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Indigenous medicinal knowledge of plants used in the treatment of malaria in Mazowe and Shamva districts, Zimbabwe

[1]David Singleton Nyasvisvo✉, [2]Christopher Chapano
[1]Department of Biological Sciences and Ecology, University of Zimbabwe,
P. O. Box MP167 Mt. Pleasant, Harare, Zimbabwe
[2]National Herbarium and Botanic Garden, Fifth Street Extension, Alexandra Park,
P. O. Box A889, Avondale, Harare, Zimbabwe
ORCID ID: 0009-0008-0729-4159

✉ david.nyasvisvo@students.uz.ac.zw

Abstract.

Aims*.** The indigenous medicinal knowledge (IMK) of plants used in the treatment of malaria in selected localities of Mazowe and Shamva districts was assessed and documented. ***Methods*.** An anthropological method comprising structured interviews was used to collect data from 25 purposively sampled key informants. Relative frequency of citation (RFC) was used for data analysis. Eleven plant species from eight families, comprising native (63.6 %) and exotic (36.4 %) species were listed. ***Results. Based on RFC data, the most frequently mentioned plants were *Lippia javanica* (Burm.f.) Spreng (88.0 %) and *Capsicum frutescens* L. (84.0 %). Trees (45.5 %) and herbs (36.4 %) were the primary sources of medicinal plants, while roots (36.4 %), leaves (27.3 %), and bark (18.1 %) were the most commonly used parts. Decoction (54.5 %), infusion (36.4 %), and oral administration (100 %) were the most common methods of preparation and administration. A few of the plants (36.4 %) have documented antimalarial activities, while the majority of them (81.8 %) have similar ethnomedicinal uses in other parts of the country. ***Conclusions*.** In this context, the results obtained from this study could be used as a basis for developing future malaria medicines using local IMK and resources.

Key words: Anthropological method, exotic plants, native plants, decoction, infusion, oral administration.

Медичні знання корінних народів Зімбабве про рослини, що використовуються для лікування малярії в районах Мазове та Шамва

[1]Девід Сінглтон Нясвісво✉, [2]Крістофер Чапано
[1]Кафедра біологічних наук та екології, Університет Зімбабве, Хараре, Зімбабве,
[2]Національний гербарій і ботанічний сад, Хараре, Зімбабве
ORCID ID: 0009-0008-0729-4159

✉ david.nyasvisvo@students.uz.ac.zw

Реферат.

Мета. Оцінити й задокументувати місцеві лікарські знання (МЗК) щодо рослин, які використовуються для лікування малярії в окремих населених пунктах Мазовецького та Шамвського районів Зімбабве. ***Матеріали і методи.*** Для збору даних використовували антропологічний метод, що включав структуровані інтерв'ю від 25 цілеспрямовано відібраних ключових респондентів. Для аналізу даних використовували метод відносної частоти цитування (ВЧЦ). До списку опитування було включено одинадцять видів рослин з восьми родин, зокрема 63,6 % аборигенних та 36,4 % екзотичних видів. ***Результати***. Згідно з даними ВЧЦ найчастіше згадуваними рослинами були *Lippia javanica* (Burm.f.) Spreng (88,0 %) та *Capsicum frutescens* L. (84,0 %). Дерева (45,5 %) і трави (36,4 %) були основними джерелами лікарських рослин, тоді як коріння (36,4 %), листя (27,3 %) й кора (18,1 %) були найбільш часто використовуваними їхніми частинами. Відвар (54,5 %), настій (36,4 %) та пероральний прийом (100 %) були найпоширенішими методами приготування та застосування ліків. Задокументовану протималярійну активність мали 36,4 % рослин, тоді як більшість (81,8 %) характеризуються схожим етномедичним використанням в інших частинах країни. ***Висновки***. Отже, отримані в цьому дослідженні результати, можуть бути використані як основа для розробки майбутніх ліків від малярії з використанням медичних знань корінних народів та місцевої лікарської рослинної сировини

Ключові слова: Антропологічний метод, екзотичні рослини, місцеві рослини, відвар, настій, пероральне застосування.

