Medicinal plants used for management of malaria among the Luhya community of Kakamega East sub-County, Kenya

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A B S T R A C T

Background: Malaria remains a major health problem worldwide especially in sub-Saharan Africa. In Kenya, 80% of the population is at risk of contracting the disease. Pregnant mothers and children under five years are the most affected by this disease. Antimalarial drug resistance poses a major threat in the fight against malaria necessitating continuous search for new antimalarial drugs. Due to inadequate and inaccessible health facilities, majority of people living in rural communities heavily depend on traditional medicine which involves the use of medicinal plants for the management of malaria. Most of these indigenous knowledge is undocumented and risks being lost yet such information could be useful in the search of new antimalarial agents.

Aim of study: An ethnomedical survey was carried out among the Luhya community of Kakamega East sub-County, a malaria epidemic region, with the aim of documenting the plants used in the management of malaria.

Materials and methods: Semi-structured questionnaires were used to collect information from 21 informants who included traditional medicine practitioners and other caregivers who had experience in use of plants in management of malaria. These were drawn from 4 villages located in Kakamega East sub-county, within Kakamega County based on their differences in topography. Information recorded included plant names, parts used, mode of preparation and administration and the sources of plant materials. A literature search was conducted using PubMed and google scholar to identify the reported traditional uses of these plants and studied antiplasmodial activities.

Results: In this study, 57% of the informants were aged above 50 years and a total of 61% had either no formal education or had only attained primary school education. A total of 42 plant species belonging to 24 families were identified. Most plants used in the management of malaria in this community belonged to Lamiaceae (18%), Leguminosae (9%) and Compositae (9%) plant families. Plants mostly used included Melia azedarach L, Aloe spp, Ajuga integrifolia Buch. Ham, Vernonia amygdalina Del., Rotheca myricoides (Hochst.) Steane and Mabb, Fuertia africana T.C.Er., Zanthoxylum gilletii (De Wild.) P.G.Waterman and Leucas calostachys Oliv. Rumex steudelii Hochst.ex A. Rich and Phyllanthus sepialis Müll. Arg are reported for the first time in the management of malaria. Although Clerodendrum johnstonii Oliv. (Jeruto et al., 2011) and Physalis peruviana L,(Ramadan et al., 2015) are reported in other studies for management of malaria, no studies have been carried out to demonstrate their antimalarial activity.

The plant parts mostly used were the leaves (36%) and stem-barks (26%). Majority of these plants were prepared as decoctions by boiling and allowed to cool before administration (66%) while infusions accounted for 28% of the preparations. The literature mined supports the use of these plants for the management of malaria since most of them have demonstrated in-vitro and in-vivo antimalarial activities.

Conclusion: Most of the reported plant species in this study have been investigated for antimalarial activity and are in agreement with the ethnomedical use. Two (2) plants are reported for the first time in

Abbreviations: AIDS, Acquired Immune Deficiency Syndrome; APHRC, African Population and Health Research Center; CARTA, Consortium for Advanced Research Training in Africa; DfID, Department for International Development; HIV, Human Immunodeficiency Virus; IC50, Half Maximal Inhibitory Coefficient; KIFPRA, Kenya Institute for Public Policy Research and Analysis; KNBS, Kenya National Bureau of Statistics; NCPAD, National Coordinating Agency for Population and Development; PMI, President’s Malaria Initiative; UK, United Kingdom; USAID, United States Agency for International Development; WHO, World Health Organization

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1. Introduction

The World Health Organization (WHO) estimates that 3.2 billion people are at risk of malaria infection globally. In the year 2015, a total of 214 million cases and 438,000 deaths due to malaria were reported globally. The burden was highest in WHO-Africa region where 90% of all malaria death occurred (WHO, 2015). In Kenya malaria, still remains a major health problem with 80% of the population at risk of contracting the disease (PMI, 2015). Malaria affects the poor and marginalized populations. In most cases such populations live in rural areas and lack access to adequate healthcare facilities (Yusuf et al., 2010). Therefore, such people largely depend on herbal medicines for the management of malaria and other diseases.

Kakamega county lies within the western highlands malaria epidemic region in Kenya (KNBS and ICF Macro, 2011 and USAID, 2013). This region experiences seasonal malaria outbreaks. The epidemics are favored by the high temperature of above 18 °C during the long rainy seasons which is optimal for breeding of mosquitoes. The poverty level in this county is estimated at 57% (NCAPD, 2005). The high malaria incidences, high poverty levels and the proximity to the tropical forest, Kakamega forest, promotes the use of plants in management of various ailments including malaria.

Most of the African societies have a long history of indigenous healing practices. This knowledge is often passed from generation to generation by word of mouth. The Luhya community in Kakamega has a rich culture of herbalism. The practitioners of herbal medicine are well known within the community and are sought after for their skills in management of diseases. However other members of the community who are not herbal practitioners too have some knowledge on use of plants in management off common diseases and only employ within family context such as mothers in management of children illnesses without consulting the recognized herbalists (Wane, 2011). This knowledge is likely to be lost if not documented. This study therefore sought to document the ethnopharmacological knowledge in the management of malaria in Kakamega County.

