ASIAN JOURNAL OF ETHNOBIOLOGY
Volume 4, Number 2, November 2021 E-ISSN: 2580-4510
Pages: 86-92 DOI: 10.13057/asianjethnobiol/y040203

Utilization of mangrove plants as a source of Malaria medicine in North Maluku Province, Indonesia

M. NASIR TAMALENE[1], UDAY KUMAR SEN[2,♥], RAM KUMAR BHAKAT[2], EVA VIANTI[1], BAHTIAR[1], SUPARMAN[1]

[1]Program of Biology Education, Faculty of Teacher Training and Education, Universitas Khairun. Jl. Bandara Babullah, Ternate 97728, North Maluku, Indonesia
[2]Ecology and Taxonomy Laboratory, Department of Botany and Forestry, Vidyasagar University. Midnapore-721 102, West Bengal, India.
♥email: uudaysen@gmail.com

Manuscript received: 13 August 2021. Revision accepted: 1 September 2021.

Abstract. *Tamalene MN, Sen UK, Bhakat RK, Vianti E, Bahtiar, Suparman. 2021. Utilization of mangrove plant species as medicine against malaria in North Maluku Province, Indonesia. Asian J Ethnobiol 4: 86-92.* Local communities have still used plants as a source of medicine since immemorial time. Most local communities mix the plants to treat various diseases, including malaria. Almost half of 250 million of Indonesia's population lives in malaria-endemic areas, and about 15 million people look for clinical malaria treatment every year. This research aims to survey mangrove plants as a source of Malaria medicine utilized by six ethnic groups of North Maluku Province, Indonesia. Data were collected from 98 informants on the local names of the used species, the parts, and the "modes of preparation." The Fidelity Level serves to find out various outcomes. Six mangrove plant species, *Lumnitzera littorea*, *Rhizophora mucronata*, *Scyphiphora hydrophyllacea*, *Sonneratia alba*, *Xylocarpus granatum*, and *Xylocarpus moluccensis*, are used as malaria medicine. The traditional treatment that used mangrove rinds, barks, fruits, and flowers was a popular method practiced in the community social life. The mangrove plants have cultural, ecological, and economic values; Authors suggest that further investigations be undertaken on the pharmacological properties and level of toxicity of potion made using mangrove plant species. This will lead to stating scientific information related to the safety of consuming traditional medicines.

Keywords: Indonesia, local knowledge, malaria, mangrove, medicinal plants

INTRODUCTION

The use of plants as medicinal raw materials has been conducted since formulating process is known to local communities. Traditional medication is a way used by local communities to treat diseases. Raw materials, including plant parts containing active components, serve as medicine. Most local communities mix more than one plant to treat various diseases, including malaria (Husain et al. 2019; Kasmawati et al. 2019; Sen and Bhakat 2020).

The Asia continent contributes almost 40% of malaria disease globally (Gething et al., 2012). The disease is generally found in Southeast Asia areas, including Brunei Darussalam, Cambodia, China, Indonesia, Laos, Malaysia Peninsula, Myanmar, Philippines, Singapore, Thailand, Timor, and Vietnam. Most areas are at risk of vector-borne diseases, especially malaria, transmitted by mosquitoes from the *Anopheles* genus (Suwonkerd et al., 2013). Almost half of the population of 250 million in Indonesia live in malaria-endemic areas, and about 15 million people look for clinical malaria treatment every year (Elyazar et al. 2012; Herdiana et al. 2016).

Malaria is one of the life-threatening diseases in developing countries with high mortality risk (del Prado et al., 2014). In Southeast Asia, Indonesia is reported as the third-highest rank for malaria cases, 229819 cases with the number of deaths of 432 people (Dale et al. 2005; WHO 2012). Based on the data from the Health Research and Development Agency of the Republic of Indonesia, malaria prevalence in Indonesia is 6 percent, and 15 provinces that have malaria prevalence above the national rate are primarily located in East Indonesia. Of the 15 provinces, five provinces with the highest malaria incidence include Papua 29.57%, West Papua 20.85%, East Nusa Tenggara (NTT) 12.81%, Maluku 6.0% and North Maluku 3.32% (Elyazar et al. 2012). In Indonesia, malaria caused by *Plasmodium* parasites includes *Plasmodium falciparum*, *Plasmodium malariae*, *Plasmodium ovale*, *Plasmodium vivax*, and a mix (Manning et al. 2011).

