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Medicinal Plants with Antimalarial Potentials from Northern Nigeria: A Review

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Abstract

Malaria is a prevalent infectious disease that is transmitted by parasites through the bite of infected mosquitoes. Despite advancements in medical science, malaria is still a significant global health challenge, especially in regions like northern Nigeria. Medicinal plants have long played a pivotal role in traditional healthcare systems, serving as valuable sources of therapeutic compounds. In the context of malaria, certain plants in Northern Nigeria have been traditionally recognized for their antimalarial properties, offering an alternative or complementary approach to conventional treatments. The significance of these medicinal plants lies in their potential to provide accessible, cost-effective, and culturally relevant solutions for managing malaria. Traditional knowledge about these plants has been passed down through generations, contributing to the resilience of local communities against the disease. This review explores the rich diversity of medicinal plants in Northern Nigeria with antimalarial properties. Through extensive research utilizing various search engines, we identified and examined 30 distinct plant species traditionally used in the treatment of malaria across the region. The documented uses, phytochemical compositions, and therapeutic potentials of these plants contribute valuable insights into the traditional medicinal practices of Northern Nigeria. Our findings underscore the importance of further scientific investigation and documentation of these natural resources, with the potential for developing novel antimalarial drugs and fostering sustainable healthcare practices in the region.

Keywords: Antiplasmodial, Malaria, Traditional.

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1. Introduction

There are fewer than 400,000 flowering plants on the planet, 12% of them are employed in conventional medicine. About 10,000 of such plants have already been studied and described scientifically. Around 25% of prescribed medications in the Western medical system are higher plant-derived chemicals, and 74% of the 121 bioactive plant-derived compounds were discovered through research based on leads from traditional medicine. The elder generation passed on their knowledge of medical plant usage to the younger generation through trial and error, but this knowledge and transmission are now in jeopardy because there isn't always a guarantee that it will happen (1). Indigenous people have long used plants as health-restoring products. The effectiveness of plant-based therapies in treating a variety of ailments has been confirmed. According to the WHO, nearly 70% of people worldwide rely on herbal remedies to heal illnesses (2). The development of new antimalarial medications has historically been dominated by the utilization of medicinal plants. These compounds can be taken directly from the

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plant, manufactured, or utilized as structural models for semi-synthetic antimalarials. Early in the 18th century, the antimalarial compound quinine was initially extracted from Cinchona bark. It served as a base for the later synthesis of chloroquine, mefloquine, and other medications with a similar mechanism of action (3).

The five single-celled eukaryotic Plasmodium parasite species that cause malaria—*P. falciparum*, *P. ovale*, *P. malariae*, *P. vivax*, and *P. knowlesi*—are all spread by means of female anopheles mosquitoes' bite that are carrying the parasite. Malaria is a significant public health issue with international significance and scientific interest. In 2016, malaria was the sixth largest cause of death globally, it is estimated that 216 million cases and 719,600 deaths take place despite a decline in occurrences of the disease of 25.9% from 2006 to 2016 (4).

P. falciparum is the germ that causes the most dangerous type of malaria. The female anopheles mosquito serves as the insect vector for the complex life cycle of *Plasmodium* sp while second host is the vertebrate human (5). The sporozoites in the female anopheles mosquito's saliva enter the host's body while feeding on blood, starting a period of hepatic malarial infection lasting 5-7 days. Thousands of merozoites are produced during this asymptomatic phase. Clinical signs begin to manifest 48 hours after the merozoites enter the bloodstream. Chills, fever, prostration, cerebral malaria, anemia and multiple organ failure with a fatal outcome are some of the clinical symptoms. In addition to its asexual reproduction cycle, the parasite divides into sexual forms called gametocytes. The female anopheles mosquitoes take the gametocytes while feeding on blood, and the sexual cycle starts in the host mosquito's stomach (5).

There has been a pressing need to locate new antimalarial chemotherapeutic agents from natural sources, mainly medicinal plants, to potentially prevent problems associated with drug resistance. This is because the malaria parasites have a resistance to many of the current treatment regimens. The two main antimalarial lead compounds quinine and artemisinin are produced by medicinal plants, and because they were frequently used in various traditional medical systems to treat malaria (6). Over time, various nations have documented the usage of medicinal herbs to treat the symptoms of malaria, which includes fever paroxysms. This practice is widespread in Nigeria, and research on a few medicinal herbs has shown that they are effective against plasmodial infection (7).