Introduction. Malaria is an important and infectious, mosquito-borne disease that is a public health challenge in Zimbabwe where approximately 75 % of the malaria cases are recorded from three provinces namely Manicaland, Mashonaland East, and Mashonaland Central (PMI, 2023). Mazowe and Shamva districts are malaria-endemic districts in Mashonaland Central Province. Challenges associated with malaria control are increased resistance of malaria vectors to all WHO-approved insecticides and of malaria parasites to available antimalarial drug regimens (WHO, 2022). The constant threat of drug-resistant malaria drives the need for new

antimalarial drugs. This calls for strategies, research, and innovation to better leverage existing tools and to develop new tools against drug resistance. One such strategy involves the application of indigenous medicinal knowledge (IMK) in the ethnopharmacological screening of plants for the discovery of new and effective antimalarial drugs, since many plants are traditionally used to confer protection against malaria.

Indigenous medicinal knowledge is knowledge inherited in the form of skills, beliefs, value systems, and the concept that people in a given area have developed and continue to develop based on experience and adapted to the local culture and immediate environments (Chavhunduka, 1994). Indigenous people in different parts of the world have depended on herbal medicine or plants for their primary health care needs as either primary therapies or complementary medicines (Shoppo et al. 2022). People in developing countries depend on local medicinal plants fulfilling own primary care needs due to their easy accessibility, the efficacy of treatment, and affordable cost (Konno, 2004; Maroyi, 2011). According to S. M. K. Rates (2001), 25 % of prescription drugs used in modern medicine are derived from plants and most of the drugs are made from precursor compounds of plant origin.

The concept of IMK has been of great importance in Zimbabwe since pre-historic times because people have been using traditional herbs to treat various human ailments before the advent of modern medicine (Shoppo et al., 2022). Even today, traditional medicines provide solutions to the health needs of people who cannot afford expensive modern medicines in clinics, hospitals, and private health facilities (Dimene et al., 2020). The popularity and demand for traditional medicine in Zimbabwe are evidenced by the increase in the number of herbal clinics in both urban and rural parts of the country. Yet, despite the increasing acceptance and use of traditional medicine in Zimbabwe, this IMK is not adequately documented and remains a family specialization that is transmitted orally and kept without any written records.

To avoid distortions and promote the conservation of IMK and the sustainable utilization of plants for medicinal purposes, documentation is necessary. Only a few studies were conducted in some parts of Zimbabwe on IMK of plants used in the treatment of malaria (Ngarivhume et al., 2015). Similar studies are lacking in Mazowe and Shamva districts in Mashonaland Central province. This study was undertaken to assess and document the IMK of plants used in the treatment of malaria in selected localities of Mazowe and Shamva districts, Mashonaland Central province, Zimbabwe.

Materials and Methodology. Study area. Mazowe district, located about 50 km north of Harare (Zimbabwe's capital city), is characterized by lower seasonal malaria transmission in comparison to other districts in the province. Whilst Shamva district, located about 90 km northeast of Harare, is characterized by moderate to high malaria transmission (Malaria Control..., 2020). In 2022, there were a total of

627 malaria cases and 4 deaths recorded in Mazowe district and a total of 4159 malaria cases and 5 deaths recorded in Shamva district (Zimbabwe DHIS2).

The study was conducted at Bare (16.87°S; 31.12°E; alt 1244m) and Mupfurudzi (16.97°S; 31.66°E; alt 956 m) wards in Mazowe and Shamva districts respectively, Mashonaland Central province, Zimbabwe. The two wards were selected based on the previously reported high number of malaria cases (Bare and Mupfurudzi Rural Health Centres (RHCs) unpublished data) and perceived medicinal plant use practices of the community since they also rely on plants for protection against mosquito bites (Nyasvisvo et al., 2024). Twenty-five (25) key informants, 9 from Bare and 16 from Mupfurudzi, were selected for the interviews using purposive sampling with assistance from the Environmental Health Technicians (EHTs) from Bare and Mupfurudzi RHCs, community leaders, and Community Health Workers (CHWs).

Data collection. Structured interviews were conducted individually with each key informant to avoid direct influences from third parties using the native Shona language. The interviews focused on collecting information on the key informant's knowledge of plants used in the treatment of malaria, as well as plant parts used, method of preparation, and method of administration. Demographic information such as age, gender, employment status, and education level were also collected during the interviews.

Plant collection and identification. Plants mentioned by the key informants were identified in the field with assistance from the key informants. Specimens of the identified plants were collected following herbarium standards, processed using standard taxonomic procedures, and presented to a taxonomist at the National Herbarium and Botanic Garden in Harare, Zimbabwe for species (ID) confirmation. Voucher specimens were deposited for future reference and record purposes at the National Herbarium, Harare, Zimbabwe.

