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Ethnobotanical survey of medicinal plants used for the treatment of malaria by tribal communities of Anuppur district, Central India

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Medicinal plants are abundant sources of bioactive secondary metabolites and play a crucial role in the treatment and management of various diseases. The present research involves the documentation of ethnomedicinal plants used by tribal people residing in the district of Anuppur, Madhya Pradesh, Central India. To obtain data on ethnomedicinal plants, a semi-structured interview schedule was conducted with the local tribal people, who have engaged in the folk practice and use ethnomedicinal plants to treat malaria disease. The obtained data were analyzed using statistical parameters like Relative Frequency Citation (RFC), Relative Importance Index (RI), Frequency Citation (FC), and Jaccard Coefficient of Similarity (JCS) etc. In the present study, a total of 44 respondents were exclusively interviewed, who revealed information about the medicinal plants used to treat malaria. A total of 24 medicinal plants, belonging to 20 plant families were documented, in this study. In conclusion, the majority of plants used by the tribal communities were used in combination form (24%) rather than a single plant. In order to conserve this important traditional knowledge, documentation is necessary which may provide new lead(s) for drug discovery in the future. Thus, the present research aims to demonstrate and document the importance of folk medicine in the study region as a novel source of anti-malarial drug(s).

Keywords: Anuppur district, Ethnomedicinal plants, Malaria, Traditional practitioner, Tribal community

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Malaria is a worldwide critical public health crisis for both developing and developed countries, especially in tropical countries like Asia and Africa; it is transmitted to humans through blood parasites produced by the bite of infected female mosquitoes (*Anopheles mosquitoes*)[1]. The malaria parasites are classified into six categories that are *Plasmodium vivax*, *P. falciparum*, *P. ovalewallikeri*, *P. ovalecurtisi*, *P. malariae* and *P. knowlesi* which can spread malaria and can affect the communities in a mass scale[2]. According to the WHO, around 41 percent of the global population lives in high-risk malaria-endemic areas[3]. The two plasmodial species *viz.*, *P. falciparum* and *P. vivax* are the highly dangerous parasites with greatest threat. *P. falciparum* is the leading and deadly malaria parasite species in Asia and African countries, while *P. vivax* is the most predominant malaria parasite species in countries outside the continent like Americas, eastern Mediterranean region and European region.

Based on the World Malaria Report 2022, 247 million cases of malaria were reported in the year 2021 in endemic countries, an increase from 245 million cases in 2020, with most of this coming from African Region. In the past peak years between 2019-2021, an additional 13.4 million malaria cases were reported and 63 thousand additional malaria deaths due to disruptions to essential malaria services during the COVID-19 pandemic[5].

India is slated for malaria elimination by 2030. However, it contributed 1.7% of malaria cases and 1.2% deaths globally, while 83% of the estimated malaria cases and 82% of malaria deaths in South-East Asia Region were observed in 2020[6,7]. Various studies reflected that most traditional community cultures have developed ways and means of preventing malaria attacks and treatment methods for those infected with malaria[8,9].

The utilization of folk medicinal plants, potential sources of a variety of secondary metabolites that can treat and manage various ailments, has become widespread in many nations across the globe. The indigenous tribes of the Anuppur district of Central India

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utilize traditional medicinal plants to prevent and treat various vector-borne diseases. Therefore, the documentation of these local tribal efforts is vital to preserve the traditional knowledge of folk medicine. Hence, the current study attempted to identify effective plants for treating malaria by tribal people or community members of the Anuppur district, Madhya Pradesh.

Materials and Methods

Study area

Anuppur district is situated in the easternmost part of the Indian state of Madhya Pradesh (Fig. 1) spreading over an area of 3724 square kilometers lying between latitude 22º7'- 23º25'N and 81º10'- 82º10'E in length. Shahdol district surrounds the district from north-west to north, Umaria district from the west, and Dindori district to the south-west of Madhya Pradesh state, while Pendra-Gaurela-Marwahi district of Chhattisgarh to the southeast and from Manendragarh of Chhattisgarh state in the east. The Anuppur district is divided into 4 blocks *viz.*, Anuppur, Kotma, Jaithari, and Pushprajgarh, where the Anuppur block is the administrative headquarters of this district. The district is mostly hilly and forest area is inhabited by various tribal communities like *Gond, Baiga, Bhill, Muria, Panica* etc. Amarkantak region of Maikal Hills is the source of three major rivers: the Son River, the Narmada River, and the Johila River. Almost the entire district lies in the Ganges basin, with a smaller fraction in the Narmada basin in the south[10].

