BIOTROPIA ISSN: 0215-6334 | e-ISSN: 1907-770X
The Southeast Asian Journal of Tropical Biology
Vol. 31 No. 3, 2024: 402 - 421
DOI: 10.11598/btb.2318.31.3.2318

Research Article

ANTIMALARIAL MEDICINAL PLANTS USED BY TRADITIONAL HEALERS IN BENGKULU PROVINCE OF INDONESIA

Dian Susanti[1], Aditya Dwi Permana Putra[1], Devi Safrina[1], Nur Rahmawati Wijaya[1], M. Bakti Samsu Adi[1], Rohmat Mujahid[1], Rizal Maarif Rukmana[1], Dyah Subositi[1], Sari Haryanti[1], Usman Siswanto[2], Yuli Widiyastuti[1*]

[1]Research Center for Pharmaceutical Ingredients and Traditional Medicine, National Research and Innovation Agency, Bogor 16911, Indonesia.

[2]Faculty of Agriculture, University of Bengkulu, Bengkulu 38371, Indonesia

ARTICLE HIGLIGHTS

- This research provides information on the use of medicinal plants for treating malaria among ethnic groups in Bengkulu Province.
- This research was part of RISTOJA (Research on Medicinal Plants), national research conducted by the Ministry of Health of the Republic of Indonesia.
- Several compounds found in medicinal plants used by traditional healers in the Bengkulu Province have been scientifically proven to be effective as antimalarial medication.

Article Information

Received 8 August 2024
Revised 22 August 2024
Accepted 3 September 2024

Reviewer:
Suratman & Nurainas

***Corresponding author, e-mail:**
ywidiyasis@gmail.com

ABSTRACT

Malaria, a disease with a high mortality rate, is still a significant problem globally, including Indonesia. Bengkulu Province is among provinces in Indonesia that uses a diversity of medicinal plants to treat malaria. This research aimed to make an inventory of medicinal plants and to evaluate the use of those medicinal plants to treat malaria in Bengkulu Province. The methods used were observation, interviews, and collection of plants samples. Respondents consisted of traditional healers from 7 ethnic groups in Bengkulu. Several analyses were conducted on plant species, such as use value (UV), fidelity level (FL), family use value (FUV), relative frequency of citation (RFC), and plant parts value (PPV). This study found 32 specific herbal concoctions and identified the use of 47 medicinal plant species belong to 29 families used by 20 traditional healers in 6 of 7 ethnic groups. *Carica papaya*, *Peronema canescens*, and *Tinospora crispa* had the highest use value, fidelity level, and relative citation frequency. The *Lamiaceae* and *Caricaceae* families had the highest family use value (0.15). The leaves (43.9%) and barks (13.6%) were the most frequent used parts of medicinal plants for treating malaria. Decoction was the method most widely used by traditional healers in Bengkulu to prepare conventional medicine formula.

Keywords: antimalarial herbal formula, Bengkulu Province, medicinal plants, traditional healer

INTRODUCTION

People tend to use local resources for health purposes and treatments of diseases. Modernization may lead to the loss of traditional knowledge, especially on medicinal plants (Yulia *et al.* 2020). The role of medicinal plants in supporting public health will be increasingly important due to global changes of diseases patterns related to epidemiological transitions, where degenerative diseases and metabolic disorders are increasing in prevalence (Theodoridis *et al.* 2023). Medicinal plants are very suitable for promotive and preventive efforts in maintaining and improving the quality of public health (Fetene *et al.* 2019).

Local knowledge regarding the use of medicinal plants in maintaining and overcoming health problems needs to be further inventoried and studied to be preserved and developed (Budiarti *et al.* 2020). Medicinal plants are among Indonesia's priceless biodiversity which are regarded as a source and strong basis for future alternative medicinal technology (Pamenang 2021; Zakiyah *et al.* 2022; Theodoridis *et al.* 2023). Local knowledge on utilizing medicinal plants to overcome health problems and to prevent diseases is an important topic for studies (Wibowo *et al.* 2021). Malaria is among diseases in communities, widely treated using medicinal plants, especially in rural and remote areas in Indonesia.

Malaria, the most prominent disease caused by parasitic vectors of several mosquito species, remains a worldwide major health problem. Indonesia is one of tropical countries with a high incidence of malaria. Government programs in malaria prevention and treatment have reduced the prevalence rate from 2.9% in 2010 to only 1.9% in 2013. There are ten provinces in Indonesia with malaria incidence rates above the national average, most of which are located in the eastern parts of Indonesia (Kementerian Kesehatan Republik Indonesia 2013). A significant decrease in malaria prevalence until 2013, which stagnated until 2018, showed that the government's program to reduce malaria cases had not run optimally. Innovation is needed to support the malaria elimination program (Kementerian Kesehatan Republik Indonesia 2019; Lusiyana 2020).

In 2022, Indonesia achieved a Malaria Annual Parasite Incidence (API) < 1 per 1,000 populations, namely 459 districts/cities from the specified target (484 districts/cities) or an achievement performance of 94.8% Malaria API. Bengkulu was one of the provinces that managed to maintain a Malaria Positivity Rate (PR) of < 5% in all districts/cities (Kementerian Kesehatan RI 2022). Therefore, Bengkulu was chosen as the object of this research on medicinal plants utilization for treating malaria.

Drug resistance has led to the failure in eliminating malaria disease in Indonesia. Meanwhile, Indonesia's medicinal plants, has been widely utilized for the treatment of malaria by Indonesian community (Nugraha *et al*. 2022; Rahmasari *et al*. 2022). Bengkulu Province has a high biodiversity of medicinal plants due to the presence of extensive tropical rainforests (Wiryono *et al*. 2017). Research on Medicinal Plants and Herbs (RISTOJA) conducted by the Ministry of Health of the Republic of Indonesia in Bengkulu Province revealed abundant information on the use of medicinal plants for diseases treatment and health services by ethnic groups in Bengkulu Province (Subositi & Wahyono 2019)so it has a high economic value. The aim of this study was to record the use of the species of the genus Curcuma as traditional herbal medicines in Indonesia.

The study was a part of a project called RISTOJA (Research on Medicinal Plants and Traditional Herbal Medicines. Medicinal plants in Bengkulu Province needs to be studied in terms of the utilization of medicinal plants for health care, especially in treating malaria in the community. Information on the utilization of medicinal plants for treating malaria in each ethnic group in Bengkulu Province is also still limited. Therefore, this study was conducted to make an inventory of medicinal plants and to evaluate the use of those medicinal plants in Bengkulu Province to treat malaria.

MATERIALS AND METHODS

Study Site

Geographically, Bengkulu Province is located at 2°16'-3°31' N and 101°01'-103°41' E, with a maximum temperature of 32.9-34 °C and a minimum temperature of 22-23 °C (Badan Pusat Statistik 2017). Bengkulu Province is located along the west coast of Sumatra Island for approximately 525 km.

Data Collection

Data on medicinal plants used for antimalarial were obtained from results of RISTOJA conducted in 2012. Source of the data were 36 respondents from 7 ethnic groups in Bengkulu Province, namely Serawai, Lembak, Rejang, Muko-muko, Pasemah, Pekal and Enggano.

Number of sample points were determined based on populations of ethnic groups having at least 1,000 members. Six of the 7 ethnic groups in Bengkulu Province presumably have antimalarial concoctions, i.e., Serawai, Lembak, Rejang, Muko-muko, Pasemah, and Enggano (Fig. 1).

Respondents were traditional healers from local community who utilized medicinal plants to treat diseases. Those respondents were selected by means of purposive sampling approach based on information from indigenous community leaders, village heads, staff of government health facilities, and local health office.

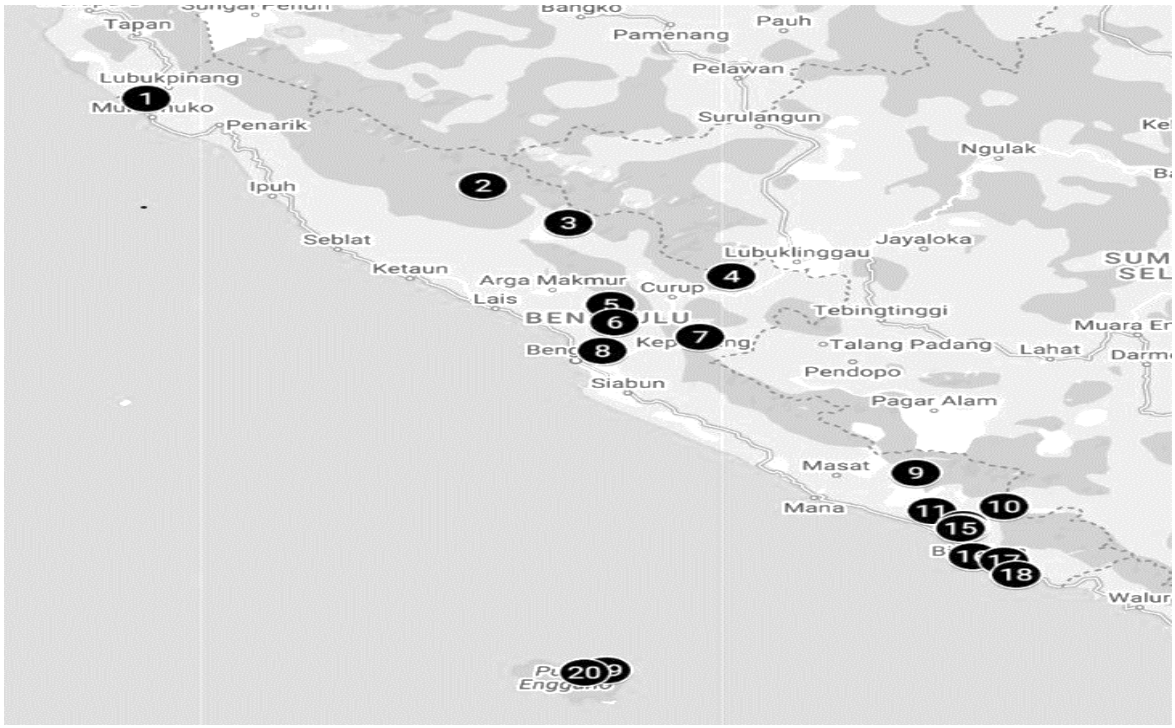

Figure 1 Ethnic groups in Bengkulu Province which have antimalarial concoctions.
Notes: 1. Muko-muko; 2. Rejang1; 3. Rejang2; 4. Rejang3; 5. Lembak1; 6. Lembak3; 7. Rejang4; 8. Lembak2; 9. Serawai; 10. Pasemah8; 11. Pasemah9; 12 Pasemah6; 13. Pasemah3; 14. Pasemah2; 15. Pasemah1; 16. Pasemah7; 17. Pasemah5; 18. Pasemah4; 19. Enggano1; 20. Enggano2.

Method used for data collection in this study is in accordance with the guidelines from 2012 RISTOJA (Kementerian Kesehatan Republik Indonesia 2012; Syafni & Bakhtiar 2022). Of the 7 ethnic groups that became respondents, only 6 ethnic groups were selected because these 6 ethnic groups utilize medicinal plants to treat malaria.

In this study, all medicinal plants used as antimalarial concoctions by the respondents were inventoried, recorded, and collected. The collected specimens were identified and stored in the Herbarium Tawangmanguensis of the Ministry of Health of the Republic of Indonesia.

Prior to the interview session, the study objectives and methods were explained to the respondents. Informed consent was also obtained from each respondent. Information collected from the respondents were medicinal plants used, parts of medicinal plants used, local names of medicinal plants, medicinal plant habitat, concoction preparation methods, dosage, existing knowledge on medicinal plants and malaria, as well as attitudes and practices related to the recognition, control, and treatment of malaria.

Data Analysis

Data processing was started with initial cleaning of the data from errors, followed by grouping the data based on similar knowledge. After the grouping, data were analyzed to determine UV (use value), FL (fidelity level), FUV (family use value), and RFC (relative frequency of citation).

