Assessment of indigenous knowledge on medicinal plants used in the management of malaria in Kafin Hausa, north-western Nigeria

Ali Muhammad Zakariya, Abdulmalik Adamu, Aliyu Nuhu and Idris Zakariyya Kiri

Correspondence

Ali Muhammad Zakariya[*1], Abdulmalik Adamu[1], Aliyu Nuhu[2], Idris Zakariyya Kiri[1]

[1]Department of Biological Sciences, Faculty of Natural and Applied Sciences, Sule Lamido University, Kafin Hausa, Nigeria
[2]Department of Pharmacognosy and Drug Development, Faculty of Pharmaceutical Science, Ahmadu Bello University, Zaria, Nigeria

[*]Corresponding Author: zakariya.alimuhammad@slu.edu.ng

Research

Abstract

Background: Malaria is a major health burden among populations with poor economic status in tropical and subtropical regions of the world. Ineffective cost of drugs, multi-drug resistance of malaria parasites and inadequate health facilities are the major factors responsible for high mortality rates in these regions. These has prompted the need to identify new, efficient, safe and cheap drugs. This study was carried out to collect and document information on medicinal plants and how they are traditionally applied in the treatment of malaria in Kafin Hausa.

Methods: Questionnaires were used for data collection by means of oral interview. Analysis of data collected was done using ethnobotanical indices.

Results: Forty-three (43) respondents were interviewd and 15 plant species were mentioned. The plants were classified into 12 families with Buseraceae having the largest number of species. Senna occidentalis had the highest RFC (75.7%). *Boswellia dalzielii, Boswellia serrata, Azadirachta indica* and *Vitex doniana* all had fidelity level of 100%. Informant consensus factor of 0.87 was recorded. Literature search on antimalarial activities of the medicinal plants mentioned, showed that extracts from these medicinal plants had IC_{50} values ranging from 2.3 - <50 µgml^{-1}, while isolated compounds from some of the mentioned plants had IC_{50} values between 0.7 - 24 µgml^{-1}.

Conclusion: This research has provided background data on the medicinal plants traditionally employed for malaria treatment in Kafin Hausa. These findings could serve as a basis for the advancement of pharmacological studies on these medicinal plants with emphasis on safety, standardization and dosage.

Keywords: Ethnobotany, Medicinal plants, Malaria, Kafin Hausa, Nigeria

Background

Malaria is regarded as a serious disease in the world that is most prevalent in the tropics (Bremen 2001). A protozoan, *Plasmodium* sp., causes the disease, and the vector, *Anopheles* mosquito is responsible for its transmission. The disease primarily affects populations of poor economic status living in the tropics, having climatic conditions (temperature and rainfall) that favors parasite and vector development (Greenwood et al. 2008). The World Health Organization (WHO) reported that, in 2015, there were about 212 million incidences with 429,000 deaths resulting from malaria, with sub-Saharan Africa taking the largest share of the disease burden i.e 90% malaria cases and 92% deaths from malaria occurring mostly in children <5 years of age (WHO 2015). In 2018, Africa recorded the most malarial incidence with 213 million cases. In the same year, the region recorded 94% deaths as result of malaria (WHO 2019).

Nigeria is known to contribute about ¼ of malaria incidences in Africa (WHO 2008a). The disease is transmitted throughout the year in the southern region, unlike in the northern region, where transmission is seasonal. A report by the Federal Ministry of Health in 2004 showed that in Nigeria, malaria is the most common disease with half of its entire population being susceptible to one or more malaria infection annually (Adebayoa and Krettli 2011). In sub-Saharan Africa, six countries were responsible for more than half of all malarial cases in the world with Nigeria ranking first having 25% cases. Africa and India were reported to have accounted for the 85% deaths globally, as a result of malaria, of which Nigeria accounted for 24% of these deaths (WHO 2019). *Plasmodium falciparum* is responsible for the majority of malaria incidences in Nigeria and was reported in 2004 as the major cause of death in the world from one infectious pathogen (WHO 2008b).

Multi-drug resistance of *Plasmodium* sp. resulting from inappropriate drug administration and changes in parasite genetic composition have necessitated the need to search for new compounds that are therapeutically potent against the parasite (Alecrim et al. 1999; Krettli 2009). This could be achieved by ethnobotanical studies on medicinal plants, an invaluable tool for identifying new compounds that are efficient and safe for the management of malaria (Willcox et al. 2011). The ineffective cost of malaria drugs, inadequate health facilities especially in the rural areas of the country has led to increased reliance on traditional medicine. Ngbolua et al. (2013) reported that, factors such as inability to assess health facilities, shortage in health and medical workers, and socio-cultural attitudes have prompted the increased use of herbal medicines for healthcare in Africa as practiced in other malaria endemic regions.

The flora of Nigeria is rich and diverse with numerous medicinal plants employed by locals for therapeutic purposes (Adebayoa and Kretlli 2011). Over 1,200 medicinal plant species classified into 160 different families have been reportedly employed in the management of malaria or fever (Willcox and Bodeker 2004). The use of medicinal plants in the management of malaria have been reported in several African nations including Ethiopia (Bekalo et al. 2009), Kenya (Njoroge and Bussmann 2005), Ghana (Asase et al. 2005), Cameroon (Titanji et al. 2008) and southern part of Nigeria (Odugbemi et al. 2007; Olowokudejo et al. 2008; Idowu et al. 2009). This rich and diverse biochemical constituents present in medicinal plants from a region such as Nigeria with high biodiversity that is relatively untapped can serve as a potential source of new lead compounds. Concurrently, the application of ethnobotanical survey to collect and document indigenous knowledge on medicinal plants is envisaged as an important tool for identifying potential active principles with antimalarial activities from the abundant plant species (Dike et al. 2012). Ethnobotanical studies on medicinal plants employed by locals in the management of malaria have been reported, however, there is a huge number of plants that have not been identified (Dike et al. 2012). Based on available knowledge, no data on medicinal plants and how they are used traditionally in the management of malaria has been reported from Kafin Hausa, North-west Nigeria. Therefore, this study was carried out to collect and document information on medicinal plants and how they are used traditionally in the management of malaria in Kafin Hausa.