The aim of this review exercise is to compile the most utilized medicinal plants for malaria in Northern Nigeria with a goal of improving their national standards which will consequently be used to establish their herbal monographs.

2. Sources of the Literature

The search for medicinal plants was conducted using various search engines including Google Scholar, PubMed, Institute for Scientific Information, Hinari, Scopus, Scientific Information Database, etc. The keywords such as malaria endemic, antimalarial plants, antiplasmodial, ethnopharmacology, and northern Nigeria regions are used in this approach.

3. Selected Medicinal Plants with Antimalarial Potentials in Northern Nigeria

3.1 Magnifera Indica

Mangifera indica, which is commonly referred to as mango is a type of flowering plant belonging to the Anacadiaceae family. There are 69 different kinds of mango found on tropical and subtropical continents around the globe. Mango's significance cannot be overstated. In addition to being consumed, the fruits are also utilized to make juice and wine (8). The leaves, fruit and immature stem of *Magnifera indica* is used as decoction in the treatment of malaria in northern part of Nigeria (9). The aqueous extract of *Magnifera indica* exhibited IC_{50} of 18.11 µg/ml, 20.08 µg/ml, and 10.23 µg/ml against three strains of P. *falciparum*, (NF54, CamWT_C580Y, and FA08) respectively (10). The *Artemisia* species have been found to contain flavonoids, which have been shown to have potent anti-malarial effects against *P. falciparium*. The flavonoids and alkaloids were discovered in *Magnifera indica* extracts, leading to the suggestion that their presence may be the cause of the plant's therapeutic effects. Meanwhile, the findings partially support assertions made in conventional medicine about the effectiveness of this plant in combating malaria (8).

3.2 Cymbopogon citratus

Popular names for *Cymbopogon citratus* include citronella grass and lemongrass. This species is a member of the Gramineae family, which has 8,000 plant species and 500 genera. A tufted perennial grass, lemon grass may reach a height of one meter and possesses a number of stiff, leafy stems which emerge from roots that are short and rhizomatous. It has an estimated five-year economic lifetime (11). The linear, tapered leaf blade may reach a maximum length of 50 cm and a maximum width of 1.5 cm. The leaf-sheath serves as a pseudo stem and has a tubular form. The leaves are long, glaucous, green, and linear which are tapered upwards and along the edges (12).

Herbalists believe that *C. citratus* has a variety of medical benefits. In Nigeria, concoction preparations of lemon grass have been used to cure illnesses like typhoid, fever, stomach pains, as well as malaria when combined with other herbs. Its folkloric uses as a possible malaria-controlling medication have been validated (13). Alkaloids, carbohydrates, tannins, flavonoids, cardiac glycosides, steroids, saponins, anthraquinones, carotenoids, volatile and non-volatile terpenoids were found in the aqueous leaf and root extracts of *C. citratus*, in accordance with the phytochemical screening results which were implicated in antiplasmodial activity of some herbal preparations making the extract a potential antiplasmodial candidate (14). Numerous herbal treatments for malaria may have antiparasitic benefits not only by directly combating the infection but also by indirectly enhancing the host's natural and adaptive defensive systems (15). When compared to chloroquine, *Cymbopogon citratus* extracts and its essential oils were demonstrated to have 86.6% decrease in the development of *Plasmodium berghei* (considering 100% inhibition by chloroquine as the reference point) (16, 17).

3.3 Abrus precatorius

Abrus precatorius known by other names including rosary pea and jequirity pea. In Hausa language it is known as 'Idon Zakara'. It belongs to Papillionaceae family, it has glabrous internodes and leaves which twines around trees, shrubs, and hedges. Its leaflet length ranges from 1.2 to 1.8 cm. It produces fruit, which is a tiny pod with a deflexed beak and a flat, truncate form. The fruit has three to six ovoid crimson seeds with a black mark at the base that are around 0.6 cm in diameter. It grows worldwide in tropical and subtropical climates (18). Its seeds are interesting since they are generally bright, beautiful crimson with black at the hilum. This unique black and red backdrop resembles the eyes of a chicken (19).