Ethnomedicinal data collection

The ethnomedicinal information of folk medicinal plants that were utilized in the management and treatment of malaria was collected and recorded from the local tribal people of Anuppur district, Madhya Pradesh, Central India. The field investigations were conducted from December 2020 to March 2022. A semi-structured interview schedule was administered over the informants to document/collect the information of folk medicinal plants that were utilized by local tribal people of this district[10].

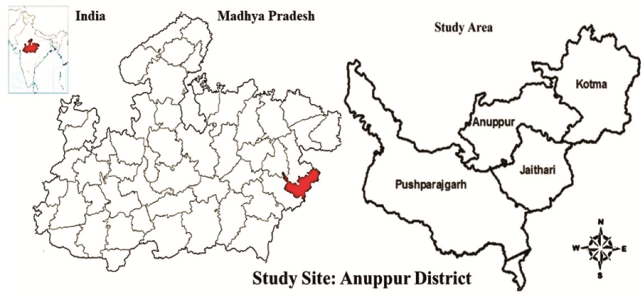

Fig. 1 — Location of the study area: Anuppur District of Madhya Pradesh, Central India (Source: https://www.google.com/maps/place/Anuppur; recreated by the authors based on the study)

Before conducting the field investigation, permission was taken from the village head, called Sarpanch's of each area. After that, formal and informal discussions were held with the knowledge holders with their prior permission. A semi-structured interview schedule was administered on the informants to collect the information on medicinal plants in the study area.

Identification of ethnomedicinal plants

For the identification of medicinal plants, the scientific taxonomical data of the collected medicinal plants was validated using standard plant databases like www.worldfloraonline.org, www.theplantlist.org, www.imppat.org, and www.ipni.org. Finally, the plant specimen's identification was confirmed in consultation with a taxonomic specialist from the Department of Botany, I.G.N.T.U.- Amarkantak, and the herbarium specimens (voucher sheets) were deposited at the Department of Pharmacy, I.G.N.T.U.- Amarkantak, India[11,12].

Statistical data analysis

For the purpose of data analysis, MS Office (Microsoft Excel) was used to analyze the field data using various parameters, and the results were presented graphically. Various statistical parameters such as Relative Frequency Citation (RFC), Relative Importance Index (RI), Frequency Citation (FC), and Jaccard Coefficient of Similarity (JCS) were also assessed for determining the importance of each plant used in treatment of malaria; using the following methodology:

Relative Frequency Citation (*RFC*)

To find out the importance of a specific plant species by respondents, RFC was used, which is determined by the ratio of total number of respondents who cited the utilization of a particular individual plant species (called FC) to the total respondents who participated in the study (N)[13]. RFC can be calculated based on the formula:

RFC = FC/N

Relative Importance Index (*RI*)

This index is used when the use categories have no subcategories. This can be calculated by the average of RFCs (max) relative frequency citation above the maximum and RNUs (max) relative number of use

categories above the maximum. The RFCs (max) can be calculated as same as mentioned above. The RNUs (max) can be calculated as the ratio of total uses of the particular plant species to that of the total number of all species that is recorded in the study area[14]. The given formula was used to calculate the RI:

$RI_s = (RFCs_{(max)} + RNUs_{(max)})/2$

***Frequency Citation* (*FC*)**

For the expression of plant species that were documented in the present study, with and without repetition, can be analyzed by this method. The FC was calculated for all documented medicinal plant species that were recognized in the study[15]. FC can be computed using the given formula:

FC = (The value of a single species documented in the study region/total number of species that were documented in the study region) ×100.

***Jaccard Coefficient of Similarity* (*JCS*)**

The JCS is the statistical analysis where the medicinal plant species were compared in their similarity with other study areas by different researchers in India[16]. The JCS was computed using the given equation:

JCS = c/(a + b - c)

Where "a" represents the total plant species recorded in the investigated region of A (present study area), "b" represents the entire plant species recorded only in the investigated region of B (other study area), and "c" denotes the common species recorded in both investigated regions of A and B.