Materials and Methods
Study area
This survey was conducted at Kafin Hausa Local Government Area, Latitude $12^0 14'$ N and Longitude $9^0 54'$ E, Jigawa State, North-western Nigeria (Figure 1). Hausa and Fulani are the major ethnic groups in the area. The predominant vocations of Kafin Hausa people are farming, hunting and trading. The area is characterised by both wet and dry seasons that lasts from June-September and from October-May every year.
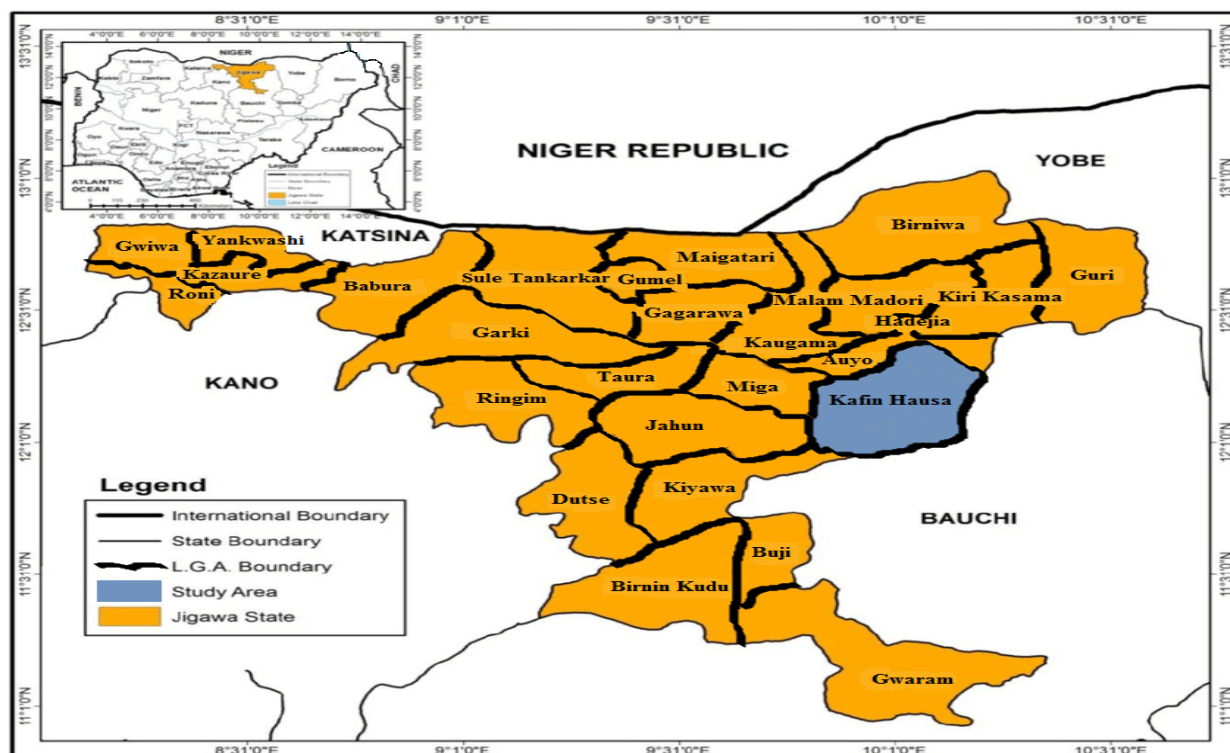
Fig. 1. Map of Nigeria Showing Kafin Hausa (Adapted and Modified from Google Maps)

Sample population

Respondents were sampled from the population by the use of purposive sampling technique as described by Bitrus et al. (2016). The target populations were Traditional Medicine Practitioners (TMPs), herbalists, farmers, nomads and traditional birth attendants without gender discrimination.

Data Collection

Before data collection, consent from relevant authorities and individual respondents were sort. Semi-structured questionnaires were used for data collection by oral interview using the most spoken dialect (Hausa). The questionnaires were translated to Hausa and used for the data collection and then back translated to English after data collection with the help of an expert from Department of languages, Hausa unit, Sule Lamido University Kafin Hausa. The questionnaires were filled by the interviewer and direct questions were avoided. Confirmation of information given by the respondents were made by making one more visit after the first visit.

Plant Collection and Identification

Collection of medicinal plants mentioned by respondents were from the wild. Respondents were responsible for the collections to avoid the collection of the wrong medicinal plant due to variation in local names. Medicinal plants collected were identified with the help of a distinguished Professor of botany from the Department of Biological Sciences, Federal University Dutse, in addition to comparison with reference materials such as standard identification text, monographs and herbarium specimens. Scientific names of the plants were verified on http://www.theplantlist.org, accessed 27/11/2020. All the medicinal plants collected were prepared and deposited at the herbarium unit, Department of Biological Sciences, Sule Lamido University Kafin Hausa for further reference.

Data Analysis

Descriptive statistics using bar chart and pie chart were employed in data description. Data on medicinal plants were analyzed using ethnobotanical indices (RFC, FL and F_{ic}).

Relative Frequency of Citation (RFC)

Relative frequency of citation of medicinal plants mentioned was evaluated according to Tardio and Pardo-De-Santayana (2008) using the equation:

$$RFC = Fc/N$$

F_c= Number of respondents who mentioned the use of plant
N= Total number of respondents

Fidelity Level (FL)
Fidelity level of medicinal plants mentioned was evaluated according to Friedman et al. (1986) using the equation:

$$FL = Ns / N \times 100$$

Where;
N_s= Number of particular species mentioned for a particular ailment
N= Total number of citation for that species

Informant Consensus Factor (F_{ic})
This was evaluated for the medicinal plants according to Fisseha et al. (2009) using the equation:

$$F_{ic} = Nur - Nt/ Nur - 1$$

Where;
Nur= Number of citations for each particular disease
Nt= Number of species reported to cure that disease

Results and Discussion
Socio-demographic data of respondents
Majority of the respondents that participated in this study were between 40-60 years. Only few of the respondents had the opportunity to complete primary or secondary education. Primary occupation of the respondents include; traditional medicine practitioner, farming, traditional birth attendant, herbalist and nomad. Majority of the respondents were of the male sex.

