Prospective Plants with Corroborated Antimalarial Actions: A Review

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Abstract
Malaria is a serious illness resulted from parasites that are communicated to people through the bites of infected female Anopheles mosquitoes. Malaria is still in a worrying trend, particularly in tropical and subtropical climates although it is curable and preventable. In spite of a noteworthy abetment in incidence and death rates caused by malaria, even in 2017, a big number of people (219 million) have been affected by it along with 435 thousand confirmed death cases. Though a lot of synthetic drugs have been commercialized to treat malaria, those are compromised with some serious side effects. On the contrary, plant sources are always getting a big focus to develop novel and effective therapeutics in the treatment of different ailments i.e. quinine and artemisinin to treat malarial complications. The usage of herbal plants against malaria has also a very ancient root. Several families of plant species have showed potential antimalarial activities in previous research works. In this review work, families of these plants have been compiled so that prospective researchers can find a hint to discover more effective and safer plant-derived therapeutic options against malaria.

Keywords: Malaria, Plants, Antiplasmodial, Ethnobotany, Plasmodium falciparum.

Introduction
Malaria is a generic word for protozoa of the Plasmodium genus that is frequently used in conjunction with the term "Malaria parasites". It is defined as an ailment or disease state resulted from parasites of this genus in the blood or tissues of a person. Presence of the parasites at any stage in the human body suggests the existence of malarial infection (Hempelmann et al., 2013). Mosquitoes preserved in amber dating back 30 million years ago provided the first proof of the presence of malaria (Poinar, 2005). During the Middle Ages, the disease continued to be a problem, when malaria epidemics caused the coastal plains of Italy and England to lose their global dominance (Dobson, 1994). Though, between 2000 and 2015, the incidence and death rates declined by 37% and 60%, respectively worldwide (WHO, 2016). It causes deaths of around one million people per year in the tropical and subtropical zones (Mojarrab et al., 2014). Eventually, around 90% of cases of malaria have been ascertained in Sub-Saharan Africa, (Nguta et al., 2010). Even in 2017, Africa still has the highest burden of malaria calamity, with 200 million cases which attribute to 92% of total cases (WHO, 2018). Research showed that, the disease affects 4 to 5 million Ethiopians each year (Ayele et al., 2012) with 70,000 mortalities (PMI, 2008). 219 million cases of malaria recorded globally in 2017 with an increment of almost 2 million cases than the previous year, resulting in 435 thousand deaths, which attributes to 1190 death per day (WHO, 2018). WHO stated that malaria caused...
by *P. falciparum* was responsible for 99% case of all malaria associated deaths (WHO, 2015; Alebie *et al*., 2017). Even in Bangladesh, malaria is endemic in 13 of 64 Bangladeshi districts and a total of 14 million individuals are in danger. But with a ray of hope like other countries, malaria incidences are in a declining phase in Bangladesh too (6.2 per 1000 people in 2008 to 2.1 per 1000 people in 2012) (Haque *et al*., 2014).

Many synthetic drugs like chloroquine, mefloquine, atovaquone–proguanil, doxycycline, and artemisinin derivatives are used for malaria treatment (Grabias and Kumar, 2016). However, several neuropsychiatric adverse effects including nausea, headache, vertigo, loss of balance, depression, sleep disturbances, psychoses have been recorded for these antimalarial drug options. Moreover, neurotoxic, gastrointestinal, and genitourinary adverse effects like vomiting, abdominal pain, and vaginitis along with teratogenic adverse effects were also observed from those drugs (Grabias and Kumar, 2016). These conventional antimalarial drugs are often expensive and/or unavailable in many malaria-affected populations. Besides, developing drug resistance by the malaria parasite *P. falciparum* is another major issue which becomes a major concern nowadays (Greenwood and Mutabingwa, 2002). For these reasons, the urge to discover novel and effective antimalarial drugs with unique modes of action has become more pronounced (Ogbuehi *et al*., 2013).