Use value was calculated to figure out the importance of each medicinal plant for each traditional healer. The formula to calculate use value was the following (Najem *et al.* 2020; Susanti et al. 2023):

$$UV = \frac{\Sigma Ui}{n}$$

where:
U = number of use reports cited by each respondent for a medicinal plant species
n = total number of respondents interviewed for a medicinal plant species

Fidelity level was determined to analyze the importance of medicinal plants for a given remedy, which was calculated by using the following formula (Najem et al. 2020; Asiimwe et al. 2021):

$$FL(\%) = \frac{Ip/Iu}{n} x100$$

where:
Ip = number of respondents who independently reported the use of a specific medicinal plant for the same illness
Iu = overall number of respondents who cited the medicinal plant for any illnesses in general

Family use value was determined to identify the significance of medicinal plant families and was calculated by the following formula (Najem *et al.* 2020):

$$FUV = \frac{\Sigma UVs/Ns}{n}$$

where:
UVs = use value of medicinal plant species belonging to the same family
Ns = total number of medicinal plant species present in each family

Relative frequency of citation was determined to show the local importance of each medicinal plant species, and it was calculated by the following formula (Najem et al. 2020; Asiimwe et al. 2021):

$$RFC = \frac{FC}{N}$$

where:
FC = number of respondents using a given medicinal plant species
N = total number of interviewed respondents

Plant part value was determined to show the most used plant parts by the respondents (Najem *et al*. 2020; Biara *et al*. 2021; Susanti *et al*. 2023).The highest plant part value indicates the most used medicinal plant parts by the respondents and was calculated by using the following formula (Najem *et al*. 2020; Biara *et al*. 2021; Susanti *et al*. 2023):

$$PPV = \frac{RU\ Plant\ Part}{RU}$$

where:
RU = number of uses reported by the respondents for all medicinal plant parts
RU Plant Part = the sum of uses reported by the respondents for each part of the medicinal plant.

To explain knowledge differences on antimalarial medicinal plants in each ethnic group, a cluster dendrogram was established by using R-4.3.2.

RESULTS AND DISCUSSION

Respondent Characteristics

Twenty traditional healers from 6 ethnic groups in Bengkulu Province who prescribed antimalarial concoctions made from medicinal plants were selected as respondents in this study (Table 1).

In our study, traditional healers who prescribed antimalarial concoctions in Bengkulu Province were found in 6 ethnic groups, i.e., Enggano, Muko-muko, Rejang, Lembak, Serawai, and Pasemah. Traditional healers who prescribed the highest number of antimalarial concoctions were from Pasemah ethnic group, which is related to a larger coverage area, namely Pagaralam, Empat Lawang, Lahat Regency, Ogan Komering Ulu, the Muara Enim area, and Mount Dempo, an active volcanic area. From their study, Huda *et al*. (2019) stated that the long distance from the residential area to health facilities encouraged people to dwell into the knowledge of utilizing medicinal plants in overcoming health problems.

Male gender dominated the respondents in our study (12 of 20 respondents). The dominance of male gender as traditional healer is related to people's perception in requirements of being a traditional healer, one of which is being a male descent of a traditional healer (Djamaluddin *et al*. 2020), because the medicinal skill should be passed down from their ancestors. The respondents in our study were mostly in lower educational level.

In regard to age, 16 of 20 traditional healers were at the age of 50 or above and one healer even reached the age of 80. This indicated that medicinal profession have not been the interest of younger generations in concurrent with several

Table 1 Traditional healers from 6 ethnic groups who used medicinal plants for treating malaria in Bengkulu Province selected as respondents

Ethnic group	Traditional healers (Respondent)	Gender	Age	Education	Number of patients per month
Enggano	1	Male	78	Elementary	0-25
	2	Male	61	Elementary	0-25
Muko-muko	1	Female	62	Elementary	26-50
Rejang	1	Male	41	Senior High School	0-25
	2	Male	40	Senior High School	0-25
	3	Male	50	Illiterate	0-25
	4	Female	58	Junior High School	0-25
Lembak	1	Female	56	Illiterate	0-25
	2	Female	55	Illiterate	0-25
	3	Female	59	Illiterate	0-25
Serawai	1	Male	60	Illiterate	0-25
Pasemah	1	Male	80	Junior High School	> 100
	2	Male	51	Elementary	> 100
	3	Female	75	Elementary	> 50
	4	Female	50	Elementary	> 50
	5	Male	51	Illiterate	> 50
	6	Male	47	Junior High School	> 100
	7	Male	66	Elementary	26-50
	8	Female	58	Elementary	0-25
	9	Male	47	Senior High School	> 100
Total respondents	20				

obstacles that hinder the regeneration efforts by the older traditional healers. Transfer knowledge on medicine requires special skills and basic medical knowledge, which is not easily transferred to potential successors. There are basic requirements for someone to become a traditional healer. A study conducted by Efrianto (2018) showed that not everyone has the ability to become traditional healer. Efrianto (2018) also mentioned that there are four ways to pass on knowledge, namely learning, inspiration, dreaming and meditating.

Monthly number of patients received by respondents in our study were mostly in the range of 0-25 (11 of 20 respondents). Some respondents even received more than 100 patients per month (4 of 20 respondents). However, our respondents did not keep notes on which of their patients were prescribed antimalarial concoctions.

Our study also showed that most village communities have a good knowledge on traditional medicine and a lot of interests in using traditional medicine. The knowledge and interests were mostly inherited by their families. Knowledge is a factor influencing the use of traditional medicine. Lack of knowledge on health care and modern medicine has resulted in the use of herbal medicine as one of treatments for various diseases (Adiyasa & Meiyanti 2021).

The Use of Medicinal Plants for Treating Malaria

Our study showed that not all traditional healers have antimalarial prescriptions. In Bengkulu Province, the 6 ethnic groups claimed to have medicinal plants for treating malaria. Traditional healers diagnose a patient as having malaria based on fever symptoms and testimony of the patient. There were 47 medicinal plant species belonging to 29 plant families used for antimalarial medication (Table 2). Fifteen plant specimens could not be identified by the scientific names.

Table 2 Medicinal plants used for antimalarial medication by 6 ethnic groups in Bengkulu Province

Family	Species name	Local name	Ethnic group	UV	RFC	FL (%)
Acanthaceae	*Andrographis paniculata* (Burm.f.) Wall ex. Ness	*Sambilato, Kenina*	Rejang, Lembak	0.10	0.10	10.00
	Justicia gendarussa Burm.f.	*Sekanjang hitam, Sekanjang putih*	Pasemah	0.10	0.10	10.00
Acoraceae	*Acorus calamus* L.	*Jerangau*	Enggano	0.05	0.05	5.00
Annonaceae	*Annona muricata* L.	*Sirsak*	Lembak	0.05	0.05	5.00
Asteraceae	*Adenostemma lavenia* (L.) Kuntze	*Pepulut*	Pasemah	0.05	0.05	5.00
	Blumea balsamifera (L.) DC.	*Capao*	Serawai	0.05	0.05	5.00
Caricaceae	***Carica papaya* L.**	*Pepaya, Kates lanang*	Enggano, Rejang	0.15	0.15	15.00
Dilleniaceae	*Tetracera scandens* (L.) Merr.	*Simpor darat,*	Pasemah	0.05	0.05	5.00
Euphorbiaceae	*Macaranga tanarius* (L.) Mull.Arg.	*Sapat laut*	Pasemah	0.05	0.05	5.00
Fabaceae	*Ototropis multiflora* (DC.) H. Ohashi & K.Ohashi	*Patiak tat*	Rejang	0.05	0.05	5.00
	Pongamia pinnata (L.) Pierre	*Malapari*	Enggano	0.05	0.05	5.00
Goodeniaceae	*Scaevola taccada* (Gaertn.) Roxb.	*Nanni*	Enggano	0.05	0.05	5.00
Lamiaceae	***Peronema canescens* Jac**k	*Sukei/Sungkai*	Rejang, Lembak	0.15	0.15	15.00
Loranthaceae	*Loranthus* sp.	*Singgah kecil, Singgah besar*	Pasemah	0.05	0.05	5.00
Malvaceae	*Melochia umbellata* (Houtt.) Stapf	*Ndilau bincil, Sindilau rutu*	Pasemah	0.10	0.10	10.00
	Pterospermum diversifolium Blume	*Bayur elang*	Pasemah	0.05	0.05	5.00
	Pterospermum javanicum Jungh.	*Bayur malukut*	Pasemah	0.05	0.05	5.00
	Sida cordifolia L.	*Nagori kecik*	Pasemah	0.05	0.05	5.00
	Sida rhombifolia L.	*Nagori besak*	Pasemah	0.05	0.05	5.00
	Thespesia populnea (L.) Sol. ex Correa	*Baru laut*	Pasemah	0.05	0.05	5.00
Meliaceae	*Lansium* sp.	*Langsat air-air*	Pasemah	0.05	0.05	5.00
Menispermaceae	*Fibraurea tinctoria* Lour.	*Akar kuning*	Enggano	0.10	0.05	5.00
	***Tinospora crispa* (L.) Hook.f. & Thomso**n	*Protowali, Cintowali, Brotowali*	Rejang	0.15	0.15	15.00
Moraceae	*Artocarpus elasticus* Reinw. ex Blume	*Keluncup lantung*	Pasemah	0.05	0.05	5.00
	Ficus grossularioides var. *grossularioides*	*Pemantung kerbau,*	Pasemah	0.05	0.05	5.00
Musaceae	*Musa* sp.	*Pisang sabe*	Pasemah	0.05	0.05	5.00
	Musa x paradisiaca L.	*Pisang gemuk*	Pasemah	0.05	0.05	5.00
Myristicaceae	*Knema intermedia* (Blume) Warb.	*Kayu siamang*	Pasemah	0.05	0.05	5.00
Myrtaceae	*Psidium guajava* L.	*Jambu putih,*	Pasemah	0.05	0.05	5.00
	Syzygium aqueum (Burm.f.) Alston	*Jambu air,*	Pasemah	0.05	0.05	5.00
Oleaceae	*Jasminum grandiflorum* L.	*Bungo pekan*	Muko-muko	0.05	0.05	5.00
	Jasminum sambac (L.) Aiton	*Bungo susun*	Muko-muko	0.05	0.05	5.00
Onagraceae	*Ludwigia grandiflora* (Michx.) Greuter & Burdet	*Bungo tengah hari*	Muko-muko	0.05	0.05	5.00
Phyllanthaceae	*Antidesma ghaesembilla* Gaertn.	*Alay*	Pasemah	0.05	0.05	5.00
Poacaea	*Gigantochloa verticillata* (Willd.) Munro	*Bambu haur*	Pasemah	0.05	0.05	5.00
	Gigantochloa apus (Schult.f.) Kurz ex Munro	*Haur kapal*	Pasemah	0.05	0.05	5.00
	Oryza sativa L.	*Beras ketan*	Pasemah	0.05	0.05	5.00
Rosaceae	*Rosa x damascena* Herrm.	*Bungo ros*	Muko-muko	0.05	0.05	5.00
Rubiaceae	*Nauclea orientalis* (L.)	*Kayu bengkal, Kayu diwil*	Pasemah	0.05	0.05	5.00
Sapindaceae	*Cardiospermum halicacabum* L.	*Kengkelam*	Pasemah	0.05	0.05	5.00

Family	Species name	Local name	Ethnic group	UV	RFC	FL (%)
Simaroubaceae	*Brucea javanica* (L.) Merr.	*Pedu beruang*	Lembak	0.05	0.05	5.00
	Eurycoma longifolia Jack	*Pasak bumi*	Pasemah	0.05	0.05	5.00
Solanaceae	*Physalis angulata* L.	*Seletup*	Rejang, Pasemah	0.10	0.10	10.00
Urticaceae	*Boehmeria grandis* (Hook.&Arn.) A.Heller	*Ndilau nasi, pemantung ayam*	Pasemah	0.10	0.10	10.00
Zingiberaceae	*Curcuma longa* L.	*Kunyit*	Enggano, Rejang	0.10	0.10	10.00
	Curcuma zanthorrhiza Roxb.	*Temulawak*	Enggano	0.05	0.05	5.00
	Zingiber officinale Roscoe	*Jahe*	Rejang	0.10	0.10	10.00

Notes: UV = Use Value; RFC = Relative Frequency of Citation; FL = Fidelity Level.