Plant species
Thirty-seven (37) out of the forty-three (43) respondents mentioned 15 plant species used in the management of malaria infection in this study, while 6 of the 43 respondents claim to treat the disease at hospitals. These plants were classified into 14 genera and 12 families. Burseraceae had the most plant species (3). Second to it was family Myrtaceae that had (2) species, while all other families had single species representation each (Table 1). *Senna occidentalis* was the most mentioned of all the plant species, having an RFC of 75.7% (Table 1). This finding is in contrasts to previous findings from southern Nigeria (Dike et al. 2012; Iyamah and Idu 2015) and south-eastern Nigeria (Odoh et al. 2018) where *Azadirachta indica* was the most mentioned anti-malaria plant. The difference in the choice of antimalarial plant could be attributed to the disparity in traditional medicine practice by the people in the three distinct regions having different climatic conditions as well as differences in the raw materials employed in the herbal preparations to treat malarial infection. *Azadirachta indica*, *Psidium guajava* and *Mangifera indica* were among plants mentioned for the management of malaria in this study. This is in-line with a study conducted at Maiduguri by Ene et al. (2010) where they reported *Azadirachta indica*, *Psidium guajava* and *Mangifera indica* as common plants employed by Hausa, Yoruba and Igbo ethnic groups to treat malaria. *Boswellia dalzielli*, *Boswellia serrata* both had RFC of 45.9 % each, just behind *Senna occidentalis* (Table 1).

Table 1. Ethnobotanical information on medicinal plants by respondents

Plant species	Plant Family	Voucher No.	Local name	Plant form	Plant part used	RFC(%)	FL(%)
Senna occidentalis L.	Leguminosae	ABU090021	Mazamfari	Herb	Leaves	75.7	90.3
Boswellia dalzielii Hutch	Burseraceae	ABU02448	Hano	Tree	Stem Bark	45.9	100
Boswellia serrata Roxb.ex Colebr.	Burseraceae	ABU0331	Ararrabi	Tree	Leaves	45.9	100
Commiphora africana A. Rich	Burseraceae	ABU0900121	Dashi	Tree	Stem Bark, Leaves	29.7	91.7
Azadirachta indica A. Juss	Meliaceae	ABU0900151	Darbejiya	Tree	Leaves, Stem Bark	21.6	100

Eucalyptus camaldulensis Dehnh.	Myrtaceae	ABU03254	Bishiyar turare	Tree	Leaves, Seed	18.9	77.8
Cochlospermum tinctorium Perrier ex A. Rich	Bixaceae	ABU0123	Rawaya	Shrub	Stem	13.5	100
Moringa oleifera Lam.	Moringaceae	ABU0517	Zogale	Shrub	Leaves, Seed	13.5	55.6
Leptadenia hastata Vatke	Asclepiadaceae	ABU09578	Yadiya	Herb	Whole plant	10.8	57.1
Guiera senegalensis J.F Gmel	Combretaceae	ABU01823	Sabara	Shrub	Leaves, Stem	10.8	100
Psidium guajava L.	Myrtaceae	ABU002	Goiba	Shrub	Leaves	8.1	37.5
Mangifera indica L.	Anacardiaceae	ABU01944	Mangwaro	Tree	Stem Bark, Leaves	8.1	27.3
Olea europaea L.	Oleaceae	ABU0901354	Zaitun	Tree	Leaves	2.7	5.2
Ziziphus mauritiana Lam.	Rhamnaceae	ABU045	Magarya	Tree	Root	2.7	14.2
Vitex doniana Sweet	Lamiaceae	ABU090076	Dinya	Tree	Stem Bark	2.7	100

RFC= Relative frequency of citation; FL= Fidelity level

Plant parts and forms used

Majority (75%) of the respondents cited the use of leaves for their herbal preparations, and second to it was the stem bark having 41.7% frequency of citations (Figure 2). This is in agreement with the findings (Iyamah and Idu 2015; Odoh et al. 2018). Conservation wise, the collection and utilization of the leaves seems more sustainable than the use of other parts such as stem bark, root, root bark or whole plant that may be destructive.

Tree was observed to be the most mentioned medicinal plant form in this study (Figure 3). It was closely followed by shrubs (33.3%) and herbs (16.7%). The predominance of tree over other plant forms may be due to the presence of this form throughout seasons and its resistance to seasonal variations (Abuquerque 2006). This result is in line with report of Suleman et al. (2018).
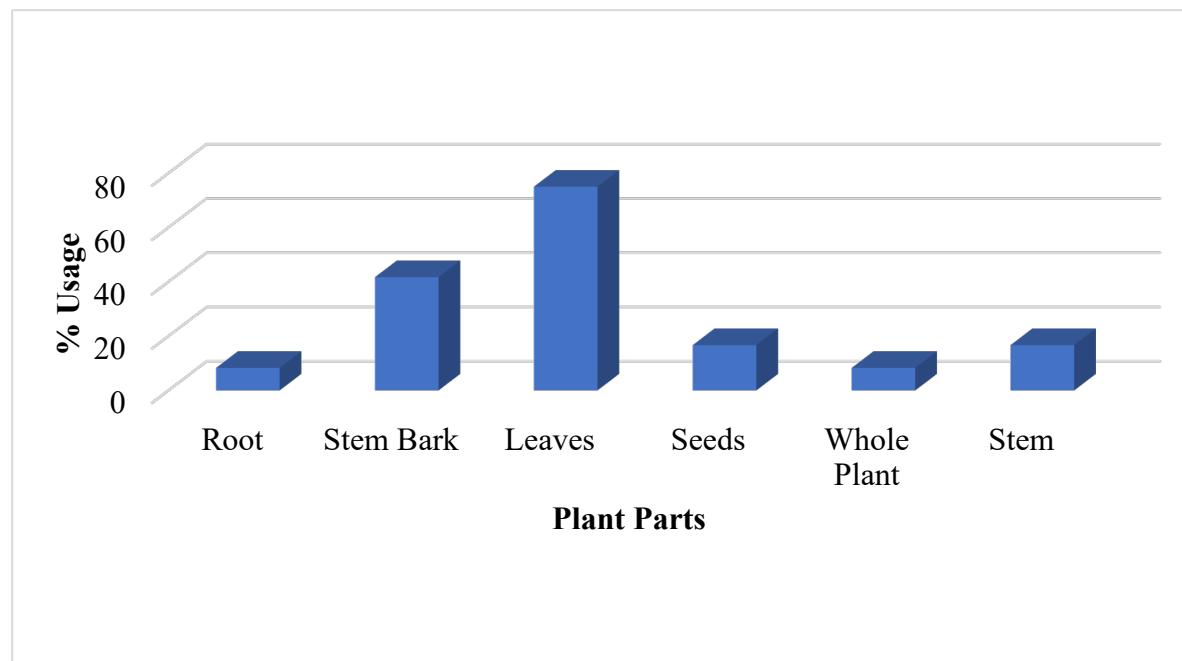

