An ethnobotanical study of plants used for the treatment of malaria in Budondo sub-county, Eastern Uganda

Geoffrey M. Malinga, Kalori Baana, Karlmax Rutaro, Francis Atube, Robert Opoke, Hector Opika-Opoka, Christine Oryema

Research

Abstract

Background: Malaria is a leading cause of morbidity and mortality in most developing countries, and in Uganda over 95% of the country is endemic with malaria. Given the increasing widespread resistance to current drugs, the use of herbal medicines is seen as a sustainable solution to malaria treatment. This study documented medicinal plants that are traditionally used for the treatment of malaria in Budondo sub-county, Eastern Uganda.

Methods: The ethnobotanical survey was conducted between December 2017 to January 2018. A total of 273 household members were interviewed on knowledge and use of anti-malarial plants, using semi-structured questionnaires administered in five parishes of Budondo sub-county. Voucher specimen of each plant species were preserved at the Makerere University herbarium, Uganda.

Results: Overall, 97.5% of the respondents had knowledge regarding the plants used to treat malaria. A chi-square analysis shows a significant association between respondents' knowledge regarding anti-malarial plants and gender (p-value =0.008) and occupation (p-value =0.025) but not with age (p-value =0.379), educational status (p-value =0.066), average monthly income (p-value =0.419), and religious affiliation (p-value =0.064) of respondents. A total of 37 plant species, belonging to 25 plant families were used to treat malaria. The most cited plant was *Vernonia amygdalina* Delile (64.8%), followed by *Aloe vera* (L.) Burm.f. (41.9%), *Callistemon citrinus* (Curt.) Stapf (29.3%), *Mormodica feotida* Schumach (22.0%), *Cyphostemma adenocaule* (A. Rich) wild & Drumm. (16.1%) and *Eucalyptus globulus* Labill. (15.4%). Among the plant parts, stem bark (99.6%) and leaves (90.8%) were the most frequently used. The habits of the plants encountered were shrub, tree, herb, rhizomes and climber. The commonest modes of preparation included boiling in water, squeezing fresh leaves, crushing and pounding, and chewing. Oral route/drinking was the most common mode of administration, followed by steam inhaling of vapours from the aqueous extracts and skin bathing.

Conclusion: The present study shows that the people living in Budondo sub-county traditionally use diverse flora to treat malaria. Further investigations are required to evaluate the potential toxicological effects and to isolate the active components of the reported plants whose antimalarial activities have not been investigated which could be developed into effective, safe and affordable anti-malarial medicines in the future.

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Background

Malaria is one of the key causes of ill health, deaths and poverty in most of developing countries. In 2016, the world experienced 216 million malaria cases and an estimated 445,000 deaths from malaria was reported (WHO 2017). Ninety percent of these deaths occurred in sub-Saharan Africa, where nearly all malaria is caused by *Plasmodium falciparum*. Pregnant women and children below five years with lowered immunity are the most affected by the disease (Stangeland *et al*. 2011, WHO 2016). Uganda ranks 6th among African countries with high clinically diagnosed malaria related mortality and morbidity rates, accounting for approximately 30-50% of outpatient visits at health facilities, 15-20% of all hospital admissions, 9-14% of hospital deaths, according to the health sector strategic plan (Uganda Ministry of Health 2005). Despite recent key interventions in malaria control like supply of insecticide treated mosquito bed nets and intensified treatment of cases, the disease remains a major public health problem and a leading cause of outpatient visits, admissions and death in the country (Uganda Health Sector Strategic and Investment Development Plan 2010/11-2014/15). Furthermore, the increasing widespread development of resistance of malarial parasites to standardized phytomedicines poses a major threat in the fight against malaria (Mukungu *et al.* 2016), necessitating continuous search for new antimalarial drugs.

