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Traditional Utilization of Plants for Malaria Prevention and Treatment by The Sumba Tribe, East Nusa Tenggara

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ABSTRACT
Malaria is a tropical disease that remains a major public health problem in Indonesia. The eastern region of Indonesia, including Sumba Island, is recorded as an area with a high prevalence of endemic malaria cases. This study aims to identify plant species used for the prevention and treatment of malaria, determine the plant parts most commonly utilized, and analyze the Use Index Value (UVi), Relative Frequency of Citation (RFC), and Fidelity Level (FL) of each plant species used. This study employed structured interview techniques using the snowball sampling and purposive sampling methods on 25 informants, consisting of 76% males and 26% females. Field observations were conducted to identify plant species, and documentation was carried out. Plant species were identified using the Flora of Malesiana book, while species verification was conducted using the Plants of the World Online (POWO) database. The data were analyzed quantitatively. This study identified 43 plant species from 32 families used for malaria treatment on Sumba Island. The families with the highest number of species were Fabaceae and Meliaceae. Most of the plants used were trees (51%), with the most common processing method being decoction (53%). The most frequently utilized plant part for therapeutic preparation was the leaves (49%). The plant most commonly used for malaria treatment, based on the highest UVi value (0.64) and the highest RFC value (0.56), was Carica papaya L. Additionally, 24 plant species with an FL of 100% were recommended as potential materials for malaria prevention and treatment. Medicinal plants should be preserved due to their ecological value, such as maintaining soil fertility, acting as natural pest control, balancing water cycles, producing oxygen, and providing habitats. This study demonstrates that ethnomedicine practices play a crucial role in people's lives. The medicinal plants used have the potential to be further developed as natural alternative treatments. Therefore, efforts should be made for conservation and further research on their effectiveness and safety. The contribution of this study lies in the preservation of biodiversity and the improvement of public health, particularly on Sumba Island.

Keywords: *medicinal plants, ethnobotany conservation, ethnomedicine, antimalarial, tropical diseases.*

INTRODUCTION
Malaria is a leading cause of mortality and morbidity in many developing countries [1]. The transmission of malaria is influenced by three main factors: the presence of the *Plasmodium* parasite, mosquitoes as vectors carrying the parasite, and humans as intermediary hosts [2]. Malaria can spread and have widespread impacts, making it a re-emerging disease. Re-emergence is influenced by imported cases in non-endemic areas, environmental factors, and climate [3]. Additionally, it is affected by the vector's ability to transmit the parasite [4].

Sumba is an island in East Nusa Tenggara Province, Indonesia, with a land area of 10.710 km^2. The island is divided into four regencies: East Sumba Regency, Central Sumba Regency, West Sumba Regency, and Southwest Sumba Regency. Malaria cases vary across these regencies, with 3.912 cases in West Sumba, 1.636 in East Sumba, 127 in Central Sumba, and 8.496 in Southwest Sumba [5] Based on data from these four regencies, the highest number of malaria cases is found in Southwest Sumba.

The presence of malaria cases has encouraged the community to take preventive and treatment measures through various means, such as seeking medical care at hospitals or using traditional medicine. In fact, malaria prevention and treatment efforts by the community are still largely carried out using traditional methods. The significant availability of natural resources that support healthcare presents a great opportunity for further research, particularly on plants used for malaria prevention and treatment by the people of Sumba Island [6].

The public's interest in rediscovering the natural wealth of medicinal plants, as traditionally used by their ancestors, has been growing. Research conducted by WHO 2025 indicates that 80% of the global population utilizes medicinal plants as an alternative form of traditional treatment, particularly in rural areas [7] The increasing demand for traditional medicine coincides with societal changes, where traditional knowledge is at risk of being lost, leaving many without a clear understanding of how to obtain, use, and process traditional remedies.

Traditional healing practices are passed down orally across generations, yet modernization and lifestyle changes have led to a decline in interest among younger generations [8]. Given the limitations in transmitting this knowledge, there is concern that information about medicinal plants and traditional healing practices will diminish as time and technology advance. The rapid development of modern science and technology should not completely overshadow or replace the role of traditional medicine. Instead, both should coexist and complement each other.