The plant leaves and roots that have a sweet taste have been used for centuries to treat a variety of conditions including fever, stomatitis, bronchitis, asthma, diabetes, chronic nephritis, cancer, sores, scratches, and wounds as well as leucoderma, tetanus, boils, and abscesses. They also have a known hematonic and plasma expander effect (20). The leaves decoction of *A. precatorius* have also been utilized in northern Nigeria for the management of myriad of ailments including malaria, eye infection, typhoid respiratory tract infections, cough, hepatitis and skin diseases (21, 22).

More than 166 chemical constituents have so far been extracted or identified from *A. precatorius*; these constituents belong to many groups of substances, such as proteins, polysaccharides, alkaloids, esters, flavonoids, phenolics, steroids, terpenoids, organic acids and other constituents (19). Abruquinone, an isoflavanquinone, was discovered in the aerial parts extract and demonstrated anti-malarial activity (23). Significant antiplasmodial efficacy against *P. berghei* was demonstrated by aqueous leaf extract of *A. precatorius* at dose levels of 25, 50, and 100 mg/kg, which was equivalent to halofantrine at dose level of 25 mg/kg (24). With an IC_{50} value of 12.1 g/ml, the n-hexane and chloroform fractions of *Abrus precatorius* leaf demonstrated the greatest inhibitory effects against chloroquine and pyrimethamine resistant *Plasmodium falciparum* (25). The presence of secondary metabolites in the plant may be the cause of the antiplasmodial action that was observed.

3.4. Anogeissus leiocarpus

A deciduous tree from the combretaceae family, *Anogeissus leiocarpus* is often found in tropical and subtropical parts of the world. It is also found in central and west African countries, where it is a common herbal remedy. The plant is known for its scaly, greyish bark, thin, frequently falling branches, and alternating, ovate-lanceleted-shaped leaves that are 2 to 8 cm long and 1.3 to 5 cm wide (26). *Anogeissus leiocarpus*, often known as the Marke (Hausa), Kojoli (Fulani) and African

birch (English). It is a significant evergreen tree that is common throughout Africa. African and Sudanese traditional medicine utilizes *Anogeissus leiocarpus* extensively to treat multiple ailments including; toothaches, respiratory illnesses, diarrhea, hepatitis, jaundice, haemorrhoids, headaches, as well as antimalarial. It has potent antibacterial and antifungal action against several pathogenic pathogens (27). Stem bark of *Angeissus leiocarpus* is boiled and taken 2 times a day for 3 days for the treatment of malaria by the Rumaya people of Kauru Local Government Area of Kaduna State in northern Nigeria (28). In Nupe land, North central Nigeria, malaria is been treated using decoction of the *A. leiocarpus*. The bark with three ties of its leaves were orally administered. A warmed portion of the decoction was also used with potash or black soap for bathing. Palm kernel oil used to be added to the other portion and the resultant mixture is rubbed on the body (29). While flavonoids were lacking, four distinct secondary metabolites, including saponins, phenols, tannins, and phytosterols, were detected in the phytochemical screening of *Anogeissus leiocarpus* stem bark extract (30).

An investigation into a chloroquine-resistant strain of *Plasmodium falciparum* found that a methanol extract of the plant's leaves and roots was highly effective in treating malaria. When the stem bark of Anogeissus leiocarpus was examined for in vitro antiplasmodial activity, butanol, ethyl acetate, and methanol extracts were found to have the strongest efficacy. The methanolic extract has strong antimalarial properties and can increase HDL levels in organisms with malaria (31).

3.5 Carica Papaya

The *Carica papaya* plant, also known as pawpaw in English and gwanda in Hausa, is a member of the Caricaceae family and has been grown in most tropical nations. *Carica papaya* is a huge, herbaceous perennial plant that resembles a tree. It has a soft single stem that may reach a height of 5 to 10 meters, sparsely spaced leaves at the top of the trunk, and a scarred lower trunk where leaves and fruits are formed. Despite having a limited lifespan on average, the plants can bear fruit for up to 20 years. The papaya has a convoluted reproductive strategy (32). The fruits are eaten as food and are a reliable source of elements (iron, calcium and potassium), vitamins (vitamin C, riboflavin and thiamine) and other nutrients. Different *Carica papaya* components have a long history of being used for medical purposes (33). In Asia, boiling and eating papaya leaves with spinach has a long tradition. Papaya leaves are one of the many plant parts with therapeutic benefits. The tea extract of *Carica papaya* leaves was displayed to have antispasmodic and antimalarial activities, and a significant effect have been observed on a variety of tumor cell lines. It has been reported to increase appetite, enhance nausea, and decrease menstrual cramps (34).