Results and Discussion

Sociocultural profile of respondents about malaria

In the present study, 140 villages of Anuppur district were involved, including 93 villages of Pushprajgarh block, 17 villages of Jaithari block; 12 villages of Anuppur block; and 18 villages of Kotma block, where a total of 395 local respondents were interviewed, among them 44 respondents are specialized in the management and treatment of malaria as shown in Table 1. Only the male informants (vaidya's) came forward to discuss their knowledge with the interviewers (field investigators), while the female respondents showed no interest in conversing with the interviewers as they felt too shy to discuss. These 44 traditional practitioners (vaidyas) have mastered using local folk plant species to treat malaria and other diseases[17,18]. Most of the respondents belong to the *Gond* tribes (36.36%), followed by the *Baiga* tribes (29.55%), other tribes (18.18%), and other non-tribes (15.91%). The *Gond* and *Baiga* tribes are the largest communities in India known for their folk medicinal system as a longstanding human civilization[19]. They have a lot of experience in diagnosing diseases based on eye color, pulse, and skin/tongue texture. The *Baigas* are noted as "children of nature," and their folk medicinal knowledge has been well identified in the Anuppur district, as well as the in Dindori and Mandla districts of Madhya Pradesh, India[20-22]. All the respondents were between 20 and 85 years of age. Frequencies for other age groups include 20-30 and more than 80 years (2.27%), 31-40 (15.91%), 41-50 (20.45%), 51-60 (34.09%), 61-70 (18.18%) and 71 -80 (06.82%) (Table 1). Middle-aged respondents (41-60 years) are more interested in traditional medicinal practices than the younger respondents due to their many years of practical experience. The educational level of these respondents was categorized as illiteracy (45.45%), primary education (36.36%), secondary education (11.36%), and higher education (06.82%) 45.45 (as

Table 1 — Socio-cultural demographic profile of respondents

Factors	Respondents	Folk Communities				Total	Percentage
		Gond Tribes	Baiga Tribes	Other Tribes	Others		
Gender	Male	16	13	8	7	44	100
Age	20-30	-	1	-	-	1	2.27
	31-40	4	2	1	-	7	15.91
	41-50	2	3	2	2	9	20.45
	51-60	6	4	3	2	15	34.09
	61-70	3	2	2	1	8	18.18
	71-80	1	1	-	1	3	6.82
	>80	-	-	-	1	1	2.27
Education	Illiterate	7	7	3	3	20	45.45
	Primary	7	5	3	1	16	36.36
	Secondary	2	1	1	1	5	11.36
	Higher	-	-	1	2	3	6.82

shown in Table 1) As a result, there is an imperative necessity to record this valuable knowledge before it erodes, as the younger generation are least interested in learning and transmitting the information of folk medicinal plants from their elder generations. Hence, the information on treating the diseases learnt through education and heredity, should be preserved for future generations.

Folk medicinal plants diversity against malaria disease

The present investigation documents medicinal plants utilized by the local tribal people and villagers for malaria treatment and were listed according to their family name, local name, botanical name, and mode of using the plant, etc. In this study, a total of 225 medicinal plants were recorded; among these, a total of 24 plant species were documented that were exclusively targeted against malaria belonging to 20 different families. Majority of these plant species belonged to Apocynaceae (2 species), Fabaceae (2 species), Menispermaceae (2 species), and Solanaceae (2 species) families. In addition, 16 families were characterized by an individual species, as given in Table 2[23,24].

Habit analysis of antimalarial medicinal plants

Habits study of medicinal plant species includes general appearance, growth habit, or architecture, which are predominantly used in developing drug formulations because they are abundant in the investigation area. The most common habit species of medicinal plants were recognized as herbs 10 (41.63%), followed by shrubs and trees 05 each (20.83%) and creepers 04 (16.67%), as shown in (Table 2 and Fig. 2). This can be specified the habit pattern of various therapeutic plant species against malaria disease in the district of Anuppur, Central India. Therefore, a wide variety of plant parts, like the combination of all and single species like leaves, roots, stems, bark, fruits, and seeds, are also utilized for medicinal and therapeutic values[25,29].