MATERIALS AND METHODS

a) Research location

This study was conducted in Southwest Sumba Regency (SBD), which is part of Sumba Island. Southwest Sumba was officially established as a regency in 2007 [9]. Geographically, this region stretches between 9°18' – 10°20' South Latitude (SL) and 118°55' – 120°23' East Longitude (EL). Southwest Sumba has a total land area of 1,445.32 square kilometers [10] and a population of 322,073 people [11]. Additionally, 85% of the population in Southwest Sumba works as farmers [12]. Southwest Sumba Regency consists of 11 districts, five of which were selected as research locations: Kota Tambolaka, Kodi Bangedo, Kodi Balaghar, Kodi, and Kodi Utara. According to SK.7875/Men LHK-PHPL/KPHP/HPL.0/12/2020, Southwest Sumba has 139,849.75 hectares of forest area, 8,233.20 hectares of plantation area, and 29,091.04 hectares of agricultural land [13]. The forest in the SBD area has a diversity of standing trees typical of production forests [14] including plant species listed for the prevention and treatment of malaria, such as *Schleichera oleosa* and *Swietenia mahagoni*. A general overview of the research location is illustrated in figure 1. The study targeted ten villages, namely Panenggo Ede, Umbu Ngedo, Homba Rande, Onggol, Kapaka Madeta, Mali Iha, Kori, Mangganipi, Radamata, and Weepangali.

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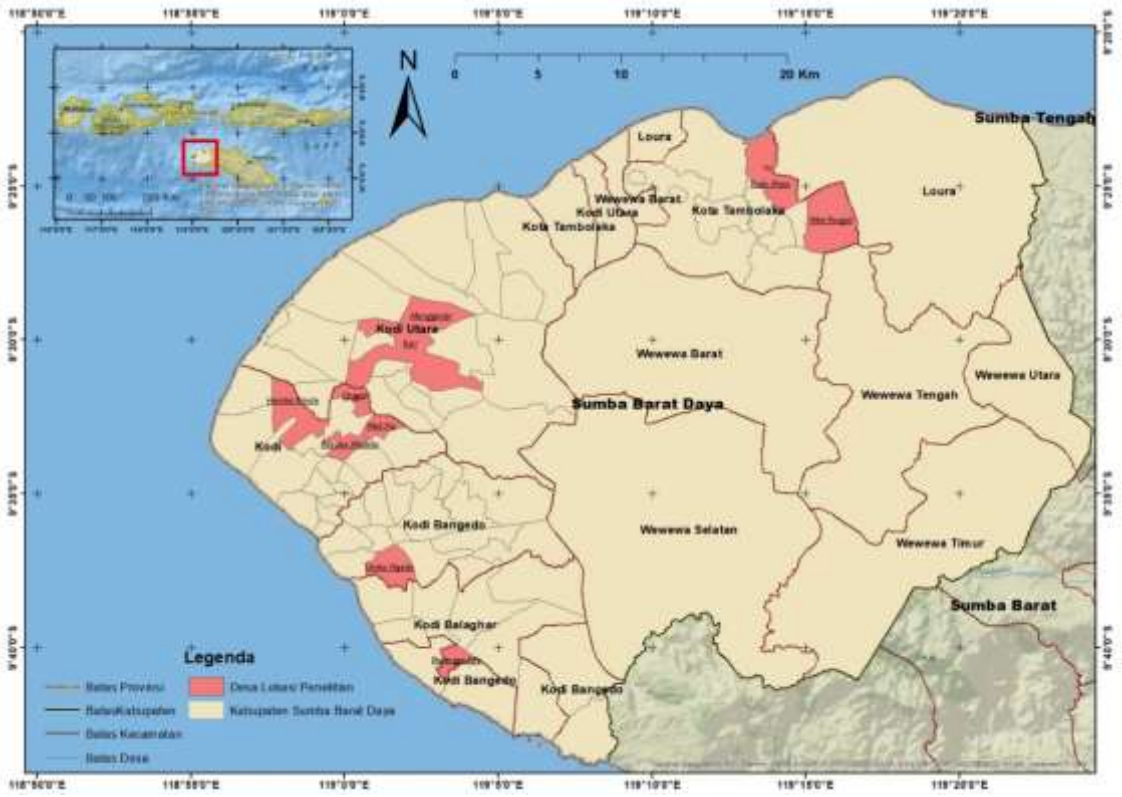