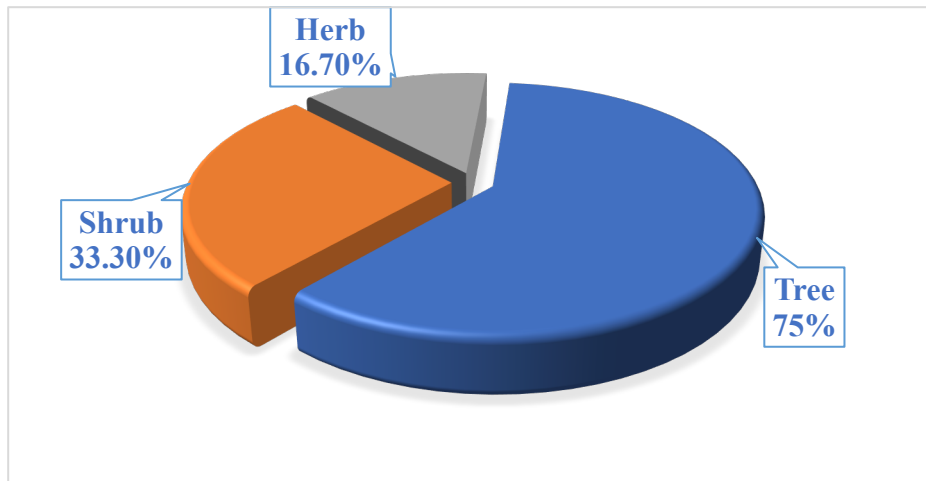Fig. 2: Representation of plant parts mentioned by respondents

Fig. 3. Representation of plant form widely used by respondents

Medicinal plants and their relative importance
Consensus analysis in any ethnobotanical studies gives a degree of reliability on any mentioned claim providing reliable evidence (Singh et al. 2012). The informant consensus factor (F_{ic}) is measured on a range between 0-1. F_{ic} values that tend strongly towards 1 are indicative of agreement on selection of medicinal plants by respondents for the management of a particular ailment, while F_{ic} values tending towards 0 are indicative of disagreement (Ragupathy et al. 2008). In this study, an informant consensus value of 0.87 was calculated on medicinal plant usage by the indigenous people of Kafin Hausa to treat malaria, thus, indicating a strong agreement amongst respondents.

Fidelity level (FL) of 90.3% was obtained for *Senna occidentalis* and 100 % each for *Boswellia dalzielii* and *Boswellia serrata* (Table 1). These high fidelity levels obtained for these plants could be attributed to their wide usage among the respondents in managing malaria infection. Medicinal plants that are widely applied by the locals in the treatment of diseases are known to have a fidelity level on the high side compared to unpopular ones (Tilahun and Mirutse 2007). Unlike *Senna occidentalis*, *Boswellia dalzielii* and *Boswellia serrata* that had higher fidelity levels corresponding to higher RFC, *Azadirachta indica, Cochlospermum tinctorium, Guiera senegalensis* and *Vitex doniana* had fidelity levels of 100 % but low RFCs (Table 1). Tilahun and Mirutse (2007) stated that, plant species employed in the treatment of one particular disease have fidelity levels of 100% compared to those that are used for the management of more than one particular type of disease. Therefore, the findings in this study could be used as bases for further scientific validation of these medicinal plants.

Diagnosis
Locally, malaria disease is commonly called "masassara", "Jante" or "zazzabin cizon sauro". It is diagnosed locally by observing symptoms such as rise in body temperature, headache, loss of appetite, body weakness, body and joint pain, vomiting and diarrhea in some cases. These symptoms mentioned by the respondents in this study are corroborated by the reports of Muthaura et al. (2015) and Suleman et al. (2018). It may be inferred that complexity of the numerous symptoms identified (Muthaura et al. 2015) may have informed the application of different varieties of medicinal plants for malaria management in Kafin Hausa as observed.

Plant collection, preparation, administration and efficacy
Respondents revealed that medicinal plants employed in the management of malaria were collected from the wild. This is in agreement with the findings of Asnake et al. (2016) and Suleman et al. (2018). However, these findings contrast with that of Odoh et al. (2018) where majority of the plant materials employed in the management of malaria were cultivated.

Two main methods; decoction and maceration, were indicated by respondents as methods used in the preparation of herbal medicine for managing malaria in this study. Majority of the respondents (62.1%) prepare the herbal remedies from these medicinal plants by decoction (Table 2). This agrees with the findings in previous studies (Gathirwa et al. 2011; Dike et al. 2012; Yetein et al. 2013; Iyamah and Idu 2015). Water was the solvent of choice among the respondents, used in the preparation of the herbal remedy from these medicinal plants. Odoh et al. (2018) reported similar finding. However, this finding contrasts with a report from south-west Nigeria (Dike et al.