Ethnobotanical indices. To determine the local importance of each species, the method by Tardio & Pardo-de-Santayana (2008) was used to calculate RFC as follows:

RFC = FC/N, where **RFC** is the relative frequency of citation; **FC** is the number of key informants mentioning the use of the species; and **N** is the total number of key informants participating in the study.

Informed consent and ethical consideration. The study was carried out following the recommendations of the International Society of Ethnobiology Code of Ethics. Permission to conduct the study was obtained from the Mashonaland Central Provincial Medical Directorate and community leaders. The purpose of the study was explained to the key informants before the interview. Informed verbal consent was obtained from each key informant who participated in the study.

Results. Demographic characteristics of the key informants. The key informants comprised 44 % men and 56 % women and were all in the 50 years and

above age category. All the key informants had no formal employment and had little formal education, with none having studied beyond primary level education. There was a high level of awareness of malaria among the informants, as they all indicated that malaria is transmitted through the bite of infected mosquitoes. This is likely due to the successful government's malaria awareness campaigns in both districts. The key informants indicated that they use a combination of at least five of the following symptoms in the diagnosis of malaria: headache, loss of appetite, vomiting, nausea, general body weakness, sweating, cold, and fever.

Plant families, species, and RFC values. The key informants listed eleven plant species belonging to eight families as traditional remedies for malaria in the study area. Of these plant species, six were listed in both districts, four in Mazowe district only and one in Shamva district only. Plants such as *Lippia javanica* (Burm.f.) Spreng and *Capsicum frutescens* L. had very high RFC values (Table 1). Four plants, namely *Lannea discolor* (Sond.) Engl., *Catharanthus roseus* (L.) G. Don, *Thespesia garckheana* F. Hoffm and *Grewia flavescens* Juss. var *flavescens* had a very low RFC value of 0.04.

Table 1. RFC values of plants used in the treatment of malaria at Bare and Mupfurudzi wards in Mazowe and Shamva districts respectively, Zimbabwe

Family	Scientific Name	Vernacular (Shona) Name	Voucher Specimen Number	RFC
Anacardiaceae	*Lannea discolor* (Sond.) Engl.	Shambavazukuru*	DSN 01	0.04
Apocynaceae	*Catharanthus roseus* (L.) G. Don.	No Shona name was given*	DSN 19	0.04
	Diplorhynchus condylocarpon (Mull.Arg.) Pichon.	Mutowa	DSN 10	0.24
Asteraceae	*Dicoma anomala* Sond.	Chifumuro	DSN 46	0.36
Caricaceae	*Carica papaya* L.	Mupopo**	DSN 48	0.08
Fabaceae	*Cassia abbreviata* Oliv.	Muremberembe	DSN 36	0.24
Malvaceae	*Thespesia garckheana* F. Hoffm	Mutohwe*	DSN 28	0.04
	Grewia flavescens Juss. var *flavescens*	Mugurumhanda*	DSN 12	0.04
Solanaceae	*Capsicum frutescens* L.	Mhiripiri	DSN 22	0.84
Verbenaceae	*Lantana camara* L.	Mbarapati	DSN 37	0.28
	Lippia javanica (Burm.f.) Spreng	Zumbani	DSN 31	0.88

*Plant listed in Mazowe district only; **Plant listed in Shamva district only

Growth form, status, parts used, and method of preparation and administration. Plants traditionally used in the treatment of malaria in the study area comprised trees (45.5 %), herbs (36.4 %), and shrubs (18.2 %). The majority of the

plants (63.6 %) are native to Zimbabwe, while the remaining (36.4 %) are exotic species. Plant parts and methods of preparation were generally the same in both districts. The key informants harvested different plant parts to prepare traditional remedies for malaria and the most used parts were roots (36.4 %), leaves (27.3 %), bark (18.1 %), and fruits and bulbs (9.1 % each).