Figure 1. Map of the Study Area

b) **Data collection**

Ethnobotanical data were collected from October to December 2024 using semi-structured interview techniques and focus group discussions [15] with 25 informants, consisting of 76% males and 26% females. Informant selection was conducted through snowball sampling and purposive sampling, with traditional healers serving as key informants [16]. Key informants were selected based on their role in preserving traditional knowledge regarding the use of plants for malaria prevention and treatment due to family traditions, occupations, age, or personal interests. These informants were expected to provide relevant information and maintain connections within the ethnic community under study [17]. Additional respondents from the general community who could provide insights and information on plants used for malaria prevention and treatment were identified based on recommendations from key informants. Key informants were individuals with essential knowledge and critical information needed for the research. Each ethnic group studied comprised indigenous and local residents within the research area. The sampling process was considered complete after conducting three additional interviews with community members beyond those recommended by traditional healers. If these additional interviews did not reveal new plant species used for malaria prevention and treatment, it indicated data saturation [18]. The demographic status of the informants is presented in table 1

Table 1. Demographic Status of Informants

Variable	Total responden	Percentage
Gender		
Male	19	76%
Female	6	24%
Age groups		
A (28-42)	5	20%
B (43-57)	10	40%
C (58-72)	7	28%
D (73-87)	3	12%

Educational qualification		
No formal education	2	8%
Primary school	9	36%
Middle school	2	8%
High school	8	32%
Advanced education	4	16%
Occupation		
Farmer	13	52%
Trader	3	12%
Housewife	4	16%
Teacher	3	12%
Employe (office worker/staff)	1	4%
fisherman	1	4%

c) **Plant data collection**

Plant data were collected through direct observation of the research objects in gardens, fields, and home yards. The purpose of the observation was to confirm interview results and verify the presence of specific plant species. The interview process was recorded using a mobile phone audio recorder as documentation evidence. Plant species confirmed to be present on Sumba Island were included in the species list [19].

d) **Identification and verification of ethnobotanical species**

Species identification was conducted using field character data and documented species photographs. The process also involved reviewing the Flora of Malesiana identification book, existing published scientific records, and consultations with taxonomic experts. The identification results were then verified using the Plants of the World Online (POWO) database (https://powo.science.kew.org). Five plant specimens were collected and preserved at the Plant Systematics Laboratory, Universitas Gadjah Mada.

e) **Quantitative Ethnobotanical Data Analysis**

1. **Use Value Index (UVi):** The medicinal use value of plants in ethnobotany is determined using a quantitative index. UVi is used to evaluate the utility value, indicating plants with multiple medicinal benefits [20]. The higher the UVi, the greater the number of medicinal uses associated with a plant species. The UVi value ranges from 0 (if a plant species has no use) to 1 (if the plant is considered useful). The Use Value Index can be calculated using the following formula:

$$\text{UVi} = \frac{\sum Ui}{N}$$

The function of calculating the Use Value Index (UVi) is to measure the importance of a plant species to the community.

2. **Relative frequency of Citation (RFC):** RFC indicates the popularity of a plant species used for malaria prevention and treatment [21]. RFC can be calculated using the following formula:

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

A high Relative Frequency of Citation (RFC) value indicates that the species is widely recognized and frequently used by the community

3. **Fidelity level (FL):** FL is used to determine the significance of a species use by informants [22]. FL can be calculated using the following formula:

$$\text{FL} = \frac{NP}{N} x\ 100$$

A high FL value (approaching 100%) for a plant indicates that its reported use has a significant effect on a particular disease [23]. Fidelity Level analysis is conducted to identify specific plant species used for malaria prevention and treatment.

RESULTS

A. Diversity of Medicinal Plants in Southwest Sumba

Based on interviews and observations, the community in Southwest Sumba Regency recognizes a total of 43 plant species used for the prevention and treatment of malaria in table 2.

Table 2. list of plant species for malaria prevention and treatment in Sumba Tribe