2. Methods

2.1. Study area

The ethnopharmacological survey was carried out in Kakamega sub-county in Kakamega County. Kakamega County is located in Western Kenya (Fig. 1). The county lies within the longitudes 34° 20′ 35.29″ E- 35° 09′ 27.04″ E and latitudes 0° 05′ 19.12″N- 0° 53′ 53.81″ N. It boarders several other counties, Bungoma to the North, Trans Nzoia to the North East, Uasin-Gishu and Nandi Counties to the East, Vihiga to the South, Siaya to the West and Busia to the West. According to the 2009 census, the county has a total population of 1,660,651 people with population density of 515 people per km². The poverty level in the county is estimated to be 57% (KIPPA, 2013).

Kakamega East District, the focus of this study is one of the 6 districts in Kakamega County. The district is mainly a rural set-up with no single urban center. The entire district is served with only dispensaries and health centers (NCAPD, 2005). The nearest high level health facility, Kakamega County hospital, 20 km away.

Kakamega East District is the home to the Kakamega forest, the only tropical rain forest in Kenya. This forest is the main source of herbal medicines for rural communities in the region (Nyunja et al., 2009). The poor health facilities and proximity to the forest are promote the use of herbal medicines in this community.

2.2. Ethical approval for the study

Ethical approval for the ethnobotanical survey was obtained from the Kenyatta National Hospital/University of Nairobi Ethics and Research Committee (P186/03/2015). The community gate keepers, who included village elders and church leaders were consulted and subsequently approved the study to be conducted within the local villages. The participants in this study were provided with information on the nature of study, benefits and risks involved. Those who agreed to participate signed a written consent at the beginning of the study.

2.3. Ethnobotanical survey

An ethnobotanical survey was carried out between the August and October 2015 in Kakamega East Sub-county of Kakamega County. The region was subdivided into 4 villages based on the differences in topography. Interviews were conducted using semi-structured questionnaires. The study was concluded when no more new information was realized. A total of 21 respondents, both male and female, who utilized antimalarial plants either for self-medication or for treating others were interviewed. A research assistant known to the locals accompanied the researchers during the interviews. Voucher specimens were prepared for all plants collected and deposited at the Department of Botany, University of Nairobi.

3. Results and discussion

3.1. Socio-economic characteristics of respondents

The majority (57%) of respondents in this survey were male aged > 50 years of age (Fig. 2). The age ranged between 21 and 85 years. Usually the older members of the society have experience in the practice of traditional medicine and pass it on to the younger generation. The younger generation are also not readily accepted by the community as traditional practitioners as they are considered inexperienced (Lambert et al., 2011). In this study, the older practitioners were more recognized by the community than the younger ones. This explained why more than half the respondents were advanced in years.

Most of the respondents had a primary school level of education (Fig. 3). The practice of traditional medicine has been for a long time been restricted to the less educated since the most
educated people view it as ancient form of medicine that is primitive and inappropriate. Most of the practitioners only charge a small fee or no fee at all in managing the common diseases such as malaria since the plants are obtained locally making it not a lucrative business.

3.2. Source of Ethnomedical Knowledge

Majority of the respondents (48%) had acquired the knowledge of the practice of traditional medicine from the older members of their families such as parents and grandparents. However, a relatively large proportion (43%) had acquired the knowledge though other means such as apprenticeship under practicing herbalists or by reading books about traditional medicine. Only 1 person had acquired the knowledge through formal training. This is similar to findings in other studies where apprenticeship is the commonest means of learning traditional practices (Lambert et al., 2011). In the recent years, there has been a global increase in demand and acceptability of traditional medicine (Abdullahi, 2011). In view of

Fig. 1. Map of Kakamega county showing study site. (Source: CRA, 2013)
this, there is increase in commercialization of herbal medicines and more people learning about herbal medicine as a source of income. This may be the reason for the higher number (52%) of people in this study who practice herbalism even though they did not inherit the practice.

3.3. Antimalarial plants diversity

Most of the respondents in this study identified fever as the main symptom associated with malaria. Other symptoms mentioned included headache, vomiting, diarrhea and joint pains. They were also aware of severe form of malaria (cerebral malaria). Only one respondent claimed he could treat cerebral malaria. The rest indicated that such cases should be referred to hospital.

A total of 42 plant species belonging to 39 genera within 24 families were identified (Table 1). A large proportion of these plants were from the Lamiaceae (18%), Leguminosae (9%), and Compositae (9%) families (Fig. 4). Most of these plants were shrubs (42%) and trees (27%) followed by climbers (24%) and herbs (7%). Plants mostly cited included Melia azedarach L, Ajuga integrifolia Buch.-Ham and Aloe spp. Rumex steudelii Hochst.ex A. Rich and Phyllanthus sepialis Müll. Arg are reported for the first time in the management of malaria.