Current antimalarial drugs are derived from plants (e.g., Artemisinin from *Artemisia annua* L., family Asteraceae). In several African countries including Uganda, there is a long tradition of treating disease with medicinal plants. This practice is still common in most rural parts particularly in areas where the health centres are poorly equipped both with personnel and medicines and lack the necessary infrastructure and resources to manage and control malaria (WHO 2003). This knowledge is often passed by word of mouth from generation to generation. Several plant species are used to treat malaria in Uganda. For example, Tabuti *et al.* (2003) reported over 20 species in Bulamogi County, Eastern Uganda for treatment of malaria and malaria-related ailments. Kakudidi *et al*. (2000) and Oryem-Origa *et al.* (2003) reported *Vernonia amyygadalina* Delile and *Senna didymobotrya* (Fresen) Irwin and Barney as two of the most common species used in south western and central Uganda. In Shinile district, Ethiopia, Mesfin *et al*. (2012) recorded 27 antimalarial plants and *Azadirachta indica* and *Tamarindus indica* were the most commonly reported plants. However, up until now there has been no documentation of the use of medicinal plants for treatment of malaria in Budondo sub-county. The aim of the present study was to identify and document the plants that are commonly used by the indigenous people of Budondo sub-county in the treatment of malaria infection.

Materials and methods

Study area

The ethnobotanical survey was carried out in Budondo sub-county located along the bank of river Nile in Jinja district, Uganda, approximately 92 km by road, north-east of the capital city, Kampala. The area has five parishes, Nawangoma, Buwagi, Ivanumba, Namizi and Kibibi and an estimated 10,084 households (Uganda Bureau of Statistics 2014).

The area is richly endowed with diverse flora, and the traditional healers are reported to be many. The rainfall pattern is bimodal (range: 1,250 to 1,500 mm per annum) with a dry season from November to February and two short rains from April to May and from September to October (Tabuti & Mugula 2007). The majority of people in Budondo are poor (Jinja District Development Plan 2015/2016-2019/2020), with very limited health facilities (the sub county has only one health unit, Budondo health centre IV), and there are high malaria incidences, with 7,815 cases (41%) reported in 2016 (MOH 2016). Furthermore, the sub-county has several wetlands, sugar cane plantations and streams which serve as breeding and hiding places for mosquitoes.

Ethnobotanical survey

Ethnobotanical data on the use of medicinal plants for treatment of malaria was collected between December 2017 and January 2018. Data was collected through a survey by administering semi-structured interviews to randomly selected household representatives (i.e., either the household head, spouse or any adult child above 15 years). Interviews were conducted in Lusoga, the principal language spoken in the area. A total of 273 respondents (125 men and 148 women) above 15 years were sampled in the five parishes (Table 1). Data collected included biodata of the respondents, local name of plant species used to treat malaria, plant parts used, habit, mode of remedy preparation and administration, including dosage of the claimed medicinal plants. Prior to conducting the study, permission from the chairpersons of area local councils were obtained and the study was approved by the Gulu University Research and Ethics committee (GUREC-022-19). Written informed consent or assent was sought from each respondent before the onset of interview. The researcher explained to each respondent the objectives of the

study. Voucher specimens of the reported antimalarial plants were identified by a taxonomist, Rwamburindore P., labeled and deposited in the Herbarium of Makerere University, Uganda. The correctness of the species and family names were checked using the online flora of Tropical Africa database (http://www.tropicos.org, accessed 10/06/2018) and APG IV, (2016), respectively.

Data analysis

Ethnobotanical data were analyzed using descriptive statistics such as frequencies and percentages. The association between respondents' knowledge with their gender, age, educational status, occupation, religion and income level per month was tested with chi-square analysis (Sokal 1995). All data were analyzed using SPSS, version 23 at a 95% confidence interval (P = 0.05).

Results

Socio-economic characteristics of respondents

The profile of the 273 respondents interviewed in this study is presented in Table 1. 125 (45.8%) of the respondents interviewed were men and 148 (54.2%) were women. The majority (45.8%) were between 26 to 35 years old. Most of the respondents (65.9%) had basic primary school level of education. The majority (79.5%) of respondents were peasant farmers and only 21 (7.7%) of the interviewed respondents were formally employed. Most of the respondents earned below Uganda Shilling (UGX) 100,000 (approximately 30 US dollars) per month and the majority belonged to the mainstream religions and were mostly Catholics (32.2%), Anglican (28.2%), Pentecostals (16.8%) and Muslims (16.1%). Overall, 96.7% (264/273) of respondents had knowledge about antimalarial plants (Table 1).

Traditional knowledge on antimalarial plants

A chi-square analysis shows significant associations in the knowledge of the antimalarial plants and gender (χ^2 = 7.0, df=1, *P*-value=0.008), and occupation (χ^2 = 9.3, df=3, *P*=0.025). The women were more knowledgeable than the men (Table 2). The peasant farmers were more knowledgeable than the others. However, there was no significant association with education status (χ^2 = 8.8, df=4, *P* = 0.066), religion (χ^2 = 10.4, df=5, *P*<0.064) and income status of respondents (χ^2 = 6.0, df= 6, *P*=0.419) (Table 2).