Plants are very good sources of therapies to treat different kinds of illness from the ancient age (Alam *et al*., 2020; Emon *et al*., 2020). Natural products derived from plants have recently become the focus of attention as a primary source of innovative, safer, and more effective secondary bioactive metabolites with therapeutic capabilities (Emon *et al*., 2021; Rudra *et al*., 2020; Ogbuehi *et al*., 2013). Almost 80% of all drug products are either directly derived from plants or their modified forms (Alam *et al*., 2021). The history of plant products against malaria has a very ancient root (Muthaura *et al*., 2007). Based on ethnobotanical leads, initially, antimalarial drugs like artemisinin and quinine were derived from the herbaceous plants *Artemisia annua* L. and *Cinchona pubescens* Vahl., respectively (Wongsrichanalai, 2002). Till 2004, almost 1277 plants from 160 families have been reported with promising antimalarial activities (Rasoanaivo *et al*., 2011; Uzor *et al*., 2020). In different studies, various phytochemicals including alkaloids, indole alkaloids, naphthoisoquinolines, furoquinolines, acridones, amides, cryptolepines, terpenoids, clerodane and labdane diterpenoids, bisonterpenes, acyclic triterpenes, cassane furanoditerpenes, abietane diterpenes, coloratane sesquiterpenes, beilschmiedic acid derivatives, pentacyclic triterpenes were found active against the disease (Onguéné *et al*., 2013). In this review article, we have classified plants based on their family who have showed antimalarial properties in previous researches so that prospective researchers, drug developers and other related personnel can find a contemporary clue in order to facilitate the discovery of novel and effective antimalarial therapeutics.

**Materials and Methods**

**Article search strategy:** An extensive literature search was conducted using several online databases including Web of Science, Scopus, PubMed/Medline, ScienceDirect, Wiley Online Library, and Google Scholar during this review. We have used ‘Antimalarial’, ‘Antiplasmodial’, ‘Malaria', ‘Plasmodium’, ‘Plant products’ and ‘Herbal’ as key words to gather the related information. Considering peer reviewed and published articles only, describing malaria and role of plants and plant products against malarial complications as inclusion criteria. 118 out of 253 distinct articles were included in this review.

**Notable plant families with antimalarial actions**

**Annonaceae**

*Enantia chlorantha* Oliv. is an ornamental tree with thick leaf and a spreading crown and grows to a height up to 30m. It is found in densely wooded forests in east and south part of Cameroon, as well as in the south section of Nigeria, Angola, Gabon and the Democratic Republic of the Congo (Tchéghebe *et al*., 2016). In Cameroon, the stem bark of *E*.
*chloranthra* was commonly used to cure malaria, jaundice and various fevers (Adjianohoun *et al.*, 1996). The aqueous extract of *E. chlorantha* was shown to be efficient to ameliorate *P. yoelii* infection in mice after administered orally in drinking fluid at 0.2–150 mg/ml, but no effect was seen when administered via oral cannulation or subcutaneously. The ethanol extract of *E. chlorantha* also exhibited effective result in eliminating the parasites after being administered subcutaneously in doses of 0.05–0.5 mg/g (Agbaje and Onabanjo, 1991).

*Aphonon muricata* L., an evergreen tree which is typically 5–10m tall, has low branches with a diameter of 15–83cm. It is seen in Central and South America’s tropical areas, as well as Southeast Asia and Western Africa (Coria-Téllez *et al.*, 2018). *A. muricata* aqueous leaf extract demonstrated strong LC50 and LC50 values against third instar larvae of *Aedes aegypti* (LC50 51.13μg/ml and LC90 82.08μg/ml) *Culex quinquefasciatus* (LC50 88.72μg/ml and LC90 151.30μg/ml) and *Anopheles stephensi* (LC50 61.38μg/ml and LC90 156.55μg/ml) (Santhosh *et al.*, 2015.)

*Xylopia parviflora* Spruce is a small tree with a height of up to 3m. It is native to East Africa (Woguem *et al.*, 2014). The methanol extracts of leaves and stem from *X. parviflora* had a strong antiplasmodial activity with IC50 values ranging from 1.07 to 5.83μg/ml (Boyom *et al.*, 2011).

**Apocynaceae**

*Rauvolfia vomitoria* Afzel. is a small tree that grows to around 15m in height and can be found widely all over the world, especially in Asia and West-African countries (Olatokunboh *et al.*, 2009). Water, hexane, dichloromethane and methanol extracts from leaves of *R. vomitoria* demonstrated a very effective antimalarial activity against chloroquine-sensitive NF54 strains of *P. falciparum* with IC50 values ranging from 0.63 to 20.19μg/ml (Cynthia, 2018).