More than 90% of the plants were referred to by their local names. However four of the plants could not be identified by their local names indicating that they may have been introduced into the region. Justicia betonica L. was referred to as the dark “Imbuli yu mutakha” which refers to Ajuga integrifolia Buch.-Ham that is commonly known in this region. The association of this plant with the Nandi (Jeruto et al., 2011) is due to the use of leaves which are used as improving the cosmetic appearance of the body. Conservationists warn of over-exploitation of medicinal plants which are valued for their root parts and stem barks (Maroyi, 2013). In this study a total of 47% of the plants were valued for the root parts or stem barks therefore threatened by over-exploitation. Leaves and fruits are the most preferred parts for sustainable plant use since they are the least destructive to the plant and they accounted for 38% in this study.

3.4. Preparation of antimalarial medicines

Various methods are used in preparation of herbal medicine among the community. The most common preparation were decoctions (70%), which were made by boiling plant material before use. Other methods included cold maceration (30%), steaming (12%), roasting (8%) to obtain ash or chewing (8%). In most of the cases, the plant material was harvested and prepared just before use. Nevertheless, where the plants are not easily accessible, material was preserved by air-drying under shade and stored for use.

3.5. Sources of plant material

The herbal medicines used for malaria were mainly obtained from the wild (77%) with only 23% cultivated. The cultivation of medicinal plants was mainly done for those plants not easily available in the community, the introduced plants or those that face extinction. In this study, Justicia betonica L. an introduced herb, was mainly planted along river beds. Ajuga integrifolia Buch.-Ham which almost faces extinction was also planted by the herbalists. Previous studies carried out in Kenya show that most of the herbal products are exclusively obtained from the wild. This strongly indicates the unsustainability of herbal practice in Kenya (McMullin et al., 2012).

3.6. Reported traditional uses and antiplasmodial activity

The identified plants in this study have been used in many communities for the management of various ailments including malaria and other febrile illnesses. A total of 38 out of the 42 identified plants have been tested in the laboratory for in-vivo and/or in-vitro antiplasmodial activities as summarized in Table 2. In vitro antiplasmodial activity is classified as high (IC₅₀ < 5 μg/ml), promising (5 < IC₅₀ < 15 μg/ml), moderate (15 < IC₅₀ < 50 μg/ml) and inactive (IC₅₀ > 50 μg/ml) (Lekana-Douki et al., 2011). Based on this criteria, 14 of the plants from our study are classified as possessing high antiplasmodial activity with Albizia gummifera (J.F.Gmel.) C.A.Sm., Leucas calostachys Oliv., Tithonia diversifolia and Harungana madagascariensis Lam. ex Poir. having the highest antiplasmodial activity of < 1 μg/ml. Although Tithonia diversifolia (Hems.) A. Gray has promising antiplasmodial activity, study by Elufioye et al. (2009) showed that it is toxic to the liver and kidney therefore limiting its widespread use in the management of malaria.

Although Clerodendrum johnstonii Oliv. (Jeruto et al., 2011) and Physalis peruviana L. (Ramadan et al., 2015) are reported in other studies for management of malaria, no studies have been carried out to demonstrate their antiplasmodial activity. Less than half of these plants have antiplasmodial compounds isolated as shown in Table 2.

Several ethnobotanical studies to identify antimalarial plants have been carried out in Kenya. These studies identify a variety of plants used by different ethnic communities or regions in Kenya. They include the Nandi (Jeruto et al., 2011), Digo in Kwale
Table 1
Plants used in the management of malaria among the Luhya community, Kakamega East sub-County.