In addition to chemical drugs obtained from a drug store, local communities use various medicinal plant species to prevent, recover, and treat malaria disease (Asase and Asafo-Agyei 2011). Local knowledge is key-from community traditions in formulation plant species to be made as traditional medicines to treat malaria disease (Belayneh et al., 2012). Plant species in coastal areas have a high potential for medicine, such as mangrove plants with a utility as a local community medicine source (Dossou-Yovo et al., 2021). The plants grow on small islands in North Maluku Province, such as Bacan, Buton, Gorap, Maba, Makian, Ternate, and Tidore ethnic groups. These islanders have traditional knowledge of mangrove plants to treat malaria disease. The composition of malaria potion in each ethnic is not standardized. The concoction of medicinal herb composition still uses knowledge inherited from generations. Various mangrove plant species are used

by ethnic groups in the North Maluku islands area as a source of malaria medicine (Sukardjo 2016).

The research aims to describe the local wisdom of communities on the islands of North Maluku Indonesia in the formulation and to utilize mangrove plants as a source of medicine to treat malaria disease. The data would provide important information to the researchers in the health and medicinal, pharmaceutical, and medical field and biology and chemistry to test the efficacy and toxicity of malaria potion using mangrove plants as the primary ingredient.

MATERIALS AND METHODS

Study area

The research was conducted at Tuada and Baneigo villages in West Halmahera District; Dodaga and Gotowasi villages in East Halmahera District; Anggai and Wayaua villages in South Halmahera District; and Loleo and Gita Raja villages in Tidore Island City of North Maluku District, Indonesia (Figure 1).

The research data sources included Bacan, Maba, Buton, Tidore, Makian, and Ternate ethnics. The research locations were tropical regions of the islands. Participants were selected based on their ethnomedicinal knowledge. The interviews were carried out on plants used in ethnomedicine among the villagers. Individuals who were locally recognized as knowledgeable on plant use were identified with the assistance of the village elders. The selection in the questionnaire was described systematically and through the participatory rural appraisal (PRA) method. Plants were collected from the forest with the help of the locals. Plant specimen vouchers were collected using the standard method (Martin 2014).

Ethics statement

Before the survey, a meeting was held with the head of the village, traditional figures as traditional leaders, public figures, and members of environmental associations to clearly explain the purposes of the survey. Since all selected informants were adults, an agreement was made with each informant before the interview through agreed voluntary consent forms. Each informant was convinced to be interviewed in each stage of research. However, all informants actively participated, and no one refused to be interviewed. The informant code number was used to replace the informant's name, and the information collected was concealed. The research result feedback was conducted through discussion meetings and dissemination upon completing the survey for data verification.

Field survey and data collection

An in-depth interview with primary informants had been chosen using purposeful sampling (A'Yunin Al-Isyrofi et al., 2021). The authors collected data from March 2018 to August 2020. The in-depth interview, participant assessment, group discussion, and field visit collected data on mangrove plants' communities (McClatchey and Gollin 2005). An open questionnaire was asked to uncover key informants' knowledge maps (Qu and Dumay 2011). The interview was conducted in the local language through the individual visit of each informant. Before ethnobotanical data collection, the informants obtained an agreement (Medinaceli 2018; Dossou-Yovo et al. 2021). The research informants consisted of 98 key informants are presented in Table 1. The informants were selected for an interview and collect information related to name, age, gender, and level of education (Table 2). A semi-structured questionnaire served to collect data on the local names, plant parts, modes of preparation, routes of administration, and doses of various medicines. Data on the informant's occupation were also collected. Before the data collection, group discussion was conducted with the key informants to explain the research purposes.