Table 2 — Medicinal plants utilized against malaria by the tribal communities of Anuppur district, Central India

Family	Scientific Name and Voucher No.	Local Name	Plant Parts	Habit	Reference
Acanthaceae	*Andrographis paniculata* (Burm.f.) Wall. ex Nees, (IGNTU/DP/16)	Bhuneem /Kalmegh	R, Wp, L	H	[17]
Anacardiaceae	*Mangifera indica* L. (IGNTU/DP/130)	Aam	B	T	[10]
Apocynaceae	*Calotropis gigantea* (L.) W.T. Aiton (IGNTU/DP/40)	Akwan/Madar	Fl	S	[18]
	Holarrhena antidysenterica (L.) Wall. (IGNTU/DP/114)	Koraya/ Kuruchi	B, R	T	[17]
Asteraceae	*Baccharoides anthelmintica* (L.) Moench (IGNTU/DP/24)	Vanjeer	Sd, Fr	H	[18]
Cleomaceae	*Cleome viscosa* L. (IGNTU/DP/57)	Hulhul	L	H	[19]
Combretaceae	*Terminalia arjuna* (Roxb. ex DC.) Wight & Arn. (IGNTU/DP/192)	Arjun	B	H	[10]
Convolvulaceae	*Cuscuta reflexa* Roxb. (IGNTU/DP/71)	Amarbel	St	C	[25]
Cucurbitaceae	*Cucumis pubescens* Willd. (IGNTU/DP/13)	Kacheri	Fr	C	[18]
Euphorbiaceae	*Euphorbia hirta* L. (IGNTU/DP/92)	Doodhi Ghas	Wp	H	[26]
Fabaceae	*Caesalpinia bonduc* (L.) Roxb. (IGNTU/DP/38)	Gataran	L, Fr	S	[27]
	Senna tora (L.) Roxb. (IGNTU/DP/43)	Chakaura	R	H	[27]
Lythraceae	*Woodfordia fruticosa* (L.) Kurz. (IGNTU/DP/207)	Surteli	R	S	[19]
Malvaceae	*Thespesia lampas* (Cav.) Dalzell (IGNTU/DP/196)	Charmuhi	R	H	[18]
Meliaceae	*Azadirachta indica* A. Juss. (IGNTU/DP/23)	Neem	L	T	[27]
Menispermaceae	*Cissampelos pareira* L. (IGNTU/DP/52)	Padhin	R	C	[18]
	Tinospora cordifolia (Willd.) Hook.f. & Thomson (IGNTU/DP/197)	Gurij/Giloe	Wp	C	[17]
Myrtaceae	*Psidium guajava* L. (IGNTU/DP/162)	Amrud	Fr	T	[10]
Ranunculaceae	*Thalictrum foliolosum* DC. (IGNTU/DP/195)	Jhilmili/pili jadi	R	H	[19]
Sapotaceae	*Mimusops elengi* L. (IGNTU/DP/134)	Girsali	L	T	[28]
Smilacaceae	*Smilax perfoliata* Lour. (IGNTU/DP/178)	Ramvan	R	S	[10]
Solanaceae	*Datura metel* L. (IGNTU/DP/75)	Dhatura	Sd	H	[10]
	Solanum xanthocarpum Schrad. & J.C.Wendl. (IGNTU/DP/181)	Bhatkataiya	Fr	H	[27]
Zygophyllaceae	*Tribulus terrestris* L. (IGNTU/DP/198)	Gokhru	Fr	S	[23]

Abbreviation: R- Root; Wp- Whole plant; B- Bark; Fl- Flower; Sd- Seeds; Fr- Fruit; L-Leaf; St- Stem; H- Herb; S- Shrub; T- Tree; C- Climber

