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Full Length Research Paper

A review for selecting medicinal plants commonly used for malaria in Uganda

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The menace of current cases of parasite resistance to antimalarial drugs, non- availability and accessibility, and the high costs of pharmaceutical products contribute to the high rate of medicinal plants consumption in the treatment of malaria in Uganda. Different ethnobotanical surveys on medicinal plants with antimalarial properties have been conducted across different geographical regions in Uganda in order to identify and select the most commonly used antimalarial plants as candidates in the proposed national herbal pharmacopoeia. The available literature on the medicinal plants used against malaria in the western, central, eastern and northern geographical regions in Uganda was selected from reputable journals using various citation databases as guides. The commonly used antimalarial plants in the regions were searched using relevant journals on previously established ethno-botanical survey. They were then ranked in order of percentage frequency of appearance in the literature from surveys across the country. Fifteen medicinal plants were selected in this way from several antimalarial plants cited. *Vernonia amygdalina* and *Azadirachta indica* appeared most (100%), followed by *Carica papaya*, *Mangifera indica* and *Hoslundia opposita* with 80% appearance each across the 4 regions.The medicinal plants from this review were therefore ranked as the most used for treatment of malaria in Uganda and therefore, could be recommended for herbal pharmacopoeial standards development.

Key words: Antimalarial, medicinal plants, antiplasmodial, herbal pharmacopoeial standards.

INTRODUCTION

Malaria remains one of the major health challenges in developing countries despite the efforts of different organizations including the World Health Organization (WHO), West African Health Organization (WAHO), Centers for Disease Control and Prevention (CDC), the African Union's Scientific, Technical and Research Commission (AU/STRC) among others to control and eradicate it (WHO, 2018).

It was reported that 219 million cases of malaria occurred worldwide in 2017 and 92% of these cases

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were from African region with 435,000 mortalities. This malaria endemic region was followed by the South-East Asia Region with 5% and the Eastern Mediterranean Region with 2% (WHO, 2017, 2018). The Uganda Malaria Reduction Strategic Plan (UMRSP) reported malaria cases of 1 out of 3 out-patient visits to health facilities and 50% of the in-patient pediatric mortalities are associated with malaria disease yearly (MoH, 2016). The setback to malaria fight has been attributed to non-availability of effective vaccine, resistance to pyrethroid-treated mosquito nets, high costs of antimalarial drugs and the recent widespread chloroquine-resistant *Plasmodium falciparum* (WHO, 2018).

In malaria chemotherapy, medicinal plants have always played a leading role in drug discovery and such drugs are used in natural form or synthesized or act as structural models for semi-synthetic antimalarial drugs. Quinine was first time isolated from *Cinchona* bark against malaria in the early 18th century and became a skeleton from which chloroquine (resochin), mefloquine and other similar antimalarial drugs were later synthesized (Achan et al., 2011).

The most successful battle against the sudden appearance of chloroquine-resistant *P. falciparum* led to the isolation of artemisinin from the Chinese *Artemisia annua.* Its synthetic chemical derivatives (e.g. artemether, dihydoartemisinin and artesunate) are now combined with existing antimalarial drugs to artemisinin-based combination therapy (ACT) such as artemartemether-lumefantrine, artesunate-amodiaquine, etc. which are referred to as ACT (Chen, 2014). Currently, ACTs remain the recommended choice of drugs for malaria despite recent reports on the *P. falciparum* resistance in Greater Mekong subregion (GMS) including Cambodia, Lao People's Democratic Republic, Vietnam, Thailand and Myanmar (WHO, 2018), etc.

Historically (from *Cinchona* to *Artemisia*), the plant kingdom remains the source for antimalarial drug discovery. Similar history has shown many current therapeutic drugs (e.g. digoxin, reserpine, morphine, etc.), at conventional health care levels for the management of other diseases from medicinal plants. According to the World Health Organization, 60% of the world's population depends on traditional medicine and 80% of the people in developing countries depend entirely on traditional medicine practices due to their accessibility, folklore and affordability for their primary health care needs (Chikezie and Ojiako, 2015).

The high acceptability of medicinal plants therefore requires the needs for their national standards which guarantee the consistence, definite identification, reproducible safety, efficacy and qualities as a valuable scientific reference for drug authorities, manufacturers, general public and researchers (WHO, 2011). These plants are normally selected based on their frequent used across the country. This review exercise aimed at compiling the most used medicinal plants for malaria in Uganda with a view to developing their national standards which will subsequently be used to develop their herbal monographs.

