contaminated soil caused by the wide spread of fertilizers on agricultural soils on which the medicinal plants are grown. (Manju, 2015).

Prolonged human exposure to cadmium results in its accumulation in the body and leads to diseases mainly affecting lungs and kidneys IARC (1993). Jabeen *et al.* (2010) reported that some of the damages caused by excessive cadmium consumption to include vascular, kidney, liver and immune system damage. Similarly, Inaba *et al.* (2015) reported that a long-term exposure to high-dose cadmium causes Itai-itai disease, which affects mainly women and is characterized by severely impaired tubular and glomerular function and generalized osteomalacia and osteoporosis that result in multiple bone fractures.

This suggests that consumers who use these selected anti-malarial herbs for a long period of time may suffer from any of the cadmium associated diseases. As earlier suggested, the proper standardization of herbal drugs manufactured in Nigeria is imperative to prevent consumers from suffering from vascular, renal, hepatic, and immune system which may result from improper standardized herbal drugs.

Concentration of cobalt in the selected anti-malarial herbal drugs

Concentrations of cobalt in this study are between 4.5 $mgkg^{-1}$ and 10 $mgkg^{-1}$ with the maximum concentration of in sample A (10 $mgkg^{-1}$) (Table 2). The maximum level of cobalt in herbs established by WHO is 0.48 mg kg^{-1} (WHO, 1998). This shows that the concentration of cobalt in this study are above WHO maximum limit. Jabeen *et al*. (2010), in their study of herbs in Turkey, reported that the concentrations of cobalt ranged from 0.14 mg kg^{-1} to 0.48 mg kg-^{1}.

Annan *et al.* (2013) attributed high concentration of cobalt in herbs to the large deposition of cobalt present on land surface where the herbal plants are harvested.

Table 2: Concentration of heavy metals in the selected antimalarial herbal drugs.

	Concentration of heavy metals in mgkg^{-1}				
	Cobalt	**Cadmium**	**Lead**	**Copper**	**Manganese**
Sample A	10.0	2.0	3.5	8.5	35.0
Sample B	5.0	0.5	3.0	5.0	80.0
Sample C	4.9	0.5	4.5	3.0	55.0
Sample D	4.6	1.5	0.5	5.5	95.0
Sample E	4.5	1.3	1.5	4.0	115.0
WHO(MPL)	0.48	0.3	10.0	10.0	200.0
Reference	WHO (1998)	Soylak, *et al.,* (2004)	WHO (1998)	WHO (1998)	WHO (1998)

(MPL) means maximum permissive limit

Qualitative phytochemical screening of the selected anti-malarial herbal drugs

The results of phytochemical screening of the herbal drug samples used in this study are as contained in Table 3a.

Table 3a: Qualitative phytochemical screening of the selected anti-malarial herbal drugs.

Phytochemical	**Sample**				
	A	**B**	**C**	**D**	**E**
Tannin	+	+	+	+	+
Flavonoid	+	+	+	+	+
Alkaloid	+	+	+	+	+
Phenol	+	+	+	+	+

Where (+) means present

The result from the qualitative analysis of the selected anti-malarial herbal drug showed the presence of flavonoids, tannins, alkaloids and phenols as indicated in Table 3a. The presence of phytochemicals in plants is linked with their uses for treating different ailments and having a potential of providing useful drugs for human use (Kunle *et al.,* 2011). Therefore, the availability of these bioactive compounds (flavonoids, tannins, alkaloids and phenols) indicates that the selected antimalarial herbal drugs have some medicinal properties. The result obtained from the qualitative analysis of the selected antimalarial herbal drugs agrees with the result obtained from the study of Kunle *et al.* (2011).

Quantitative phytochemical screening of the selected anti-malarial herbal drugs

The results of quantitative determination of phytochemicals in the samples of herbal drugs analyzed in this study are shown in Table 3b.