Family	Scientific name	Local name (Kodi/Indonesia)	Parts of plant	Habit	Preparation method	UVi	RFC	FL
Acanthaceae	*Andrographis paniculata* (Burm.f.) Wall. ex Nees	Sambiloto	Leaf	Herb	Boil	0,16	0,16	100
Amaranthaceae	*Amaranthus dubius* Mart. ex Thell.	Rongali banga/ Bayam duri	Leaf/ Bark	Herb	Boil	0,04	0,04	100
Amaryllidaceae	*Allium cepa* L.	Lona doro/ Bawang merah	Bulb	Herb	Soak	0,08	0,08	100
	Allium sativum L.	Lona kaka/ Bawang putih	Bulb	Herb	Boil	0,08	0,04	50
Anacardiaceae	*Anacardium occidentale* L.	Blimbi/ Jambu mete	Leaf/ Fruit	Tree	Boil	0,12	0,08	50
Annonaceae	*Annona muricata* L.	Korndahi/ Sirsak	Leaf	Tree	Boil	0,08	0,04	50
	Uvaria hamiltonii Hook.f. & Thomson	Mleke/ Akar layak	Root/ Leaf	Liana	Boil	0,08	0,08	100
Apocynaceae	*Alstonia macrophylla* Wall.	Haleyo/ Kayu susu	Bark/ Root	Tree	Boil	0,12	0,12	100
	Alstonia scholaris (L.) R.Br.	Rica/ Pulai	Root	Tree	Boil	0,08	0,08	100
Araliaceae	*Polyscias scutellaria* (Burm.f.) Fosberg	Mangkokan	Leaf	Shrub	Boil	0,04	0,04	100
Araceae	*Alocasia macrorrhizos* (L.) G.Don	Polwiyomete/ Talas hitam	Petiolus	Herb	Roast	0,04	0,08	100
Arecaceae	*Areca catechu* L.	Labba/ Pinang	Leaf	Tree	Boil	0,04	0,04	100
	Cocos nucifera L.	Ngiyo/ Kelapa	Fruit	Tree	Burn	0,04	0,04	100
Asteraceae	*Helianthus annuus* L.	Bunga matahari	Leaf	Herb	Boil	0,12	0,04	33
	Vernonia amygdalina Delile	Daun Afrika	Leaf	Tree	Soak	0,12	0,04	33

Family	Scientific name	Local name (Kodi/Indonesia)	Parts of plant	Habit	Preparation method	UVi	RFC	FL
Balsaminaceae	*Impatiens parviflora* DC.	Katundul/ Balsam kecil	Leaf	Herb	Rub	0,04	0,04	100
Cannabaceae	*Trema orientale* (L.) Blume	Linyo/ Mengkirai	Bark	Tree	Soak	0,04	0,04	100
Caricaceae	*Carica papaya* L.	Klodawa / Pepaya	Leaf	Tree	Pound	0,64	0,56	86
Cucurbitaceae	*Momordica balsamina* L.	Ropaddu / Peria hutan	Leaf	Liana	Squeeze	0,36	0,24	50
Euphorbiaceae	*Jatropha curcas* L.	Ndommo/ Jarak pagar	Bark	Bush	Boil	0,12	0,04	33
Fabaceae	*Caesalpinia bonduc* (L.) Roxb.	Kroko/ Kebiul	Seed/ Root	Liana	Soak	0,20	0,16	33
	Gliricidia sepium (Jacq.) Kunth	Gamal	Leaf	Tree	Rub	0,12	0,04	33
	Sesbania grandiflora (L.) Poir.	Wunga/ Turi	Leaf	Tree	Boil	0,16	0,04	25
Flagellariaceae	*Flagellaria indica* L.	Paneta/ Rotan tikus	Leaf	Liana	Boil	0,04	0,04	50
Lauraceae	*Persea americana* Mill.	Alpukat	Peel	Tree	Soak	0,04	0,04	100
Loganiaceae	*Strychnos lucida* Wall.	Kayu ular	Bark	Tree	Brew	0,16	0,2	100
Malvaceae	*Helicteres isora* L.	Kapoleh/ Ules	Bark/ Root	Bush	Boil	0,08	0,08	100
Meliaceae	*Melia azedarach* L.	Lommo / Mindi kecil	Leaf	Tree	Boil	0,04	0,08	100
	Swietenia mahagoni (L.) Jacq.	Mahoni	Fruit	Tree	Pound	0,28	0,28	100
	Azadirachta indica A.Juss.	Ghayo dawa/ Mimba	Leaf	Tree	Boil	0,08	0,04	100
Menispermaceae	*Tinospora cordifolia* (Willd.) Hook.f. & Thomson	Purahu/ Brotowali	Stem	Liana	Soak	0,32	0,28	86
Moraceae	*Artocarpus altilis* (Parkinson) Fosberg	Karara/ Sukun	Flower	Tree	Burn	0,08	0,04	50
	Ficus septica Burm.f.	Rokmbukiele/ Awar-awar	Leaf	Tree	Rub	0,12	0,04	33
Olacaceae	*Heisteria macrophylla* Oerst.	Hombong	Root	Bush	Boil	0,04	0,04	100