METHODOLOGY

Literature data collection for the selection of antimalarial medicinal plants

The plants were searched through different search engines including Google Scholar, Institute for Scientific Information, PubMed, Scopus, Hinari, Scientific Information Database, etc., using antimalarial plants, antiplasmodial, malaria endemic, ethnopharmacology and Uganda regions as the keywords.

In this progression, different ethno-botanical survey articles on antimalarial plants in a particular region were first compiled and then ranked based on their frequency of occurrence in literature within the same region. Thereafter, their physical occurrences in the literature from other geographical regions of Uganda were considered. The antimalarial plants, found occurring in at least 2 out of the 4 regions (Central, Eastern, Northern and Western Uganda) and those mentioned in PROMETRA records (Association for the Promotion of Traditional Medicine), Uganda, East Africa, were selected. The following formula was applied to the plant collected prior to their ranking:

Formula: (x/N)×100

Where, x is the total number of appearances ascribed to each antimalarial plant across the regions, while N (5) is the total number of regions together with PROMETRA antimalarial plants.

A comprehensive literature search was thereafter carried out to review the extent of previous studies on each of the selected plants.

RESULTS AND DISCUSSION

Fifteen medicinal plants belonging to 12 families were found to be commonly used for the control of malaria in Uganda among which 4 species (*Bidens pilosa* L., *Tithonia diversifolia* (Hemsl.) A. Gray, *Vernonia amygdalina* and *V. lasiopus* O. Hoffm) belonged to the family Asteraceae. *V. amygdalina* Del. leaf and *Azadirachta indica* A. Juss. (Meliaceae), being the most used across Uganda with 100% appearance, were followed by *Carica papaya* L. (Caricaceae), *Hoslundia opposita* Vahl (Lamiaceae) and *Mangifera indica* L. (Anacardiaceae) with 80%. *B. pilosa* L., *Cymbopogon citratus* (DC.) Stapf. (Poaceae), *Justicia betonica* L. (Acanthaceae), *Markhamia lutea* (Benth.) K. Schum. (Bignoniaceae), *Moringa oleifera* Lam. (Moringaceae), *T. diversifolia* (Hemsl.) A. Gray, *V. lasiopus* O. Hoffm showed 60% appearances while *Aristolochia elegans* Mast. (Aristolochiaceae), *Cajanus cajan* (L.) Huth (Fabaceae) and *Toddalia asiatica* (L.) Lam. (Rutaceae) gave 20% appearance representing the least commonly used antimalarial plants across Uganda.

Adia et al. (2014) studied some medicinal plants used

for the treatment of malaria by PROMETRA in Central Uganda; about 75% of the traditional medical practitioners (TMPs) of Uganda were interviewed from Mpigi and 25% from Butambala District. Eighty-six medicinal plants from 39 families were reportedly used in the treatment of malaria ailment by the TMPs out of which 32% belonged to Asteraceae, followed by Lamiaceae (24%), Euphorbiaceae (12%) and Poaceae 10%. Out of these, *V. amygdalina* was the most recorded plant. These plants, used by TMPs, were either used individually (in mono-component remedies) or in combination (in multi-component preparations). The leaf and root are the morphological parts most frequently used and prescribed by the TMPs (Adia et al*.,* 2014).

Tugume et al*.* (2016) conducted an ethnobotanical survey on medicinal plants used for various ailments in Baganda, Banyarwanda, Basoga, Bagisu, Bakiga, Banyankole, Bagwere and Batoro tribes from Naluvule, Bukuku, Buwoola and Kalagala villages which were mostly Bantu ethnic groups from Central Uganda. The study reported 190 species (from 61 families) in which 20 species were listed for antimalarial herbal remedy and out of which the following 6 species were commonly used in other regions: *A. elegans*, *H. opposita*, *J. betonica*, *M. lutea*, *V. amygdalina* and *V. lasiopus*. In the Central Uganda region, *V. amygdalina* was highly classified as the most important species in the treatment of malaria. The remedies for malaria treatment were either prepared as decoctions (Table 1) or infusions, each containing single plants or in combination with other plants (Tugume et al., 2016).