*Holarrheana floribunda* (G.Don) T.Durand & Schinz, called faux rubber tree, is a 4.5-15m tall shrub to a medium-sized tree (Ahmed 2017). The leaf extract of *H. floribunda* decreased parasitaemia caused by *P. berghei* with 6.96%, 29.06%, and 37.71%, respectively at 100, 250, and 500 mg/kg body weight doses (Hoekou *et al.*, 2017).

*Tithonia diversifolia* (Hems.) A.Gray, generally termed as Mexican sunflower, is a perennial or annual shrub which typically grows to a height of 1.2–3m. It is native to North and Central America, but has been naturalized in Africa, Australia, and Asia too (Ajao and Moteetee, 2017). The aqueous and methanol extracts of leaves of *T. diversifolia* were 50% and 74% effective against *P. berghei* and the LC50 of the aqueous extract was found to be 1.2ml/100g body weight in mice (Oyewole *et al.*, 2008).

**Asteraceae**

*Artemisia annua* L., commonly known as sweet wormwood, sweet anise or sweet sagewort is an annual herb growing more than 2m. This herb is native to Asia mainly China, but has been naturalized all across the world including the United States (Das, 2012). Based on previous research work, 72g of *A. annua* crude alcohol extract was 100% effective against *P. vivax* and *P. falciparum*, while 20g and 35 g aqueous infusions of *A. annua* were 100% and 93% effective against *P. falciparum*, accordingly. *A. annua* aqueous decoction was also 92% effective at 20g amount against *P. falciparum* (Willcox *et al.*, 2004). Artemisinin, extracted from the leaves of this Chinese plant has a very pronounced antimalarial application (Tajuddeen and Heerden, 2019). Co-administration of artemisinin with other drugs or its derivative *i.e.* artesunate has been considered as effective combination therapy to treat multi-drug resistant malaria (Batista *et al.*, 2009).

**Bignoniaceae**

*Spathodea campanulata* P.Beauv., popularly known as the African tulip tree, is broadly spread throughout Africa and found numerously in Cameroon also. (Ngouela *et al.*, 1991). The hexane and chloroform extracts of *S. campanulata* exhibited inhibitory action against *P. berghei* and suppressed malaria in mice models (Amusan *et al.*, 1996).
Capparidaceae

The evergreen perennial shrub, Buchholzia coriacea Engl. commonly known as “Wonderful kola” is found in African nations such as Nigeria, Ghana, and Liberia. B. coriacea seeds were found to decrease parasitemia levels substantially. The seed extracts (20, 40, and 600 mg/kg body weight dose) were administered for four days continuously to find the desired actions (Enechi et al., 2021).

Cleome rutidosperma DC. is a low-growing shrub with trifoliate foliage and tiny violet-blue blooms that become pinks with the age. It is found in waste grounds and grassy areas. The plant is native to West Africa, but it has been naturalized in many regions of tropical America and Southeast Asia including Malaysia and India (Ghosh et al., 2019). Ethanol extract of the plant had shown moderate effect against P. falciparum strain with IC50 value of 34.4µg/ml whereas diethyl ether extract demonstrated a good antiplasmodial effect with IC50 value of 8.1µg/ml (Bose et al., 2010).

Clusiaceae

Allanblackia monticola Mildbr. ex Engl. is a big forest tree that occurs in Cameroon’s West and South regions. The methanol extract of A. monticola had IC50 ranging from 0.6 to 8.9 g/ml on P. falciparum F32 and FcM29 strains (Azebaze et al., 2007).

Combretaceae

Terminalia superba Engl. & Diels is a large deciduous tree with a stem diameter of 120 cm and a height of 30-50m. T. superba is native to West and Central Africa (Kuete et al., 2010). The aqueous extract from leaves of T. superba showed a very good antiplasmodial activity and selectivity with IC50 values ranging from 0.57µg/ml and 1.26µg/ml on PfINO and Pf3D7 strains of P. falciparum, respectively (Mbouna et al., 2018).