Traditionally used antimalarial medicinal plants

A total of 37 plant species both cultivated and wild belonging to 25 different families were reported to be used in treatment and cure of malaria infection in Budondo sub county (Table 3). The family Asteraceae was the most commonly represented with five species, followed by Myrtaceae (four species), Solanaceae (three species), and the families Bignoniaceae, Verbenaceae and Rutaceae were represented with two species each. The rest of the families (19) had one species each. Most of plants were reported to be native to Budondo with exception of *Azadirachta indica* Juss*, Callistemon citrinus* (Curt.) Stapf and *Cannabis sativa* L. which were introduced from other areas. The most commonly used plant was *Vernonia amygdalina* (mentioned by 64.8% of the respondents). Other commonly used plants included *Aloe vera* L. (41.8%), *Callistemon citrinus* (Curt.) Stapf (29.3%), *Mormodica feotida* Schumach (22.0%), *Cyphostemma adenocaule* (A. Rich) Wild & Drumm. (16.1%), *Eucalyptus globulus* L. (15.4%) (Table 3). Herbs constituted the highest number of medicinal plants (16 species), followed by trees (14 species) and shrubs (7 species) (Table 3).

Table 1. Socio-demographic characteristics of the respondents (*n=273*)

Characteristics	Frequency	Percent
Gender		
Male	125	45.8
Female	148	54.2
Age of respondents (years)		
15-25	22	8.1
26-35	125	45.8
36-45	70	26.6
46-55	35	12.5
56-65	14	5.1
Above 66	7	2.6
Educational status		
None	16	5.9
Primary	180	65.9
Ordinary secondary	33	12.1
Advanced secondary	21	7.7
Post-secondary	23	8.4
Occupation		
Peasant (small farmers)	217	79.5
Civil servant	21	7.7
Trader/self-employed	12	4.4
Student	23	8.4
Religion		
Catholic	88	32.2
Anglican	77	28.2
Muslim	46	16.8
Pentecostal	44	16.1
Traditionalist	13	4.8
Others	5	1.8
Monthly income status		
Less than 10,000	28	10.3
10,000-100,000	97	35.5
101,000-200,000	70	25.6
201,000-300,000	45	16.5
301,000-400,000	12	4.4
401,000-500,000	10	3.7
Above 500,000	11	4.0
Knowledge on anti-malarial plants		
Yes	264	96.7
No	9	3.3

Table 2. Knowledge on antimalarial plants in relation with age, gender, educational status, religion, occupation and income status of the respondents

Characteristics	Total number of respondents	Knowledge on antimalarial plants		χ^2	P-value
		No	Yes		
Gender					
Male	125	8	117	$\chi^2 = 7.0$, *df*=1	P=0.008
Female	148	1	147		
Age (years)					
15-25	22	1	21	$\chi^2 = 5.3$, *df*=5	P=0.379
26-35	125	7	118		
36-45	70	0	70		
46-55	35	1	34		
56-65	14	0	14		
Above 66	7	0	7		
Educational status					
Illiterate	16	0	16	$\chi^2 = 8.8$, *df*=5	P=0.066
Primary	180	5	175		
Ordinary secondary	33	0	33		
Advanced secondary	21	1	20		
Post-secondary	23	3	20		
Occupation					
Peasant (small farmers)	217	6	211	$\chi^2 = 9.3$, *df*=3	P=0.025
Trader/self-employed	23	0	23		
Religion					
Catholic	88	1	87	$\chi^2 = 10.4$, *df*=5	P=0.064
Anglican	77	2	75		
Muslim	44	1	43		
Pentecostal	46	5	41		
Traditionalist	13	0	13		
Others	5	0	5		
Monthly income status (UG X)					
Less than 10,000	28	2	26	$\chi^2 = 6.0$, *df*=6	P=0.419
101,000-200,000	70	1	69		
201,000-300,000	45	3	42		
301,000-400,000	12	0	12		
401,000-500,000	10	0	10		