The work of Ssegawa and Kasenene (2007) on the medicinal plants of Sango bay area covered: Kaiso, Malabigambo, Namalala, Tero West, Tero East and Kigona forest blocks. One hundred and eighty-six medicinal plants were reported from which 21 plant species were recorded for malaria treatment in this area while in southern part of Uganda, a total of 39 were said to be commonly used for malaria. Among these medicinal plants, *A. elegans*, *A. indica*, *M. lutea*, *M. oleifera*, *V. amygdalina* and *V. lasiopus* were the only species used in the other regions for malaria. Tabuti (2008) studied the medicinal plants used for malaria in selected villages from Budiope County in Eastern Uganda which comprised Busambira and Buseete villages of Kinambogo Parish in the Kamuli district of Eastern Uganda. In his work, 27 medicinal plant species, mainly young leaves, parts of shrubs or trees (singly or in combination), belonging to 16 families, were reportedly used for antimalarial remedies in that County, either as decoctions or infusions (Table 1). The parts are collected and used fresh at no specific time of the day or season. Out of the 27 species reported by Tabuti (2008), 5 species (*A. indica*, *C. cajan*, *M. indica*, *M. oleifera* and *V. amygdalina*) were commonly used in other regions of Uganda.

Philip et al*.* (2017) also studied ethnobotanical survey on medicinal plants used for malaria in Butebo County in the eastern region of Uganda which comprised five sub-Counties: Kakoro, Kabwangasi, Petete, Butebo and Kibale in Pallisa District. In his study, 50 respondents were interviewed, comprising 10 from each sub-County from which 33 plant species belonging to 23 families were reported. Among the 33 medicinal plant species reported, 6 plants were commonly used in other regions which included: *A. indica*, *B. pilosa*, *C. papaya*, *C. citratus* and *M. indica*.

In the survey conducted by Anywar et al. (2016), 90 respondents interviewed in three different villages were mainly farmers some of whom are traditional medical practitioners. Twenty medicinal plants from 15 families were reportedly being used for preventing and treating malaria in Cegere sub-County of Uganda and these are mainly herbs. Twelve of the plants are used for the management of malaria, eight for prevention while two are for both prevention and treatment. These plants predominantly belong to Asteraceae and Fabaceae families, and are mostly used as decoctions or infusions (Table 1). The leaves of *A. indica*, *H. opposita*, *C. papaya*, *T. diversifolia* and *M. oleifera* (also root) were similarly found useful in antimalarial therapy in other parts of Uganda. The study of Opio et al. (2017) on survey of antimalarial plants in Abukamola, Angeta, Oculoko and Omarari areas of Alebtong District reported 43 antimalarial plants out of which only 3 plants are used in other regions for malaria treatment while other antimalarial plants listed in Alebtong DISTRICT are either used for other ailments or do not appear in other regions.

Kamatenesi et al. (2011) reported 71 medicinal plants used for different ailments in Ngai and Otwal Sub Counties of Oyam District, including four (*Acacia hockii* De Wild, *C. cajan, Ocimum basilicum* L., and *V. amygdalina*) of the listed plant species used for malaria and only two plants (*C. cajan* and *V. amygdalina*) appeared in other regions. Hamill et al. (2000) recorded medicinal plants used for general ailments in three districts of south-western Uganda: Rukungiri, Kisoro and Kabale districts of Baganda kingdom. In the first part of the report, 48 plant species were reported from which 6 species were commonly used for malaria in other regions. In the second part among Baganda people of south-western Uganda, all the medicinal plants studied were summed up to 168 with additional 8 species commonly used for malaria (Hamill et al*.,* 2003).

Katuura et al*.* (2007) studied medicinal plants used for malaria in Mbarara municipality and Rwampara County from where 20 medicinal plants were reported, out of which 19 species were identified with their leaves or roots being used as decoctions or infusions (Table 1), either individually or in combination. Four of the plant species namely, *M. indica*, *T. assiatica*, *V. amygdalina* and *V. lasiopus*, commonly used for malaria treatment in this

Table 1. Selected commonly used antimalarial plants in Uganda and their biological activities.