Except for *C. frutescens* L., fresh or dried parts of the plants used to treat malaria are mixed with water as either a decoction or an infusion and taken orally as medicine. The fruit of *C. frutescens* L. is swallowed directly without chewing. In the treatment of malaria, monotherapy prevailed, and combination therapy was used only with *C. papaya*, which was mixed with *Mangifera indica* L., *Bidens pilosa* L., and *Cymbopogon citratus* (DC) Stapf. in a certain ratio to obtain an herbal preparation with several active ingredients. Plant growth form, status, plant part used along with the method of preparation and administration are described in the following paragraphs:

1). *Lannea discolor* (Sond.) Engl. — commonly known as the Live-long tree, is a medium-sized deciduous tree that is native to Zimbabwe and widely distributed in the country and other southern African countries (Chapano & Mamuto, 2003). It grows on the termite mounds, either stony slopes or rocky outcrops in open woodlands. *Lannea discolor* (Sond.) Engl. logs used as fencing poles easily grow roots and flourish again. Its leaves are markedly discolorous (upper surface green, lower surface grey), compound with more than ten pairs of leaflets and a terminal leaflet (Chapano & Mamuto, 2003). Flowering occurs between September and October. Flowers are cream to yellow in color and are produced in sweetly scented spikes. It is used in traditional medicine to cure various ailments by many rural Zimbabwean communities (Maroyi, 2011, 2013, 2018a). An infusion or decoction of the bark (Fig. 1. A) and roots are prepared and administered orally for the treatment of malaria, fevers, and constipation.

2). *Catharanthus roseus* (L.) G. Don. — commonly known as pink periwinkle, graveyard plant, or bright eyes is a perennial herb that grows up to 1m in height. It is exotic to Zimbabwe but is widely grown or cultivated in the country for its ornamental qualities, medicinal properties, and potential uses in cancer treatment and diabetes management. It is cultivated in gardens for its ornamental flowers, and landscape purposes, including as a container plant. Furthermore, it is also used for edging, ground cover, and naturalizing. Root decoctions are prepared and administered orally for the treatment of malaria and stomach ache problems.

3). *Diplorhynchus condylocarpon* (Mull.Arg.) Pichon. — commonly known as Horn pod tree, is a shrub or small deciduous tree with a drooping appearance that grows up to over 2 m in height. It is native to Zimbabwe and other southern African countries (Chapano & Mamuto, 2003). It grows in open woodlands and on stony hillsides. Its leaves are shiny yellowish-green, opposite, elliptic, pointed at the apex with conspicuous pale-yellow midrib and lateral veins (Fig. 1. B). Flowering occurs

from September to December and its flowers are sweetly scenting, and are white to cream, and occur in loose clusters near the ends of branches. Its bark is rough and deeply fissured. Its fruits are produced in paired, dark brown, woody, boat-shaped pods that are beaked at the apex and heavily dotted with pale lenticels. All the plant parts contain a milky latex (Chapano & Mamuto, 2003). *Diplorhynchus condylocarpon* (Mull.Arg.) Pichon**.** is a valuable tree whose significance in local Zimbabwean communities varies from medicinal to practical purposes (Maroyi, 2011, 2013). Its diverse uses range from traditional medicine (leaves, bark, and roots), to sources of firewood, fodder, charcoal, latex, and timber. Its traditional medicinal applications include the treatment of pneumonia, and rushes (Maroyi, 2011, 2013). For the treatment of malaria, bark decoction is prepared and take orally.

4). *Dicoma anomala* Sond. — commonly known as fever bush, is an erect, perennial shrub or herb that bears aromatic semi-woody tubers at the base of a woody subterranean stem (Maroyi, 2018b). It is commonly found in tropical Africa, where it is a significant plant. It is native to Zimbabwe and other southern African countries, where it is considered a valuable plant due to its diverse medicinal, pharmacological, and phytochemical properties (Maroyi, 2011, 2013, 2018b). Habitually, it grows in grasslands and open woodlands. The plant may grow up to 60 cm in height as few to many hairy, erect stems arising from one woody rootstock. Its leaves are simple, stalkless, narrow, linear, or lanceolate and positioned alternately on the stem (Maroyi, 2018b). They are olive green on the upper surface, and white, and downy on the lower surface. Its flower heads are pinkish-white, terminal, and cup or cone-shaped (Fig. 1. C). *Dicoma anomala* Sond. is widely used in ethnomedicine in the southern African region for the treatment of various ailments in humans and animals. For example, its root decoction is used for treating gall sickness in animals while its dried powders are used for treating sores and wounds in both humans and animals (Maroyi, 2011, 2013, 2018b). It has potential in cancer treatment (Maroyi, 2018b). Bulb or root decoctions are prepared and administered orally for the treatment of stomach upsets and malaria.