| Voucher number | Family               | Plant name                      | Local name         | Growth form | Plant part used  | Frequency of citation (%) | Mode of preparation       |
|----------------|----------------------|--------------------------------|-------------------|-------------|-----------------|---------------------------|---------------------------|
| NMA2015/01     | Acanthaceae          | Justicia betonica L.           | Busangula         | Herb        | Aerial          | 14.3                      | Pound, add cold water/Boil|
| NMA2015/02     | Anacardiaceae        | Searis nutansis (Borh.ex C. Krauss) |                | Herb        | Leaves, Stem Bark | 4.8                     | Boil in water             |
| NMA2015/03     | Apocynaceae          | Carissa edulis L.              | Shikata/Achoka    | Shrub       | Root Bark       | 4.8                      | Boil in water/Inhale steam|
| NMA2015/04     | Compositae           | Acmella cauliflora Del.        | Ing'oi            | Shrub       | Root, Leaves    | 9.5                      | Boil in water             |
| NMA2015/05     | Compositae           | Tithonia diversifolia (Hems.) A. Gray | Masambu mahulu/linizo | Shrub      | Leaves          | 9.5                      | Pound, add cold water     |
| NMA2015/06     | Compositae           | Vernonia amygdalina Del.       | Shuliitisa        | Shrub       | Leaves          | 19.0                     | Pound in cold water/Boil  |
| NMA2015/07     | Bignoniaceae         | Markhamia lutea (Benth.) K.Schum. | Lusiola           | Tree        | Stem Bark       | 9.5                      | Boil in water             |
| NMA2015/08     | Bignoniaceae         | Spathodea campanulata P.Beauv. | Mutisulio         | Tree        | Stem Bark       | 14.3                     | Boil without crushing     |
| NMA2015/09     | Compositae           | Warbugia ugandensis Sprague    | Apachi            | Tree        | Leaves, Stem Bark | 14.3                   | Boil in water             |
| NMA2015/10     | Compositae           | Acmella cauliflora Del.        | Ing'oi            | Shrub       | Root, Leaves    | 4.8                      | Boil in water             |
| NMA2015/11     | Cucurbitaceae        | Cucumis acutatus Cogn.         | –                 | Climber     | Leaves          | 4.8                      | Pound, add cold water     |
| NMA2015/12     | Euphorbiaceae        | Crotom macrostachys Hochst. ex Del. | Musutsu           | Tree        | Stem Bark       | 4.8                      | Boil in water             |
| NMA2015/13     | Leguminosae          | Albizia guinjifera (J.F.Gmel.) C.A.Sm. | Musenzeli        | Tree        | Stem Bark       | 9.5                      | Boil without crushing     |
| NMA2015/14     | Leguminosae          | Erythrina abyssinica DC.       | Murembe           | Tree        | Stem Bark       | 4.8                      | Boil in water             |
| NMA2015/15     | Leguminosae          | Senna didymobotrya (Fresen.) H.S.Irwin and Barney | Luhulu          | Shrub       | Leaves          | 4.8                      | Boil in water             |
| NMA2015/16     | Leguminosae          | Senna occidentalis (L.) Link    | Imbindi           | Shrub       | Root            | 4.8                      | Pound, add cold water     |
| NMA2015/17     | Hypericaceae         | Harungana madagascariensis Lam. ex Poir. | Musila            | Tree        | Stem Bark       | 4.8                      | Boil in water             |
| NMA2015/18     | Lamiaceae            | Ajuga integrifolia Buch.-Ham. | Imbuli yu intakha | Herb        | Aerial          | 23.8                     | Pound, add cold water     |
| NMA2015/19     | Lamiaceae            | Clerodendrum johnstonii Oliv.  | Shiteng’otengo    | Shrub       | Leaves          | 4.8                      | Pounded in cold water/Boil|
| NMA2015/20     | Lamiaceae            | Rotheca myricoides (Hocht.) Strane and Mabb. | Shishalakokho | Shrub       | Root, Bark, Leaves | 19.0                   | Boil in water/Boil        |
| NMA2015/21     | Lamiaceae            | Fuerstia africana T.C.E.FR.    | Museresu         | Herb        | Aerial          | 19.0                     | Boiled or roasted         |
| NMA2015/22     | Lamiaceae            | Leucas calostachys Oliv.       | Lumesetani        | Herb        | Aerial          | 19.0                     | Pound, add cold water/Boil/Steam|
| NMA2015/23     | Lamiaceae            | Ocmum kilimandsharcium Gürke  | M’monyi           | Herb        | Aerial          | 4.8                      | Inhale steam              |
| NMA2015/24     | Lamiaceae            | Plecranthus barbarus Andrews  | Shikaka           | Shrub       | Leaves          | 9.5                      | Chew bud/Boil in water    |
| NMA2015/25     | Meliaceae            | Melia azedarach L.             | Mairubaini        | Tree        | Leaves, Stem Bark | 47.6                   | Boil in water             |
| NMA2015/26     | Meliaceae            | Trichilia emetica Vahl         | Munyama           | Tree        | Stem Bark       | 4.8                      | Boil in water             |
| NMA2015/27     | Menispermaceae       | Cissampolos mucronata A.Rich.  | Mukoye            | Climber     | Root            | 4.8                      | Chewing                   |
| NMA2015/28     | Moraceae             | Ficus thomlongii Blume         | Mutoto            | Tree        | Stem Bark       | 9.5                      | Boil in water             |
| NMA2015/29     | Rutaceae             | Zanthoxylum parviflorum Sims   | Mullungu           | Shrub       | Leaves          | 4.8                      | Boil in water/Steam       |
| NMA2015/30     | Rutaceae             | Physalis peruviana L.          | Shikama           | Tree        | Stem Bark       | 9.0                      | Boil in water             |
| NMA2015/31     | Rutaceae             | Rubus pinnatus Wild.           | Shikakha          | Herb        | Leaves          | 9.5                      | Pound, add cold water     |
| NMA2015/32     | Rutaceae             | Physalis peruviana L.          | Shikakha          | Herb        | Leaves          | 4.8                      | Pound, add cold water     |
| NMA2015/33     | Rutaceae             | Zanthoxylum parviflorum Sims   | Mullungu           | Shrub       | Leaves          | 9.5                      | Boil in water/Steam       |
| NMA2015/34     | Rutaceae             | Physalis peruviana L.          | Shikama           | Herb        | Leaves          | 4.8                      | Pound, add cold water     |
| NMA2015/35     | Rutaceae             | Zanthoxylum parviflorum Sims   | Mullungu           | Shrub       | Leaves          | 9.5                      | Boil in water/Steam       |
| NMA2015/36     | Rutaceae             | Physalis peruviana L.          | Shikama           | Herb        | Leaves          | 4.8                      | Pound, add cold water     |
| NMA2015/37     | Rutaceae             | Malpighia ciliata (L.) hook.f. ex Benth. | Shikama           | Tree        | Stem Bark       | 9.0                      | Boil in water             |
| NMA2015/38     | Rutaceae             | Physalis peruviana L.          | Shikama           | Shrub       | Leaves          | 4.8                      | Boil in water/Steam       |
| NMA2015/39     | Rutaceae             | Physalis peruviana L.          | Shikama           | Shrub       | Leaves          | 9.5                      | Boil in water/Steam       |
| NMA2015/40     | Rutaceae             | Physalis peruviana L.          | Shikama           | Shrub       | Leaves          | 9.5                      | Boil in water/Steam       |
| NMA2015/41     | Vitaceae             | Physalis peruviana L.          | Shikama           | Shrub       | Leaves          | 9.5                      | Boil in water/Steam       |
| NMA2015/42     | Xanthorrhoeaceae     | Aloe species                   | Shikakha          | Shrub       | Leaves          | 43.0                     | Boil in water             |
Muthaura et al., 2007), Msambweni (Nguta et al., 2010), Kisumu (Orwa et al., 2007), Central Kenya communities (Njoroge and Bussmann, 2006) and Kilifi (Gathirwa et al., 2011). This is the first study to document antimalarial plants used among the Luhya community in Kenya.