Plant parts used, mode of preparation, dosage and administration of remedies

Stem was the most commonly used plant part in the preparation of remedy against malaria constituting 99.6% of the preparations, followed by leaf (90.6%), fruits (11.4%), seeds (5.1%), flowers (2.6%) and the least was whole plant (0.7%). Majority used fresh parts except the seeds that were dried first. The principal modes of preparation included boiling in water, squeezing fresh leaves, crushing and pounding, and chewing. Cold or hot water was the main solvent for herbal preparations. In the majority of cases, the respondents mostly used single plant species in remedy preparations. However, plants like *Mangifera indica* L, *Persea americana* Mill., *Carica papaya* L., *Coffea canephora* Froehner and *Markhamia lutea* (Benth.) K.Schum. were reported to be prepared as mixtures. The majority of the antimalarial plant remedies (33 species) were taken orally. Most of the plants administered through oral route were reported to have a bitter taste. The plants were used until the patient's condition had improved and there were variations in unit of measurements, dosages, frequency and appropriate times for the administration of remedies. Dosages were estimated using different units such as cup and teaspoon and children were often given half of the dosage of adults. Most of the herbal remedies prescribed were taken twice or three times a day.

Discussion

Our results revealed that 37 plant species belonging to 25 different families are commonly used for treatment of malaria in Budondo sub county, with Asteraceae and Myrtaceae being the most predominant plant families in terms of number of species. The use of Myrtaceae and Asteraceae in the treatment of malaria has been reported in several earlier previous studies, such as in Cameroon (Simbo 2010), Uganda (Namukobe *et al*. 2011) and in Nigeria (Olorunnisola *et al.* 2013). Different

species of Asteraceae are reported to have pharmacological properties, for example Olorunnisola *et al*. (2013) reported three plant species (*Chromolaena odorata* L; *Vernonia amygdalina* Delile and *Ageratum conyzoides* L.) that are used for treating malaria in Southwest Nigeria. Most of the plants cited in the current study have been reported by different communities elsewhere in Uganda and other countries in Africa for management of malaria (Tabuti 2008, Ssegawa & Kasenene 2007, Stangeland *et al.* 2011, Mesfin *et al.* 2012) suggesting that these species may be effective in the treatment of malaria. For example, *V. armygdalina, Aloe sp,* and *A. indica* were reported by Stangeland *et al*. (2011) to be used for treating malaria in western Uganda whereas Ssegawa and Kasenene (2007) reported *A. indica* and *Citrus limon* (L.) Osbeck (Rutaceae) for treatment of malaria in southern Uganda. In Ethiopia, Mesfin *et al*. (2012) mentioned *Aloe* sp, *A. indica* and *Tamarindus indica* to be used in treatment of Malaria in Shinile district, Somali region of Ethiopia. However, the number of plant species reported (37 plant species) are higher than those reported (20 species) in the mostly swampy sub-county of Cegere in northern Uganda (Anywar *et al.* 2016), although lower than those reported (48 species) in Nyakayojo sub-county in western Uganda (Stangeland *et al*. 2011).

Overall, the results of the present study clearly indicated that the people of Budondo in Uganda were knowledgeable (97.8% of respondents) concerning antimalarial plants. However, there was no significant difference observed between knowledge of plants used to treat malaria and the educational status, religion, age and average income status of respondents. This suggests that the plants are well known by the community irrespective of educational status, age, religious affiliation and income status. Nevertheless, the knowledge of antimalarials was significantly associated with gender (p-value = 0.008) and occupation (p-value = 0.025) of the respondent. Women were more knowledgeable about the plants than men because women are more responsible for the health care of the family members, especially children than men (Oreagba *et al*. 2004). Besides, malaria majorly affects pregnant women and children below five years old (Stangeland *et al*. 2011), and thus women easily obtain this information to curb down the disease. The present result is consistent with the findings of Tabuti *et al.* (2003) in Badiope county, Eastern Uganda.

Furthermore, our results also indicated that the people of Budondo mostly use stem (99.9%) and leaves (90.6%). This agrees with the work of Anywar *et al.* (2016) on medicinal plants of Cegere, in northern Uganda and with the works of Pierre *et al.* (2011) in Cameroon, where they showed that leaves and stem constituted the majority of the plant parts used. Leaves and stem are the plant parts most commonly used by traditional medicine practitioners in many African countries (Olorunnisola *et al*. 2013, Mukungu *et al.* 2016). The routine use of leaves could be a result of the fact that leaves are the sites for synthesis and storage of the majority of plant secondary metabolites or bioactive compounds which are presumed to have anti-plasmodium actions (Pierre *et al*. 2011). Besides, regular harvest of leaves poses minimal threat to the survival of individual plants and this could be a conservation strategy of the plants by the communities. However, frequent usage of stem for herbal preparations can be risky for the survival of a plant species. Therefore, to ensure sustainable utilization of medicinal plant resources, application of proper harvesting strategies and conservation measures is necessary.