Family	Scientific name	Local name (Kodi/Indonesia)	Parts of plant	Habit	Preparation method	UVi	RFC	FL
Oxalidaceae	*Averrhoa carambola* L.	Mblimbi/ Belimbing	Flower	Tree	Boil	0,08	0,04	50
Picramniaceae	*Picramnia spruceana* Engl.	Kluga mnipih/ Kulit kayu tipis	Bark	Bush	Boil	0,04	0,04	100
Piperaceae	*Piper aduncum* L.	Uta lara/ Sirih hutan	Leaf	Bush	Soak	0,08	0,04	50
Poaceae	*Cymbopogon citratus* (DC.) Stapf	Serai	Whole plant	Herb	Soak	0,08	0,04	50
Rhamnaceae	*Ziziphus mauritiana* Lam.	Bidara	Root/ Leaf	Tree	Boil	0,08	0,04	100
Rutaceae	*Lunasia amara* Blanco	Langapa / Sanrego	Root	Tree	Boil	0,04	0,04	100
Sapindaceae	*Schleichera oleosa* (Lour.) Oken	Komi/ Kesambi	Bark/ Leaf	Tree	Boil	0,08	0,04	50
Zingiberaceae	*Zingiber officinale* Roscoe	Liga/ Jahe	Rhizome	Herb	Soak	0,08	0,08	100
	Curcuma longa L.	Kabuni/ Kunyit	Rhizome	Bush	Pound	0,12	0,12	100

B. Number of Species family

A total of 32 plant families were documented. Fabaceae and Meliaceae were the families with the highest number of species, as shown in figure 2.

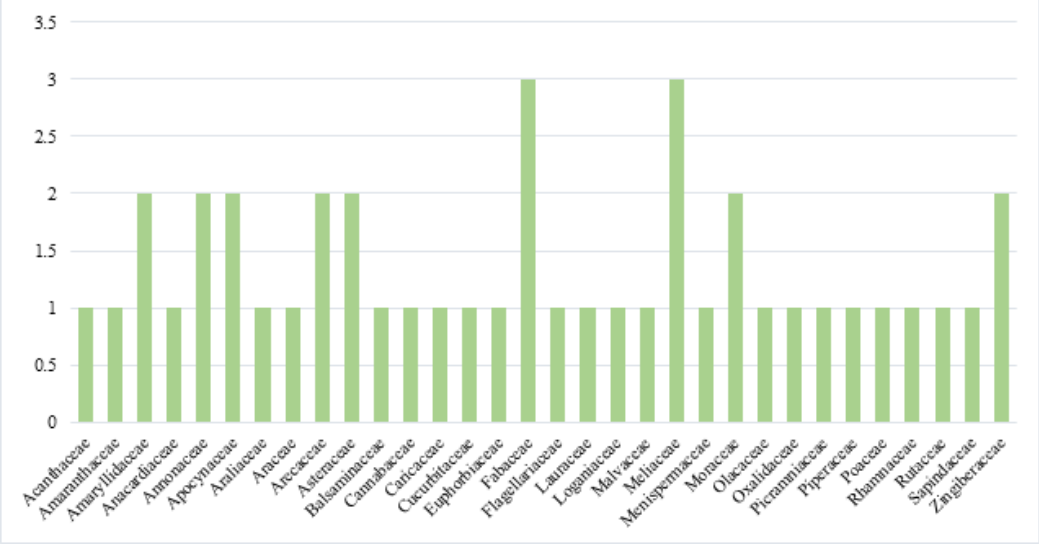

Figure 2. Contribution of different families to ethnomedicinal flora in the study area

C. Use of Plants for Malaria Prevention and Treatment by the Sumba Tribe

The use of medicinal plants is categorized based on growth habit in figure 3, preparation methods in figure 4, and plant parts used in figure 5.