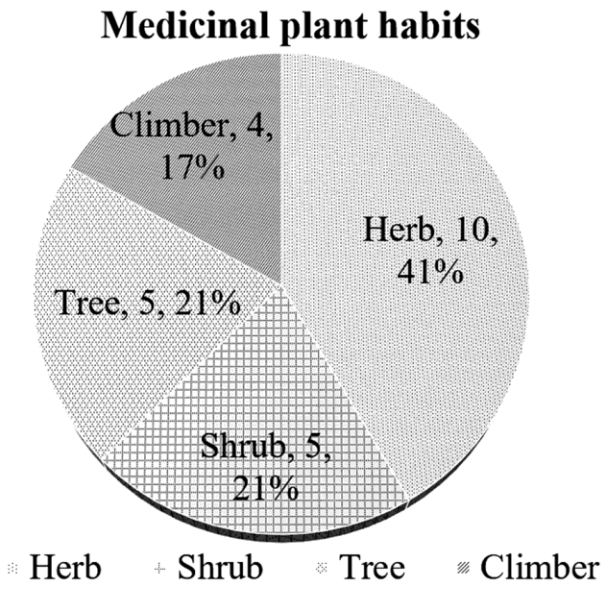

Fig. 2 — Habit pattern of different medicinal plants against malaria

Medicinal plant parts used against malaria disease

Different parts of medicinal plants like leaves, bark, flowers, roots, fruits, seeds, stems etc., or whole plants are used by the local practitioners either as single or in combination with various parts of other plant species. However, all the parts of medicinal plants have had a prominent effect on treating various diseases, including malaria, as shown in Table 3. In the current investigation, it was observed that the majority of medicinal recipes are utilized for the treatment of malaria are as follows: a combination of various parts of medicinal plants (24%), followed by fruits, leaves, and roots (14%), whereas, whole plant (10%), bark, seeds and stems (07%) and flowers (03%) constitute minor fraction of the uses (Fig. 3).

Herbal recipes preparation and mode of administration

Local folk vaidyas and other informants provided traditional knowledge about the local plant names, parts used, plants with other combinations to be used, dosage form, method of recipe preparation, and route(s) of consumption etc. The documented information was systematically tabulated in Table 3. Respondents from the study area used to prepare various recipes, such as maceration, decoction, infusion, powder, juice, paste, etc., to treat malaria disease. The most common type of recipe preparation was powder form 12 (41.38%), followed by decoction 11 (37.93%), juice 05 (11.36%), and fresh plant 01 (03.45%) as shown in (Fig. 4). The mode of application or route of administration is the way the medicinal plant is utilized to treat the disease and is absorbed into the body[26,30]. However, in the present investigation, almost all medicinal plant recipes are taken via oral route only, as indicated in Table 3.

Relative Frequency Citation (RFC)

RFC reflects the local importance and priority of each type of popular medicinal plant, as it is based on the number of respondents reporting the use of a specific type of medicinal plant[31]. The RFC was found to be between 0.386 and 0.023 in the present investigation, as shown in Table 4. Higher RFC values were determined for *Baccharoides anthelmintica* (0.386) against the malaria disease, followed by *Cissampelos pareira* (0.182), *Andrographis paniculata* (0.068), *Caesalpinia bonduc*, *Cuscuta reflexa*, *Holarrhena antidysenterica*, *Tinospora cordifolia*, *Woodfordia fruticosa* (0.045), and rest of plant species (0.023). These findings are significant because they may serve as a research foundation for future investigations of plant-derived therapeutic biomolecules, perhaps leading to new therapeutic lead discoveries[32,33]. Phytochemical, pharmacological, and biological investigations should be conducted on these medicinal plant species with more RFC values to assess and confirm their availability in producing promising leads[34].

Relative Importance Index (RI)

RI is the average mean of relative citation frequency and relative number of usage categories, as shown in Table 4. In the present investigation, the RI is ranging from 0.407 to 0.044. Higher RI value is observed for *Baccharoides anthelmintica* and *Cissampelos pareira*, while the lowest were *Azadirachta indica*, *Calotropis gigantea*, *Cleome viscosa*, and many more species. The RI index hypothetically varies from 0-1, where 0 is for that plant when no use was mentioned, and 1 is for that plant when it is stated for the majority of its benefits and the maximum number of user groups[14].

Frequency Citation (FC)

FC was computed for all the medicinal plant species documented in the present investigated area. The maximum values of FC were identified for *Baccharoides anthelmintica* and *Cissampelos pareira.*