2012) where ethanol was the most preferred solvent. This could be attributed to the cultural differences between the two regions. In another study by Iyamah and Idu (2015), aqueous extract from fermented maize was reported to have been the most preferred solvent in the preparation of malaria herbal medicine compared to other methods.

Table 2. Preparation, efficacy and administration of medicinal plant by respondents

Variables	Frequency	Percentages (%)
Mode of Preparation		
Decoction	23	62.16
Maceration	14	37.84
Efficacy		
Highly Effective	19	51.35
Moderately Effective	11	29.73
Slightly Effective	7	18.92
Duration of Administration		
1-5 days	5	13.51
1-7 days	30	81.08
1-14days	2	5.41

Furthermore, the respondents mentioned the use of some plants singly or combined with other plants as malaria remedy. Often times, some plants are regarded as being potent enough to be used in single form, while the potency of other plants could be enhanced by combining them with other plants (Gathirwa et al. 2011) thereby creating a synergistic effect (Dike et al. 2012). *Senna occidentalis, Boswellia dalzielii, Leptadenia hastata, Cochlospermum tinctorium* and *Ziziphus mauritiana* were mentioned by respondents in this study as used singly for managing malaria. The leaves of *Olea europaea* and stem bark of *Vitex doniana* were mentioned by the respondents as used singly or in combination with the leaves of *Annona senegalensis*. Furthermore, the leaves of *Psidium guajava* were identified as being used singly or combined with *Senna occidentalis* (whole plant). In certain instances, various parts of a particular plant are combined and applied in the management of malaria as some parts are regarded as being more potent than other parts, and their selection is based on the severity of the disease (Gathirwa et al. 2011). Respondents in this study mentioned similar practice (Table 1), and this agreed with the findings in previous studies (Idowu et al. 2009; Olorunnisola et al. 2013; Iyamah and Idu 2015; Odoh et al. 2018).

Respondents in this study stated that, herbal preparations for malaria were administered orally, and not mixed with additives such as honey, milk or sugar that are known to be added to some herbal mixtures administered orally in order to make them palatable. This is in line with the findings of Iyamah and Idu (2015) and Suleman et al. (2018). In other studies (Tabuti 2008; Iyamah and Idu 2015), steam bath and inhalation of the herbal preparation has been reportedly used as a mode of administration. In terms of efficacy, majority of the respondents (51.4%) claim the medicinal plants used are highly effective (Table 2), while 18.9% of the respondents claim the medicinal plants are slightly effective. None of the respondents reported any of the medicinal plant as ineffective. Irrespective of the claims by people in the local communities that medicinal plant preparations are effective and safe, it is imperative to look towards scientific standardization and validation of their safety, efficacy and dosage (Singh and Singh 2014) for them to be used adequately.

The duration of administration of the medicinal plant preparations varied among the respondents. Majority of the respondents (81.06%) claim to administer the herbal remedy for a period of 1-7 days, while only 5.41% of the respondents claim to administer it for up to 14 days. In contrast to our findings, Tabuti (2008) reported in his study that, administration of herbal preparations for the management of malaria is between 1-3 days. However, he did add that, sometimes the treatment may last beyond 3 days until full recovery. The duration of administration have been reported to vary depending on the severity of the disease, usually between 3 and 7 days (Gathirwa et al. 2011).

Literature review on antimalarial activities of mentioned plants
In vitro and in vivo antimalarial potential of medicinal plants mentioned by respondents were searched in scientific databases (Google scholar, science direct and researchgate) using "scientific names" of the plants and their "antimalarial activity". In vitro activities of the medicinal plants were categorized as: high or pronounced activity ($IC_{50} \leq 5$ μgml^{-1}); good or promising activity (5 $\mu gml^{-1} < IC_{50} \leq 15$ μgml^{-1}); moderate activity (15 $\mu gml^{-1} < IC_{50} \leq 50$ μgml^{-1}) and weak activity (50 $\mu gml^{-1} < IC_{50} \leq 100$ μgml^{-1}). The activity of a pure compound is regarded as "highly active" when its $IC_{50} \leq 1$ μgml^{-1} (Jonville et al. 2008; Memvanga et al. 2015). All data are given in Table 3.

Table 3. Literature information on antimalarial activities of medicinal plants mentioned by respondents