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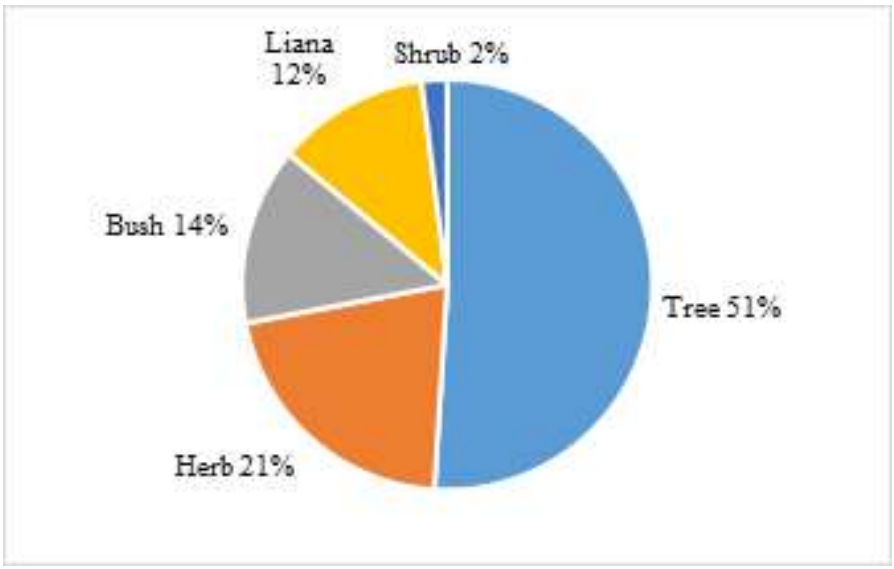

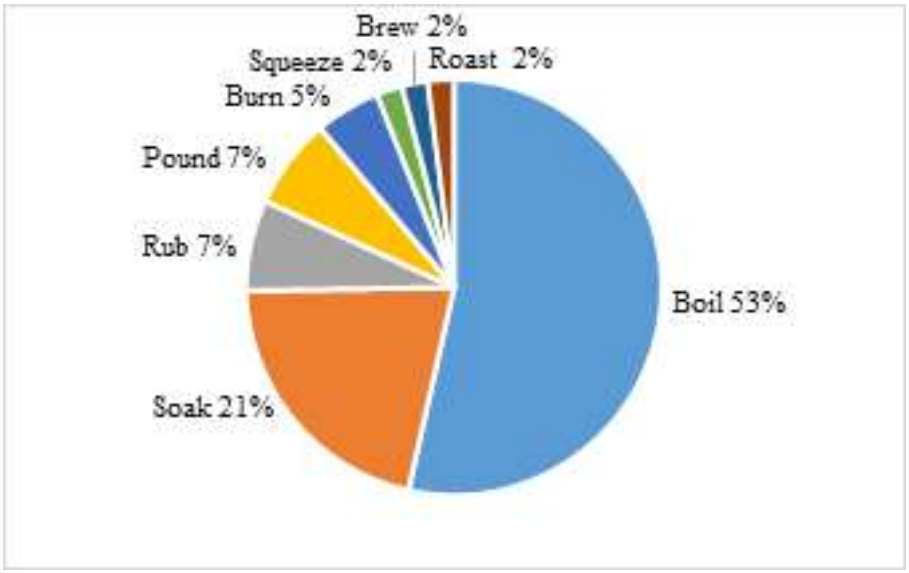

Figure 3. Percentage of medicinal plants by growth habit. **Figure 4**. Percentage of medicinal plants based on preparation method