5). *Carica papaya* L. — commonly known as papaya tree, is a tropical plant with a single trunk and large, simple, and lobed leaves (Fig. 1. D). It is exotic to Zimbabwe but is widely cultivated locally in gardens, orchards, and homesteads for its medicinal, nutritional, cosmetic, and landscaping features. *Carica papaya* L. produces fragrant flowers along with the fruit. The plant is known for its sedative, muscle relaxant, contraceptive, and purgative properties and is traditionally used in the treatment of various ailments, including inflammatory conditions (Kazembe & Makusha, 2012). Its fruit is valued for its nutritional and potential health benefits. Water extracts of *C. papaya* L. seeds repel various kinds of insects, while juice extracted from the immature fruit controls termites (Kazembe & Makusha, 2012). For the treatment of malaria, infusions of leaves or roots of *C. papaya* L. are prepared,

mixed with infusions of *M. indica* L., *B. pilosa* L., and *C. citratus* (DC) Stapf. and taken orally.

***6). Cassia abbreviata* Oliv.** — commonly known as the sjambok pod or long-tail cassia, is a tropical shrub or small rounded tree that is native to Zimbabwe, eastern and southern African countries (Chapano & Mamuto, 2003; Mojeremane et al., 2005). It grows in grasslands and open woodlands. Its leaves paripinnate without any glands on the rachis or petiole young leaves are hairy on the under surface and leaflets are in 7–12 pairs (Fig. 1. E). The bark is greyish-brown and is longitudinally furrowed (Fig. 1. F). Flowering occurs from September to October and the flowers are yellow (Drummond, 1981). Its fruit is a long and cylindrical pod that is brown (Fig. 1. E). It has diverse properties and uses. *Cassia abbreviata* Oliv**.** has traditional medicinal applications and potential insecticidal properties (Mojeremane et al., 2005). Its phytochemical constituents including tannins contribute to its potential health benefits and medicinal properties. Its bark and roots are traditionally used for medicinal purposes in Zimbabwe (Maroyi, 2011, 2013; Ngarivhume et al., 2015; Nyagumbo et al. 2022; Shoppo et al., 2022) and in Botswana (Mojeremane et al., 2005). Bark and root decoctions are prepared and administered orally for the treatment of malaria.

***7). Thespesia garckheana* F. Hoffm.** — also known as the African tulip tree, is a semi-deciduous that is native to Zimbabwe, and other southern and eastern African countries (Chapano & Mamuto, 2003; Chapano & Mugarisanwa, 2003). It grows in a wide range of habitats ranging from rocky places in grasslands, and riverine vegetation to open woodlands. It grows up to 10 m and is readily recognizable by the distinctive longitudinal fissure on the mid-vein beneath (Chapano & Mugarisanwa, 2003). The fissure may be differently coloured to the rest of the leaf or not, and may be of various sizes. Its lamina of the leaves is subcircular in outline, palamately 3–5-lobed with a 5–10 mm linear fissure on the mid-vein from below. Flowering occurs from December to May and its flowers are purplish or yellowish with a dark purple or dark red centre. *Thespesia garckheana* F. Hoffm. fruit is a capsule that is subspherical to broadly ovoid or ellipsoid, glutinous (Fig. 1. G). Various parts (leaves, bark, roots, fruits) of the plant are utilized for traditional medicinal applications (Maroyi, 2011, 2013). Root decoctions are prepared and administered orally for the treatment of malaria.

8). *Grewia flavescens* Juss. var *flavescens.* — commonly known as Donkey-berry, is a scrambling shrub with older branches that are distinctly square-angled. It is native to Zimbabwe and is found throughout tropical Africa, the Arabian Peninsula, and India (Chapano & Mamuto, 2003). It grows on termite mounds in open woodland, rocky outcrops or hillsides, and along the margins of riverine and evergreen forests. *Grewia flavescens* Juss. var *flavescens* leaves are light green, oblanceolate to obovate, and with stellated hairs on both sides. Leaf margins are irregularly toothed (Fig. 1. H). It produces yellow flowers that are axillary in groups

of two or three. It is used in traditional medicine to treat various ailments in many rural Zimbabwean communities (Maroyi, 2011, 2013). Leaf infusions are prepared and taken orally for the treatment of malaria.