Most of the plants used for treating malaria were prepared by squeezing juice out of the fresh leaves and boiling in water (Table 2) which is in agreement with previous study by Olorunnisola *et al*. (2013) in south-west Nigeria and by Mukungu *et al*. (2016) in Kenya. Also, water was mostly used as solvent in making herbal preparations as earlier reported by Kamatenesi *et al*. (2011). The herbal remedies were primarily administered through oral route, but rarely through intranasal and whole-body steam baths. Fresh parts were also eaten and chewed directly upon collection or after initial pounding. These findings are in agreement with observations in other studies elsewhere (Kamatenesi *et al*. 2011, Olorunnisola *et al.* 2013, Mukungu *et al*. 2016). The oral route is suited for systemic treatment of malaria because the disease is caused by intracellular haemo-parasites and its treatment require taking sufficient circulating concentration of suitable anti-protozoan compounds from herbal medication. This allows comparatively rapid absorption and distribution of bioactive compounds from the plants, allowing the delivery of adequate curative power (Teklay *et al*. 2013).

Conclusions

The present study shows that the people living in Budondo have a rich knowledge on anti-malarial plants which could be exploited in the development of new anti-malarial drugs. However, future research on in-vitro anti-plasmodial efficacy and toxicological studies of the plants are needed to generate confidence in their use. Also, it is needed to identify and isolate bioactive compounds in these plants that could be developed into new effective and affordable standardized phytomedicines.

Table 3. Plants used for the management of malaria among the Basoga community in Budondo sub county, Uganda

Family and scientific name	Lusoga name	Part used	Life form	Cultivated / wild	Mode of preparation and administration	Frequency of mention	Percent	Reported antimalarial or anti-plasmodial activity (if known)	Active chemical constituent
ALLIACEAE									
Allium sativum L. GMM032	Katunguluccumu	Leaves	Herb	Cultivated	Chew the leaves and swallow	3	1.1	No record	
AMARYLLIDACEAE									
Allium cepa L. GMM028	Katungulu	Leaves, Bulb; Fruits	Herb	Cultivated	Crush the leaves/bulb, add water and drink or just chew the leaves and swallow	4	1.5	No record	
ANACARDIACEAE									
Mangifera indica L. GMM014	Muyembe	Leaves, Bulb	Tree	Cultivated	Boil leaves or bark for 20 minutes, allow to cool and drink the filtrate, three table spoons three times or a full cup twice	15	5.5	Chloroform: methanol (1:1) hot water extract inhibited growth of chloroquine resistant strain of *P. falciparum* by >50% at 50µg/ml (Zirihi *et al*. 2005)	Phenolics (Barreto *et al*. 2008)
ARISTOLOCHIACEAE									
Aristolochia elegans Mast. GMM007	Nakasero	Leaves, Stems	Herbaceous climber	Cultivated / wild	Squeeze, add water and drink, two table spoons three times for adults, or one table spoon twice (children)	35	12.8	Inhibited >50 (*Plasmodium falciparum* sensitive strain: 3D7); undetectable chloroquine resistant *P. falciparum*, W2 (Muganga *et al.* 2010)	Sesquiterpenoids, diterpenoids, monoterpenoids, alkaloids (Wu *et al*. 2004, Shi *et al*. 2004)
ASPHODELACEAE									
Aloe vera (L.) Burm.f. GMM002	Kikaka/Kigagi	Leaves	Herb	Cultivated	Boil fresh leaves in water and drink	114	41.8	Anti-plasmodial activity with respect to effective dose (ED_{50}) values from crude aqueous extracts ranged from 0.289 to 1.056 µg/ml (chloroquine sensitive) (Kumar *et al*. 2017)	Anthraquinone,Aloin, aloe-emodin (Kumar *et al*. 2017)
ASTERACEAE									
Vernonia amygdalina Dellile GMM001	Lubilili	Leaves, Stems	Shrub	Wild	Fresh leaves squeezed and mix with cold water and drunk (either two tablespoon, three times or a quarter of a cup three times).	177	64.8	Ethanolic extracts of leaves IC_{50} 9.8 mg/ml (Omoregie *et al*. 2011).	Coumarine; sesquiterpene lactones and steroid glycoside (Jisaka *et al*. 1992; Erasto *et al*. 2006)