Table 3 — Herbal recipes preparation and routes of administration

Local Name	Botanical Name	Plant Parts	Mode of preparation
Akwan/Madar	*Calotropis gigantea* (Apocynaceae)	Flower	The decoction of fresh flowers is given orally in little spoon with the addition of black pepper and honey thrice a day for seven days.
Amarbel	*Cuscuta reflexa* (Convolvulaceae)	Stem	The powder obtained from its stem is heated with milk and consumed with a little soon per day for six days.
Arjun	*Terminalia arjuna* (Combretaceae)	Bark	The bark powder of this plant is given to the patient in a little cup with drinking water and honey twice a day for three days.
Bhatkataiya	*Solanum xanthocarpum* (Solanaceae)	Fruit	Grind its fruit and heat it, then take it daily in the morning for 3 days.
Bhuneem/ Kalmegh	*Andrographis paniculata* (Acanthaceae)	Root	The root decoction is prepared and then given orally in a small glass with the addition of black pepper and honey three times a day for three days.
		Whole Plant	The decoction of fresh plant parts is administered orally in one tablespoon twice a day.
		Leaf	The juice is extracted from leaves and consumed orally in one teaspoon with honey twice a day for one week.
Charmuhi	*Thespesia lampas* (Malvaceae)	Root	The decoction of the fresh root is prepared and given to the patient orally in a little cup twice a day for four days.
Dhatura	*Datura metel* (Solanaceae)	Seed	The seeds are ground and made into a powder, which is then administered with water in a little cup twice a day for three days.
Doodhi Ghas	*Euphorbia hirta* (Euphorbiaceae)	Whole Plant	Ground the whole plant and make the pills with jaggery, and then take the pills seven times once a day for seven days.
Gataran	*Caesalpinia bonduc* (Fabaceae)	Leaf	The decoction of the leaf with water is administered orally in case of malaria.
Gokhru	*Tribulus terrestris* (Zygophyllaceae)	Fruit	The fruit is decocted in a little cup with the addition of black pepper and honey twice a day for five days.
Hulhul	*Cleome viscosa* (Cleomaceae)	Leaf	The decoction of leaves is given orally in a spoonful with honey twice a day for seven days.
Kacheri	*Cucumis pubescens* (Cucurbitaceae)	Fruits	The fresh fruit powder is given orally in a spoonful with honey twice a day for seven days.
Koraya/ Kuruchi	*Holarrhena antidysenterica* (Apocynaceae)	Bark	The bark decoction is administered orally in a little cup with the addition of milk, brown sugar, and honey twice a day for seven days.
Neem	*Azadirachta indica* (Meliaceae)	Leaf	The decoction of its leaves is made and given to the malaria patient in one tablespoon twice a day for three days.
Padhin	*Cissampelos pareira* (Menispermaceae)	Root	The powder form of root is given orally to the patient in a little spoonful with fresh honey thrice a day for seven days.
Gurij/ Giloe	*Tinospora cordifolia* (Menispermaceae)	Whole plant	The whole part of this plant is made into powder by grinding it, and then administered orally in a little cup with warm water once a day for four days.
		Stem	Its stem is ground with black pepper, dissolved in water, and given to the patient in spoonfuls twice a day for three days.
Ramvan	*Smilax perfoliata* (Smilacaceae)	Root	The powder of the fresh root is administered orally in a spoonful with brown sugar twice a day for six days.
Vanjeer	*Baccharoides anthelmintica* (Asteraceae)	Seeds	The seed powder of this plant is given orally in a little cup with honey twice a day for seven days.
		Fruit	The decoction of the fruit is administered orally with honey a small glass twice a day for seven days to treat malaria.
Amarbel, Amrud & Chakaura	*Cuscuta reflexa* (Convolvulaceae), *Psidium guajava* (Myrtaceae) & *Senna tora* (Fabaceae)	Climber, Fruit & Root	All parts of these plants are ground together, dissolved in water, and drunk in a little cup 3 times a day for three days.
Gataran & Vanjeer	*Caesalpinia bonduc* (Fabaceae) & *Baccharoides anthelmintica* (Asteraceae)	Fruit	The decoction of both plant fruits are administered orally in a little cup with addition of honey and black pepper for seven days.
Girsali & Jhilmili/pili jadi	*Mimusops elengi* (Sapotaceae) & *Thalictrum foliolosum* (Ranunculaceae)	Leaf & Root	Grind these two together and extract their juice, then administer orally in a little cup twice a day for three days.

(*Contd.*)

Table 3 — Herbal recipes preparation and routes of administration (*Contd*.)