9). *Capsicum frutescens* L. — commonly known as chili pepper, is an annual or short-lived perennial herb. It is exotic to Zimbabwe but is cultivated locally in gardens and around homesteads for its medicinal and nutritional properties. It also grows in abandoned cultivated areas and roadsides. Its leaves are smooth, medium-sized, and elliptical. *Capsicum frutescens* L. flowers are white with a greenish-white or greenish-yellow corolla. Its fruits are used in pharmaceutical products for conditions such as arthritis and athlete's foot. Its powders are used to repel mosquitoes in some rural parts of Zimbabwe (Kazembe, 2011; Nyasvisvo et al., 2024). The fruits are traditionally used to relieve symptoms of colds, hangovers, sore throats, and fevers (Kazembe & Makusha, 2012). The fruits are swallowed directly without chewing for the treatment of malaria.

10). *Lantana camara* L. — commonly known as cherry pie, is an untidy spreading shrub or ornamental weed with four-angled stems with thorns that grows up to 2 m or higher (Etuh et al., 2021). It is an invasive shrub species that is exotic to Zimbabwe but has spread extensively throughout the country, competing with and replacing indigenous species (Chapano & Mamuto, 2003). *Lantana camara* L. is originally from Central and South America (Castairs et al., 2010). It grows in disturbed or formerly cultivated areas and woodlands. Its leaves are dark green, oval, rough, and sometimes hairy (Fig. 1. I). Flowering occurs from September to April, and it produces small clustered leaves that are often pink, red, orange, yellow, or white. *Lantana camara* L. unripe fruits are glossy green but turn purplish black when ripe. It is one of the most important medicinal plants all over the world (Dua et al., 1996; Sharma, 2001). Its leaves and green berries are toxic to livestock, but decoctions prepared from *L. camara* L. leaves are traditionally used in herbal medicine for fever treatment, skin rashes, wound healing, influenza, and stomach ache treatments (Chharba et al., 1993). Root infusions are prepared and administered orally for the treatment of malaria.

11). *Lippia javanica* (Burm.f.) Spreng. — commonly known as fever tree, wild tea, wild sage or lemon bush is a woody erect, multi-stemmed perennial shrub or herb that is native to Zimbabwe and other parts of southern, eastern, and Central Africa (Maroyi, 2017). *Lippia javanica* (Burm.f.) Spreng is drought-resistant, adapts well to different soil types, and grows on hillsides, roadsides, stream-banks, forest edges, grasslands, and bush-veld (van Wyk & Geriche, 2000). It grows up to 2 m in height. The leaves are opposite, often in whorls of up to four, 3–4 cm long, and hairy on both sides (Fig. 1. J). The leaves are very aromatic and give off a lemony scent when crushed (van Wyk & Gericke, 2000). *Lippia javanica* (Burm.f.) Spreng bears dense rounded flower heads that vary in color from white, cream to yellow and flowers continuously from February to May (Maroyi, 2017).

Lippia javanica (Burm.f.) Spreng is a nutraceutical (both nutritional and medicinal) plant, since it has several beneficial nutritional and medicinal components. The plant has a wide range of pharmacological activities such as antioxidant, antidiabetic, antiplasmodial, antimalarial, pesticidal, and insecticidal effects (Lukwa et al., 2009; Maroyi, 2017). *Lippia javanica* (Burm.f.) Spreng is a good source of phenolic compounds, antioxidants, and phytochemicals such as flavonoids, alkaloids, iridoids, and essential oils which contribute to its medicinal properties (Lukwa et al., 2009; Maroyi, 2017). The plant is also widely used as a mosquito repellent, herbal tea and for treating skin infections, asthma, sore throats, pneumonia, coughs, and sinuses in Zimbabwean communal areas (Lukwa et al., 2009; Maroyi, 2017; Nyasvisvo et al., 2024). Crushed fresh or dried leaves infusions, as well as infusions of twigs, are used to treat malaria or as a prophylactic against malaria and are taken orally.