Species (family)	Regions	Local name (Language)	Habit	Part used	Preparation	Ethnomedicinal uses	Pharmacology	Chemical Constituents	Toxicity	References
Aristolochia elegans Mast. Syn. *A. littoralis* (Aristolochiaceae)	W, C	Musuja welaba (Banyankole) /Nakasero (Luganda)	Shrub	Leaf, stem root	Decoction	Malaria, asthma, scorpion bite, toothache and rheumatic pain	Anti-venom, cytotoxic, antibiotic, insecticidal, anticholinergic, expectorant, antitussive, antiasthmatic, analgesic, antihistamine, detoxicant, antiprotozoal, antimycobacterial	Flavonoids, anthraquinones, alkaloids, saponins, tannins, coumarins, steroids	Necrosis of tubular epithelial cells, focal parenchymal hemorrhages, mild to moderate hepatocellular degeneration at 5000 mg/kg	Hussein and El-Sebakhy, 1974; Rastrelli et al., 1997; Broussalis et al., 1999; Gadhi et al., 2001; Murillo et al., 2001; Wu et al., 2002; Hamill et al., 2000; 2003; Shi et al., 2004; Belay, 2011; Stangeland et al., 2011; Jimenez-Arellanes et al., 2012; Zamilpa et al., 2014;
Azadirachta indica A. Juss. (Meliaceae)	Pr, C, E, N, W	Neem	Tree	Leaf	Decoction	Inflammation, malaria, infections, fever, skin diseases, dental disorders, diarrhoea, peptic ulcer	Anti-hyperglycaemic, antibacterial, antifungal, anthelmintic, antioxidant, anti-inflammatory, antimalarial, antiplasmodial, antitrypanosomal, anticancer, antiviral, larvicidal, antiulcer, spermicidal, antidiabetic, anti-implantation, immunomodulating, molluscicidal, nematicidal, immunocontraceptive and insecticidal	Diterpenoids, Triterpenoids: limonoids, gedunin and its derivatives. Alkaloids, Flavonoids. Phenolic compounds: quercetin, kaempferol, myricetin. Proteins, amino acids, carbohydrates and tannins	Stem-bark: ethanol extract toxic to liver and kidney at > 100 mg/kg. Neem oil: mild damages on the liver and kidney at 177 mg/kg with regeneration after withdrawal	Tidjani et al., 1989; Stone, 1992; Hamill et al., 2000; 2003; Tabuti 2008; Ghimeray et al., 2009; Mbaya et al., 2010; Stangeland et al., 2011; Ashafa et al., 2012; Wang et al., 2013; Adia et al., 2014; Jamra et al., 2014; Mahilrajan et al., 2014; Prashanth and Krishnaiah, 2014; Yan et al., 2015; Kamatenesi et al., 2011; Anywar et al., 2016; Anand et al., 2016; Opio et al., 2017; Philip et al., 2017; Sinha et al., 2017
Bidens pilosa L. (Asteraceae)	Pr, E, W	Ssere (Rukiga/Luganda)/Kalala (Rukiga)	Shrub	Whole plant	Decoction	Pain relief, fever, diabetes, infections, inflammation, flu	Antibacterial, antimicrobial, antiviral, antifungal, antioxidant, antileukemic, anti-hyperglycemic, antiulcer, anti-inflammatory, analgesic, immunosuppressive, hepatoprotective, antimalarial, antidiabetic, anticancer, antiparasitic antiangiogenic	Sterols, terpenoids, flavonoids, essential oil	LC_{50}=21.09 mg/mL	Geissberger and Séquin, 1991; Zulueta et al., 1995; Brandão et al., 1997; Wang et al., 1997; Brandão et al., 1998; Alvarez et al., 1999; Pereira et al., 1999; Ubillas et al., 2000; Chang et al., 2001; Khan et al., 2001; Chiang et al., 2003; 2003; Kusano et al., 2003; Motsei et al., 2003; Qin et al., 2003; Andrade-Neto et al., 2004; Dong et al., 2004; Oliveira et al., 2004; Wu et al., 2004; 2007; Grombone-Guaratini et al., 2005; Rojas et al., 2006; Chang et al., 2007; Deba et al., 2008; Horiuchi and Seyama, 2008; Kviecinski et al., 2008; Chien et al., 2009; Hsu et al., 2009; Kumari et al., 2009; Tobinaga et al., 2009; Pharm et al., 2010; Asiimwe et al., 2013; Cortés-Rojas et al., 2013; Wu et al., 2013; Adia et al., 2014; da Silva et al., 2014; Fotso et al., 2014; Wachira et al., 2014; Philip et al., 2017