Vernonia lasiopus O. Hoffm. GMM009	Lubirizi olutono Kaluluza	Leaves	Shrub	Wild	Crush a handful of fresh leaves, mix with cold water and drink one table spoon three times a day for a week.	24	8.8	Methanol extract of leaves in hot water IC_{50} values: 44.3 µg/ml (chloroquine sensitive, D6); 52.4 µg/ml (Chloroquine resistant, W2) (Muregi *et al*. 2007; Okello & Kang 2019).Petroleum ether extract exhibit anti-malarial activity against wild strain of *P. plasmodium* (IC_{50}=43.9), chloroform extract >50, ethanolic extract >50 (Katuura *et al.* 2007)	Sesquiterpene lactones, polysaccharides (Koul *et al*. 2003); polysaccarides (Nergard *et al*. 2004)
Lactuca capensis Thunb. GMM025	Isseja	Leaves	Herb	Wild	Boil for 30 minutes and drink a half a cup two times	5	1.8	No record	
Senecio discifolius Oliv, GMM026	Kakyamusure	Leaves	Herb	Wild	Vaporization and intranasal inhaling only to individuals above 20 years twice a day.	4	1.5	No record	
Aspilia africana (Pers.) C. D. Adams GMM036	Makayi	Leaves	Herb	Wild	Squeeze sap from either the leaves, and drink the sap	2	0.7	Ethyl acetate extract, inhibitory concentration (IC_{50}) 9.3 µg/ml against the chloroquine sensitive (D10) strain of *P. falciparum* and 11.5 µg/ml against the chloroquine sensitive (KI) strain (Waako *et al*. 2007).	Saponins, terpenoids, alkaloids, resins, tannins, flavonoids, sterols (Okoli *et al.* 2007)
BIGNONIACEAE									
Markhamia lutea (Benth) K. Schum. GMM011	Musambya	Leaves, Stem bark	Tree	Wild / Cultivated	Vaporization and intranasal inhaling	17	6.2	Ethyl acetate extract of leaves in hot water caused 71% inhibition of *P. falciparum* at 10 µg/ml (Lacroix *et al*. 2009)	Cycloartane triterpenoids, Phenylpropanoid glycosides (Kernan *et al*. 1998; Lacroix *et al*. 2009)
Spathodea nilotica Seem. GMM033	Kinalisa	Leaves	Tree	Wild	Boil for 20 minutes and drink the filtrate, a whole cup two times	2	0.7	Ethyl acetate extract of stem bark in water inhibition of *P. falciparum* by 28.9% at 10 µg/ml (Lacroix *et al*. 2011)	Quinone (Lacroix *et al*. 2011)

CANNABACEAE									
Cannabis sativa L. GMM035	Enjaye	Leaves	Herb	Cultivated	Boil leaves in water for 30 minutes while covering the container, allow the victim to inhale the vapor while covering the head with a thick cloth	2	0.7	No record	
CARICACEAE									
Carica papaya L. GMM021	Mapapali	Leaves, Fruit	Tree	Cultivated	Vaporization and intranasal inhaling or boil leaves in water/steam for 20 minutes, make decoction and drink; three tablespoons for adults above 16 years	6	2.2	Ethyl acetate extract of *C. papaya* leaves showed IC_{50} of 2.96 against *P. falciparum*- chloroquine sensitive, D10; 3.98 (Chloroquine resistant, DD2); Methanol extract of leaves: 10.8 (chloroquine sensitive, D10). (Melariri *et al*. 2011, Teng *et al.* 2019)	Alkaloids, saponins, tannins and glycosides (Melariri *et al*. 2011,)
FABACEAE									
Senna didymobotrya (Fresen.) H.S.Irwin & Barneby (GMM029)	Muvuvumira	Leaves	Shrub	Wild	Boil fresh leaves in water for 30 minutes and drink the resulting filtrate-three table spoonful for adults and one tablespoon for children below 10 years three times a day	4	1.4	Methanol extract of leaves in hot water showed anti-plasmodial activity (IC_{50}=100 mg/ml against the Chloroquine sensitive strain of *P. falciparum*, K39 (Muregi *et al*. 2003)	Quinones (Alemayehu *et al*. 1989)
CUCURBITACEAE									
Momordica foetida Schumach. GMM004	Eibombo	Leaves, Stems	Herbaceous climber	Wild	Squeeze, add water or infusion and drink or bath	60	22	Aqueous extract of shoot in hot water: 6.16 (chloroquine sensitive, NF54); 0.35 (Chloroquine resistant, FCR3) (Adia *et al*. 2016).	Saponins, alkaloids, cardiac glycosides (Adia *et al*. 2016)
CUPRESSACEAE									
Cupressus sempervirens L. GMM016	Kurismasitri	Leaves	Tree	Cultivated	Either burn three days old harvested leaves to produce the smoke and inhale the smoke or boil the leaves for 30 minutes covering the container and inhale the resulting vapor	9	3.3	No record	