Quantity of phenol in the selected anti-malarial herbal drugs

The phenolic contents of the herbal drugs analyzed ranged from 16.10 - 6.16% as seen in Table 3b. Sample A and D contained highest (16.10%) and lowest (6.16%) phenolic compounds respectively. Okwu and Omodamiro (2005) reported that phenol enhances the immune system of the body; prevents clumping of the platelets and inhibits enzymes that promote inflammations. The presence of phenolic in each of the herbal drugs in appreciable quantity suggests that each of them has a potential to enhance the immune system of the users.

Table 3b: Quantitative phytochemical screening of the selected antimalarial herbal drugs.

Sample	Phytochemical (%)			
	phenols	**Tannins**	**Alkaloids**	**Flavonoids**
A	12.750±0.12	18.470±0.24	0.620±0.21	1.830±0.22
B	10.460±0.12	17.780±0.12	2.410±0.02	19.250±0.28
C	11.200±0.16	17.870±0.37	2.100±0.46	6.520±0.24
D	6.160±0.33	10.560±0.13	5.080±0.28	21.320±0.12
E	16.100±0.27	7.980±0.41	3.150±0.42	12.450±0.43
Average	11.334±0.2	14.532±0.2	2.672±0.27	12.274±0.26

Means ± standard deviations of triplicate determinations.

Quantity of tannins in the selected anti-malarial herbal drugs

The quantity of tannins in samples ranged from 18.47- 7.98% respectively as shown in Table 3b. Tannin quantity is highest in sample A and lowest in sample E. Chang *et al.*, (1998) reported that tannins are useful as antibiotic, they accelerate blood clothing and reduce blood pressure. Thus the selected antimalarial herbal drugs can function as high blood pressure suppressant and antibiotics. Tannins also have the potency of healing wounds and curing skin infections.

Quantity of alkaloids in the selected anti-malarial herbal drugs

The quantity of alkaloids in samples A, B, C, D and E are 0.620, 2.410, 2.100, 5.080 and 3.150 % respectively as seen in Table 3b. Alkaloid value is highest in sample D and lowest in sample A. Dua *et al. (*2013) reported the substantial anti-malarial activity exhibited with slight cytotoxic effect from steroidal alkaloid conessine that was isolated from the bark of Holarrhena antidysentrica. Thus, the acclaimed potency of the five samples (A, B, C, D and E) against malaria may be due to the presence of alkaloids in them.

Quantity of flavonoids in the selected anti-malarial herbal drugs

The amount of flavonoids in sample A, B, C, D and E are 1.830, 19.250, 6.520, 21.320 and 12.450 % respectively in Table 3b. The highest quantity of flavonoid in this study was found in sample D and lowest quantity in sample A. Chandel and Bagai (2010) reported that flavonoids possess the ability of elevating red blood cell oxidation and prevent the parasite's protein synthesis. (Adele and Kelvin 2008) also reported the dietary flavonoid (luteolin) antimalarial activity against chloroquine resistant Plasmodium. The acclaimed efficacy of the herbal drugs by the locals, may be linked with the presence of flavonoids in the anti-malaria herbal drugs analyzed in this study.

4. Conclusion

The anti-malarial herbal drugs analyzed in this study were found to be slightly acidic and alkaline in nature, showing that they may be absorbed in the buccal cavity, small and large intestines which may aid fast dissolution of the drugs. The following heavy metals: Mn; Cu; Pb; Cd; and Co were detected and quantified in all the five samples of the herbal drugs. Their concentrations are relatively high, although they are below WHO maximum limits except Co whose concentration is above WHO maximum limit. Thus, the production and use of these drugs deserve urgent attention of drug regulatory agencies in the country. The public also needs to be cautious of indiscriminate purchase and use of such herbal drugs because, bioaccumulation of heavy metals in them may cause serious health implications. Bioactive compounds such as flavonoids, tannins, alkaloids and phenols were detected in the herbal drugs analyzed. The presence of these phytochemicals signifies that the selected antimalarial herbal drugs may possess some medicinal properties. The infrared spectra of the herbal drugs showed some functional groups which bear some correlations to the phytochemicals found in them. Thus, the information obtained from this study will be of use for agencies responsible for monitoring herbal drugs production and safety.

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