Table 1. Cont'd

Cajanus cajan (L.) Huth (Fabaceae)	E, W	Entondaigwa (Banyankole)/ Nkolimbo	Shrub	Leaf	Decoction	Ulcer, diarrhea, pain, diabetes, cough, sores, dysentery, hepatitis, measles, malaria febrifuge, irregular menstrual period	antiplasmodial, hypoglycemic, antihyperglycemic, antidiabetic, antiviral, antisickling, antinociceptive, immunomodulatory, anti-inflammatory, antioxidant	Alkaloids, saponins, tannins, glycosides, flavonoids, reducing sugars, carbohydrates	No biochemical, haematological and histopathological abnormalities at < 1500 mg/kg. Increase in kidney weight at 3000 mg/kg	Morton, 1976; Duke, 1981; Ekeke and Shode, 1990; Akojie and Fung, 1992; Amalraj and Ignacimuthu, 1998; Duker-Eshun et al., 2004; Tabuti 2008; Ezike et al., 2010; Zu et al., 2010; Nwodo et al., 2011; Pal et al., 2011; Stangeland et al., 2011; Wu et al., 2011; Lai et al., 2012; Asiimwe et al., 2013; Nix et al., 2015; Hassan et al. 2016; Tang et al., 2017
Carica papaya L. (Caricaceae)	Pr, E, N, W	Amapapaali (Rukiga)/ Apapalo/ Mapapali (Luganda)/Paapali essajja/ Ipapali (Banyankole)	Tree	Leaf	Decoction	Typhoid fever, wound healing, asthma, fever, diarrhea, boils, hypertension	Anticancer, antibacterial, antifungal, antioxidant, antihypertensive, hypoglycemic, hypolipidemic, antisickling, antitumor, immunomodulator, antimicrobial, anti-inflammotory, antiulcerogenic	Vitamins A, B & C, terpenoids, tannins. Alkaloids: carpaine, pseudocarpaine. Saponins, steroids, phenols, fixed oils and fats. Proteolytic enzymes: Papain, quimiopapain, benzyl isothiocyanate	Bark aqueous extract showed deleterious effects on both the seminiferous tubules and testicular interstitium at 100 mg/kg,	Kurian, 2001; Oloyede, 2005; Mohamed and Riffin, 2006; Oduola et al., 2006; Owoyele et al., 2008; Cyril-Olutayo et al., 2009; Gurung and Skalko-Basnet, 2009; Ezike et al., 2009; Kusemiju et al., 2010; Otsuki et al., 2010; Chávez-Quintal et al., 2011; Melariri et al., 2011; Stangeland et al., 2011; Nguyen et al., 2013; Adia et al., 2014; Brail et al., 2014; Pinto et al., 2014; Maniyar and Bhixavatimath, 2015; Kamatenesi et al., 2011; Anywar et al., 2016; Barroso et al., 2016; Pandey et al., 2016; Philip et al., 2017; Siddique et al., 2017
Cymbopogon citratus (DC.) stapf (Poaceae)		Akisube (Rukiga)/Kisubi (Luganda)/Omuteete (Banyankole)	Shrub	Leaf	Decoction	Gastric, fever, jaundice, throat and chest infections, hypertension, diabetes mellitus, obesity, nervous, hypertensive disorders	Anti-inflammatory, antitumor, immunomodulatory, analgesic, antioxidant, antimicrobial, antimutagenic, gastroprotective, antifungal, anti-leishmania, sedative, anticonvulsant, anxiolytic, antinociceptive, insecticidal, hypoglycemic, hypolipidemic	Saponins, alkaloids, flavonoids, tannins, esters, glycosides, essential oils	No hepatotoxic effect	Vinitketkumnuen et al., 1994; Viana et al., 2000; Sacchetti et al., 2005; Adeneye and Agbaje. 2007; Fandohan et al., 2008; Silva et al., 2008; Blanco et al., 2009; Pereira et al., 2009; Figueirinha et al., 2010; Olivero-Verbel et al., 2010; Bassolé et al., 2011; Stangeland et al., 2011; Machado et al., 2012; Francisco et al., 2013; Gbenou et al., 2013; Ukpai and Amaechi, 2012; Bao et al., Adia et al., 2014; 2015; Ekpeyong et al., 2015; Sagradas et al., 2015; Chukwuocha et al., 2016; De Silva et al., 2017; Philip et al., 2017; Venzon et al., 2018
Hoslundia opposita Vahl (Lamiaceae)	Pr, C, N, W	Kamunye (Rukiga/Luganda)/Itu tu/ Esitaimwe (Banyankole)	Shrub	Leaf	Decoction	Snake bites, herpes, conjunctivitis, epilepsy, chest pain, yellow fever, stomach troubles, mental disorders, malaria	Anticonvulsant, antibacterial antimalarial, antimicrobial, insecticidal	Flavonoids, monoterpenoids, 5,7-dimethoxy-6-methylflavone, hoslunddiol, eusxaphic, pyrone, 1,8-cineole, sesquiterpenes, abietane-type esters:3-O-benzoylhosloppone, 3-O-cinnamoylhosloppone, 3-0-benzoylhinokiol, 3-0-benzoylhosloquinone		Weenen et al., 1990; Achenbach et al., 1992; Gundidza et al., 1992; Mujovo et al., 2008; Usman et al., 2010; Gathirwa et al., 2011; Lacroix et al., 2011; Stangeland et al., 2011; Salame et al., 2012; Asiimwe et al., 2013; Adia et al., 2014; Babarinde et al., 2014; Kamatenesi et al., 2011; Anywar et al., 2016; Opio et al., 2017