Carica papaya leaves is used among diverse tribes in northern Nigeria for the management of malaria. Concoction of leaves of *Carica papaya* is been taken orally and also vapour bath to treat malaria by the people of Madobi town in Kano state north-western Nigeria (35). The fresh leaves of *C. papaya, Psidium gujava*, and *Cymbopogen citratus* were combined, heated in water, and then left to cool. For a week, a cupful is consumed three times every day to cure anemia and malaria by the Kanuri tribes of north-eastern Nigeria (36). Also, infusion of the leaves and fruit of *Carica papaya* is been taken orally to treat malaria by the people of Rukuba town in Bassa Local Government Area of Plateau State north-central Nigeria (37).

Phytochemical components found in papaya leaves include saponins, cardiac glycosides, anthraquinones, alkaloids, flavonoids, and other phenolic chemicals (38). According to a study, *C. papaya* methanolic leaf extracts at 400 and 600 mg/kg body weight caused a dose-dependent and gradual decline in malaria parasites throughout the course of a curative test (39). According to another study, when compared to the control group, the average daily parasitemia of infected mice treated with chloroquine, 400 mg/kg of papaya leaf extract, and 200 mg/kg of papaya leaf extract each decreased considerably ($P<0.05$). However, they found no discernible difference between the infected mice treated with 100 mg/kg of *Carica papaya* leaf extract and the control group in terms of the amount of parasitemia ($p > 0.05$) (40). The antimalarial properties of *C. papaya* methanolic leaf extract may be due to flavonoids and alkaloids which have been demonstrated to have strong *in vitro* antimalarial activity against *P. falciparum*

(41).

3.6 Citrus aurantifolia

A tiny shrubby tree with a height of around 5 m, *C. aurantifolia* known as lime (English) and lemun tsami (Hausa). It is a tree that is both evergreen and everbearing, has thickly and erratically branching leaves, and has short, stiff spines (thorns). The leaves are alternate, elliptical to oblong-oviate in form, and have a crenulate edge (4-8 cm by 2-5 cm). A subtle purple hue can be seen on the border of the 1-inch-diameter, yellowish-white blooms. The fruits are globose to ovoid berries that range in size from 3 to 6 cm in diameter and may feature an apical papilla (42). Although it is commonly grown in green for commercial purposes, it turns yellow when fully mature. Fruits and blooms are present all year in the Northern Hemisphere, but are most abundant from May to September. The fruit skins have segments that are heavily glandular and contain pulp vesicles that are yellow-green in color. Fruit juice is sour like lemon juice but more aromatically acidic and fragrant. It is typically prized for having a distinct flavor from other limes. The seeds have a white embryo and are tiny, plump, oval, pale, and smooth (42). Initial analysis of the fruit and other parts of *C. aurantifolia* revealed the presence of reducing sugars, alkaloids, flavonoids, tannins, saponins, steroids, cardiac glycosides, carbohydrates, and phenols (43).

A decoction of leaves of *C. aurantifolia* is taken orally and also vapor bath to treat malaria by the people of Madobi town in Kano state northwestern Nigeria (35). The leaves of *C. aurantifolia* is boiled in water together with the leaves of *Magnifera indica* and *Psidium gwajava*, a cupful of the decoction is administered orally three times daily for five days by the Kanuri tribes of north-eastern Nigeria to treat malaria (36). Also, decoction from the root, bark, fruit, stem-twigs and leaves of the plant is taken orally to treat malaria by the people of Rukuba, Bassa Local Government Area of Plateau State north central Nigeria (37). When compared to the standard Chloroquine, *C. aurantifolia* leaf extracts of various solvents (aqueous, hexane, chloroform, petroleum ether, and ethanol) had a considerable inhibitory impact on the schizont development of *P. Falciparum* parasites (44). A study found that *C. aurantifolia* leaf extract has potent *in vivo* antiplasmodial activity that is dose independent. In another study it was reported that the plant extract tested positive for alkaloids, saponins, flavonoids, cardiac glycosides, and tannins during phytochemical screening. These components may be responsible for the plant's antiplasmodial properties. This study provides a foundation for the ethnomedical use of herbs in Nigeria to treat malaria (45).