Our study showed that *C. papaya, P. canescens,* and *T. crispa* had UV, RFC, and FL values of 0.15, 0.15, and 15.00, respectively. Ethno medicinal data were quantitatively analyzed using RFC, indicating the local importance of medicinal plant species. The species having the highest RFC (*C. papaya, P. canescens*, and *T. crispa*) were the species most often used by traditional healers in Bengkulu Province to cure malaria, because these plants were easy to find and easy to cultivate. People believe that the bitter taste of *C. papaya, P. canescens*, and *T. crispa* leaves can be used for treating malaria (Shinta 2005; Taek 2020).

Several research results showed that *C. papaya, P. canescens,* and *T. crispa* leaves have pharmacological properties as antimalarial medicine. Papaya extract contains a total phenolics of 27.99±1.46 mg GAE/g and a total flavonoids of 18.24±1.36 mg QE/g, which prevent the immune system from destroying platelets, decrease the virus-induced bone marrow damage, and stabilize infected cell membranes, leading to the acceleration of natural healing process by boosting platelets count and averting problems (Babalola *et al.* 2024). *T. crispa* contains an active compound called tinocrisposide which works in the erythrocytic phase by inhibiting the growth of parasites in erythrocytes; therefore *T. crispa* can be an alternative medicine for treating malaria (Abdillah *et al*. 2015; Malik 2015). The ethanol fraction of *P. canescens* leaves at a dose of 0.084 g/kgBW is the most effective dose for treating malaria and has potential as an antimalarial medicine (Prasiwi *et al*. 2018).

The fidelity level (FL) represents the proportion of traditional healers who reported utilizing specific plant species to treat a particular sickness in the research area. The highest fidelity level value for a particular plant species signifies its critical importance and frequent application as a therapeutic agent (Padhan & Panda 2016; Chaachouay *et al*. 2019)informant consensus factors (FIC. In our study, *C. papaya, P. canescens*, and *T. crispa* had the highest fidelity level (15%), indicating that traditional healers often use these plants as antimalarial medicine in Bengkulu Province.

C. papaya contains many advantageous chemical components in its fruits, leaves, flowers, stems, bark, and roots, such as papain, chymopapain, cystatin, à-tocopherol, ascorbic acid, flavonoids, cyanogenic glucosides, and glucosinolates. Leaf extract of *C. papaya* were demonstrated to possess antimalarial properties by effectively eliminating *Plasmodium falciparum* larvae within a concentration range of 25 ug/mL to 150 ug/mL (Kovendan *et al*. 2012). *P. canescens* leaves contain phytochemical compounds, including flavonoids, phenolics, terpenoids, and alkaloids, which act as antioxidants, antibacterial, anti-inflammatory, antidiabetic, and antimalarial agents (Maigoda *et al*. 2022)ethanol extract extracted by maceration method using 96% ethanol as solvent from P. canescens. The Dragendorff's and Mayer test carried out the qualitative phytochemical analysis, FeCl3 test, Salkowski method, Liebermann–Burchard method, foam test, and NaOH reagent. The total phenolic and flavonoid levels were tested using the Folin–Ciocalteu method. In vitro antioxidant activity was carried out using the DPPH (1,1-diphenyl-2-picrylhydrazyl.

In their study, Suwandi *et al*. (2018) showed that the aqueous extract from *P. canescens* leaves had antispasmodic properties which effectively reduced the development of *Plasmodium falciparum* with

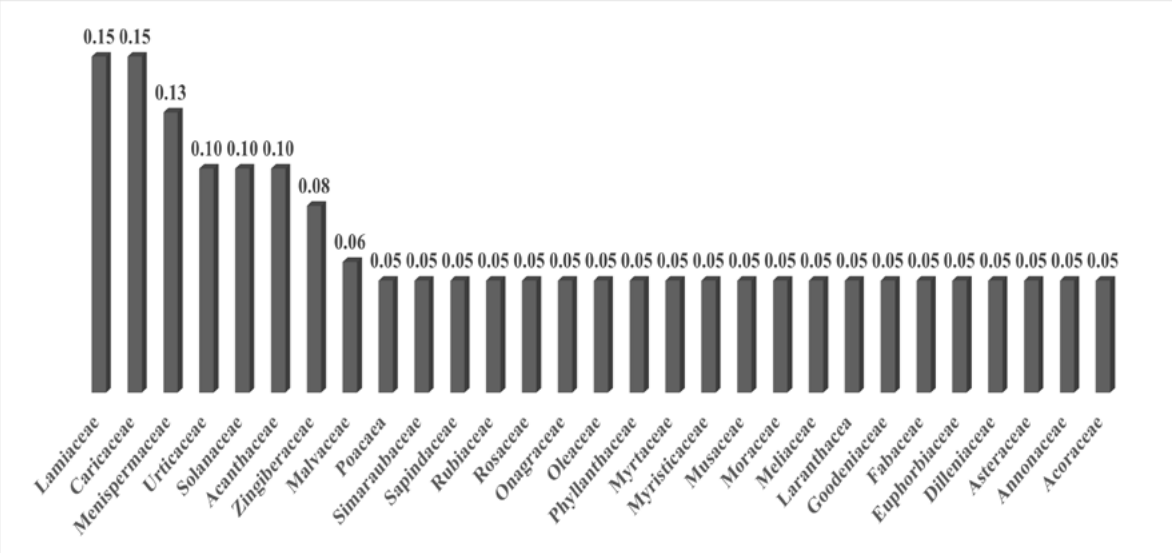

Figure 2 Family Use Value of medicinal plants used as antimalarial medicine in Bengkulu Province

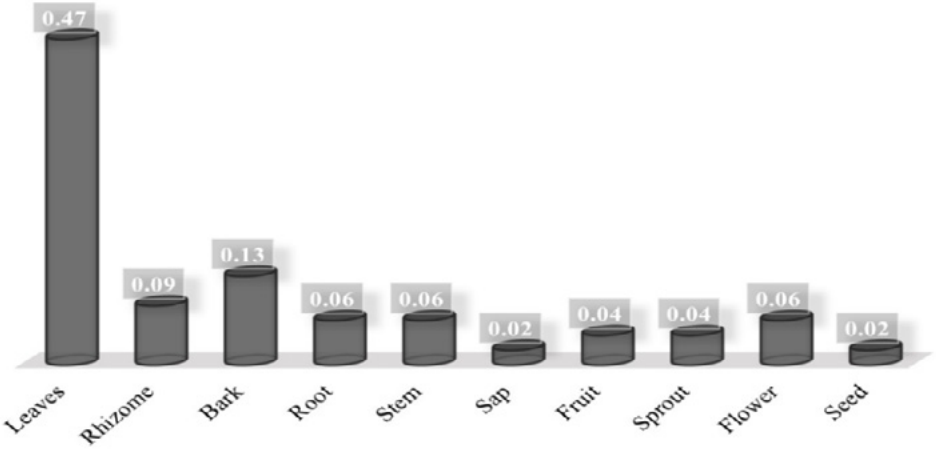

Figure 3 Parts of medicinal plants used for antimalarial medication by traditional healers in Bengkulu Province

an IC50 value of 12.26±1.05 µg/mL. *T. crispa* plant has been extensively utilized by traditional healers in Bengkulu Province for its antimalarial properties. Research conducted by Niljan *et al.* (2014) indicated that extract of *T. crispa* exhibits antimalarial properties in mice infected with *Plasmodium berghei,* while combining the extract of *T. crispa* with pyrimethamine enhances the efficacy of *T. crispa* as antimalarial medicine.

The family use value of medicinal plants in our study showed that both *Lamiaceae* and *Caricaceae* had the highest FUV (0.15), while *Menispermaceae* had the second highest value of 0.13 (Fig. 2).

Lamiaceae had long been used as traditional medication for treating malaria. Various studies stated that *Lamiaceae* family, previously referred to as *Labiatae*, contains several active compounds that act as antimalarials, such as abietane, diterpenes, diterpenoids, triterpenoids, and flavonoids (Tjitraresmi *et al.* 2020). *Caricaceae* family, especially *C. papaya*, plays a role in producing alkaloids having larvicidal activity against *Anopheles stephensi* mosquitoes (Singh *et al.* 2022). Alkaloids produced by various plants are known as antimalarial medication (Omagha *et al.* 2020). Several species of Menispermaceae family, such as *Arcangelisia flava* (Nain *et al.* 2022; Pratama *et al.* 2023) and *Tinopsora crispa* (Fitri *et al.* 2019; Merici *et al.* 2020), contain alkaloids in the form of berberine, which function as antimalarial medication.

Herbal materials used by traditional healers consist of various parts of medicinal plants ranging from leaves, flowers, stems, bark, and roots (Fig. 3).

Leaves (43.9%) and barks (13.6%) were the most frequent used parts of medicinal plants for treating malaria. Leaves are mostly used in herbal preparations by traditional healers because leaves are easily recognized, taken, and utilized part of medicinal plants. Leaves can be harvested at any time without depending on weather conditions and are the easiest plant part to process or mix as ingredients for herbal preparations (Widiyastuti *et al*. 2017)forest areas are still the main habitat of medicinal plants germplasm. Sigogor Nature Reserve in Ponorogo Regency, East Java, is a potential area that has a diversity of medicinal plants and has not been widely studied. The exploration of medicinal plants in the Sigogor Nature Reserve area aims to know the diversity, abundance and knowledge of the surrounding community about the existence of these medicinal plants. The method used is explorative survey with qualitative approach. The data collected in the form of secondary data and primary field observation results and literature studies of previous research results. Data analysis was carried out descriptively for the identification of medicinal plant specimens, qualitative vegetation analysis to determine plant habitus type, than percentage of habitus type and plant part was calculated based on observation result. The results of exploration activities show there were 43 species of medicinal plants from 33 families have been found in the sorrounding area of Sigogor. Habitus of medicinal plants found mostly were herbs (39.5%.

In utilizing plant parts for herbal preparations, it is important to consider the conservation aspect of medicinal plants. The use of bark, stems, and roots in herbal preparations can have a long impact on population decrease of medicinal plants, because the harvesting process of those plant parts will include the process of injuring the plants, leading to the plant death and eventually, the extinction of the plants (Bamigboye & Tshisikhawe 2020).

Medicinal plants used in preparing antimalarial medication in Bengkulu Province came from five different sources, i.e., from the wild (38%), garden (30%), forest (28%), seashore (3%), and market (1%) (Fig. 4). Traditional healers mostly (69%) utilize medicinal plant from nature, either from the wilds or harvested from a forest or from a seashore.

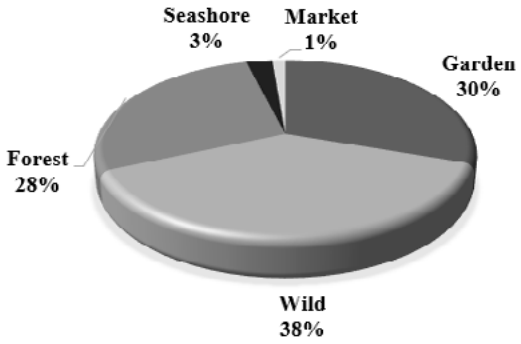

Figure 4 Sources of medicinal plants used as antimalarial medication in Bengkulu Province

Natural conditions of Bengkulu Province are relatively pristine, not much impacted by industrial and residential areas; therefore, allowing the community to obtain medicinal plants from the wilds of the surrounding environment (Seitz *et al*. 2022). The ease of obtaining medicinal plants both from the wilds (69%) and from gardens (30%) has resulted in low sales of medicinal plants in markets (1%) (Fig.4), showing that sources from 'Garden' and 'Forest' provide a significant contribution, while sources from 'Seashore' and 'Market' ' are the least utilized, indicating that local traditions and knowledge play as the primary roles in supporting local health care (Balinado & Chan 2017). Only 30% of the raw materials used by traditional healers came from medicinal plants planted or naturally grown in their gardens, while the remaining medicinal plants came from wild plants found in the forest, primarily trees that are challenging to cultivate (Dajic-Stevanovic & Pljevljakusic 2015).