Euphorbiaceae

Alchornea cordifolia (Schumach. & Thonn.) Müll.Arg. often known as Schum-Thron, is a shrubbery plant that grows throughout coastal regions of West Africa (Osadebe and Okoye, 2003). Ethanol extract of A. cordifolia leaves had moderate in vitro activity over P. falciparum in the mice model though chloroform and ether extracts didn’t show any promising action (Banzouzi et al., 2002).

Euphorbia hirta L. is a reddish or purplish-colored, slender-stemmed, annual plant with many branches from the ground to the top reaching a height of up to 40 m. E. hirta is found in landfill areas along roadsides in the hotter areas of India and Australia (Kumar et al., 2010). The methanol extract of E. hirta aerial parts exhibited major active chromatographic fractions that inhibited P. falciparum growth by 90% at 5 g/ml concentration (Liu et al., 2007).

Fabaceae

Cajanus cajan (L.) Millsp, is a perennial or annual leguminous plant which is broadly distributed in tropical and subtropical portions of the world including Asia, Africa and South America (Kong et al., 2010). C. cajan leaf extract inhibited the growth of P. falciparum at IC50 value of 2.0µg/ml (Ajaieoba et al. 2013).

Leguminosae

Guibourtia coleosperma (Benth.) Leonard or giant false mopanie, is a tree native to southern Africa which can be found in Namibia, Zambia, Zaire, Zimbabwe and Angola also (Bekker et al., 2006). G. coleosperma aqueous and organic extracts both had moderate antimalarial activity, with IC50 values of 31.61 and 28.17g/ml, respectively (du Preez et al., 2020).

Liliaceae

Allium sativum L. is a fragrant herbaceous plant that grows up to 30 to 80cm tall (Sendl., 1995). A. sativum is thought to have evolved in Central Asia 600 years ago and has subsequently expanded over Southwest Asia and the Mediterranean (Malik et al., 2020). A. sativum was tested against larvae of Anopheles stephensi and the LC50 values for hexane extract were 7.5 ppm after 24 hours and 7.6 ppm after 48 hours of exposure. Moreover, the LC90 values were 22.1 ppm after 24 hours, and 15.4 ppm after 48 hours of exposure (Shrankhla et al., 2012).
**Malvaceae**

*Sida acuta* Burm. f. familiar as as Kurumthotti, is a weedy perennial shrubbery plant having a smooth bark (Sreedevi *et al.*, 2009). The shrub is native to Central America and Mexico, although it has since spread throughout the tropics and subtropics (Karou *et al.*, 2007). Ethanol fraction of *S. acuta* was found to have a significant action against *P. falciparum* at the IC₅₀ value 4.37µg/ml during a study of *in vitro* antimalarial test (Karou *et al.*, 2003).

**Meliaceae**

*Khaya grandifoliola* C.DC. is a large-leaved evergreen tree that is also known as African mahogany, Benin mahogany or Senegal mahogany. Benin, Ghana, the Democratic Republic of the Congo, Sudan, Ivory Coast, Guinea, Togo, Nigeria, and Uganda are all home to it (Ojokuku *et al.*, 2010). Antimalarial activity of *K. grandifoliola* stem and bark against *P. berghei* was investigated in mice by a group of researchers. Based on the study, the n-hexane extract, the crude and purified fractions provided very good antimalarial activities with around 91% chemosuppression *in vivo* and IC₅₀ values of 1.4µg/ml (for multi-drug resistant clone of *P. falciparum*) and 0.84 µg/ml (for Nigerian *P. falciparum* isolates). (Agbedahunsi *et al.*, 1998).

**Melianthaceae**

*Bersama engleriana* Gürke is a small to medium-sized tree that reaches a height of 6 to 9m, hardly surpassing 25m. It's often found throughout tropical Africa, Senegal to Zaire, Southern Africa as well as areas of favoring areas with more rainfall or evergreen woods (Watcho *et al.*, 2014). The methanol extract of *B. engleriana* leaves displayed a prospective antiplasmodium effect, with an IC₅₀ of 2.7g/ml against *P. falciparum* (Ngemenya *et al.*, 2005).

**Menispermaceae**

*Penianthus longifolius* Miers is a tall shrub reaching up to 3–4.4m which is native to the rain forests of Cameroon, Nigeria, Gabon, Equatorial Guinea, Central African Republic, Congo and Angola (Tabekoueng *et al.*, 2019). *P. longifolius* methanol extract had shown promising *in vitro* activity on two *P. falciparum* malarial clones designated as Indochina (W-2) and Sierra Leone (D-6) types with IC₅₀ values of 350.066 and 284.377ng/ml, respectively (Tane *et al.*, 2005).