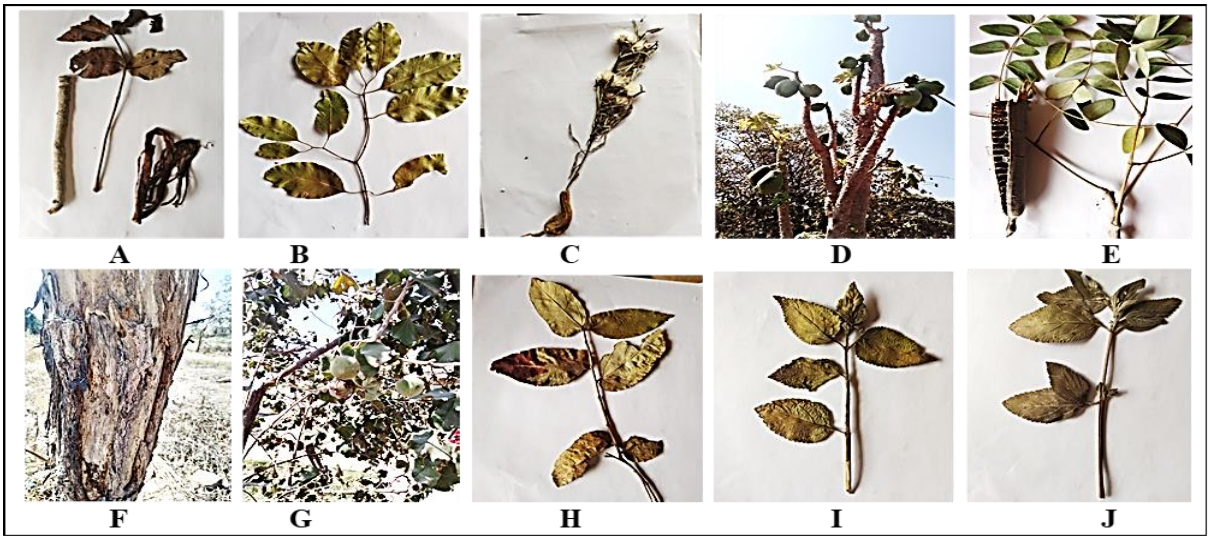

Figure 1. **A** — *L. discolor*; **B** — *D. condylocarpon*; **C** — *D. anomala*; **D** — *C. papaya*; **E** — *Cassia abbreviata*, leaves & fruit pod; **F** — *C. abbreviata*, stem & bark; **G** — *T. garckheana*; **H** — *Grewia flavescens*; **I** — *Lantana camara*; **J** — *Lippia javanica*

Discussion. The present study provides an additional inventory of herbal plants that can be selected for use in the development of future complementary malaria medicines. The reliance on plants in the treatment of various ailments is a common practice in Zimbabwe, other African countries, and other parts of the world where people rely on plants to meet their primary healthcare needs (Maroyi, 2013; Sreekeesoon & Mahomoodally, 2014; Ngarivhume *et al*., 2015; Shoppo *et al*., 2020; Ndhlovu *et al*., 2023). Plants such as *C. roseus* (L.) G. Don., *D. condylocarpon* (Mull.Arg.) Pichon., *D. anomala* Sond., *C. papaya* L., *C. abbreviata* Oliv., *C. frutescens* L., *L. camara* L., and *L. javanica* (Burm.f.) Spreng listed in this study have similar uses in other parts of the country (Maroyi, 2011, 2013; Ngarivhume et al., 2015; Maroyi, 2018a, b; Nyagumbo et al., 2022; Shoppo et al., 2022). Furthermore, all the plants are also used for repelling mosquitoes in the two districts (Nyasvisvo et

al., 2024). Similarities in the cross-cultural usage of traditional plant remedies are a strong indication of the bioactivity potential of the plants (Maroyi, 2013). Thus, the results of this study enrich the growing pharmacopoeia for the treatment of malaria and, with due attention, can contribute to national antimalarial drug development.

There were huge similarities in the list of plants utilized by the key informants and the utilization methods despite the spatial separation of the two districts in this study. However, some of the plants were different from those used to treat malaria in Chipinge district and other parts of the country (Maroyi, 2011, 2013; Ngarivhumme et al., 2015; Maroyi, 2018a, b; Nyagumbo et al., 2022; Shoppo et al., 2022). This brings novelty concerning knowledge of plants used in the treatment of malaria in Zimbabwe. The differences also indicate that there are variations in the quality and quantity of IMK across Zimbabwe. Indigenous medicinal knowledge is dependent on social and economic status, age, education, gender, functional responsibilities in the community, level of curiosity, and control over natural resources (Quave & Pieroni, 2015). According to Quave & Pieroni (2015), similarities and differences in indigenous knowledge among different communities living within the same ecological region provide an understanding of how cultural reflection can change individual viewpoints about the environment and guide interactions between humans and resources in their ecosystems.

Four of the plants namely *C. abbreviata* Oliv. and *T. garckheana* F.Hoffm. (Connelly et al., 1996), *L. camara* L. (Batista et al., 2009) and *L. javanica* (Burm.f) Spreng (Maroyi, 2017) have documented antimalarial activities. It is important to investigate and validate their efficacy and safety in future studies before these plants can be considered for use in the development of future malaria medicines. The scientific evaluation of the antimalarial efficacy or properties of the other plants is an essential future perspective.