The preference of utilizing medicinal plants from the wilds over those cultivated ones is related to the concentration of bioactive chemicals produced by the medicinal plants that may be impacted by environmental factors associating with the therapeutic process (Pandey et al. 2023).

Antimalarial Treatments

In regard to the use of medicinal plants for treating malaria, each traditional healer has different ingredients and methods compared to

other ethnic groups. Peculiarities in the utilization of these medicinal plants are greatly influenced by culture, educational background, availability of public health facilities, experiences of traditional healers and availability of medicinal plants resources in residential region of traditional healers (Gaoue *et al*. 2017; Cain *et al. 2*018; McQuaid & Landier 2018; Purwoko *et al*. 2023).

Our study established a comprehensive overview of different herbal preparations used for antimalarial medication, ingredients specifications, preparation methods, dosage, usage frequency and treatment duration for antimalarial treatment conducted by traditional healers from 6 ethnic groups in Bengkulu Province (Table 3).

Table 3 Herbal preparations, ingredients specifications, preparation methods, dosage, usage frequency, and treatment duration of antimalarial treatment by traditional healers in Bengkulu Province

Ethnic group		Herbal preparations, ingredients specifications, preparation methods, dosage	Usage frequency	Treatment duration
Enggano	1	Two inches of *akar kuning* (*F. tinctoria*) roots, cut into pieces, boil with three glasses of water to half a glass, let it cool, then drink.	3 times/day	3 days
	2	Cut into pieces: *akar kuning* (*F. tinctoria*), *temulawak* (*C. zanthorrhiza*), *kunyit* (*C. longa*), *jahe* (*Z. officinale)*, and *jeringau* (*A. calamus*), add three glasses of water and stir evenly, boil until the water is thick, let it coll, then drink.	3 times/day	3 days
	3	Three pieces of Nanni leaf stalks (*S. taccada*) to be pounded, add half a glass of water, squeeze until the juice comes out, then drink the juice.	Once a day	3 days
	4	Remove the bark of malapari stem (*P. pinnata*) and scrape the stem. Mix the scrape with a glass of hot water, drink half the water, leaving the dregs in the glass. Then, put the dregs on top of the stomach.	half-a glass a day	3 days
	5	Grind the *bihaan* (unidentified species) leaves, add water, and drink.	Once a day	Until recovered
	6	One old papaya leaf (*C. papaya*), to be brewed with hot water, then rub on the forehead.	Once a day	3 days
Muko-muko	1	*Bungo pekan* (*J. grandiflorum*), *bungo ros* (*R. damascena*), *bungo susun* (*J. sambac*), and *bungo tengah hari* (*L. grandiflora*) to be mashed, then rub on the forehead.	Once a day	3 days
Rejang	1	Take a clean handful of papaya leaves (*C. papaya*), boil in one liter of water to one glass, let it cool, then drink at once.	Once a day in the morning	2 days
	2	Take three *sungkai* leaves (*P. canescens*), clean and squeeze, add one glass of boiled water, then squeeze until the juice comes out, then drink the juice.	Once a day	2 days
	3	Take a handful of *protowali* leaves (*T. crispa*), clean and boil the leaves with a half-liter of water, let it cool, then drink.	Once a day	2 days
	4	Crush the *patiak tat* root (*O. multiflora*) and blend with *seletup* (unidentified species) and *sukei* (unidentified species) leaves, boil the leaves, let it cool, then drink.	3 times a day	3 days
	5	Boil a 10 cm of *cintowali* stem (*T. crispa*) until boiled, let it cool, then drink.	3 times a day	7 days
	6	Two papaya leaves (*C. papaya*) to be washed and directly eaten.	Once a day	3 days
	7	Mix *brotowali* stem (*T. crispa*), *sambiloto* herb (*A. paniculata*), *jahe* (*Z. officinale*) and *kunyit* (*C. longa*) then dry and grind. Put the powder into a 500 mg size capsule.	3 times a day	3 days
Lembak	1	*Sungkai* leaves (*P. canescens*) to be squeezed with a glass of boiled water, then drink.	Once a day	Until the shivering stops
	2	*Sirsak* leaves (*A. muricata*) to be chopped and mixed with one tablespoon of rice. The mixture is then divided into three parts, two parts to be placed on the navel in the morning and evening, and the third part to be removed. Note: do not eat sour-taste foods and do not drink iced beverages/ice during the implementation of this medication.	Twice a day	1 day
	3	*Kenina/sambiloto* leaves (*A. paniculata*) to be soaked in one glass of boiling water, then drink the water 3 times a day for three days.	3 times a day	3 days
	4	The fruit of *pedu beruang* (*B. javanica*) to be washed and eaten immediately like taking pills.	2 fruits in a day	3 days
Serawai	1	Several old *capao* leaves (*B. balsamifera*) that are still attached or still hanging on the stem, to be boiled with three glasses of water to a glass, then drink.	One glass	Until recovered
Pasemah	1	*Bengkarung, gadung itam*, and *kayu siamang* (*K. intermedia*) to be mixed and ground, then use for rubbing the entire body.	As often as possible	2 weeks
	2	*Uwi manau lanang, uwi dahanan, uwi temiang*, and *uwi semut* to be soaked with earthworms in boiled water until the color of the earthworms turns white, then drink.	3 times a day	2 weeks

Ethnic group		Herbal preparations, ingredients specifications, preparation methods, dosage	Usage frequency	Treatment duration
	3	Mix and wash the barks of *kayu bengkal* (*N. orientalis*), *ndilau bincil* (*M. umbellata*), *diwil* (*N. orientalis*), *simpor darat* (*T. scandens*), *jambu air* (*S. aqueum*), and *ndilau nasi* (*B. grandis*). Slice and pound the barks, then mix with water and squeeze until the juice comes out. Drink the juice and smeared the dregs on the ailing body part.	3 times a month	3 months
	4	Barks of *semanggat* and *jambu putih* (*P. guajava*) to be mixed, sliced, then boiled with three glasses of water until well boiled, let it cool, then drink.	Twice a day	3 days
	5	The leaves of *sekanjang hitam* (*J. gendarussa*), *sekanjang putih* (*J. gendarussa*), *memaye merah, memaye putih, singgah besar* (*Loranthus* sp.) and *singgah kecil* (*Loranthus* sp.) to be squeezed in boiled water, then rub the whole body with the concoction, wait until the concoction is dried on the body. Repeat the treatment after the body is dry from the concoction.	3 times a day	1 day
	6	The roots of *pasak bumi* (*E. longifolia*) and *langsat* (*Lansium* sp.) to be cut into pieces and boiled until the water is half, then let it cool. The decoction to be drunk as often as possible.	As often as possible	3 days
	7	Combine and chop *ingur-ingur, tukup jaring,* and *pisang sabe* (*Musa* sp.), then soak them with crust soaking water, followed by heating using a pot lid and put the concoction on the sore spot. Note: change the concoction every night; the patient will feel itchiness during first hour as a reaction from the concoction.	Once at night	3 days
	8	Five leaves of each of *sekanjang hitam* (*J. gendarussa*), *sekanjang putih* (*J. gendarussa*), *pepulut* (*A. lavenia*), *kengkelam* (*C. halicacabum*), *bayur elang* (*P. diversifolium*), *bayur malukut* (*P. javanicum*), *bambu haur* (*G. verticillata*), *sapat laut* (*M. tanarius*), *baru laut* (*T. populnea*), *keluncup lantung* (*A. elasticus*), *nagori besak* (*S. rhombifolia*), and *nagori kecik* (*S. cordifolia*), to be mixed and squeezed, then rub the concoction all over the body.	3 times a day	1 day
	9	Five leaves of *alay* (*A. ghaesembilla*) to be mixed with the sprouts of *haur kapal* (*G. apus*), then cut into 4 pieces and shredded, then rub the concoctions all over the body.	3 times a day	1 day
	10	Thirty (30) cm of inner stem of *pisang gemuk* (*M. paradisiaca*) to be mixed with 7 glutinous rice grains and mashed, then rub the concoctions all over the body.	3 times a day	until recovered
	11	Six-finger-long bark of *sindilau rutu* (*M. umbellata*) to be bruised and soaked in boiled water, then drink half a glass.	10 times a day	1 day
	12	*Seletup* (*P. angulata*) to be boiled, let it cool, then drink.	3 times a day	Until recovered
	13	Sap from roots of *pemantung kerbau* (*F. grossularioides* var. *grossularioides*) and sap of *pemantung ayam* (*B. grandis*) to be collected during the night, then to be drunk the next morning.	3 times a day	Until recovered

Usage frequencies varied from once a day to 10 times daily or frequently, and the treatment durations ranged from one day to until recovered. The most common usage frequencies for antimalarial medication were 3 times a day and once daily (Table 3), indicating how often traditional healers administered specific antimalarial medication in Bengkulu Province. There were also variations in the usage frequencies of antimalarial therapies based on the type of treatment, which were primarily prescribed to be taken once, twice, or three times per day for a fixed number of days, such as 3 days, 7 days, or a month. Less expected frequencies included half a glass a day or 10 times a day. Some treatments were less frequent, like once a day, once a night, or a few times per month for an extended period, such as 3 months, and there were a few treatments specifying to take the medication frequently or as needed until symptoms resolve. The usage frequency of prescription made from medicinal plants for antimalarial medication can vary depending on the type of medicinal plants and how it is processed (Caunca & Balinado 2021; Hastiana *et al*. 2023). The misuse of medicinal plants, whether excessive consumption of concoction or in combination with other medicinal plants that are not compatible can cause side effects (Alkhamaiseh & Aljofan 2020; Başaran *et al*. 2022).

Preparation of traditional antimalarial medications by traditional healers in Bengkulu Province can be categorized as internal and external usages (Fig. 5). For internal usage, the herbal preparations for antimalarial medication were made in the form of decoction, infusion, dry powder in capsules, and raw consumption.

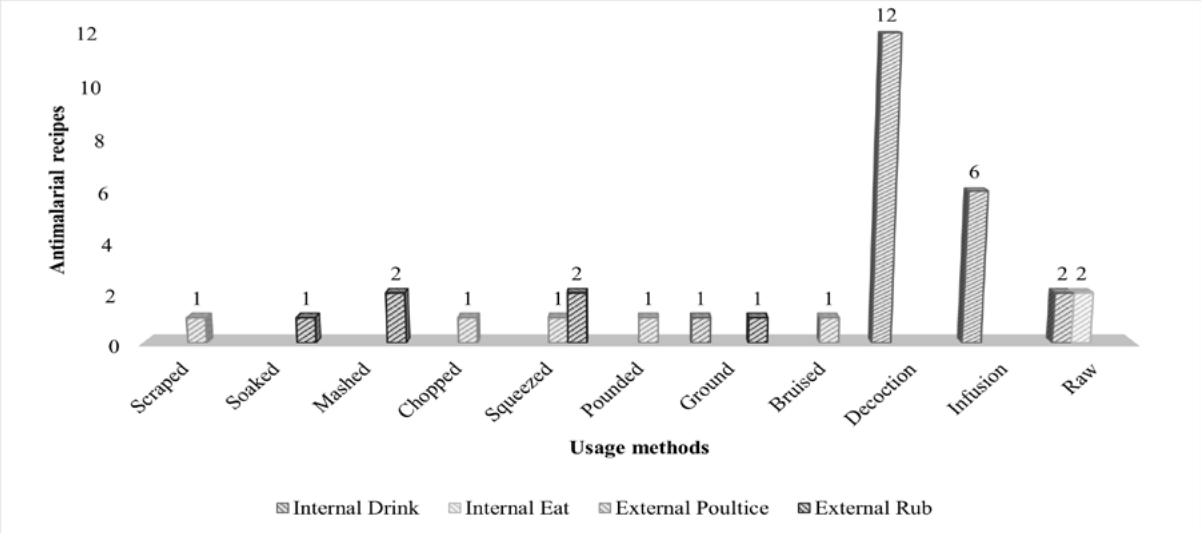

Figure 5 ethods used to make antimalarial medication by traditional healers in Bengkulu Province

The differences in treatments and medicinal recipes were based on the experience and knowledge of traditional healers learned from their ancestors. This study showed that the most widely used methods in traditional medication practiced by traditional healers in Bengkulu Province were decoction and infusion (Fig. 5).