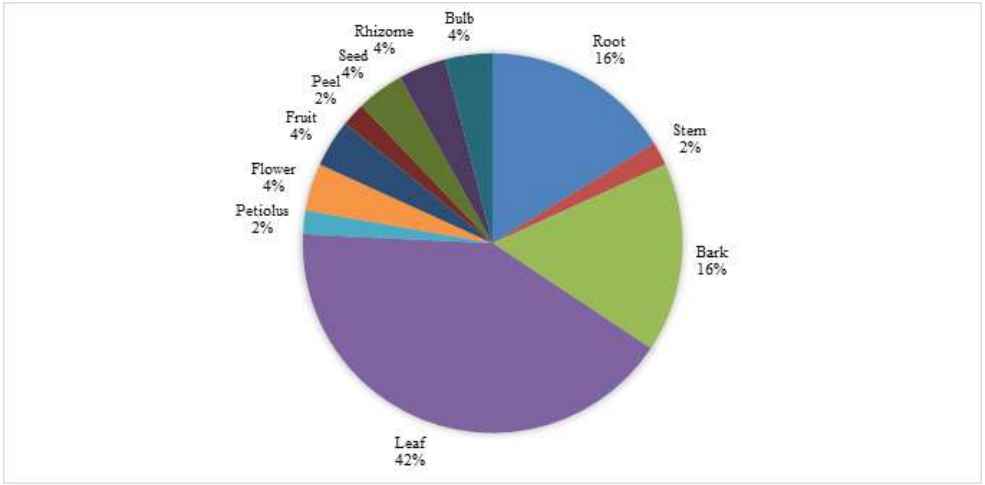

Figure 5. Medicinal plants based on the parts used

DISCUSSION

A. Community Knowledge of Medicinal Plants in Southwest Sumba Regency

Community knowledge was analyzed based on respondent categories, including gender, age range, education level, and occupation. Table 1 shows that the percentage of male respondents was higher (76%) compared to female respondents (24%) out of a total of 25 respondents. This indicates that men have greater knowledge of medicinal plants than women. Similar findings were reported which showed that 73.1% of men had more knowledge about traditional medicine development compared to women [24]. Differences in knowledge are influenced by varying access to ecosystems and landscapes [25]. Men are responsible for planting and collecting plants from fields [26] even though women handle household health issues [27]. It can be concluded that men in Southwest Sumba Regency have greater ecological knowledge and engage more frequently in wild plant exploration.

Most information about medicinal plants was provided by age group B (43–57 years), accounting for 40% of respondents. This is because more individuals in this age group possess knowledge of medicinal plants compared to other groups. This was followed by group C (28%), group A (20%), and group D (12%). Older informants in groups C and D did not significantly contribute knowledge within the study scope. Previous research has shown that plant species knowledge declines after the age of 60 [28], as mental function and physical ability tend to deteriorate, contributing to a decline in maximum knowledge scores over time [29]. The use of medicinal plants is recognized across age groups, from young adults to the elderly, as they still maintain a strong cultural awareness and adhere to the teachings passed down by their ancestors [30].

In general, education level in Southwest Sumba Regency does not significantly affect community knowledge of medicinal plants, as supporting facts and theories present conflicting findings. The primary school group (36%) provided the most information compared to other education levels, including middle school, high school, and advanced education. Additionally, the high school group contributed more knowledge about medicinal plants than the middle school group. A study conducted in Ciamis Regency similarly found no significant difference in traditional medicine knowledge among individuals with different educational backgrounds [31].

Farmers accounted for 52% of respondents and contributed information on 32 medicinal plant species. This is because rural farmers tend to have poorer health conditions and a greater need for healthcare [32]. In Southwest Sumba Regency, many farmers were previously employed by their parents as family laborers. During farming activities, they frequently experienced unexpected incidents, such as cuts from glass shards or snake bites. These real-life conditions encouraged parents to pass down their local knowledge on medicinal plants to prevent and treat illnesses affecting their children or neighbors.

B. Flora diversity

The community in Southwest Sumba Regency recognizes five plant growth habits. Among them, trees are the most dominant habitus for malaria treatment. The Apocynaceae family, which includes tree species, has been used for medicinal purposes in at least nine countries [33]. Species from the Apocynaceae family found in this study include *Alstonia macrophylla* and *Alstonia scholaris*. Meanwhile, the Meliaceae family has the highest number of tree species, including *Melia azedarach*, *Swietenia mahagoni*, and *Azadirachta indica*. Seasonal herbs are not available year-round [34]. For example, *Helianthus annuus* was not found at the study site during the research period.

C. Plant part used

Leaves are the most commonly used plant part, accounting for 49% of the species. Similar studies have shown that leaves are the most frequently utilized plant part because secondary metabolites are predominantly stored in leaves [35]. The utilization of different plant parts is closely related to the presence of secondary metabolites. These compounds are rarely found throughout the entire plant but are more commonly stored in specific tissues or organs [36]. Additionally, not all secondary metabolites are synthesized and stored in the same organ [37]. Therefore, the variation in plant organ usage for

malaria prevention and treatment depends on where these bioactive compounds are concentrated within the plant.