Table 1. Cont'd

Justicia betonica L. (Acanthaceae)	Pr, W, C	Nalongo(Banyankole) /Lukawa/Kwiniini, Omuganda (Luganda)	Climber	Whole plant/leaf	Decoction	Asthma, dysentery, cough, leucorrhea, jaundice, pain, malaria	Antibacterial, antiviral, analgesic, anti-inflammatory, antiplasmodial	Steroids, Triterpenoids, Alkaloids, Saponins, Triterpenoid glycosides: justiciosides A, B, C & D, Alkaloidal glycoside: jusbetonin		Kanchanapoom et al., 2004; Subbaraju et al., 2004; Namukobe et al., 2011; Katuura et al., 2007; Stangeland et al., 2011; Asiimwe et al., 2013; Bbosa et al., 2013; Gangabhavani and Ravishankar, 2013; Adia et al., 2014; Parvatkar et al., 2017
Mangifera indica L. (Anacardiaceae)	Pr, E, W, C	Emiyembe (Banyankole)/ Omuyembe (Rukiga)/ Muyembe (Luganda)/ Gwakona	Tree	Leaf/stem-bark	Decoction	Asthma, dysentery, cough, leucorrhea, jaundice, pain, malaria	Antiplasmodial, analgesic, cytotoxic, antidiarrheal, antipyretic, antihypertensive, antioxidant, anti-inflammatory, anthelminthic, antiallergic, antidiabetic, antiulcerogenic	Phenolic acids: gallic acid, 3,4-dihydroxy benzoic acid, benzoic acid. Phenolic esters: gallic acid methyl ester, gallic acid propyl ester, benzoic acid propyl ester. α and β- pinenes, myrcene, limonene, fenchone, carophyllene epoxide, Flavan-3-ols: catechin, epicatechin, quercetin. Xanthones: mangiferin	Observed vacuolar degeneration, necrosis and increment of apoptosis of the acinar cells in the exocrine pancreas of rats at 1000 mg/kg of mangiferin	Chatterjee and Pakrashi, 1994; Nuñez-Sellés et al., 2002; Garcia et al., 2003; Sairam et al., 2003; Schieber et al., 2003; Bidla et al., 2004; Berardini et al., 2005; Knodler et al., 2008; Tabuti 2008; Chieli et al., 2009; Namukobe et al., 2011; Katuura et al., 2007; Severi et al., 2009; Ajila et al., 2010; Basha et al., 2011; Khan and Islam 2012; Mohan et al., 2013; Adia et al., 2014; Pierson et al., 2014; Jahurul, 2015; Prado et al., 2015; Ronchi et al., 2015; Kim et al., 2016; Oliveira et al., 2017; Philip et al., 2017
Markhamia lutea (Benth.) K. Schum. (Bignoniaceae)	Pr, C, W	Musambya (Luganda)/ Muzanganda/ Omushambya/ Omusha (Banyankole)	Tree	Root	Decoction		Antiviral, antitrypanosomal, antiplasmodial and antileishmanial activities	Phenylpropanoid glycosides: luteosides A, B & C, verbascoside, isoverbascoside. Cycloartane triterpenoids: musambins A, B & C. Glycosides: musambiosides A, B & C. Phaeophorbide A, β-sitosterol, pentacyclic triterpenes and arjunic acid		Kernan et al., 1998; Hamill et al., 2000; 2003; Lacroix et al., 2009; Adia et al., 2014
Moringa oleifera Lam. (Moringaceae)	C, N, E	Muringa (Luganda)	Tree	Leaf	Decoction	Constipation, headache, arthritis, genito-urinary diseases, diabetes, hypertension, typhoid fever	Antimicrobial, antihypertensive, antidiabetic, anti-cancer, antibacterial, antinociceptive, larvicidal, antifungal, antifatigue, anti-inflammatory, analgesic, antioxidant, antisickling	Phenols: glucosinolates, isothiocyanates. Flavonoids, alkaloids, glycosides, amino acids, carotenoids, vitamins, sterols	Slight increase in urea and creatinine levels at >1500mg/kg. risk of nephrotoxicity hepatotoxicity after a prolonged administration.	Cáceres et al., 1991; Hamill et al., 2000; 2003; Diallo et al., 2001; Dangi et al., 2002; Nikkon et al., 2003; Anwar et al., 2007; Chinmoy, 2007; Tabuti 2008; Sreelatha and Padma, 2009; Atawodi et al., 2010; Adejumo et al., 2012; Awodele et al., 2012; Awuku et al., 2012; Maldini et al., 2014; Adedapo et al., 2015; Al-malki and El-Rabey, 2015; Kayode and Afolayan, 2015; Kamatenesi et al., 2011; Anywar et al., 2016; Dzotam, et al., 2016; Lamou et al., 2016; Nayak et al., 2016; Igado et al., 2017; Martínez-González et al., 2017; dos Santos et al., 2018