The different Kenyan communities utilize plants within the local communities in the management of malaria. The differences in geographical and climatic conditions which determine the flora available in a given region. However some plants have a wider distribution and therefore most likely used by most communities. For instance, Aloe species and Melia azedarach L. are plants utilized in all these studied communities. Very few similarities were observed in the utilization of plants among the Luhya community and the Coast Kenya regions communities (Msambweni and Kilifi). For instance, only 3 plants were used in by both the Luhya and Kilifi communities.

Several similarities were observed in the antimalarial plants used in Central Kenya, Nandi and the Luhya community. For instance, 30% of the plants used by the Luhya community were also utilized by the Nandi community. The Nandi and Luhya communities boarder each other. The similarities in the use of the plants could be either due to similarities in vegetation as a result or similar climatic conditions. It could also result from the interchange of knowledge within communities. It is therefore important to consider factors such as ecology, culture and even religious context in the protection of indigenous knowledge and not just a matter of ethnic group. To address this, the concept of ‘Collective Biocultural Heritage’ (BCH) was developed to consider cases where different communities share traditional knowledge within given shared territories and resources. This concept has been utilized in Peru where Inter-Community Agreement for equitable benefit sharing between 6 communities (Swiderska, 2007).

4. Conclusion

This study provides a documentation of plants used in the management of malaria in the Luhya community of Kakamega East sub-county. Most of the plants cited in this study have been reported elsewhere for management of malaria and have demonstrated antiplasmodial activities. This indicative of the rich nature of ethnomedical knowledge in this community. Rumex steudelii Hochst.ex A. Rich and Phyllanthus sepialis Müll. Arg are reported for the first time in the management of malaria. There is therefore need to preserve the ethnomedicine knowledge from this community given that most of the practitioners of traditional medicine are older generation with less education.

Conservation methods need to be put in place to secure the future of traditional medicine practice in this community. The current status of harvesting from the wild and use of roots and barks should be done in a sustainable manner. Members of the community should be educated on sustainable harvesting and cultivation of medicinal plants.