Our study also showed that the use of medicinal plants in the form of a decoction was most preferred considering that this method provided greater extraction yields and higher concentration of active phytochemicals; thus, potentially increased the efficacy of herbal preparations. In processing medicinal plants, it is important to apply safe heating limits when boiling the medicinal plants, so as not to destroy the active ingredients contained in the plants. Destruction of active ingredients during boiling using high temperature occurs because some secondary metabolite compounds contained in the boiled medicinal plants have thermolabile properties. In addition, decoction is the oldest and simplest way of preparing traditional medicine, whether using fresh or dried ingredients (Balinado & Chan 2017; Caunca & Balinado 2021; Mir *et al.* 2021; Sujana *et al.* 2021). Infusion is preferred for preparing antimalarial medication, along with other traditional medications which use ingredients having bioactive contents that are easily degraded and easily soluble (Petrakou *et al.* 2020). Traditional medications used by ethnic groups are generally in the form of decoctions, infusions, raw foods, poultices, powders, and others (Boyzel *et al.* 2019).

Plants selected for treating malaria traditionally were those having bitter taste. Several research revealed that some plants have been proven to have antimalarial activity; for instant quinine from *Cinchona* spp. and artemisinin from *Artemisia annua* (Nonaka *et al.* 2018; Tajuddeen & Van Heerden 2019). Our study investigated almost all of 11 medicinal plants to determine their antimalarial activity and the content of major phytochemical compound, except for *Boehmeria grandis*, in the Pasemah ethnic group (Table 4).

Empirical facts about *B. grandis* can be used as an initial information for conducting research on the potential *B. grandis* in controlling malaria. Further research on *P. canescens*, *J. gendarussa*, and *M. umbellata* are still required because their extracts are still in crude form, and the main bioactive compounds that act as antimalarial medication are not yet known.

Several studies had determined bioactive compounds of 7 medicinal plants, namely *C. papaya* (carpaine) (Arifuddin *et al.* 2019), *T. crispa* (13 hydroperoxyoctadeca 9, 11 dienoic acid (13[S] HPODE), Columbine, and berberine), *A. paniculata* (andrographolide), *C. longa* (curcumin), *P. angulata* (physalin) (Arruda *et al.* 2021), *Z. officinale* (gingerenone), and *F. tinctoria* (berberine).

Table 4 Cross-references of antimalarial activity and major phytochemical compounds of 11 most frequently used medicinal plants for treating malaria in Bengkulu Province based on published literatures

Species	Antimalarial activity	Major phytochemical compound
Carica papaya L.	*C. papaya* extract is responsible for antioxidant and antimalarial activity (Airaodion *et al*. 2019; Eze *et al*. 2022).	Total phenols (27.99±1.46 mg GAE/g), total flavonoids (18.24±1.36 mg QE/g), glycosides, saponins, tannin, alkaloids, reduced sugars, proteins, terpenoids and steroids (Atanu *et al*. 2021).
Peronema canescens Jack	Ethanol fraction of the leaves of *P. canescens* with 0.084 g/kgBB is the most effective dose and potential as an antimalarial medication (Prasiwi *et al*. 2018).	Flavonoid, saponins, tannin, steroids, terpenoids, alkaloids, and phenols (Prasiwi *et al*. 2018).
Tinospora crispa (L.) Hook.f.&Thomson	Brotowali (*T. crispa*) showed antimalarial activity at 100 and 200 mg/kg of usage. Combination of *T. crispa* stem extract and earthworm extract can prevent erythrocyte hemolysis in non-immune mechanisms. Extract of brotowali stem can restrain the growth rate of malaria parasites, inhibit the sporulation process, and suppress the spread of hemozoin pigment. In addition, brotowali provides anti-hypoglycemic effects (Ounjaijean *et al*. 2019; Kusumarini *et al*. 2020).	Total content of phenols obtained from ethanol extract of *T. crispa* stem was 43.34±1.92% per dry weight. Total flavonoids content was 74.26±1.32 per dry weight (Merici *et al*. 2020)
Andrographis paniculata (Burm.f.) Ness	*A. paniculata* extract can be used as a companion to conventional medicine to treat malaria, due to the increasing resistance of artemisinin to *Plasmodium*. *A. paniculata* also inhibits hempolymerase (Septiana *et al.* 2017, Makmur *et al.* 2022).	Andrographolide (Makmur *et al*. 2022).
Boehmeria grandis (Hook.&Arn.) A.Heller	Not found yet	Not found yet
Curcuma longa L.	In single or combined use, *C. longa* can increase phagocytosis of erythrocytes infected by malaria parasites, induce damage, and affect the life cycle and DNA replication of malaria parasites. In addition to inhibiting malaria parasites, *C. longa* effectively reduces blood parasitemia levels by 80-90%. *C. longa* has the potential as antimalarial agent. In addition, curcumin compounds also have antioxidant effects, which may provide additional benefits in fighting inflammation and cell damage caused by malaria infection (Donipati & Harasreeramulu 2015; Lwin *et al*. 2017; Heydarian *et al.* 2019; Fahira *et al*. 2023)	Curcumin, flavonoids, alkaloids, and phenols (Omagha *et al*. 2020; Fahira *et al*. 2023)
Justicia gendarussa Burm.f	*J. gendarussa* has some unique activities as a larvicide and adulticide that can kill both larvae and adult mosquitoes (Chandra & Lo 2021). There is no literature related to further research on the utilization of *J. gendarussa* as an antimalarial medication.	Alkaloids, polyphenols, flavonoids, glycosides, phytosterols, saponins, triterpenes, and quinines (Shinwari *et al*. 2020; Jain *et al*. 2024).
Melochia umbellata (Houtt.) Stapf	The cytotoxic data of ethyl acetate, methanol, and water extracts contained in *M. umbellata* that show antimalarial activity in vero cells prove that the three extracts have strong potential to fight dengue virus type 2 (DENV-2) (Soekamto *et al*. 2018).	Stigmasterol, Waltherione C, Moracin M, steroids and alkaloids (Soekamto *et al*. 2018; 2019; 2020).
Physalis angulata L.	EPA exhibits potent, selective, and broad-spectrum antiparasitic activity of *P. angulata* against *Trypanosoma cruzi*. In addition, EPA shows that *P. angulata* reduces parasite load by rapidly disrupting the cell cycle in obligate hosts (da Silva *et al*. 2015; Meira *et al.* 2015)endemic in Latin America and emerging in several countries, is limited by the frequent side effects and variable efficacy of benznidazole. Natural products are an important source for the search for new drugs. Aim/hypothesis Considering the great potential of natural products as antiparasitic agents, we investigated the anti-Trypanosoma cruzi activity of a concentrated ethanolic extract of Physalis angulata (EEPA.	Physalin B, D, F, and G (Arruda *et al.* 2021).
Zingiber officinale Rosc.	*Z. officinale* has antiplasmodial activity (Biruksew *et al*. 2018).	Vanillin, gingerenone A, 4-methoxybenzaldehyde, 6- shagaol, 8-shogaol, 10-shogaol and a-linolenic acid (Faloye *et al*. 2023).
Fibraurea tinctoria Lour.	Combination therapy of *F. tinctoria* Lour methanol extract and artemisinin was shown to have antimalarial effects against *Plasmodium berghei in vivo* (Fikriah & Sawitri 2020)	Sesquiterpene hydrocarbons, oxygenated monoterpenes, oxygenated sesquiterpenes, geranial, linalool, N-hexane, and steroid (Sulistiarini *et al*. 2022; Chac *et al*. 2023)

Each of these bioactive compounds has its mechanism and role as an antimalarial medication. Although the antimalarial mechanism is unknown, it is estimated that carpaine directly inhibits the parasite (Arifuddin *et al*. 2019; Teng *et al.* 2019; Dwivedi *et al*. 2020; Haldar *et al*. 2020). At the tests of 13 hydroperoxyoctadeca 9, 11 dienoic acid (13[S] HPODE), the reduction in parasitemia occurs suppressive, prophylactically, and shows a schizonticidal effect. Columbine and berberine have similar mechanisms, working as an antimalarial medication using a dihydrofolate reductase-thymidylate synthase (DHFR-TS) inhibitory mechanism (Chester *et al.* 2017; Bare *et al*. 2020; 2022; Purwaningsih *et al.* 2023)hypertension, atherosclerosis, and cancer. For decades, anti-adipogenic potential of many herbal extracts has been investigated. One example is Garcinia cambogia extract (GE. The mechanism of andrographolide is to inhibit the growth of parasitemia (Sari *et al*. 2018). Curcumin has several mechanisms of action, including anti-inflammatory, antioxidant, antinociceptive, antiparasitic, and wound-healing effects (Urošević *et al*. 2022; Jamil *et al*. 2023). *Physalin* works by inhibiting the function of the P2X7 receptor, which regulates the production of pro-inflammatory cytokines (Arruda *et al*. 2021). Gingerenone works as an antimalarial medication by binding to plasmepsin II and *Plasmodium falciparum* dihydrofolate reductase-thymidylate synthase (Faloye *et al*. 2023).

Traditional Knowledge on Antimalarial Medication of Ethnics Groups in Bengkulu Province

In Bengkulu Province the 20 traditional healers, who were selected as respondents in this study, had diverse traditional knowledge on malaria treatment. This study developed a dendrogram to represent four main clusters, where one cluster (Pasemah7) has no similarity to the other clusters (Fig. 6).

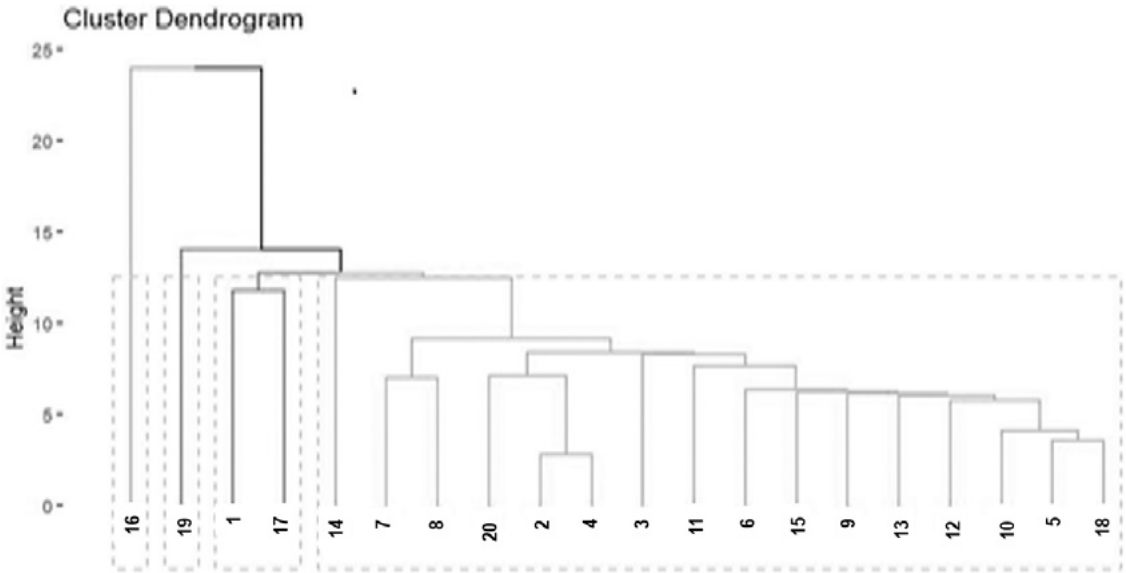

Figure 6 Cluster dendrogram representing traditional knowledge of ethnic groups in Bengkulu Province on medicinal plants having antimalarial activity.
Notes: 1. Muko-muko; 2. Rejang1; 3. Rejang2; 4. Rejang 3; 5. Lembak1; 6. Lembak3; 7. Rejang4; 8. Lembak2; 9. Serawai; 10. Pasemah8; 11. Pasemah9; 12 Pasemah6; 13. Pasemah3; 14. Pasemah2; 15. Pasemah1; 16. Pasemah7; 17. Pasemah5; 18. Pasemah4; 19. Enggano1; 20. Enggano2.