High RFC values for plants such as *L. javanica* (Burm.f.) Spreng and *C. frutescens* L. in the present study indicate the cultural importance that is attached to these plants. The popular use of these medicinal plants for the treatment of malaria within the cultural folklore of the local communities in the study area could have been influenced by factors such as availability and indigenous success. Availability and indigenous success influence the cultural importance of plants (Caetano et al., 2020). The adventitious nature of the key informants in this study is reflected in their knowledge and use of exotic plants, such as *C. roseus* (L.) G. Don., *C. papaya* L., *C. frutescens* L., and *L. camara* L. in the treatment of malaria.

The growth forms of plants listed in the present study (trees, shrubs, and herbs) are drought-resistant and are available almost year-round since they are not affected by seasonal variations (Albuquerque, 2006). The high use of herbs for treating malaria in the study area is encouraged from a conservative perspective, since herbs regenerate and grow faster after being harvested (Ndhlovu et al., 2023).

Various plant parts such as leaves, roots, bark, and fruits are used to prepare traditional malaria medicine in the study area. These plant parts are known to contain bioactive compounds that have wound-healing, antimicrobial, anti-inflammatory, and antioxidant properties (Ndhlovu et al., 2023). Leaves and fruits are rich sources of bioactive compounds such as flavonoids, carotenoids, sterols, tannins, phenolics, lipids, tocopherols, anthocyanins, vitamins, and minerals while the bark contains glycosides, phenolics, tannins, sterols, flavonoids, and terpenoids. Flowers are rich in pigments, such as betalains, carotenoids, and anthocyanins, and other bioactive compounds, such as resins and sterols while seeds contain many secondary metabolites such as alkaloids, saponins, phenolics, and sterols. Roots were the most commonly used part, while whole plants are rarely used for the treatment of malaria in the study area. The use of the entire plant results in the destruction of the plant. Roots are rich in and are storage organs of secondary metabolites such as terpenoids, alkaloids, and flavonoids and are believed to have higher concentrations of active ingredients (Ndhlovu et al., 2023). However, harvesting parts such as roots and bark increases the conservation strains of the plants.

To ensure sustainable utilization of the medicinal plant resources, the key informants indicated that in cases where roots or barks are used, they cut a few parts and leave the plant to survive for future use. For the bark, harvesting is done on the eastern and western sides, where the sun speeds up the healing of the cut area. Most of the plants used in the treatment of malaria in this study are harvested from the wild, and they may face extinction from uncontrolled harvesting. It is therefore critical to educate the key informants on the significance of conserving the flora around their communities.

The results on the use of plants' decoctions and infusions correlate with the results of previous studies on their use in Zimbabwe traditional medicine (Maroyi, 2013; Ngarivhume et al., 2015; Shoppo et al., 2022; Ndhlovu et al., 2023). Although the parts used and methods of preparation were the same in both districts, there was no standardization of dosages since key informants from the different districts indicated that they prescribed different dosages, through estimation, for the same plant to different age groups and different physical conditions of the patient with older people getting higher dosages than children. This lack of standardization and quality control is one of the disadvantages of traditional medicine (Bekalo et al., 2009). Hence, there is also a need to standardize the preparation and dosage of traditional medicines in the study area and match them with western or modern medicine procedures.

Although monotherapies were dominant in this study, the concept of synergy or combinatorial effect reflected a shift from mono-substance therapy to combination therapies in traditional medicine in the study area. *Carica papaya* L., *M. indica* L., *B. pilosa* L. and *C. citratus* (DC) Stapf are mixed in a given ratio to come up with an herbal formula with multiple active components for the treatment of malaria.

A holistic formulation is believed to have additive or synergistic therapeutic activities that each ingredient lacks when used in isolation (Bussman & Sharon, 2006).

Conclusions. The emergence of drug-resistant malaria pathogens requires new antimalarial drugs. Findings from this study revealed IMK practices used to confer protection against malaria in Mazowe and Shamva districts, Zimbabwe. The results enrich a growing base of pharmacopeia in the management of malaria and provide a basis for developing future malaria medicines using local IMK and resources. To confirm the claims of the key informants in this study, an evaluation of the antimalarial efficacy and safety of the documented plants in future studies is required and significant.

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