EUPHORBIACEAE									
Manihot esculenta Crantz GMM015	Mowoga	Leaves	Shrub	Cultivated	Boil leaves in a saucepan for 30 minutes, remove the cover and allow the person to inhale the vapor twice a day (for individuals above 20 years)	9	3.3	No record	
LAMIACEAE									
Ocimum basilicum L. GMM019	Kakubansiri	Leaves, Whole plant	Herb	Wild	Vaporization and intranasal inhaling at least twice a day	8	2.9	Methanolic leaf extracts showed anti-plasmodial activity against chloroquine sensitive, D6 (IC_{50}=16.4) (Muthaura *et al*. 2015), and against chloroquine sensitive, CQ-s (IC_{50}=68.14 µg/ml); and chloroquine resistant, CQ-r (IC_{50}=67.27 µg/ml) (Murugan *et al*. 2015).	Quinones (Alemayehu *et al*. 1989)
LAURACEAE									
Persea americana Mill GMM012	Fakedo	Leaves, Bark, Seeds	Tree	Cultivated	Vaporization and intranasal inhaling	16	5.9	Ethanol extract of leaves in hot water effective against chloroquine sensitive, 3D7 (IC_{50}=10.15 µg/ml), chloroquine sensitive, CQ-s (IC_{50}=68.14 µg/ml) and chloroquine resistant, W2 (IC_{50}=44.94 µg/ml) (Komlaga *et al*. 2016)	Phenolics (Canini *et al*. 2007, Komlaga *et al*. 2016)
MELIACEAE									
Azadirachta indica A. Juss. GMM008	Neem	Leaves, Seeds	Tree	Cultivated	Fresh apical leaves or stem are pound and mixed with cold water and the filtrate drunk, three tablespoons for adults and two for children below five years	29	10.6	Ethanol extract of leaves in hot water showed anti-plasmodial activity against the Chloroquine sensitive, D6 (IC_{50}=17.9 µg/ml) and Chloroquine resistant, W2 (IC_{50}=43.7 µg/ml) (Biswas *et al.* 2002, Nanyingi *et al*. 2010)	More than 100 compounds have been isolated including isoprenoids, terpenoids and gedunin (Biswas *et al.* 2002, Nanyingi *et al*. 2010)

MORINGACEAE									
Moringa oleifera Lam. GMM017	Moringa	Leaves	Tree	Cultivated	Chew the leaves seven times a day	9	3.3	Methanol extract of leaves in hot water: 9.8 (chloroquine sensitive, D6); not detected (Chloroquine resistant, W2) (Muthaura *et al*. 2015)	Flavonols (Muthaura *et al*. 2015)
MYRTACEAE									
Callistemon citrinus (Curt.) Stapf GMM003	Mwambula butonya	Leaves, Bark, Fruits	Tree	Wild	Chew fresh leave, 10 leaves five times a day or boil fresh leaves or bark and drink the filtrate, a quarter cup three times a day	80	29.3	No record	
Eucalyptus globulus L. GMM006	Kalituunsi	Leaves	Tree	Cultivated	Boil leaves or bark in water for 30 minutes, leave to cool, drink filtrate (3 tablespoons for adults or one tablespoon for children < 6 years) or simply chew fresh leaves	42	15.4	No record	
Psidium guajava L. GMM013	Mupera	Leaves	Tree	Cultivated	Boil leaves for 30 minutes and drink the filtrate, two tablespoons (adults) or one tablespoon (children)	16	5.9	Hot water extract of stem bark: 10-20 (chloroquine sensitive D10) (Pillay *et al*. 2008)	Phenolics, flavonoids, catenoids, terpenoids (Pillay *et al*. 2008)
Syzygium guineense (Wild.) DC. GMM031	Muziru	Leaves	Tree	Wild	Decoction and drink, a whole cup twice a day	3	1.1	Crude ethanol extract of leaves in hot water chemo-suppressed *P.berghei* by 49.09% at 400 mg/kg (Tadesse & Wubneh, 2017)	No record
OXALIDACEAE									
Oxalis corniculata L. GMM024	Kanunu	Leaves	Herb	Wild	Boil 6-10 leaves in 4 litres of water for 1 hour and drink half a cup of the filtrate three times a day	5	1.8	No record	
RUBIACEAE									
Coffea canephora Froehner GMM022	Mwanyi	Leaves	Shrub	Cultivated	Vaporization and intranasal inhaling for leaves or boil the leaves for 20 minutes, leave to cool and drink	6	2.2	No record	