Table 1. Cont'd

Tithonia diversifolia (Hemsl.) A. Gray (Asteraceae)	Pr, N, W	Akechakech/ Kimyula/Ngaro Itano/Komanyoko (Banyankole)	Shrub	Leaf	Infusion	Malaria, diabetes, diarrhoea, liver diseases, stomach-ache, wounds snakebite	Antimalarial, antiplasmodial, antidiabetic, antihyperglycemic, antibacterial, antioxidant, antimicrobial, antiulcer, anticancer, antifungal, anti-inflammatory, analgesic activities	Alkaloids, flavonoids, phlobatannins, tannins, terpenes, saponins, reducing sugars	Hepatocellular damage at >100 mg/kg. Nephro- and hepato-toxicity at 400 mg/kg	Heinrich et al., 1998; Goffin et al., 2002; Gu et al., 2002; Bidla et al., 2004; Elufioye and Agbedahunsi, 2004; Miura et al., 2005; Ajaiyeoba et al., 2006; Yemele et al., 2006; Kuroda *et. al*, 2007; Xu et al., 2007; Oyewole et al., 2008; Adebayo et al., 2009; Elufioye et al., 2009; Sánchez-Mendoza et al., 2011; Stangeland et al., 2011; Ezeonwumelu et al., 2012; John-Dewole and Oni, 2013; Li et al., 2013; Linthoingambi and Singh, 2013; Passoni et al., 2013; Adia et al., 2014; Nafiu et al., 2014; Odeyemi et al., 2014; Olukunle et al., 2014; Wahyuningsih et al., 2015; Kamatenesi et al., 2011; Anywar et al., 2016; Agboola et al., 2016; Anthoney et al., 2016; Mayara et al., 2016; Hiransai et al., 2016; Ajao and Moteetee, 2017; Pulido et al., 2017
Toddalia asiatica (L.) Lam. (Rutaceae)	Pr, W	Kabakura (Banyankole)/ Kamule (Rukiga)/ Kawule	Tree	Leaf/root back	Decoction/ infusion	Malaria, cough, indigestion, influenza, snake bite, lung diseases, treat nasal, bronchial pains, rheumatism	Antimalarial, antimicrobial, antifungal, antidiabetic, antioxidant, antiplasmodial, antinoceptive and anti-inflammatory activities	Ulopterol, toddasin, toddanol, toddanone, toddalenone, geranyloxycoumarins, alkaloids; flindersine, toddalidimerine, also hexacosanoic acid and β-sitosterol		Kokwaro, 1993; Oketch-Rabah et al., 2000; Meyer, 2005; Orwa et al., 2008; Duraipandiyan and Ignacimuthu, 2009; Wang et al., 2009; Namukobe et al., 2011; Katuura et al., 2007; Muthumani et al., 2010; Stangeland et al., 2011; Irudayaraj et al., 2012; Kariuki et al., 2013; Raj et al., 2012; Orwa et al., 2013; Adia et al., 2014; Shan et al., 2014; Sukieum et al., 2017
Vernonia amygdalina Del. (Asteraceae)	Pr, C, E, N, W	Omubirizi (Banyankole) /Omululuuza (Rukiga) /Mululuza (Luganda)/NgaroItano/ Komanyoko	Shrub	Leaf/root	Decoction	Malaria, schistomiasis, amoebic dysentery and gastrointestinal problems	Antimalarial, cytotoxic, anthelmintic, antimicrobial, antitumoral, antihyperglycemic,, antinociceptive, antioxidant, hepatoprotective, antidiabetic, anti-inflammatory and anticancer activities	Sesquiterpene lactones: vernodalin, vernolide, vernomydin, vernodalol, hydroxyvernolide and vernolepin. Sigmastane-type steroid glycosides: vernoniosides A1, A2, B1, B2 and B3 and diterpenoids. Steroidal saponins, terpenes, coumarins, tannins, alkaloids and flavonoids	Aqueous extract: non toxic	Kupchan et al., 1969; Jisaka et al., 1992; Jisaka et al., 1993; Igile et al., 1994; Huffman et al., 1996; Hamill et al., 2000; 2003; Alawa et al., 2003; Njan, 2004; Erasto et al., 2006; Iwalokun, 2006; Njan et al., 2008; Tabuti 2008; Yedjou et al., 2008; Ibiba et al., 2010; Namukobe et al., 2011; Katuura et al., 2007; Ademola and Eloff, 2011; Omoregie et al., 2011; Luo et al., 2011; Stangeland et al., 2011; Asiimwe et al., 2013; Atangwho et al., 2013; Adedapo et al., 2014; Adia et al., 2014; Okon and Umoren, 2017; Opio et al., 2017
V. lasiopus O. Hoffm. (Asteraceae)	Pr, W, C	Omujuma (Banyankole)/Kaluluza (Luganda)/Akaluluza (Rukiga) kasajja/katono	Herb	Leaf/root	Infusion	Stomach-ache, gastrointestinal problems, worms, malaria, scabies, venereal diseases, sores and purgative	Antiprotozoal, antimalarial, antimicrobial, antiplasmodial and cytotoxic activities.	Elemanolides; epivernodalol and lasiopulide		Hamill et al., 2000; 2003; Koul, et al., 2003; Muregi et al., 2003; Muregi et al., 2007; Katuura et al., 2007; Dharani et al., 2010; Namukobe et al., 2011; Katuura et al., 2007; Stangeland et al., 2011; Asiimwe et al., 2013; Adia et al., 2014; Njenga et al., 2015; Rachuonyo et al., 2016