3.7 Psidium guajava

The *Psidium guajava* tree which is normally known as gwava in English and gwaiba in Hausa is around 10m-tall with thin, smooth, uneven, and flaking bark. The oval, 5-15 cm long leaves are opposite, short-petiolate, and have noticeable pinnate veins. The spectacular flowers have many stamens and white petals up to 2 cm long. It thrives in tropical and subtropical regions around the world (46). It belongs to the Myrtaceae family, which has more than 3,800 species and 133 genera. The leaves and bark of the *P. guajava* tree have been used medicinally for a long time and are being used up to today (47). All parts of *Psidium guajava*, including the bark, fruit, leaves, and roots, have a long history of therapeutic value in the treatment of a number of illnesses, including trypanosomiasis, malaria infection, wound healing, diabetes, ulcers, hypertension, stomach aches, cholera, obesity, diarrhea, and ulcerative colitis (48). Traditional herbalists also recognize *Psidium guajava* as a key ingredient in antimalarial polyherbal formulations (48).

The plant is used to cure malaria, according to an ethnobotanical study of *P. guajava* in the town of Mubi in the Adamawa state, north-eastern Nigeria (49). Decoction of the leaves and bark is taken orally with little potash in it to treat malaria according to ethnobotanical studies carried out in some northern part of Nigeria (35). Using chloroquine and quinine as the reference drugs, *Psidium guajava* extract was tested for its *in vitro* antimalarial action against *P. falciparum* strain. The IC_{50} values for methanolic and ethanolic extracts against the *P. falciparum* strain were found to vary from 0.048 µM to 0.965 µM. Compared to quinine (IC_{50}= 0.832 µM) and chloroquine (IC_{50}= 0.065 µM), these substances demonstrated superior action against the *P. falciparum* strain (50). In mice infected with *Plasmodium berghei*, the crude

extract of *Psidium guajava* effectively ($p < 0.05$) suppressed parasite multiplication, avoided body weight loss, and reduced packed cell volume (51).

3.8 Anacardium occidentale

The *Anacardium occidentale* tree which is known as cashew in English and kashu in Hausa has the potential to reach a height of 12 meters and is spreading, evergreen, and heavily branched. It seldom grows taller than 6 meters when planted in lateritic, gravelly, or coastal sandy regions. When produced from seed, the mature root system consists of a very noticeable taproot and a well-established and vast network of lateral and sinker roots. Young leaves are pale green or reddish; mature leaves are dark green. The genuine fruit, which is the nut, dries up and does not crack open. The edible cashew nut is a huge, curving seed that is approximately 2.5 cm long. The fleshy, fruit-like structure, which is widest at the apex and is commonly referred to as the fruit, quickly grows from the stalk (receptacle) at the base of the nut as it matures (52). Worldwide ethnomedical traditions have demonstrated the therapeutic potential of extracts from various sections of the *A. occidentale* tree for the treatment of malaria, dyspepsia, bronchitis, eczema, psoriasis, syphilis, nasal congestion and urinary insufficiency (53). Decoction from the stem bark and leaves of the plant is taken orally with honey added as an adative for 5 days to treat malaria in many parts of northern Nigeria (35). According to a research, 48 hours after starting therapy, chloroquine was completely curative while at 96 hours of therapy, *A. occidentale* 600 mg/kg and 800 mg/kg produced percentage curatives of 80.66% and 80.69%, respectively (54). Another finding revealed that ethanol crude extract of *Anacardium occidentale* (Cashew) exhibited significant antiplasmodial property (IC50 0.577µg/ml) (55). This has established the fundamental idea behind *A. occidentale*'s historical usage in the treatment of malaria.