Traditional healers in Pasemah ethnic group (Pasemah7) had a formula containing 14 medicinal plants having antimalarial activity that differed from the other healers, i.e., *A. lavenia*, *A. ghaesembilla*, *M. tanarius*, *P. acerifolium*, *P. javanicum*, *S. cordifolia*, *S. rhombifolia*, *T. populnea*, *A. elasticus*, *M. paradisiaca*, *G. verticillata*, *G. apus*, *O. sativa*, and *C. halicacabum*. One traditional healer from Enggano ethnic group (Enggano-1) had a formula using 4 different medicinal plants having antimalarial activity, namely *A. calamus*, *S. taccada*, *F. tinctoria*, and *C. zanthorrhiza*.

Our study observed that Pasemah was the ethnic group with the highest usage of medicinal plants for treating malaria. Knowledge on medicinal plants acquired by the Pasemah ethnic group may have been caused by local wisdom, culture, beliefs, and accessibility inherited within the ethnic group (Adi *et al*. 2020; Hasyim *et al*. 2023).

Pasemah ethnic group is widely spread in Pagar Alam City, Empat Lawang Regency, Lahat Regency, and Muara Enim Regency (Ernatip *et al*. 2007), where malaria cases are high, especially in Muara Enim Regency in which malaria cases are the highest in South Sumatra, with incidence rates of 3,428 (in 2018), 3,215 (in 2019), and 6,266 (in 2020) (BPS 2023; Hasyim *et al.* 2023). In Bengkulu Province, there are open-pit mineral mining areas causing the occurrence of lots of standing water, which supports the development of malaria vector mosquitoes.

CONCLUSION

This study found that there were 47 medicinal plant species belonging to 29 plant families used by 20 traditional healers from 6 ethnic group for treating malaria and for antimalarial medication in Bengkulu Province. *Carica papaya*, *Peronema canescens* and *Tinospora crispa* were the 3 medicinal plants most widely used for antimalarial medication. Plant leaves are the most used plant part for antimalarial medication. Herbal preparations prepared by traditional healers are mostly in the form of decoctions with oral administration methods. Our study also observed several compounds contained in medicinal plants that have been scientifically proven to be efficacious as antimalarial medication.

ACKNOWLEDGMENTS

Authors greatly appreciate the team who carried out the ethno-medicine survey from University of Bengkulu and the Center for Research and Development of Medicinal and Traditional Plants. The research was funded by DIPA of the Center for Research and Development of Medicinal and Traditional Medicinal Plants, the National Institute Health Research and Development, Ministry of Health of the Republic of Indonesia with Decision Letter Number 378/MENKES/SK/X/2012 dated 23 October 2012, involving stakeholders from the central government to the regions and various parties. The data usage has been approved by the National Institute Health Research and Development of the Ministry of Health of the Republic of Indonesia with letter number 30011829-032 dated 6 March 2018.

REFERENCES

Abdillah S, Tambunan RM, Farida Y, Sandhiutami NMD, Dewi RM. 2015. Phytochemical screening and antimalarial activity of some plants traditionally used in Indonesia. Asian Pac J Trop Dis 5:454-7. DOI: 10.1016/S2222-1808(15)60814-3

Adi MBS, Susanti D, Wijaya NURR. 2020. Antifever medicinal plants on native ethnics on Sumatra Island. Journal of Complementary Medicine Research 11: 19-33. DOI: 10.5455/jcmr.2020.11.01.04

Adiyasa MR, Meiyanti M. 2021. Pemanfaatan obat tradisional di Indonesia: Distribusi dan faktor demografis yang berpengaruh [Utilization of traditional medicine in Indonesia: Distribution and influential demographic factors]. Jurnal Biomedika dan Kesehatan 4: 130-8. DOI: 10.18051/jbiomedkes.2021.v4.130-138

Airaodion AI, Airaodion EO, Ekenjoku JA, Ogbuagu EO, Ogbuagu U. 2019. Antiplasmodial potency of ethanolic leaf extract of *Carica papaya* against *Plasmodium berghei* in infected Swiss Albino Mice. Asian J Med Princ Clin Prac 2: 1-8. Available from: https://journalajmpcp.com/index.php/AJMPCP/article/view/30097.

Alkhamaiseh SI, Aljofan M. 2020. Prevalence of use and reported side effects of herbal medicine among adults in Saudi Arabia. Complement Ther Med 48: 102255. DOI: 10.1016/j.ctim.2019.102255

Arifuddin M, Bone M, Rusli R, Kuncoro H, Ahmad I, Rijai L. 2019. Aktivitas Antimalaria Penghambatan Polimerisasi Heme Ekstrak Etanol Daun Jambu Biji (*Psidium guajava*) dan Daun Pepaya (*Carica papaya*) [Antimalaria activity of heme polymerization inhibition of ethanol extract of guava leaves (*Psidium guajava*) and papaya leaves (*Carica papaya*)]. Jurnal Ilmiah Ibnu Sina (JIIS): Ilmu Farmasi dan Kesehatan 4:235-43. DOI: 10.36387/jiis.v4i1.246

Arruda JCC, Rocha NC, Santos EG, Ferreira LGB, Bello ML, Penido C, …, Faria RX. 2021. Physalin pool from *Physalis angulata* L. leaves and physalin D inhibit P2X7 receptor function *in vitro* and acute lung injury *in vivo*. Biomed Pharmacother 142:112006. DOI: 10.1016/j.biopha.2021.112006

Asiimwe S, Namukobe J, Byamukama R, Imalingat B. 2021. Ethnobotanical survey of medicinal plant species used by communities around Mabira and Mpanga Central Forest Reserves, Uganda. Trop Med Health 49:52. DOI: 10.1186/s41182-021-00341-z

Atanu FO, Idih FM, Nwonuma CO, Hetta HF, Alamery S, El-Saber Batiha G. 2021. Evaluation of antimalarial potential of extracts from *Alstonia boonei* and *Carica papaya* in *Plasmodium berghei*-infected mice. Evid-Based Complement Alternat Med 2021:1-11. DOI: 10.1155/2021/2599191

Babalola BA, Akinwande AI, Otunba AA, Adebami GE, Babalola O, Nwufo C. 2024. Therapeutic benefits of *Carica papaya*: A review on its pharmacological activities and characterization of papain. Arab J Chem 17:105369. DOI: 10.1016/j.arabjc.2023.105369

Balinado LO, Chan MA. 2017. An ethnomedicinal study of plants and traditional health care practices in District 7, Cavite, Philippines. In: 2017 International Conference on Chemical, Agricultural, Biological and Medical Sciences (CABMS-17). Manila, Philippines, 23-24 January 2017. p. 131-43. DOI: 10.17758/uruae.ae0117622

Bamigboye SO, Tshisikhawe MP. 2020. The impacts of bark harvesting on a population of Encephalartos transvenosus (Limpopo cycad), in Limpopo Province, South Africa. Biodiversitas 21:8-13. DOI: 10.13057/biodiv/d210102

Bare Y, Sari DRT, Meak LEC, Mogi MC. 2020. *In silico* study of columbin from *Tinospora crispa* L as dihydrofolate reductase-thymidylate synthase (DHFR-TS) inhibitor. Bioscience 6:12. DOI: 10.24036/02022611160900-0-00

Bare Y, Sari DRT, Nita AD, Taek MM. 2022. Berberine: A potential inhibitor of dihydrofolate reductase- thymidylate synthase (DHFR-TS) for malaria. Biosfer: Jurnal Tadris Biologi 13: 93-9. DOI: 10.24042/biosfer.v13i1.11145

Başaran N, Paslı D, Başaran AA. 2022. Unpredictable adverse effects of herbal products. Food Chem Toxicol 159: 1-8. DOI: 10.1016/j.fct.2021.112762

Biara E, Egeru A, Mensah S, Salamula JB, Kadigo MM. 2021. Socio-economic factors influencing *Afzelia africana* Sm. use value and traditional knowledge in Uganda: Implications for sustainable management. Environ Dev Sustain 23:2261-78. DOI: 10.1007/s10668-020-00673-6

Biruksew A, Zeynudin A, Alemu Y, Golassa L, Yohannes M, Debella A, …, Suleman S. 2018. *Zingiber officinale* Roscoe and *Echinops kebericho* Mesfin showed antiplasmodial activities against *Plasmodium berghei* in a dose-dependent manner in Ethiopia. Ethiop J Health Sci 28:655-64. DOI: 10.4314/ejhs.v28i5.17

BPS [Badan Pusat Statistik Indonesia]. 2017. Provinsi Bengkulu dalam Angka 2017 [Bengkulu municipality in figures 2017]. Bengkulu (ID): BPS Kota Bengkulu. p 3-10.

BPS [Badan Pusat Statistik Indonesia]. 2023. Provinsi Sumatera Selatan dalam Angka 2023 (Sumatera Selatan Province in figures 2023). Palembang (ID): BPS Provinsi Sumatera Selatan. p 223-46.

Budiarti M, Maruzy A, Mujahid R, Sari AN, Jokopriyambodo W, Widayat T, Wahyono S. 2020. The use of antimalarial plants as traditional treatment in Papua Island, Indonesia. Heliyon 6: (e05562):1-10. DOI: 10.1016/j.heliyon.2020.e05562

Cain CL, Surbone A, Elk R, Kagawa-Singer M. 2018. Culture and palliative care: Preferences, communication, meaning, and mutual decision making. J Pain Symptom Manag 55:1408-19. DOI: 10.1016/j.jpainsymman.2018.01.007

Caunca ES, Balinado LO. 2021. The practice of using medicinal plants by local herbalists in Cavite, Philippines. Indian J Tradit Knowl 20:335-43. DOI: 10.56042/ijtk.v20i2.26862

Chaachouay N, Benkhnigue O, Fadli M, El Ibaoui H, Zidane L. 2019. Ethnobotanical and ethnopharmacological studies of medicinal and aromatic plants used in the treatment of metabolic diseases in the Moroccan Rif. Heliyon 5(e02191):1-9. DOI: 10.1016/j.heliyon.2019.e02191

Chac LD, Hoi Q V., Thinh BB. 2023. Chemical composition and antimicrobial activity of the essential oil of *Fibraurea tinctoria*. Chem Nat Compd 59:597-9. DOI: 10.1177/1934578X241239477

Chandra S, Lo D. 2021. A review on the bioactivities of *Justicia gendarussa*. IOP Conf. Series: Earth and Environmental Science 794 (2021) 012137: 1-6. DOI: 10.1088/1755-1315/794/1/012137

Cheng Z, Hu X, Lu X, Fang Q, Meng Y, Long C. 2022. Medicinal plants and fungi traditionally used by Dulong People in Northwest Yunnan, China. Front Pharmacol 13:1-11. DOI: 10.3389/fphar.2022.895129