Pr= PROMETRA, C=Central, E, Eastern, N=Northern, W=Western region.

region were also commonly used in other regions of the country.

The results of interview on about 28 traditional birth attendants (TBAs) by Stangeland et al. (2011) in the Nyakayoko sub-County of Mbarara District on medicinal plants commonly-used for malaria, have revealed 56 plant species from 23 families. The leaf part was found to be most widely used but the plants in this sub-County were either used individually or in combination (Table 1). All the medicinal plants used for antimalarial remedies were reported to be commonly used in other regions except, *B. pilosa*, *M. indica* and *M. oleifera* which did not appear in the report of Stangeland (2011).

Asiimwe et al. (2014) reported the use of medicinal plants by the local communities in Western Uganda around Ibanda, Isingiro, Kiruhura and Mbarara districts. The study was conducted on herbalists and traditional birth attendants based on the knowledge, skills, and practices in the use medicinal plants. Out of 231 medicinal plants from 73 families reported as remedies for different ailments, 22 plants were commonly used for malaria in the area and only 5 species (*C. cajan, H. opposita*, *J. betonica*, *V. amygdalina* and *V. lasiopus*) were commonly used in other geographical regions (Table 1). The leaf or other morphological parts were prepared individually or in combination with other plants as decoction or infusion.

Namukobe et al. (2011) reported 131 plant species from 121 genera, used for different ailments in Kibale National Park which include four parishes (Hiima, Kahangi, Kaswa and Sebitoli) in Hakibale sub-County of Kabarole district. Twenty of the listed plant species are used for malaria out of which only 3 (*J. betonica*, *M. indica* and *V. amygdalina*) are commonly used in other regions for malaria while others are either used for ailments other than malaria or not appearing at all for other regions. Meanwhile, antimalarial and other pharmacological activities of some of the selected medicinal plants have been established and reported as shown in Table 1 with some of their active ingredients, being reported. Also, reports on the safety of some of these plants have been reported with some showing degenerative effects such as nephro-/hepato-toxicity, vacuolar degeneration, necrosis, etc. (Adebayo et al., 2009; Elufioye et al., 2009; Passoni et al., 2013). This review exercise is necessary to select the plants that are commonly used as antimalarial across the country in order to develop their national standards by taking into consideration their botany, safety, efficacy and chemistry.

Conclusion

Through the literature search, fifteen medicinal plants were selected as the most commonly used in Uganda for the treatment of malaria out of many medicinal plants reported in ethnobotanical surveys across the regions and these plants could be standardized for pharmacopoeial inclusion.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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