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Table 2

| Plant name                          | Traditional uses                                      | In vitro and in vivo antimalarial activities                  | Antimalarial compounds isolated                  |
|-------------------------------------|-------------------------------------------------------|----------------------------------------------------------------|-------------------------------------------------|
| Justicia betonica L.                | Lower cholesterol, paralysis, earaches, headaches, bruises diarrhea, vomiting, constipation, pain and inflammation and Malaria (Gangahavanni and Ravishankar, 2013), fever, oral ulcer, HIV (Mugisha et al., 2014) | In-vivo parasite suppression of between 72–72.7% in combination with CQ (Chalhand and Willcox, 2009) | Methanolic extract had IC50 of 6.5 μg/ml, DCM, Leaf extract had IC50 of < 15 μg/ml (Muganga et al., 2014) |
| Searis natans (Bernh.ex C. Krauss)  | Malaria (Gathirua et al., 2011), diarreha, HIV (Wangari et al., 2014) | CHC13 leaf extract had IC50 of 1.8 μg/ml (Katuura, et al., 2007b) | No reference |
| Carissa edulis L.                   | Sickle cell anemia, fever, epilepsy, pain (Yu et al., 2013), malaria (Orwa et al., 2007) | DCM, stems extract had IC50 of 33 μg/ml (Clarkson et al., 2004) | No reference |
| Spathodea campanulata P. Beauv.     | Malaria, herpes, fever, diabetes, dysentery, ulcers, HIV (Jim, 2013) | Ethanolic leaf extract had IC50 > 68 μg/ml (Rangasamy et al., 2008) | Lapachol (Ntie-Kang et al., 2014) |
| Markhamia lutea (Benth.) K. Schum.  | Malaria (Lacroix et al., 2009), Anemia, diarrhea, malaria, microbial and parasitic infections (Ali et al., 2015) | Ethanolic leaf extract had IC50 of 9.83 μg/ml (Omoregie et al., 2011) | Musambins A-C and musambiosides A-C (Lacroix et al., 2009) |
| Warbugia ugandensis Sprague         | Worms, fever, gonorrhea, syphilis (Lacroix et al., 2011) (Were et al., 2010) | Ethanolic extract had IC50 of 8 μg/ml (Wube et al., 2008) with 69% parasite inhibition (Were et al., 2010) | Coloratases sesquiterpenes (Onguen et al., 2013) |
| Vernonia amygdalina Del.            | Febrifuge, vermifuge, lactic, malaria, wounds and as appetizer (Ileoma and Chukwunonso, 2011) | In-vivo parasite suppression of between 57.2–72.7% (Clarkson et al., 2004) | Vernoilde, vernodinal, vernodol and hydroxyvernoldine (Onguen et al., 2013) |
| Tithonia diversifolia (Hemsol) A. Gray | Diabetes mellitus, sore throat, menstrual pain, malaria, wounds (Owoye et al., 2004) | Ethanol extract IC50 of 3.5 μg/ml with parasite inhibition of 3.5–5.2% (Nyanabiti et al., 2013) | Tagetin C (Onguen et al., 2013) |
| Acmea caurhiza Del.                 | Toothache, throat and gum infections, dysentery, rheumatism, immune booster and malaria (Grubb, 2004) | In-vivo parasite suppression of between 72–72.7% (Chalhand and Willcox, 2009) | No reference |
| Microglossa pyrifolia (Lam.) Kuntze | Malaria (Jeruto et al., 2011), Headache, cough, flu, cleansing airway (Moshi et al., 2012) | Aqueous fruit extract had IC50 of > 30 μg/ml (Gakunju et al., 1995) | Diterpenes (Kohler et al., 2002) |
| Cucumis aculeatus Cogn             | Diarrhea, leprosy, migraines, wounds, gonorrhea (Engels et al., 1999), malaria (Ngorre and Rassmann, 2006) | No reference | No reference |
| Crotom macrastachyus Hochst. ex Del. | Diabetes, dysentery, wounds, malaria, purgative, stomachache (Gelaw et al., 2012) | Ethanolic stem bark extract had IC50 of 0.75 μg/ml (Goffin et al., 2002) whereas the methanolic extract had 74% parasitemia suppression (Oywole et al., 2008) | Tagetin C (Onguen et al., 2013) |
| Harungana magadacariensis Lam. ex Poir. | Anemia, malaria (Iwalawa et al., 2008), fever, nephrosis, jaundice, gastrointestinal disorders (Okoli et al., 2002) | Methanolic leaf extract, IC50 of 9.51–10.56 μg/ml and 82% parasite suppression at 600 mg/kg (Deressa et al., 2010) | No reference |
| Rotheca myricoides (Hochst.) Steane and Mabbb. | Measles, malaria, asthma, wounds, gonorrhea, rabies and eye disease (Haylor et al., 2012) | Aqueous whole plant extract had IC50 of 0.8 μg/ml with parasite inhibition of 3.5–5.2% (Nyanabiti et al., 2013) | No reference |
| Leucas calostachy Oliv.             | Colds, headache (Okello et al., 2010), malaria (Nyamabati et al., 2013) | No reference | No reference |
| Ocimum kilimandscharicum Gürke       | Colds, cough, analgesic, sedative, diarrhea, measles (Son et al., 2012), malaria (Owour et al., 2012) | Methanolic leaf extract had IC50 of 33 μg/ml (Nyamabati et al., 2013) | No reference |
| Fuerstia africana T.C.Fr.            | Eye ailments, toothache (Kipkore et al., 2014) (Muganga et al., 2010) | DCM extract had IC50 < 10 μg/ml (Owour et al., 2012) | Ferruginol (Onguen et al., 2013) |
| Clerodendrum johnstonii Oliv.       | Abscess, hernia (Quattrocchi, 2012), malaria (Jeruto et al., 2011) | No reference | No reference |
| Plectranthus barbatus Andrews       | Gastritis, respiratory disorders, cough, anagelse, hypertension, stomachache, epilepsy (Fernandes et al., 2012), malaria, break fevers (Al-Musayeib et al., 2012) | Aqueous leaf extract exhibited 90% parasite suppression (Guita et al., 2012) | No reference |
| Ajuga integrifolia Buch.-Ham. C.A.Sm. | Vermifuge, toothache, hypertension, stomachache fever (Haliu and Engidawork, 2014) (Muganga et al., 2010) | DCM, Leaves and twigs had IC50 of < 1.5 (Owour et al., 2012) | No reference |
| Albizia gummifera (J.F.Gmel. C.A.Sm. | Malaria, bacterial infections, skin diseases, stomachache (Kokila et al., 2013) | Methanolic leaf extract had IC50 of 15 μg/ml (Kigondu et al., 2011) | No reference |
| Senna occidentalis (L.) Link         | Malaria, vermifuge, analgesic, laxative, hepatoprotective, diuretic and febrifuge (Silva et al., 2011) | Methanolic extract had IC50 of 6.5 μg/ml, [Al-Musayeib et al., 2012,] | No reference |
| Senna didmotohrya (Fresen.) H.S.Irwin and Barneby | Intestinal worms, skin diseases, jaundice, venereal diseases, malaria, fever (Nagapann, 2012) | Aqueous leaf extract exhibited 90% parasite suppression (Guita et al., 2012) | No reference |
| Erythine abyssinica DC.              | Abortion, cough, malaria (Lacroix et al., 2011) | Methanolic extract had IC50 of 6.5 μg/ml, [Al-Musayeib et al., 2012,] | No reference |
|                                     | Ethanol extract had IC50 of 33 μg/ml (Clarkson et al., 2004) | Aqueous leaf extract exhibited 90% parasite suppression (Guita et al., 2012) | No reference |
|                                     | Aqueous leaf extract exhibited 90% parasite suppression (Guita et al., 2012) | The alkaloidal fraction had IC50 of 0.06 μg/ml white sparsamine alkaloid exhibited parasite suppression of 43–72% (Rukunga et al., 2007) | Ergosterol – 5,8-endoeperoxide (Ntie-Kang et al., 2014) |
|                                     | EIOH root bark extracts had IC50 < 3 μg/ml whereas 200 mg/kg of EIOH and DCM extracts exhibited > 80% parasitaemia suppression. (Tona et al., 2001) | No reference | Sparsamine alkaloids (Rukunga et al., 2007) |
|                                     | DCM/MeOH. Twigs extract had IC50 of 9.5 μg/ml (Clarkson et al., 2004) | ETOAc, Bark extract showed 83% parasite suppression (Lacroix et al., 2011) | No reference |
|                                     | No reference | ETOAc, Bark extract showed 83% parasite suppression (Lacroix et al., 2011) | No reference |
|                                     | No reference | ETOAc, Bark extract showed 83% parasite suppression (Lacroix et al., 2011) | No reference |
|                                     | No reference | Ether aerial parts extract had IC50 of 13.36 μg/ml (Bhosa et al., 2013) | No reference |
|                                     | No reference | Ethanolic extract had IC50 of 8 μg/ml (Wube et al., 2008) with 69% parasite inhibition (Were et al., 2010) | No reference |
Table 2 (continued)