Chester K, Zahiruddin S, Ahmad A, Khan W, Paliwal S, Ahmad S. 2017. Bioautography-based Identification of Antioxidant Metabolites of *Solanum nigrum* L. and Exploration Its Hepatoprotective Potential against D-Galactosamine-induced Hepatic fibrosis in Rats. Pharmacognosy Magazine 15 (62): s104-s110. DOI: 10.4103/pm.pm_359_18

Dajic-Stevanovic Z, Pljevljakusic D. 2015. Challenges and decision making in cultivation of medicinal and aromatic plants. In: Máthé, Á. (Editor). Medicinal and Aromatic Plants of the World. Vol 1. Dordrecht (NL): Springer. p. 145-64. DOI: 10.1007/978-94-017-9810-5_8

da Silva RRP, da Silva BJM, Rodrigues APD, Farias LHS, da Silva MN, Alves DTV., …, Silva EO. 2015. *In vitro* biological action of aqueous extract from roots of *Physalis angulata* against *Leishmania* (*Leishmania*) *amazonensis*. BMC Complementary and Alternative Medicine 15:1-10. DOI: 10.1186/s12906-015-0717-1

Djamaluddin A, Putra RK, Ratnasari D, Kelamin J. 2020. Persepsi Masyarakat Terhadap Pengobatan Tradisional Berdasarkan Perbedaan Jenis Kelamin [Public perception of traditional health based on gender differences]. J Holist Heal Sci 4: 67-77. DOI:https: 10.51873/jhhs.v4i2.82

Donipati P, Harasreeramulu S. 2015. *In vitro* anti-malarial activity of rhizome extracts of *Curcuma* species. J Surv Fish Sci 6(4): B1141-B1146. DOI:10.53555/sfs.v10i1.1946

Dwivedi MK, Sonter S, Mishra S, Patel DK, Singh PK. 2020. Antioxidant, antibacterial activity, and phytochemical characterization of *Carica papaya* flowers. Beni-Suef University Journal of Basic and Applied Sciences 9(23): 1-11.DOI: 10.1186/s43088-020-00048-w

Efrianto. 2018. Klasifikasi dan sistim pewarisan dalam pengobatan tradisional pada masyarakat Kaur Provinsi Bengkulu [Classification and inheritance system in traditional medicine in the Kaur Community, Bengkulu Province]. Suluah 21: 19-29.

Ernatip, Refisrul, Ajisman, Iriani. 2007. Budaya suku bangsa Pasemah di Sumatera Selatan [Culture of the Pasemah Tribe in South Sumatra]. Effendi N (Editor). Padang (ID): Departemen Kebudayaan dan Pariwisata. Balai Pelestarian Sejarah dan Nilai Tradisional. Padang. 30 pp.

Eze CC, Agbo MC, Ozioko CA, Ugwu PC, Obayiuwana AC. 2022. Antimicrobial activities and malaria parasite clearance of crude extract of *Carica papaya* seeds in mice infected with *Plasmodium berghei.* Trop J Nat Prod Res 6:1492-6. DOI: 10.26538/tjnpr/v6i9.26

Fahira M, Darmawan MA, Rivandha M, Yoga I, Irawan MR, Safira N, Andanalusia M. 2023. Potensi kurkumin pada kunyit (*Curcuma longa* sp.) dalam penatalaksanaan malaria [The potential of curcumin in turmeric (*Curcuma longa* sp.) in the management of malaria]. Lombok Medical Journal 2: 142-7. DOI: 10.29303/lmj.v2i2.2790

Faloye KO, Tripathi MK, Adesida SA, Oguntimehin SA, Oyetunde YM, Adewole AH, …, Dosumu OD. 2023. Antimalarial potential, LC-MS secondary metabolite profiling and computational studies of *Zingiber officinale*. J Biomol Struct Dyn 42(1):1-16. DOI: 10.1080/07391102.2023.2205949

Fetene N, Wendimagegn, Bezuidenhout MC. 2019. Integrating promotive, preventive, and curative health care services at hospitals and health centers in Addis Ababa, Ethiopia. J Multidiscip Healthc 12:243-55. DOI: 10.2147/JMDH.S193370

Fikriah I, Sawitri E. 2020. *In vivo* antimalarial effect of yellow root stem (*Fibraurea tinctoria* Lour) on *Plasmodium berghei*. Sys Rev Pharm 11(6):380-3. DOI: 10.31838/srp.2020.6.60

Fitri LE, Maharani D, Margareta A, Purnomo H, Rahayu M, Budiarti N. 2019. Combination artesunate and *Tinospora crispa* decreases ubiquitin, HIF-1α, VEGF and iNOS expression in brain of cerebral malaria mice model. Int J Med Res Health Sci 8(8):98-109.

Gaoue OG, Coe MA, Bond M, Hart G, Seyler BC, McMillen H. 2017. Theories and major hypotheses in ethnobotany. Econ Bot 71:269-87. DOI: 10.1007/s12231-017-9389-8

Haldar S, Mohapatra S, Singh R, Katiyar CK. 2020. Isolation and quantification of bioactive carpaine from *Carica papaya* L. and its commercial formulation by HPTLC densitometry. J Liq Chromatogr R T 43(11-12):388-93. DOI: 10.1080/10826076.2020.1725558

Hastiana Y, Novitasari N, Aseptianova A, Nawawi S. 2023. Ethnobotany study of potential and utilization of medicinal plants by local communities in Muara Enim Regency, South Sumatera. Jurnal Mangifera Edu 7:102-18. DOI: 10.31943/mangiferaedu.v7i2.152

Hasyim H, Ihram MA, Fakhriyatiningrum, Misnaniarti, Idris H, Liberty IA, …, Dale P. 2023. Environmental determinants and risk behaviour in the case of indigenous malaria in Muara Enim Regency, Indonesia: A casecontrol design. PLoS ONE 18:1-10. DOI: 10.1371/journal.pone.0289354

Heydarian P, Nateghpour M, Mazhari N, Haghi AM, Farivar L. 2019. Evaluation of effectiveness of ethanolic extract of *Curcuma longa,* discretely and in combination with chloroquine against chloroquine-sensitive strain of *Plasmo*dium berghei. Herb Med J 3(4): 133-8. DOI: 10.22087/herb

Huda N, Amilda, Sobari D. 2019. Pelestarian nilai-nilai budaya basemah pada masyarakat Pagar Alam melalui pemberdayaan keluarga [Preservation of basemah cultural values in Pagar Alam community through family empowerment). Rochmiatun E (Editor). Palembang (ID): Rafah Press. 101 pp.

Jain T, Singh MP, Bhardwaj H, Gohil KJ. 2024. Review on pharmacology activities of *Justicia gendarussa* Burm F. Pharmacol Res-Mod Chin Med 10(3):1-8. DOI: 10.1016/j.prmcm.2023.100339

Jamil SNH, Ali AH, Feroz SR, Lam SD, Agustar HK, Mohd Abd Razak MR, Latip J. 2023. Curcumin and its derivatives as potential antimalarial and anti-inflammatory agents: A review on structure–activity relationship and mechanism of action. Pharmaceuticals 16(609):1-25. DOI: 10.3390/ph16040609

Kementerian Kesehatan Republik Indonesia. 2012. Pedoman pengumpulan data dan pengisian instrumen RISTOJA 2012 eksplorasi pengetahuan lokal etnomedisin dan tumbuhan obat di Indonesia berbasis komunitas [Guidelines for data collection and filling out the 2012 RISTOJA instrument for community-based exploration of local ethnomedicinal knowledge and medicinal plants in Indonesia). Jakarta (ID): Balai Besar Penelitian dan Pengembangan Tanaman Obat dan Obat Tradisional, Badan Penelitian dan Pengembangan Kesehatan. Kementerian Kesehatan Republik Indonesia. p 1-31.

Kementerian Kesehatan Republik Indonesia. 2013. Diabetes melitus. Riset Kesehatan Dasar (Diabetes mellitus. Basic Health Research). Jakarta (ID): Kementerian Kesehatan Republik Indonesia.

Kementerian Kesehatan Republik Indonesia. 2019. Profil Kesehatan Indonesia 2018 (Indonesia Health Profile 2018). Jakarta (ID): Kementerian Kesehatan Republik Indonesia. 556 pp.

Kementerian Kesehatan Republik Indonesia. 2022. Laporan Kinerja Direktorat Pencegahan dan Pengendalian Penyakit Menular Kementerian Kesehatan 2022 (Performance Report of the Directorate of Diseases Prevention and Control Ministry of Health 2022). Jakarta (ID): Kementerian Kesehatan Republik Indonesia. 129 pp.

Kovendan K, Murugan K, Panneerselvam C, Aarthi N, Kumar PM, Subramaniam J, …, Vincent S. 2012. Antimalarial activity of *Carica papaya* (Family: Caricaceae) leaf extract against *Plasmodium falciparum*. Asian Pac J Trop Dis 2(1): S306-S311. DOI: /10.1016/S2222-1808(12)60171-6

Kusumarini S, Encephala RK, Swastomo R, Yesica R, Fauzi A, Syafitri W. 2020. Synergistic antimalarial activities: Haematocrit and histopathological studies on lien of balb/c mice infected by *Plasmodium berghei* after administration of brotowali rod (*Tinospora crispa*) and earthworms extract (*Lumbricus rubellus*). Vet Pract 21: 367-71.

Lusiyana N. 2020. Challenges of malaria elimination in Indonesia. Jurnal Kedokteran dan Kesehatan Indonesia 11: 222-3. DOI: /10.1177/1356262217750313

Lwin KM, Mon HM, Myint KH. 2017. Evaluation of the antimalarial activity of *Curcuma longa* Linn., singly and in combination with *Eupatorium odoratum* Linn. J Ayurvedic Herbal Med 3(1):11-4. DOI: 10.31254/jahm.2017.3103

Maigoda T, Judiono J, Purkon DB, Haerussana ANEM, Mulyo GPE. 2022. Evaluation of Peronema canescens leaves extract: Fourier transform infrared analysis, total phenolic and flavonoid content, antioxidant capacity, and radical scavenger activity. Open Access Maced J Med Sci 10(A):117-24. DOI: 10.3889/oamjms.2022.8221

Makmur T, Siregar FA, Siregar S, Lubis IA, Bestari R, Zein U. 2022. Open clinical trial of sambiloto (*Andrographis paniculata*) ethanolic extract capsules in treatment of malaria patients in Batubata District, Indonesia. Med Arch 76(6):419-25. DOI: 10.5455/medarh.2022.76.419-425

Malik MM. 2015. The potential of brotowali stem extract (*Tinospora crispa*) as an alternative antimalarial drug. J Majority 4(5):45-9.

McQuaid EL, Landier W. 2018. Cultural issues in medication adherence: Disparities and directions. J Gen Intern Med 33(2):200-6. DOI: 10.1007/s11606-017-4199-3

Meira CS, Guimarães ET, Dos Santos JAF, Moreira DRM, Nogueira RC, Tomassini TCB, …, Soares MBP. 2015. *In vitro* and *in vivo* antiparasitic activity of *Physalis angulata* L. concentrated ethanolic extract against *Trypanosoma cruzi.* Phytomedicine 22(11):969-74. DOI: 10.1016/j.phymed.2015.07.004

Merici A, Fitri LE, Budiarti N. 2020. The effect of artesunate and brotowali (*Tinospora crispa*) combination on histopathological, and expression of nuclear factor Kappa B (NF-kÎ²) in renal tubules of mice infected with *Plasmodium berghei*. Clin Res J Intern Med 1(1):1-12. DOI: 10.21776/ub.crjim.2020.001.01.5

Nain T, Sharma S, Chawariya N, Yadav JP. 2022. Prospect of natural compounds against malaria: A review. Bull Pharm Sci Assiut 45(2):629-53. DOI: 10.21608/BFSA.2022.271581

Najem M, Harouak H, Ibijbijen J, Nassiri L. 2020. Oral disorders and ethnobotanical treatments: A field study in the central Middle Atlas (Morocco). Heliyon 6(8):e04707. DOI: 10.1016/j.heliyon.2020.e04707

Niljan J, Jaihan U, Srichairatanakool S, Uthaipibull C, Somsak V. 2014. Antimalarial activity of stem extract of *Tinospora crispa* against *Plasmodium berghei* infection in mice. J Health Res 28(3): 199-204. Available from: https://thaiscience.info/Journals/Article/JHRE/10935094.pdf.