**Myrtaceae**

*Eucalyptus robusta* Sm., popular as swamp mahogany, is a medium to large tree that typically grows of 20 to 30 m having a width of approximately 1m (Boland *et al.*, 2006). It is widely distributed to Australia's east coast. However, it has propagated itself in other nations and is said to cover a total area of 2.3 million hectares globally (Vuong *et al.*, 2015). Aqueous extracts of *E. robusta* stem and bark demonstrated promising antimalarial activity by suppressing *P. falciparum* D10 strain with IC₅₀ Values of 10–20µg/ml in parasite lactate dehydrogenase (pLDH) assay (Nundkumar and Ojewole, 2002).

**Poaceae**

*Cymbopogon citratus* (DC.) Stapf is a perennial aromatic plant native to southern India and Sri Lanka that grows up to 2m tall with a 1.2m wide and a thick clump. It is currently cultivated all over the world, especially in tropical, subtropical and Savannah countries (Machraoui *et al.*, 2018). *C. citratus* has notable antimalarial efficacy, as evidenced by a study that found dosages of 200 to 1600mg/kg dry powder of *C. citratus* suppressed parasitaemia against *P. berghei* ANKA strain by 91.89% to 96.61% (Chukwuocha *et al.*, 2016). The essential oils from the extract of *C. citratus* leaves exhibited antimalarial activity against *P. berghei* in mice models with IC₅₀ values ranging from 6 to 9.5µg/ml (Tchoumbougnang *et al.*, 2005).

**Piperaceae**

*Peperomia vulcanica* Baker & C. H. Wright, an herbaceous plant, is seen around the world in subtropical and tropical areas, although they are most common in Central and Northern South America. The hexane and methylene chloride extracts of *P.*
Morinda lucida Benth. is a medium-sized tree with short branches and dazzling leaves that reaches up to 15m and is native to West and Central Africa (Chithambo et al., 2017). Ethanol extract of M. lucida had a good antimalarial efficacy against P. berghei while 400, 600 and 800mg doses inhibited 0.40 ± 0.20, 1.40 ± 0.24 and 1.20 ± 0.58% parasitaemia on 5th day of treatment in mice, respectively (Afolabi and Abejide, 2020).

Cinchona barks from Rubiaceae family are very popular sources of antimalarial therapeutics (Batista et al., 2009). They are found in mainly South America, particularly the Andes. It is also spread in Vietnam, India, Cameroon, Java, and a few more African and Asian nations (Raza et al., 2021). Quinine isolated from the barks is one of the very first antimalarial drugs used in early ages (Fernandez et al., 2008). It was discovered in 1820 by Pelletier and Caventou and used as lead antimalarial moiety for almost three centuries (Batista et al., 2009). Besides, quinine conjugates and its analogues can also serve promising antimalarial efficacies (Jones et al., 2015).

Rutaceae

Citrus sinensis (L.) Osbeck, a short evergreen tree of 7.5 to 15m height, is widely cultivated in tropical, semi-tropical and some warm temperate regions. This tree is native to China, Southeast Asia, Malay Archipelago, New Caledonia and Australia (EtéBu and Nwauzoma, 2014). Petroleum ether and methanol extract of ripe fruit rind of C. sinensis possessed antimalarial activity against P. falciparum FCK2 strain with IC50 values of 51.06 and 53.61µg/ml respectively (Bhat et al., 2001). In another study, the crude extracts of C. sinensis peels were found active against Anopheles subpictus larva that causes malaria with LC50 of 58.25 ppm and LC90 of 298.31 ppm (El-Akhal et al., 2015).

Scrophulariaceae

Scoparia dulcis L., also known as sweet broom weed, is a branching perennial herb with wiry stems that may reach a height of one meter. It is extensively distributed throughout tropical and subtropical areas of India, West Indies, America, Brazil and Myanmar (Paul 2017). The ethyl acetate extract of S. dulcis inhibited the growth of P. falciparum with the IC50 value 19.5µg/ml (Ngemenya et al., 2004).