Medicinal Plants	Extract/Compound	Parasite Strain	Model	Activity µgml^{-1}/ µgml^{-1}/µM	Reference
Senna occidentalis L.	Methanol leaves extract	*Plasmodium falciparum* (3D7)	In-vitro	Showed 89.81% inhibition with IC$_{50}$ of 3.79 µgml^{-1}.	Daskum et al. (2019)
Boswellia dalzielli Hutch	Methanol leaves extract	Chloroquine resistant and Chloroquine sensitive *Plasmodium falciparum*	In-vitro	Demonstrated moderate activity at 15 µgml^{-1} with IC$_{50}$ of <50 µgml^{-1}.	Jansen et al. (2010)
Boswellia serrata Roxb. ex Colebr.	(1) Dichloromethane leaves extract (2)1S, 3E, 7E, 11R-Vericilla-3,7,12(18)-triene (3) Cembrene (4) Serratol (5) rel (1S, 3E, 7R, 8R, 11E)-7, 8-epoxy-cembra-3, 11-diene-1-ol (6) Incensole oxide and rel (1S,3R,7E,11S,12R)-1,12-epoxy-4-methylenecembr-7-ene-3,11-diol (mixture) (7) Isoincensole oxide (8) Isodecaryiol (9) Oleanolic acid (10) 11-Keto-β-Boswellic acid (11) 3-epi-neoilexonol (12) β-boswellic aldehyde (13) 5α-tirucalla-8,24-dien-3α-ol and Carvacrol (14) Isoflindissone lactone (15) Isoflindissol lactone (16) rel (3β,8R,9S,20R)-tirucall-24-ene-3,20-diol (17) β-bourbonene (18) Methyleugenol (19) p-methoxycinnamaldehyde	Chloroquine sensitive NF54 *Plasmodium falciparum* (4b, 9a) Chloroquine sensitive K1 *Plasmodium falciparum* (9b) Chloroquine resistant K1 *Plasmodium falciparum* (9c) Chloroquine sensitive T9-96 *Plasmodium falciparum* (9d) *Plasmodium berghei*	In-vitro (9d) In-vivo	(1) Showed pronounced activity against malarial parasite with IC$_{50}$ of 2.6 µgml^{-1} (2) Showed pronounced activity against malarial parasite with IC$_{50}$ of 2.5 µgml^{-1} (3) Showed pronounced antiplasmodial activity against malarial parasite with IC$_{50}$ of 2.7 µgml^{-1} (4a) Showed moderate activity against the parasite with IC$_{50}$ of 24 µgml^{-1} (4b) Demonstrated antiplasmodial activity with IC$_{50}$ of 2.5 µM (5) Showed promising antiplasmodial activity against the parasite with IC$_{50}$ of 9.9 µgml^{-1} (6) Showed promising antiplasmodial activity against the parasite with IC$_{50}$ of 5.7 µgml^{-1} (7) Showed pronounced antiplasmodial activity against	Greve et al. (2017) (9a, 9d) Cimanga et al. (2008) (9b, 9c) Cimanga et al. (1999)

			the parasite with IC_{50} of 3.1 μgml^{-1} (8) Showed promising antiplasmodial activity against the parasite with IC_{50} of 2.3 μgml^{-1} (9a) Showed moderate activity against the parasite with IC_{50} of 15.2 μgml^{-1} (9b) Showed weak activity against the parasite with IC_{50} of 88.8 μgml^{1} (9c)) Showed weak activity against the parasite with IC_{50} of 70.6 μgml^{1} (9d) Demonstrated 37 % chemosupression against the parasite at 200 $mgkg^{-1}$ (10) Showed pronounced activity against the parasite with IC_{50} of 3.1 μgml^{-1} (11) Showed pronounced activity against the parasite with IC_{50} of 3.5 μgml^{-1} (12)) Showed promising antiplasmodial activity against the parasite with IC_{50} of 6.5 μgml^{-1} (13)) Showed moderate antiplasmodial activity against the parasite with IC_{50} of 21 μgml^{-1} (14) Showed very high antiplasmodial activity against the parasite with IC_{50} of 1.0μgml^{-1}	

				(15) Showed pronounced antiplasmodial activity against the parasite with IC_{50} of 1.9 μgml^{-1} (16) Showed promising antiplasmodial activity against the parasite with IC_{50} of 7.9 μgml^{-1} (17) Showed moderate antiplasmodial activity against the parasite with IC_{50} of 22 μgml^{-1} (18) Showed promising antiplasmodial activity against the parasite with IC_{50} of 5.7 μgml^{-1} (19) Showed pronounced antiplasmodial activity against the parasite with IC_{50} of 4.8 μgml^{-1}	
Commiphora africana A. Rich	Dichloromethane stem bark extract	(1) Chloroquine sensitive and Chloroquine resistant *Plasmodium falciparum* (2) *Plasmodium berghei*	(1) In-vitro (2) In-vivo	(1) Showed promising activity with IC_{50} of 4.54 μgml^{-1}. (2) Showed 64.24% inhibition at $400mgkg^{-1}$.	Kweyamba et al. (2019)
Azadirachta indica A. Juss	(1) Aqueous leaves extract (2) Gedunin (3) NeemAzal product	(1) *Plasmodium falciparum* (2) Chloroquine resistant *Plasmodium falciparum* (3) *Plasmodium berghei*	(1) In-vitro (2) In-vitro (3) In-vivo	(1) Showed 95.92% growth inhibition of schizonts at 70 $mgml^{-1}$. (2) Showed promising activity with IC_{50} of 0.72 μgml^{-1} and 1.25 μgml^{-1}. (3) Demonstrated complete blockage of oocyst development at $50mgkg^{-1}$	(1) Alkali et al. (2018) (2) Bray et al. (1990); Bickii et al. (2000) (3) Lucantoni et al. (2010)
Eucalyptus camaldulensis Dehnh	Aqueous leaves extract	NK65 *Plasmodium berghei*	In-vivo	Showed 61.88% parasite inhibition at $200mgkg^{-1}$	Anigboro et al. (2020)