| Plant name                  | Traditional uses                                                                 | In vitro and in vivo antimalarial activities | Antimalarial compounds isolated            |
|-----------------------------|----------------------------------------------------------------------------------|---------------------------------------------|--------------------------------------------|
| Trichilia emetica Vahl      | Diabetes, hypertension (Konaté et al., 2014), malaria (Diarra et al., 2015)     | DCMeOH IC50 of 1.1, leaves and twigs extract | Kurubasch aldehyde (Bero et al., 2009)     |
| Melia azedarach L.          | Hepatoprotective, malaria, skin diseases, ulcers, liver, vermilifuge, asthma (Qureshi et al., 2016) | DC, Leaf extract had IC50 of 28 μg/ml (Lusakibanza et al., 2010) | No reference                              |
| Cissampelos mucronata A.    | Antisarsenic venom, venereal diseases, malaria, menstrual disorders, wounds, febrifuge (Nondo et al., 2011) | EOAc root extract had IC50 < 3.91 with active compound, curarine IC50 of 0.24 (Omole, 2012) | Curarine (Ndiege, 2011)                    |
| Rich                        |                                                                                  |                                             |                                             |
| Ficus thommingii Blume       | Malaria (Falade et al., 2014), Diabetes, diarrhea, mental illness, gonorrhea, urinary tract infections (Dangarembizi et al., 2013) | Hexane, leaf extract IC50 of 10.4 μg/ml (Falade et al., 2014) | No reference                              |
| Flueggea virosa (Roxb. ex Wild.) Royle | Fever, stomachache, rheumatism, pneumonia, epilepsy, body pains (Magaji et al., 2007) malaria (Al-Rehaily et al., 2015) | MeOH/H2O leaves extract had IC50 of 7.8 (Willcox et al., 2011a) | Securinine and viroallosecurinine (Al-Rehaily et al., 2015) |
| Phyllanthus usipalis Müll. Arg. | Tonic in pregnancy (PROTA, 2008) dental hygiene (Bussmann et al., 2006) | No reference | No reference                              |
| Pittosporum viridiflorum Sims | Chest complaints, purgative, male impotence, asthma, coughs (Bold and Cocks, 2012) | DC whole plant extract had IC50 of 3 μg/ml (Clarke et al., 2004) | Triterpenoid estersaponin, active (Nyangbela et al., 2013) |
| Rumex abyssinicus Jacq.     | Wounds, liver diseases, malaria, gonorrhea (Muula et al., 2015) | DC, root extract had IC50 < 15 μg/ml (Muganza et al., 2014) | No reference                              |
| Rumex steudelii Hochst.ex A. Rich | Antifertility, tonsillitis, wounds, eczema, hemorrhoids, leprosy (Solomon et al, 2010) | No reference | No reference                              |
| Maesa lanceolata Forsk.     | Malaria (Katuura et al., 2007a) | -Chloroform leaf extract IC50 of 1.6 μg/ml (Katuura et al, 2007b) | No reference                              |
| Rubus pinnatus Wild         | Bleeding gums, expectorant, demulcent, diarrhea (Quattrocchi, 2012), malaria (La croix et al., 2011) | DCMeOH (1:1) 2% extract had IC50 of 5.8 μg/ml (Clarke et al., 2004) | Curarine (Ndiege, 2011)                    |
| Zanthoxylum gilletii (De Wild.) P.G.Waterman | Stomachache, gonorrhea, back pain, urinogenital infections (Gaya et al., 2013), malaria (Mukundi et al., 2014) | DCMeOH (1:1) stem bark extract had IC50 of 2.52, 1.48 and 1.43 μg/ml against W2, D6 and 3D7 strains (Mukundi et al., 2014) | Nitidine (Muganza et al., 2014) |
| Clausena anisata (Willd.) Hook.f. ex Benth. | Vermifuge, febrifuge, measles, hypertension, malaria, analgesic, rheumatism (Oskonok et al., 2012) | DC, root extract had IC50 of 10 μg/ml (Clarke et al., 2004) | No reference                              |
| Physalis peruviana L.       | Malaria, rheumatism, hepatitis, dermatitis, diuretic (Ramadan et al., 2015) | No reference | No reference                              |
| Solanum incanum L.          | Pneumonia, liver pain, headache, toothache, stomachache, sore throat (PROTA, 2008), malaria (Nguta et al, 2010) | CHCl3/MeOH, leaf extract showed 31% parasite suppression (Murithi et al, 2014) | No reference                              |
| Lantana trifolia L.         | Common cold, asthma, epilepsy, madness, childhood cerebral malaria, sickle cell anemia (Nalubega et al, 2011) | Pet-ether aerial parts extract had IC50 of 13.2 μg/ml (Katuura et al, 2007b) | No reference                              |
| Rhoicissus tridentata (L.) Wild and R.B.Drumm. | Dysmenorrhea, uteortonic, indigestion, pregnancy and childbirth. (Mukundi et al., 2015), malaria (Cakunju et al., 1995) | Aqueous root extract had IC50 > 40 μg/ml (Cakunju et al., 1995) | No reference                              |
| Aloe species                | Colds, malaria, stomachache, anemia (PROTA, 2008) | Ether leaf extract of A.dawei, IC50 of 7.9 μg/ml (Ibosa et al., 2013) | No reference                              |