Local Name	Botanical Name	Plant Parts	Mode of preparation
Koraya, Padhin & Surteli	*Holarrhena pubescens* (Apocynaceae), *Cissampelos pareira* (Menispermaceae) & *Woodfordia fruticosa* (Lythraceae)	Root	Powder of all these plant parts is given orally thrice a day for up to seven days.
Padhin &Aam	*Cissampelos pareira* (Menispermaceae) & *Mangifera indica* (Anacardiaceae)	Root & Bark	Grind both of them, take out the juice, and drink it twice daily for three days to treat malaria.
Padhin & Vanjeer	*Cissampelos pareira* (Menispermaceae) & *Baccharoides anthelmintica* (Asteraceae)	Root & Seed	Powder of these plants is administered in a little cup with water twice a day for three days.
Padhin & Surteli	*Cissampelos pareira* (Menispermaceae) & *Woodfordia fruticosa* (Lythraceae)	Root	The decoction of the roots of both plants is administered orally in one teaspoon with the addition of honey and black pepper thrice a day for seven days.

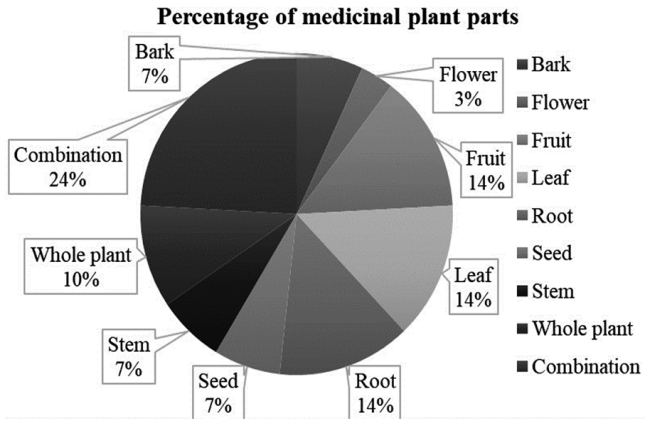

Fig. 3 — Percentage of medicinal plant parts used for the treatment of malaria

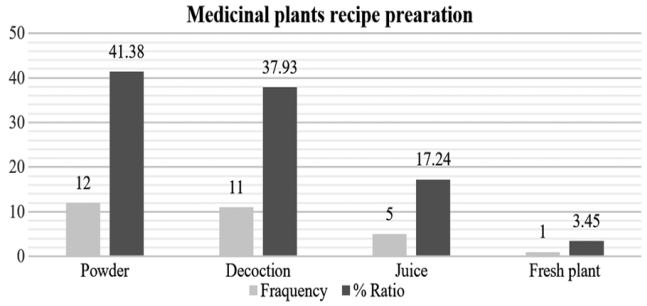

Fig. 4 — Methods used for the preparation of medicinal plant recipes

In contrast, the average values were observed for *Holarrhena antidysenterica*, *Tinospora cordifolia*, and *Woodfordia fruticosa*. The lowest FC was observed *for Mimusops elengi*, *Psidium guajava*, *Senna tora*, and *Tribulus terrestris* as shown in Table 4. The initial two species are the most familiar and well-known medicinal plants in the investigated area for the management and treatment of malaria[34,35].

Jaccard Coefficient of Similarity (JCS)

JCS represents the ethnobotanical similarity of 24 medicinal plants widely utilized to cure malaria disease among the tribal population of the district of Anuppur, Central India. The ethnomedicinal value of anti-malarial medicinal plant species in the current investigated area is compared with other study areas by different researchers in India, as mentioned in Table 5. It was observed that the highest degree of similarity was found with Madhya Pradesh state, India, with a degree of similarity (34.38%)[27] followed by Tamil Nadu state, India (13.89%)[36], Uttar Pradesh state, India (10.77%)[37], Odisha state, India (10.71%)[38], Haryana state, India (08.11%)[39] and Maharashtra state, India (05.15%)[40]. It may seem quite strange that there is very little overlap in the common medicinal plants used in such geographical areas, but this is due to different social structures, cultural practices, linguistic and cultural differences etc. Traditional knowledge was generally passed down from generation to generation only within the community and was not shared with neighboring communities[16].

The local tribal community people have had extensive information about medicinal plants based on their practical utilization in their routine life. Thus, the present study explored the traditional methods of treatment for malaria using different medicinal plants by local tribals and other communities of the district of Anuppur, Central India. This ethnomedicinal knowledge requires documentation before this rich resource is going to be lost forever. These tribal communities have a significant culture of using folk medicinal plants to manage various illnesses including malaria. This knowledge is orally transmitted from one age group to another only within their community[27,41,42].