3.9 Momordica charantia

Momordica charantia, sometimes referred to as bitter melon, bitter guard, and garahunu in Hausa, is a plant that is consumed as food and utilized as a natural remedy. All plant components, including the fruits, contain the very bitter chemical momordicinso. The plants are able to grow in tropical areas (56). *M. charantia*, a slender, climbing monoecious plant with distinct male and female flowers that are yellow in color and appear in the leaf axils and have long stalks. It belongs to the Cucurbitaceae family (56). In folk medicine, the herb is used to cure a wide range of ailments (57). In some parts of northern Nigeria, a tablespoon of *Momordica charantia*'s fresh leaf and fruit decoction is taken three times per day to cure malaria (58). The *M. charantia* leaf extract has shown an anti-malarial action, according to Akanji et al. (59), despite the fact that the mechanism remains unclear. The chemosuppression of parasitaemia and lengthened life span in infected mice treated with the extract and solvent fractions of the plant demonstrate the considerable antiplasmodial activity of the crude extract and solvent fractions of *Momordica charantia* stem (60). Fractionating the crude extract of the plant improved its ability to combat malaria, with the ethyl acetate fraction exhibiting the best antiplasmodial efficacy (60). Compared to the conventional antimalarial drugs chloroquine and arteether, *Momordica charantia* was shown to exhibit antimalarial activity; this activity may be attributable to the terpenes, alkaloids, and flavonoids or to a combination of more than one metabolite. This study supports the folk-tale that suggests *Momordica charantia*'s many parts may treat malaria (60).

3.10 Sida acuta

Sida acuta, the common wireweed belongs to the family malvaceae is known as tsanya in Hausa. The plant is a little perennial herb or small shrub with erect, branching stems that reach a height of around l.5 meters. The root of this tree is long, narrow, cylindrical, and very rough. Its bark is smooth and greenish. It has lance-shaped, almost glabrous leaves, and peduncles that are the same length as petioles. Its seeds are smooth and black, with yellow blooms that can bloom alone or in pairs. It may be found in large quantities in cultivated fields, waste areas, and roadside verges. This plant may be propagated successfully using both seeds and stem cuttings (61). The *Sida acuta* species was phytochemically screened, and it was found to contain tannins, phenolic compounds, steroids (ecdysterone, -sistosterol, stig1naterol, ampesterol), saponosides, and alkaloids including vasicine, ephedrine, and cryptolepine (the plant's

main alkaloid) (62). *Sida acuta* has been established to have a range of pharmacological potentials in traditional medicine, including antipyretic, anti-inflammatory, antibacterial, anti-ulcer, and antimalarial properties (63). The herb is commonly used in Nupe land in north-central Nigeria in the management of fever associated to malaria. The decoction of the leaves is taken orally to treat malaria in northern Nigeria (58), *Sida acuta* leaf crude ethanol extract was safe, and no overtly acute side effects were noticed. With an LD_{50} of 2154 mg/kg bodyweight, the crude alkaloid extract from *S. acuta* leaves exhibited antiplasmodial action against the *P. berghei* malaria parasite, which was comparable to chloroquine (standard drug) (64). According to study carried out by Adesina *et al* (65), *S. acuta* methanolic extract demonstrated effective *in vitro* antimalarial property against *Plasmodium falciparum* with IC_{50} value of 50 g mL^{-1}. In another study (66) Sida acuta leaf alkaloid, flavonoid, and phenolic extracts have demonstrated antiplasmodial activity. Phenolic extract at the dose of 600 mg/kg bw) indicated the highest level of plasmodial with 64.64% suppression level among the other extracts and was near to the positive control (chloroquine), that caused plasmodial suppression value of 76.79%. The various qualities of the plant and its historical use in medication are a result of bioactive constituents such as alkaloids, cardiac glycosides, coumarins, sesquiterpenes, saponins, steroids, phenolic compounds, and flavonoids in a significant amount in the plant extract.

Other medicinal plants with antimalarial

Table 1. Medicinal Plants with Antimalarial Potentials.