CHCl3—Chloroform, DC—Dichloromethane, EOAc—Ethyl Acetate, MeOH—methanol, Pet-ether—Petroleum ether

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at http://dx.doi.org/10.1016/j.jep.2016.08.050.

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Boswellia excelsa
Cinnamomum camphora
Cinnamomum verum
Cordyceps militaris
Crataegus spp.
Elaeis guineensis
Eucalyptus globulus
Ficus carica
Ficus modesta
Ficus virens
Gallicum officinarum
Ginkgo biloba
Ginkgo biloba L.
Gleditsia triacanthos
Glycyrrhiza uralensis
Glycyrrhiza inflata
Harungana madagascariensis
Hedysarum soongaricum
Hinckleya dioica
Inula helenium
Inula japonica
Inula mandshurica
Inula nigricans
Inula pedunculata
Inula strigosa
Inula viscosa
Iris setosa
Jatropha curcas
Jatropha gossypiifolia
Jatropha oleracea
Jatropha podagrica
Jatropha ootkatana
Jatropha sp.
Jatropha platensis
Jatropha pygmaea
Jatropha stenantha
Jatropha treculeana
Jatropha tubiflora
Jatropha variegata
Jatropha wrinkiana
Jatropha xylachei
Jatropha xanthocarpa
Jatropha zeyheri
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Jacaranda pulchella
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