Simaroubaceae

Quassia amara L. is a South American rain forest small tree, with a height of 2-6 m (Cachet et al., 2009). The hexane extract of Q. amara leaves exhibited promising antimalarial activity against P. berghei by suppressing the parasite density of 0.16±0.001% in the laboratory mouse. Methanol extract of Q. amara leaf also suppressed the parasite density of 0.05±0.03% at the dose of 200mg/kg (Ajaiyeoba et al., 1999).

Zingiberaceae

Renealmia alpinia (Rottb.) Maas is an herb with gregarious and simple leaves that generally grows up to 2-6 m in height. This plant is native to tropical moist lowland rainforests but widely distributed in Mexico, Peru, Brazil, Antilles, French Guiana, Guyana, Suriname and Venezuela (Gómez-Betancur & Benjumea 2014). Aqueous rhizome extract of R. alpinia demonstrated antimalarial activity against P. falciparum chloroquine-resistant strain with an IC50 value of 10 ± 1.4µg/ml (Céline et al., 2009).

Renealmia thyroidea (Ruiz & Pav.) Poepp. & Endl. is a herbaceous perennial plant which produces clumps of erect stems around a height of 0.8-5 m (Maas 1977). The species is native to tropical America. Although it is widely spread in Bolivia, Guyana, Colombia, Ecuador, Nicaragua, Panama, Trinidad, Peru, Suriname and Tobago and Venezuela (Noriega et al., 2016). Based on previous research work, aqueous rhizome extract of R. thyroidea had
shown antimalarial effect against *P. falciparum* chloroquine-resistant strain at the IC₅₀ value of 6.8 ± 1.5µg/ml (Céline et al., 2009).

**Notable Bangladeshi plant families with antimalarial actions**

**Acanthaceae**

*Andrographis paniculata* (Burm. f.) Nees, popularly known as ‘Kalmegh’, is a branching annual plant that grows to 60-70cm in height (Nyeem et al., 2017). It is widely common in Asian nations such as Bangladesh, India, Sri Lanka, Pakistan, Malaysia, and Indonesia (Nyeem et al., 2017). The methanol extract of *A. paniculata* whole plant inhibited the chloroquine-sensitive *P. falciparum* strain D10 with the IC₅₀ value of 45.74µg/ml and the resistant strain Gombak A with the IC₅₀ of 65.06µg/ml (Najila et al., 2002).

**Anacardiaceae**

*Mangifera indica* L. is a local Bangladeshi fruit producing tree and known as ‘Aam’ that grows as a medium to a large green tree that is generally 10 to 40 m in height (Parvez 2016). *M. indica* is grown in tropical regions around the world, including India, Thailand, China, Bangladesh, Malaysia and Indonesia (Pierson et al., 2014). *M. indica* aqueous extract exhibited IC₅₀ of 18.11, 20.08, and 10.23 µg/ml against NF54, CamWT_C580Y, and FA08 parasite strains of *P. falciparum*, respectively (Jibira et al., 2020).

**Apocynaceae**

*Rauwolfia serpentina* (L.) Benth. ex Kurz, locally known as ‘Sarpagandha’ is a climbing evergreen perennial shrub (Chenniappan and Kadarkari, 2010). The species is native to India, Bangladesh and other regions of Asia including Himalayas, Myanmar, Indonesia and Sri Lanka (Kumari et al., 2013). Based on a previous study, methylene chloride extract of *R. serpentina* bark exhibited notable antimalarial activity against chloroquine-resistant *P. falciparum* MRC-Pf-43 strain along with IC₅₀ value of 8.32µg/ml and 59% inhibition (Chenniappan and Kadarkari, 2010). In another study, 200 mg/kg of *R. serpentina* leaf ethanol extract showed antimalarial activity in *P. berghei* NK65 strain infected mice model with 84.14% chemo suppression, while 400 mg/kg *R. serpentina* leaf hot water extract showed 82.53% chemo suppression (O moya et al., 2019). In another *in vivo* study, a dose of 500 mg/kg of cyclohexane and methylene chloride extracts of *R. serpentina* root displayed moderate antiplasmodial activity against chloroquine-resistant *P. berghei* NK65 strain with 20% survival on 9th day of post-infection (Samy and Kadarkari, 2011).