S/N	Scientific Name	Part of the plant	Pharmacologically active component(s)	Antimalarial/Antiplasmodial Activity	Ref
1	*Tithonia diversifolia*	Leaves	Orizabin and tagitinin C a type of sesquiterpene lactones.	Its dichloromethane extract exhibited high antiplasmodial activity (IC_{50} < 10 µg/ml) *in vitro*.	(67)
2	*Ficus vallis-choudae*	Leaves	Wighteone, maslinic acid, and genistein.	It showed high activity in *in vitro* antiplasmodial and *in vivo* antimalarial assays.	(68)
3	*Zea mays*	Husk	Quinine and also tannin a polyphenol	It has demonstrated a significant *in vivo* antimalarial activity toward *P. berghei* infection in mice It also exhibited antiplasmodial activity against *P. falciparum*, chloroquine sensitive and resistant strains *in vitro*.	(69)
4	*Picralima nitida*	Seed	Akuammine an indole alkaloid	The ethanol seed extract demonstrated *in vivo* antiplasmodial activity in addition to the i*n vitro* action.	(70)
5	*Azadirachta indica*	Leaves and Stem bark	β-sitosterol, nimbolide, gedunin and other limonoids	It exhibited a good antiplasmodial activity against *P. falciparum* sensitive (3D7) and resistant (RKL9) strains.	(71)
6	*Chromolaena odorata*	Leaves	Flavonoids	The antimalarial activity of its ethanol fraction was comparable to that of the common medication chloroquine and artemether-lumenfantrine.	(72)
7	*Khaya senegalensis*	Stem bark	Fissinolide	The crude extract exhibited high antiplasmodial activity against chloroquine-resistant *P. falciparum*.	(73)
8	*Ocimum gratissimum*	Leaves	Flavonoids and anthraquinones	It has a significant effect in reducing *P. berghei* growth *in vivo*.	(74)

Continued Table 1.

9	*Vernonia cinereal*	Whole Plant	Sesquiterpene lactones	It has a very promising antiplasmodial activity.	(75)
10	*Ananas comosus*	Peel	Linoleic acid and palmitic acid	It has shown some modest antimalarial action.	(76)
11	*Afzelia africana*	Stem bark	Alkaloids, flavonoids, phenolics and anthraquinones	It exhibits antiplasmodial action against *P. falciparum* strain 3D7.	(77)
12	*Senna occidentalis*	Root	Flavonoids and anthraquinnes	It has remarkable antimalarial activity, *in vitro* and in mice.	(78)
13	*Pteridum aquilinum*	Fond	Haemanthamine	It possesses significant antimalarial activity against *P. berghei*.	(79)
14	*Phyllanthus amarus*	Whole plant	1-O-galloyl-6-O-luteoyl-R-D-glucose	*P. amarus* has good antimalarial activity in both ethanol and aqueous extracts.	(80)
15	*Acacia mellifera*	Leaves and Stem bark	3-(Z)-trans coumaroylbetulin and 3-(E)-cis coumaroylbetulin	Strong antioxidant and antimalarial properties were demonstrated by extracts from the leaves and stem bark.	(81)
16	*Moringa oleifera*	Leaves	Apigenin, kaempferol, rutin, and quercetin	*M. oleifera* leaves have high activity against *P. berghei.*	(82).
17	*Trema orientalis*	Leaves and stem bark	Xanthone, secoiridoid, triterpenes and phytosteroids	Its aqueous extracts have strong antiplasmodial properties.	(83).
18	*Vitex doniana*	Leaves	Abieta-11(12)-ene-9α,13α-endoperoxide, Abieta-11(12)-ene-9β,13β-endoperoxide and 9αH-manoyl oxide	It has the potential to be a good medication option for treating malarial infection.	(84).
19	*Burkea africana*	Stem bark	Rutin and caffeic acid	It has antiplasmodial potential and its antiplasmodial constituents are concentrated in its dichloromethane fraction.	(85).
20	*Guiera senegalensis*	Leaves	Harman and tetrahydroharman	It exhibits strong antiplasmodial activity.	(86).

potentials from Northern Nigeria are summarized in table 1:

4. Conclusion

The numerous ethnobotanical studies conducted in northern Nigeria have made it possible to describe a significant variety of plants used by the local communities to treat malaria in the areas where the disease is endemic, as discussed herein. This article discusses the species that have been tested for antimalarial activity as well as their potential as sources of novel antimalarial chemicals and therapeutic leads. This will serve as a solid foundation for future pharmacological studies and serve as a clear instruction on how to extract the key bioactive components for the manufacture of potential antimalarial medicines. One expects that the identification of active plant components may lead to the development of more potent medications that are both inexpensive and accessible to rural populations most at risk for disease morbidity.

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Conflict of Interest

The authors declare no conflict of interest.

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