Nonaka M, Murata Y, Takano R, Han Y, Bin Kabir MH, Kato K. 2018. Screening of a library of traditional Chinese medicines to identify anti-malarial compounds and extracts. Malar J 17(1):1-10. DOI: 10.1186/s12936-018-2392-4

Nugraha AS, Purnomo YD, Pratama ANW, Triatmoko B, Hendra R, Wongso H, …, Keller PA. 2022. Isolation of antimalarial agents from indonesian medicinal plants: *Swietenia mahagoni* and *Pluchea indica.* Nat Prod Commun 17(1): 1-5. DOI: 10.1177/1934578X211068926

Omagha R, Idowu E, Alimba C, Otubanjo A, Agbaje E, Ajaegbu HC. 2020. Physicochemical and phytochemical screening of six plants commonly used in the treatment of malaria in Nigeria. Jf Phytomed Ther 19(2):483-501. DOI: 10.4314/jopat.v19i2.6

Ounjaijean S, Chachiyo S, Somsak V. 2019. Hypoglycemia induced by *Plasmodium berghei* infection is prevented by treatment with *Tinospora crispa* stem extract. Parasitol Int 68(1):57-9. DOI: 10.1016/j.parint.2018.10.009

Padhan B, Panda D. 2016. Wild tuber species diversity and its ethno-medicinal use by tribal people of Koraput District of Odisha, India. Indian J Nat Prod Resour 2(1):33-6. Available from: http://www.jacsdirectory.com/jnpr.

Pamenang FDN. 2021. Local wisdom in learning as an effort to increase cultural knowledge: Students perception as prospective teachers. IJIET (International Journal of Indonesian Education and Teaching) 5(1):93-101. DOI: 10.24071/ijiet.v5i1.3050

Pandey P, Tripathi A, Dwivedi S, Lal K, Jhang T. 2023. Deciphering the mechanisms, hormonal signaling, and potential applications of endophytic microbes to mediate stress tolerance in medicinal plants. Front Plant Sci 14:1-33. DOI: 10.3389/fpls.2023.1250020

Prasiwi D, Sundaryono A, Handayani D. 2018. Aktivitas Fraksi Etanol dari Ekstrak Daun *Peronema canescens* terhadap Tingkat Pertumbuhan *Plasmodium berghei* (Activity of Ethanol Fraction of *Peronema canescens* Leaf Extract on *Plasmodium berghei* Growth Rate). Alotrop 2: 25–32. DOI: 10.33369/atp.v2i1.4601

Pratama RR, Sholikhah I, Sukardiman, Sahu RK, Widyowati R. 2023. Phytochemical compounds identification from 70% ethanol extract of *Arcangelesia flava* (L.) Merr stems using LC-MS/MS and in silico molecular docking approach as inhibitor Interleukin-1β. Pharmacognosy J 15(4):528-34. DOI: 10.5530/pj.2023.15.114

Purwaningsih I, Maksum IP, Sumiarsa D, Sriwidodo S. 2023. A review of *Fibraurea tinctoria* and Its component, berberine, as an antidiabetic and antioxidant. Molecules 28(3):1-38. DOI: 10.3390/molecules28031294

Purwoko S, Khairunnisa M, Hidayat T, Susanti D, Laksono AD, Suharmiati S. 2023. Promosi pelayanan pengobatan tradisional di Jawa Tengah: Siapakah sasaran yang tepat? [Promotion of traditional medicine services in Central Java: Who is the appropriate target?). Jurnal Kesehatan Vokasional 8(1): 1-11.DOI: 10.22146/jkesvo.77089

Rahmasari FV, Asih PBS, Dewayanti FK, Rotejanaprasert C, Charunwatthana P, Imwong M, Syafruddin D. 2022. Drug resistance of *Plasmodium falciparum* and *Plasmodium vivax* isolates in Indonesia. Malar J 21(1):1-32. DOI: 10.1186/s12936-022-04385-2

Sari R, Widyawaruyanti A, Anindita FBT, Astuti SK, Setyawan D. 2018. Development of andrographolide-carboxymethyl chitosan nanoparticles: Characterization, *in vitro* release and *in vivo* antimalarial activity study. Turk J Pharm Sci 15(2):136-41. DOI: 10.4274/tjps.53825

Seitz B, Buchholz S, Kowarik I, Herrmann J, Neuerburg L, Wendler J, …, Egerer M. 2022. Land sharing between cultivated and wild plants: Urban gardens as hotspots for plant diversity in cities. Urban Ecosyst 25(4):927-39. DOI: 10.1007/s11252-021-01198-0

Septiana E, Gianny D, Simanjuntak P. 2017. Toksisitas dan aktivitas antimalaria melalui penghambatan polimerisasi hem secara *in vitro* ekstrak daun sambiloto (*Andrographis paniculata*) [Toxicity and antimalarial activity through inhibition of heme polymerization *in vitro* of sambiloto leaf extract (*Andrographis paniculata*)]. Media Penelitian dan Pengembangan Kesehatan 27: 255-62. DOI: 10.22435/mpk.v27i4.6499.255-262.

Shinta SS. 2005. Pengetahuan, sikap dan perilaku tokoh masyarakat tentang malaria di Kabupaten Purworejo, Jawa Tengah [Knowledge, attitudes and behavior of community leaders regarding malaria in Purworejo Regency, Central Java] . Media Litbang Kesehatan XV:29-34.

Shinwari ZK, Ahmad I, Ahmad N, Fozia, Akhlaq M, Baharullah, Wahab A. 2020. Investigation of phytochemical, anti microbial activities of *Justicia gendarussa* and *Justicia adhatoda.* Pak J Bot 52(5):1745-9. DOI: 10.30848/PJB2020-5(1)

Singh P, Singh RL, Pathak N, Singh PK, Tripathi M, Mondal S. 2022. Phytochemistry and nutraceutical properties of *Carica papaya* (Linn.): A review. Diet Suppl Nutraceuticals 1(9):1-15. DOI: 10.31989/dsn.v1i9.991

Soekamto NH, Aeni N, Firdaus. 2020. Potential of n-hexane and chloroform extracts from *Melochia umbellata* (Houtt) Stapf var *bark*. *Visenia* as dengue antivirus. IOP Conf Ser Earth Environ Sci 473(1):11-5. DOI: 10.1088/1755-1315/473/1/012148

Soekamto NH, Firdaus, Ahmad F, Appa FE. 2019. Potential of stigmasterol from EtOAc extract *Melochia umbellata* (Houtt) Stapf var. *Visenia* as Dengue Antivirus. J Phys Conf Ser 1341(3):1-6. DOI: 10.1088/1742-6596/1341/3/032044

Soekamto NH, Liong S, Fauziah S, Wahid I, Firdaus, Taba P, Ahmad F. 2018. Dengue antiviral activity of polar extract from *Melochia umbellata* (Houtt) Stapf var. *Visenia*. J Phys Conf Ser 979:1-5. DOI: 10.1088/1742-6596/979/1/012017

Subositi D, Wahyono S. 2019. Study of the genus Curcuma in Indonesia used as traditional herbal medicines. Biodiversitas 20(5):1356-61. DOI: /10.13057/biodiv/d200527

Sulistiarini R, Soemardji AA, Elfahmi, Iwo MI, Puspitasari DJ, Prabandari EE, Waluyo D. 2022. Antiplasmodial activity and malate quinone oxidoreductase inhibitor of steroid isolated from *Fibraurea tinctoria*. Rasayan J Chem 15(01):377-86. DOI: 10.31788/RJC.2022.1516096

Susanti D, Rahmawati N, Sholikhah IYM, Mujahid R, Subositi D, …, Haryanti S. 2023. Medicinal plants utilized for fitness disorders treatment by ethnic groups in Papua and West Papua Province, Indonesia. J Appl Pharm Sci 13(09):149-60. DOI: 10.7324/JAPS.2023.140135

Suwandi JF, Wijayanti MA, Mustofa. 2018. In vitro antiplasmodial and cytotoxic activities of a sungkai (*Peronema canescens*) leaf extract. Int J Pharm Pharm Sci 10(10):109-13. DOI: 10.22159/ijpps.2018v10i10.25124

Syafni N, Bakhtiar A. 2022. Ethnobotanical study of ferns as traditional medicine in Central Siberut, Mentawai Island. Jurnal Biologi UNAND 10(1):10-4. DOI: 10.25077/jbioua.10.1.10-14.2022

Taek MM. 2020. Studi etnomedisin pencegahan dan pengobatan penyakit malaria masyarakat Suku Tetun di Timor Barat, Provinsi Nusa Tenggara Timur, Indonesia [Ethnomedicinal study of prevention and treatment of malaria in the Tetun community in West Timor, East Nusa Tenggara Province, Indonesia]. [Dissertation]. Surabaya (ID): Universitas Airlangga, Faculty of Pharmacy.

Tajuddeen N, Van Heerden FR. 2019. Antiplasmodial natural products: An update. Malar J 18(1):1-62. DOI: 10.1186/s12936-019-3026-1

Teng WC, Chan W, Suwanarusk R, Ong A, Ho HK, Russell B, …, Koh HL. 2019. *In vitro* antimalarial evaluations and cytotoxicity investigations of *Carica papaya* leaves and carpaine. Nat Prod Commun 14(1):33-6. DOI: 10.1177/1934578X1901400110

Theodoridis S, Drakou EG, Hickler T, Thines M, Nogues-Bravo D. 2023. Evaluating natural medicinal resources and their exposure to global change. Personal View 7(2):e155-e163. DOI: 10.1016/S2542-5196(22)00317-5

Tjitraresmi A, Moektiwardoyo M, Susilawati Y, Shiono Y. 2020. Antimalarial activity of Lamiaceae family plants: Review. Syst Rev Pharm 11(7):324-33. DOI: 10.31838/srp.2020.7.51

Urošević M, Nikolić L, Gajić I, Nikolić V, Dinić A, Miljković V. 2022. Curcumin: Biological activities and modern. Antibiotics 11(2):1-27. DOI: 10.3390/antibiotics11020135

Wibowo A, Setyawati A, Masyithoh G, Rahayu ES. 2021. Local wisdom in the preservation and diversification of medicinal plant use [A case study of the Lawu mountainside community on the Island of Java, Indonesia]. In: IOP Conf Ser Earth Environ Sci 905(1):1-8. DOI: 10.1088/1755-1315/905/1/012025

Widiyastuti Y, Bakti Samsu Adi M, Widayat T. 2017. Spesies tumbuhan obat di Cagar Alam Sigogor, Ponorogo, Jawa Timur [Medicinal plants species in Sigogor Nature Reserve, Ponorogo, East Jawa]. Jurnal Tumbuhan Obat Indonesia 10 (2): 78-87. DOI:10.22435/toi.v10i2.6736.78-87

Wiryono, Japriyanto, Erniwati. 2017. The diversity of locally utilized plants and local botanical knowledge in Central Bengkulu District, Bengkulu Province, Indonesia. Biodiversitas 18(4):1589-95. DOI: 10.13057/biodiv/d180437

Yulia, Rahman A, Faizal, Sari E. 2020. Protection of traditional knowledge of Indonesian society in the field of medicines: In the development of pharmaceutical industry technology. Intellectual Property Rights Review 3(02):221-6.

Zakiyah S, Tasikrara L, Nurfatimah. 2022. Contribution of local wisdom values to education. International Journal Social Sciences and Education (IJoSSE) 3(2):37-48. https://doi.org/10.26858/ijosse.v3i2.40119