D. Preparation method

Based on the diagram, the most dominant method of processing plants is boiling. Boiling refers to the process of placing plant parts into a container with a certain volume of water and cooking them over heat until the water reaches a boiling point or its volume decreases [38]. This is in line with a research, which states that boiling is the most commonly used process in medicine preparation [39]. The polyphenol and flavonoid content in boiled *Sesbania grandiflora* is higher compared to its fresh form. There are active compounds that are heat-sensitive due to their low boiling points, such as essential oils [40] requiring different processing methods. Processing by rubbing is used for bathing. Pounding is done to reduce particle size, increasing the contact between the extract and water as a solvent [41]. Burning involves using *Cocos nucifera* shells as a substitute for firewood, where the patient moves close to the heat source to relieve fever caused by malaria. Lowering body temperature can be done non-pharmacologically by using heat energy [42]. However, an alternative method that can be used for safety reasons is warm compresses. *Artocarpus altilis* flower organs are burned to repel mosquitoes. Derivatives of fatty acids such as capric acid, undecanoic (hendecanoic) acid, and lauric acid in species *Artocarpus altilis* have been identified as highly effective mosquito repellents [43]. Roasting is a processing method in which the petiolus of *Alocasia macrorrhizos* is roasted over charcoal to remove its sap before being applied to the patient's back. *Alocasia* exhibits analgesic and anti-inflammatory activities, making it effective in reducing fever [44]. Squeezing is used as a processing method for *Momordica balsamina* leaves, where the extracted juice is consumed directly. Brewing involves grinding *Strychnos lucida* bark into a fine powder, brewing it with hot water, and drinking it. Snakewood is effective as it inhibits the growth of *Plasmodium berghei* and enhances hemoglobin profiles, hematocrit levels, and red blood cell counts [45].

Most traditional medicines that are consumed have varying dosages, ranging from half a spoon for children to 125 –250 ml for adults per dose. The reason is that some herbal medicines are more concentrated than others, and this helps prevent overdoses [46]. In general, traditional healers recommend consuming traditional medicine 2–3 times a day for three consecutive days. Although some traditional healers suggest that patients continue taking the medicine until they recover since herbal medicine does not have serious side effects it is still essential to follow the recommended dosage, with a maximum of three days, to avoid overdose

E. Quantitative Analysis

There are two species with the highest UV values: *Carica papaya* at 0.64 and *Momordica balsamina* at 0.36. Although these two species are widely known beyond Southwest Sumba, klodawa and ropaddu continue to be extensively cultivated and have been included in the Indonesian Herbal Pharmacopoeia 2020 [47]. The highest RFC value was obtained by *Carica papaya* with an RFC value of 0.56. An RFC value approaching 1 indicates that almost all informants mentioned a particular plant for the prevention and treatment of malaria, whereas a low value suggests that only a few informants, or sometimes just one, mentioned the use of a species [48]. A total of 24 plant species have an FL value of 100%. Species with an FL value of 100% are medicinal plants used exclusively for a single therapeutic indication [49]. Plants with an FL value of 100% are recommended for the prevention and treatment of malaria.

F. Ethnobotany and Ecosystem Conservation

Medicinal plants have been cultivated in the yards of local communities. These plants play a broad socio-economic and ecological role, including uses as medicinal herbs, spices, and livestock feed [50]. Home garden-based cultivation plays a significant role in preventing environmental degradation and contributes to in-situ biodiversity conservation [51]. Medicinal plants need to be preserved due to their ecological values, such as maintaining soil fertility. The cultivation of medicinal plants can help protect

them from pesticide contamination [52]. Cultivation can also serve as a natural pest control solution, thereby promoting an environmentally friendly approach that maintains the biological processes of medicinal plants and the ecological balance of their habitats [53]. Tree habitus plants have long grown in fields or home gardens, contributing to water balance maintenance [54], oxygen production [55], and habitat provision [56].

Ecosystem conservation is closely related to the conservation of knowledge. One study noted that some traditional healers opposed the inclusion of traditional medicine in educational curricula, fearing that the secrecy of their knowledge would be violated [57]. A similar case was found during field interviews, where a traditional healer stated, "The medicinal plants I mention will not have any effect if processed and applied by someone else, because I acquired this knowledge through a dream." This case suggests that such knowledge may remain solely with the healer. However, on the other hand, the conservation of the plants may be preserved, as not everyone has access to them.

CONCLUSION

The utilization of biodiversity in malaria treatment by the people of Sumba Barat Daya Regency highlights the importance of local wisdom in maintaining health. Species with the highest use value and relative frequency of citation can be potential candidates for further research in the development of natural-based antimalarial drugs. The highest fidelity level in certain species indicates specificity of use, which can serve as a basis for scientific validation. This study not only confirms the community's trust in medicinal plants but also opens opportunities for broader pharmacological exploration to support sustainable malaria treatment.

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Data Availability:

The data that support the findings of this study are available from the corresponding author

Conflict of interest:

Declare potential conflicts of interest; otherwise declare "None" or "The authors declare that there is no conflict of interest".

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