Cochlospermum tinctorium Perrier ex A. Rich	3-o-E-p-coumaroylal-alphitolic acid		In-vitro	Showed antimalarial potential with IC_{50} of 2.3 µM	Ballin et al. (2002)
Moringa oleifera Lam.	(1a) Aqueous leaves extract (1b) Aqueous leaves extract + Artesunate (2) Ethanol and n-Hexane seed	(1) PbANKA *Plasmodium berghei* (2) Chloroquine sensitive *Plasmodium berghei*	In-vivo	(1a) showed 50% suppression at 2000 mgkg^{-1}. (1b) in combination with artesunate at 6 mgkg^{-1} and 2000 mgkg^{-1} of extract demonstrated 91% parasite suppression. (2) showed 100% and 97% parasite inhibition at 200 mgkg^{-1} respectively	(1) Somsak et al. (2016) (2) Olasehinde et al. (2012)
Leptadenia hastata Vatke	ND	ND	ND	ND	ND
Guiera senegalensis J.F Gmel	(1) Harman and Tetrahydroharman (2) GsA, GsB, GsC (3) Harman, Harmalan, Tetrahydroharman, Guiranone A	*Plasmodium falciparum*	In-vitro	(1) Showed antimalarial activity with IC_{50}< 4 µgml^{-1}. (2) Showed antimalarial activity with IC_{50} 6.77, 7.01, 4.45 µgml^{-1} respectively. (3) Showed antimalarial activity with IC_{50} 4.08-121.93 µM	(1) Ancolio et al. (2002) (2) Fiot et al. (2006)
Psidium guajava L.	(1) Aqueous stem bark extract (2) Methanol and Ethylacetate leaves extract (3) Aqueous leaves extract	(1) Chloroquine sensitive *Plasmodium falciparum* (D10) (2) Chloroquine resistant *Plasmodium falciparum* (3) *Plasmodium berghei*	(1) In-vitro (2) In-vitro (3) In-vivo	(1) Showed parasite inhibition with IC_{50} 10 µgml^{-1}. (2) Showed parasite inhibition with IC_{50} 12.5-15 µgml^{-1} (3) Showed 73.7% and 85.8% parasite suppression at 350 and 1000 mgkg^{-1}	(1) Nundkumar and Ojewole (2002) (2) Kaushik et al. (2015) (3) Rajendra et al. (2014)
Mangifera indica L.	Chloroform: Methanol leaves	F32 Plasmodium falciparum	In-vitro	Showed 50.4% parasite inhibition with an IC_{50} 20 µgml^{-1}	Bidla et al. (2004)
Olea europaea L.	(1) Methanol leaves extract (2) n-Butanol fraction	*Plasmodium berghei*	In-vivo	(1a) Suppressed parasite by 57.8% at 600 mgkg^{-1}. (1b) Rane's test showed 48.7% parasite suppression at 600 mgkg^{-}.	Misganaw et al. (2019)

				(1c) Prophylactic test showed 32.6% at 600 mgkg^{-1}. (2) Suppressed parasite by 50.6% at 600 mgkg^{-1}.	
Ziziphus mauritiana Lam.	Hydroethanolic leaves extract	(1) *Plasmodium falciparum* (K1) and some clinical isolates (ANKTC023, ANKTC024, ANKTC024, ANKTC024) (2) *Plasmodium berghei*	(1) In-vitro (2) In-vivo	(1) Showed antimalarial activity with IC$_{50}$ 9-20 µgml^{-1}. (2a) Showed parasite suppression of 88.9% at 600 mgkg^{-1}. (2b) Rane's test showed 12% decrease in parasitaemia at 600 mgkg^{-1}.	Attemene et al. (2018)
Vitex doniana Sweet	(1) Methanol stem bark extract (2) n-Hexane, ethylacetate and methanol stem bark and leaves extracts	(1) Chloroquine resistant *Plasmodium berghei* (2) *Plasmodium falciparum* (NF54 and K1)	(1) In-vivo (2) In-vitro	(1) Showed potent antimalarial activity at 100 mgkg^{-1}. (2) Showed parasite inhibition with IC$_{50}$ 2.3-16.9 µgml^{-1}	(1) Uzoho et al. (2020) (2) Abiodun et al. (2011)

The literature search showed that majority of the plants mentioned by respondents in this study have been evaluated for antimalarial potential, in vitro or in vivo and in some instances both. This further corroborates the findings in this study. The reported antimalarial activities were evaluated using *Plasmodium falciparum* strains in vitro and *Plasmodium berghei* strains in vivo. Of the medicinal plants mentioned, 25 isolated compounds have been reportedly evaluated for antimalarial potential.

In vitro activity of extracts from the plants mentioned by respondents ranged from 2.3 µgml^{-1} - <50 µgml^{-1}. Leaves methanol extract of *Senna occidentalis* (Daskum et al. 2019) and stem bark dichloromethane extract of *Commiphora africana* (Kweyamba et al. 2019) were among the plants that showed high or pronounced antimalarial activity in vitro with IC$_{50}$= 3.79 µgml^{-1} and 4.54 µgml^{-1} respectively (Table 3). While leaves methanol extract of *Boswellia dalzielii* showed a moderate antimalarial activity in vitro with an IC$_{50}$= <50 µgml^{-1} (Jansen et al. 2010). Dichloromethane crude extract from *Boswellia serrata* leaves was reported to have shown antiplasmodial activity with IC$_{50}$ of 2.6 µgml^{-1} invariably showing a pronounced activity compared to some of the compounds isolated. In vitro antimalarial potential of isolated compounds from the medicinal plants mentioned by respondents ranged between 0.7 µgml^{-1} - 24 µgml^{-1} (Table 3). Gedunin, an *Azadirachta indica* isolate was highly active against Plasmodium parasite withIC$_{50}$= 0.72 µgml^{-1}. Terpenoids isolated from Oleo-Gum-Resin of *Boswellia serrata* were reported to have shown varying degrees of activity against *Plasmodium falciparum* in vitro with IC$_{50}$ ranging from 1.0 - 24 µgml^{-1} (Table 3). The most highly active compound was Isoflindissone lactone having an IC$_{50}$ of 1.0 µgml^{-1}. Uvaol and (3α, 8R, 9S, 20R, 24S)-20, 24-epoxytirucalla-3, 25-diol showed no activity against Plasmodium falciparum NF54 strain (Greve et al. 2017).

Potent antimalarial activities, in vivo, of extracts from medicinal plants mentioned in this study have been demonstrated (Table 3). Based on these data, further validation to ascertain the safety, standardization and dose regimen for these extracts and compounds from these medicinal plants is required. Furthermore, extensive pre-clinical and clinical trials geared towards the development of new and/potent antimalarial drugs needs to be carried out on these plants, since their reported use in the traditional medicine system and the high/potent activities demonstrated scientifically makes them a promising source of new antimalarial drug candidates.

Interestingly, no scientific reports with regards to antimalarial activity on *Leptadenia hastata* have been documented based on available data. But the plant has been reported to have activity on complications associated with malaria such as inflammation. Anti-inflammatory activity of lupeol, lupeol acetate, and lupeol palmitate isolated from its latex were reported in croton oil induced ear oedema test. At 0.42 µmol/ear, all three isolates induced a significant reduction in the oedema where lupeol showed 80% inhibition better than indomethacin, 73% (Nikiema et al. 2001).