Table 4 — Data analysis of medicinal plants used for malaria

Botanical Name	Local Name	No. of cited species	Data analysis		
			RFCs	*RIs Index*	*FCs*
Andrographis paniculata	Bhuneem	3	0.068	0.089	5.56
Azadirachta indica	Neem	1	0.023	0.044	1.85
Baccharoides anthelmintica	Vanjeer	17	0.386	0.407	31.48
Caesalpinia bonduc	Gataran	2	0.045	0.066	3.70
Calotropis gigantea	Akwan	1	0.023	0.044	1.85
Cissampelos pareira	Padhin	8	0.182	0.203	14.81
Cleome viscosa	Hulhul	1	0.023	0.044	1.85
Cucumis pubescens	Kacheri	1	0.023	0.044	1.85
Cuscuta reflexa	Amarbel	2	0.045	0.066	3.70
Datura metel	Dhatura	1	0.023	0.044	1.85
Euphorbia hirta	Doodhi Ghas	1	0.023	0.044	1.85
Holarrhena antidysenterica	Koraya	2	0.045	0.066	3.70
Mangifera indica	Aam	1	0.023	0.044	1.85
Mimusops elengi	Girsali	1	0.023	0.044	1.85
Psidium guajava	Amrud	1	0.023	0.044	1.85
Senna tora	Chakaura	1	0.023	0.044	1.85
Smilax perfoliate	Ramvan	1	0.023	0.044	1.85
Solanum xanthocarpum	Bhatkataiya	1	0.023	0.044	1.85
Terminalia arjuna	Arjun	1	0.023	0.044	1.85
Thalictrum foliolosum	Jhilmili	1	0.023	0.044	1.85
Thespesia lampas	Charmuhi	1	0.023	0.044	1.85
Tinospora cordifolia	Gurij/Giloe	2	0.045	0.066	3.70
Tribulus terrestris	Gokhru	1	0.023	0.044	1.85
Woodfordia fruticose	Surteli	2	0.045	0.066	3.70

Table 5 — Correlation of present medicinal plants data with other researchers

Study Area	Study Year	Species No.	Common Species	JCS	% of similarity	References
Madhya Pradesh, India	2019	19	11	0.344	34.38	[27]
Tamil Nadu, India	2015	17	5	0.139	13.89	[36]
Uttar Pradesh, India	2014	48	7	0.108	10.77	[37]
Odisha, India	2018	38	6	0.107	10.71	[38]
Haryana, India	2022	56	6	0.081	8.11	[39]
Maharashtra, India	2020	78	5	0.052	5.15	[40]

Conclusions

It is imperative to continue the search for more effective anti-malarial drugs. In the present investigation, the most commonly utilized anti-malarial medicinal plant species are required to be exploited to determine their ability to reduce the parasite densities and malaria symptoms against the widespread resistant malaria across the world and India. This study has recognized various ethnomedicinal plant species used against malaria by local tribal people residing in the district of Anuppur, Madhya Pradesh, Central India. More ethnomedical investigations could be carried out in different regions to gain knowledge about the preparation and the toxicity risks. To support their local use, extracts prepared based on vaidyas recipes must be studied for antimalarial properties and undergo *in-vitro* and *in-vivo* studies must be conducted to determine their toxicity as well as their therapeutic potency. These results demonstrate the possibility of using locally available medicinal plants to develop a new method of recipe as an anti-malarial drug and possible lead constituents that could be used as viable phytomedicines to treat malaria. It is also recommended that certain plant species be preserved to confirm their continued availability and uses in the upcoming days and future prospects.

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Conflict of Interest

The authors declare that there is no conflict of interest

Author Contributions

VSR: Collection of the ethnomedicinal information; Conceptualization; Data curation; Formal analysis and Writing-initial draft of the manuscript. KSR: Supervision, Validation, Visualization, Writing - review & editing the manuscript according to journal instructions. Both authors have read and approved the manuscript for submission.

Prior Informed Consent

Prior informed consent was taken from the knowledge holders after that, formal and informal discussions were recorded for publication of this manuscript.

Data Availability

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

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