					the filtrate, three table spoons three times				
RUTACEAE									
Citrus limon (L.) Burm.f. GMM010	Niimu	Leaves, Fruit, Seeds	Tree	Wild	Infusion, squeeze juice of fruit, or crush dried seeds, add hot water and drink without sugar (one cup three times). Alternatively, chew six leaves for as many times as possible	18	6.6	No record	
Citrus sp. GMM034	Akalimu akatomo	Leaves	Tree	Cultivated	Either chew fresh leaves or squeeze juice out of the fruit and drink (at least two table spoons three times). Dry leaves and seeds and pound crush to obtain powder; add hot water and drink without adding sugar (at least one cup three times)	2	0.7	No record	
SOLANACEAE									
Solanum aethiopicum GMM023	Ndagi	Fruit	Herb	Cultivated	Chew the fruit and swallow several times as you can	6	2.2	No record	
Solanum anguivii Lam. GMM030	Katunkuma	Fruit	Herb	Wild	Chew the fruit and swallow several times as you can	3	1.1	No record	
Capscicum frutescens L. GMM037	Kamulali	Fruit, Seeds	Herb	Cultivated	Swallowing the seeds/fruit; eat in food or pound, add water and drink several times a day	1	0.4	No record	
VERBENACEAE									
Lantana camara L. GMM018	Kappanga	Leaves	Shrub	Wild	Boil fresh leaves in water until vapour is formed. Remove saucepan from heat when still covered and expose the nose to the vapour (intranasal inhaling), twice a day	8	2.9	The dichloromethane and methanolic extracts of reported to exhibit invitro antimalarial activity against chloroquine sensitive, 3D7 (IC_{50}=5.7 µg/ml) and chloroquine resistant, W2) strains of *P. falciparum* (IC_{50}= 14.1 µg/ml) (Jonville *et al*. 2008).	Ssesquiterpenes, triterpenes, flavonoids (Stangeland *et al*. 2011)

Lantana trifolia L. GMM020	Kasekera nyonyi/Kayukiyuki	Leaves	Shrub	Wild	Infusion and inhaling	6	2.2	Petroleum ether extract in hot water effective against wild strains of *P. falciparum* (IC_{50}=13.2 μgml^{-1}); methanol extract in hot water: >50 μgml^{-1} (Katuura *et al*. 2007)	Steroids, terpenoids, alkaloids, saponins (Katuura *et al*. 2007)
VITACEAE									
Cyphostemma adenocaule (A. Rich.) Willd. & Drumm. GMM005	Bbombo	Leaves, Seeds	Herbaceous climber	Wild	Squeeze, add water and drink, two tablespoons (for those > 10 years old) or one tablespoon (6-10 years) three times	44	16.1	No record	
ZINGIBERACEAE									
Zinger officinale L. GMM027	Ntangawuzi	Rhizomes	Herb	Cultivated	Crush, add hot water and drink the solution, half a cup three times a day or chew the stem three times a day	4	1.5	No record	

Declarations

List of abbreviations: Not applicable.
Ethical approval and consent to participate: This study was approved by the Gulu University Research Ethics Committee (GUREC-022-19). Permission to conduct this study was later granted by the local council chairpersons of respective villages. Written informed consent and assent were obtained from the adult participants and persons under the age of 18, respectively.
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Authors' contributions: GMM, KB, KR and CO participated in designing of the study; KB and HOO participated in the collection of field data and identification of plant samples. GMM, RO and FA analysed the data and wrote the initial draft of the manuscript. All the authors participated in writing and giving feedback on the manuscript and approved the final version of the manuscript.

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