**Arecaaceae**

*Areca catechu* L., commonly called ‘Supari’, is a 15-25m tall megaphanerophyte with a single stem (Peng et al., 2015; Nath et al., 2011). It is also known as ‘Areca nut’ and widely consumed with *Piper Betle* leaf (locally known as ‘Pan’) in many Asian countries. It is commonly found in the tropical Pacific, Asian and few east African Countries (Garg et al., 2014). Butanol fraction of *A. catechu* nut extract exhibited remarkable antimalarial activity against *P. falciparum* showing the IC₅₀ value of 18µg/ml (Boniface et al., 2014).

**Fabaceae**

*Erythrina variegata* L. is a branched, deciduous medium-sized woody tree growing up to 25m and is used by various tribes of Bangladesh (Rahmatullah et al., 2012). It is known as ‘Mafang’ in Bangladesh and also available in Taiwan, southern China, Philippines, Indonesia, Thailand, Myanmar, Malaysia, India, and Indian Ocean islands (Lim 2014; Rahmatullah et al., 2012). Methanol extract of the *E. variegata* leaves showed strong antimalarial activity over *P. falciparum* K1 strain with IC₅₀ value of 6.8 µg/ml (Herlina et al., 2011).

**Lamiaceae**

*Ocimum gratissimum* L. is a branching shrub that grows up to 1.9m tall which is locally known as ‘Ram Tulsi’ in Bangladesh (Prabhu et al., 2009). The species is native to tropical regions, including India, West Africa, Savannah, coastal areas of Nigeria, Srilanka, Nepal, and Bangladesh (Prabhu et al.,
Essential oils from the leaves of *O. gratissimum* were shown to be extremely potent over *P. falciparum*, with IC$_{50}$ ranging from 6.9 to 14.9 g/ml (Ngemenya et al., 2004).

**Meliaceae**

*Azadirachta indica* A.Juss., known as ‘Neem’ in Bangladesh, is a fast-growing evergreen tree having wide branches and may reach a height of 15-20m (Maithani et al., 2011). Alongside Bangladesh, it can also grow in India and Myanmar though it can grow abundantly in tropical and subtropical areas (Maithani et al., 2011). Based on a previously conducted study, *A. indica* leaves extract had antiplasmodial activity against *P. falciparum* with the LD$_{50}$ of 7.52 μg/ml, 6.76 μg/ml, and 5.96 μg/ml for ethanol, methanol and acetone extracts respectively (Deshpande et al., 2014).

**Myrtaceae**

*Syzgium cymosum* (Lam.) DC., locally known as ‘Khudijam’ in Bangladesh, can grow up to a height of 15-20m and has plain wide leaves (Hossainey et al., 2020). Tropical and subtropical regions including India, Singapore, Myanmar and Malacca are also home to this plant (Dhar et al., 2016). The crude methanol extract of *S. cymosum* leaves exhibited remarkable efficacy against chloroquine-sensitive 3D7, chloroquine-resistant Dd2 and mild efficacy against artemisinin-resistant IPC 4912 Mondulkiri strains of *P. falciparum* with the IC$_{50}$ value of 6.28μg/ml, 13.42μg/ml and 17.47μg/ml, respectively (Hossainey et al., 2020).

**Conclusion**

Herbal plants are always great wellsprings of novel therapeutics which offer more efficacy and lesser side effects against various disease states compared to other synthetic drugs. In parallel, to treat malarial complications, medicinal plants and plant products have been also documented from the very old ages in different countries, cultures and tribes. Thus, to discover novel drug therapies against malaria and related complications, researchers can consider these herbal plants although further studies are still recommended to figure out the exact phytochemicals responsible for displayed antimalarial actions and their accurate mechanism of actions.

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**Authors’ contributions**

SA and TBK conceptualized and designed the review work. ATO, AZ, HH and TBK gathered the previous works. ATO, SA, AZ and HH wrote the manuscript. TS and MAI critically reviewed the manuscript. SA edited and drafted the final manuscript and supervised the total work.

**Declarations**

The manuscript was read and approved for submission by all concerned authors. No part of the manuscript has been previously published, and no part of it is currently being considered for publication in any journal.

**Conflict of interest**

The authors state that they have no conflicting interests that could have appeared to influence the work reported in this paper.

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