Toxicity profile of bioactive compounds from medicinal plants mentioned
Harman, Harmalan, Tetrahydroharman and Guiranone A, all isolated from *Guiera senegalensis* have been reportedly evaluated for cytotoxicity using the human monocytes (THP$_1$ cells). Also, the cytotoxic effect of Guiranone A has been reportedly evaluated on two cancer cell lines, HeLa (Human cervix carcinoma) and HCT-116 (Human colon carcinoma). The results from these studies showed that Harman, Tetrahydroharman and Harmalan were relatively toxic on THP$_1$ cells with IC$_{50}$ of > 275, 538 and 544 µM respectively. Guiranone A, however, showed strong antiproliferative effect against THP$_1$ cells with an IC$_{50}$ of 13.48 µM. Similarly, Guiranone A exhibited strong cytotoxic effect against HeLa and HCT-116 cell lines with IC$_{50}$ 9.2 and 6.9 µM respectively. Its cytotoxic activity against normal skin fibroblast had an IC$_{50}$ of 7.2 µM (Fiote et al. 2006). In another study, Harman and Tetrahydroharman were reported to be toxic against THP$_1$ cells with an IC$_{50}$ of 22 µgml^{-1} and 75 µgml^{-1} respectively (Azas et al. 2002). Boeira et al. (2001) reported the cytotoxic and genotoxic properties of Harman on V79 Chinese hamster lung fibroblast (in vitro) using single cell gel assay. Harman was observed to reduce the relative survival of the cell by 22% at 150 µgml^{-1}. At 40 µgml^{-1} and 80 µgml^{-1}, Harman significantly increased chromosomal aberration in the cell cultures while mitotic index was significantly reduced at 60 and 100 µgml^{-1}. On DNA damage, Harman showed a significant increase in the values obtained for damage index and damage frequency for all concentrations tested.

Gedunin, isolated from *Azadirachta indica* was reportedly evaluated for toxicity in Zebrafish early-stage development. The result showed no morphological abnormality of Zebrafish embryos at all concentrations tested. Likewise, no significant difference was observed in the survival rate of the groups after 72 hours (Jeon et al. 2021). In another study, the cytotoxicity of Gedunin was reported with an IC$_{50}$ of 13.4 µM and a lower cell death of 8.6% after exposure of amylase secretory cell lines (AR42J) at different concentrations (Ponnusamy et al. 2015).

11-Keto-β-Boswellic acid (KBA) isolated from *Boswellia serrata* has been reported to have cytotoxic effects against non-tumor embryonic lung fibroblast (MRC5) and Pancreatic carcinoma cell lines (PANC-1) based on prediction using the CLC-Pred tool (Soliman et al. 2020). In another study, KBA alongside β-Boswellic acid, 3-O-acetyl-11-Keto-β-Boswellic acid and 3-O-acetyl-β-Boswellic acid were evaluated for antileukemic activity in vitro in human leukemia cells (HL-60). The compounds inhibited DNA and RNA synthesis as well as protein formation in a dose dependent manner with an IC_{50} 0f 0.6 - 7.1 µM (Shao et al. 1998). Proliferation inhibition and proapoptic properties of KBA on colon cancer cells and related pathways have also been reported. The compound enhanced caspase-8, caspase-9 and caspase-3 activities associated with poly (ADP-ribose) polymerase (PARP) cleavage (Liu et al. 2002).

Terpenoids isolated from the Oleo-Gum-Resin of *Boswellia serrata* (Table 3) were evaluated for cytotoxicity on mammalian cell (L6 rat skeletal myoblast cell line). The compounds showed toxicity with IC_{50} values ranging from 11 - 66 $µgml^{-1}$. However, the mixture of 5α-tirucalla-8,24-diene-3α-ol and Carvcrol showed no signs of toxicity on L6 rat skeletal myoblast cell lines among the compounds tested (Greve et al. 2017). No reports on the toxicity of 3-o-E-p-Coumaroylal-alphitolic acid were found in literature.

Conclusion
The findings of this study gave an insight for the first time into the importance of traditional medicine practice and how it is used in the management of malaria in Kafin Hausa. It also provided background data on medicinal plants traditionally employed in managing malaria in Kafin Hausa. Some of these medicinal plants have been documented as having antimalarial potential in other parts of Nigeria and Africa, this further gives credence to medicinal plants in Africa as having the potential to serve as source of novel compounds for drug development. The results of this study have further proven that despite developments in conventional healthcare systems, people in Africa still rely on traditional medical system for their health and wellbeing. Furthermore, available data showed that majority of the medicinal plants mentioned by respondents in this study were highly active or potent against strains of Plasmodium. Lastly, the findings of this study could be used as a basis for the advancement of pharmacological studies on these medicinal plants with emphasis on safety, standardization and dosage, since only preliminary studies have been conducted.

Declarations
List of abbreviations: RFC= Relative Frequency of Citation; FL= Fidelity Level; F_{ic}= Informant Consensus Factor; IC_{50}= Concentration that inhibits activity by 50%; $µgml^{-1}$= Micro Gram per Mil; $mgml^{-1}$= Milli Gram per Mil; AMZ= Ali Muhammad Zakariya; AA= Abdumalik Adamu; AN= Aliyu Nuhu; IZK= Idris Zakariyya Kiri

Ethics approval and consent to participate: Consent was sought from relevant authorities including the district heads as well as the participants before embarking on the research.

Consent for publication: Not applicable.

Availability of data and materials: Plant materials were prepared and deposited in the herbarium unit, Department of Biological Sciences, Sule Lamido University Kafin Hausa.

Competing interest: Authors declare no conflict of interest

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Author's contributions: AMZ conceived the research idea. AA and AMZ designed the research. AA carried out the research under the supervision of AMZ. The first manuscript draft was produced by AMZ. Identification of the medicinal plants were carried out under the supervision of AN. IZK and AN provided intellectual input on the manuscript that produced the final draft for submission.

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