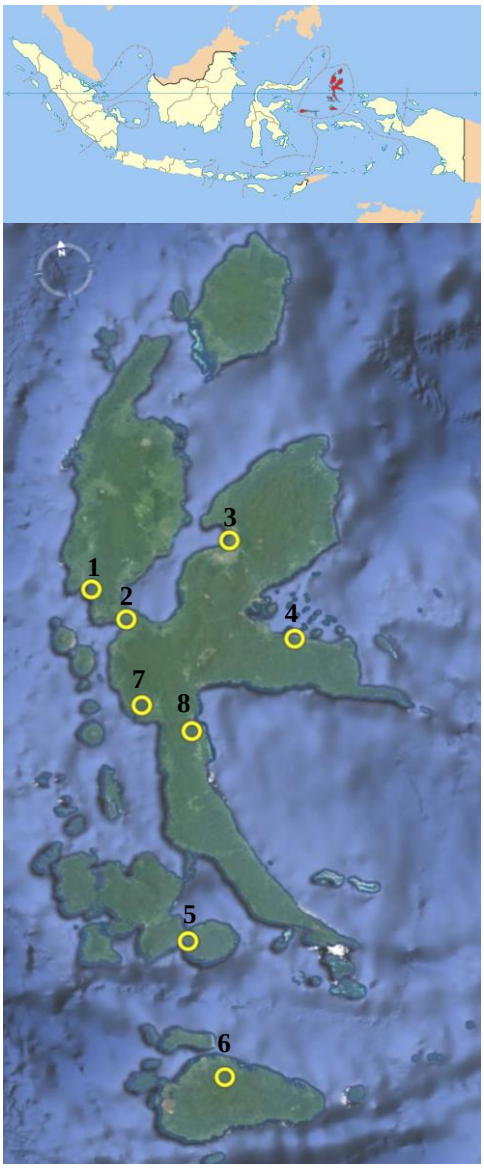

Figure 1. Research location in North Maluku, Indonesia, namely Tuada (1) and Baneigo (2) in West Halmahera; Dodaga (3) and Gotowasi (4) in East Halmahera; Anggai (5) and Wayaua (6) in South Halmahera; Loleo (7) and Gita Raja (8) in Tidore Island City

Plant collection, identification, and preservation

Uses of medicinal plants were interviewed in a structured manner. Of care was taken during the recording of information to record the local name of the plant, parts used, methods of preparation, and the uses of medicinal plants. For each specimen, photos were taken to confirm the identification of the taxonomy and the documenting of specimens. After knowing the specific use of medicinal plants, informers were taken to the fields to identify the plants based on local names. Photographs of the plant habit and reproductive structures were taken, and plants were collected for voucher sheet preparation. Voucher sheets were verified in the herbarium section, Bogoriense Botanical Laboratory of the Indonesian Institute of Science Biological Research Centre (LIPI), Cibinong, Indonesia. The certified plant specimens were housed at the Biology Laboratory, Khairun University. The plant's scientific name was checked with the World Checklist of Vascular Plant [WCVP] (WCVP 2021) website and confirmed only the accepted name.

Data analysis

Data on informant background and plants used were schematically recorded using Excel 2019 software. Data collected consisted of the local name, botanical name, and parts utilized. Data on plant utilization were calculated using the Fidelity level formula (FL %) = $Ip/Iu \times 100$ (Hoffman and Gallaher 2007). FL is a percentage of informants claiming a specific plant for the same purpose. Ip is the number of informants who independently recommended plant species for malaria, and Iu is the total. They mentioned the same plant for malaria disease.

RESULTS AND DISCUSSION

Demographic characteristics and knowledge of informants on medicinal plants

Among the informants, 40 (40.82%) respondents were male, and 58 (59.18%) were female. This repartition was not unusual in ethnobotanical investigations in Indonesia due to the importance of women in the domestic context, where most plant resources, especially dietary and medicinal plants, were managed. The current investigation also meant that women proved to be the main upholders of traditions linked to domestic life. The age of the informants was from 40 to above 89 years. Age-wise, 32 (32.65%) informants were in the age group of 60-69 years, which is much higher than the informants in the other age groups—31 (31.63%, 50-59 years), 15 (15.30%, both 40-49 and 70-79 years) and 5 (5.10%, ≥80 years), respectively (Table 1). As for educational qualifications, only 2 (2.04%) were illiterate; 5 (5.10%) had only primary school education; 23 (23.46%) had middle school education; 51 (52.04%) had secondary school education, and only 17 (17.34%) had a university degree (Table 2).

The 6 plant hats traditional healers use among the village people were interviewed, identified, and documented. Most of the medicinal plants identified belong to 5 families (Table 3).

Anti-malaria mangrove species

The local communities of North Maluku-Indonesia, especially Bacan, Buton, Gorap, Maba Makian, Ternate, and Tidore ethnic groups, used *Rorano* as their cultural identity to name medicinal herbs. The research result used the term to call potions made by the locals since it is community local knowledge preserved until now. The research data provided important information that the local ethnics utilized mangrove plants of *Lumnitzera littorea*, *Rhizophora mucronata*, *Scyphiphora hydrophyllacea*, *Sonneratia alba*, *Xylocarpus granatum*, and *Xylocarpus moluccensis* as a source of malaria medicine (Figure 2).

For the islanders, the six species were beneficial. Plant parts, including flowers, bark, rind, and fruit, had high values in combating malaria (Dossou-Yovo et al., 2017; 2021). Mangrove plants from *X. granatum* and *X. moluccensis* species were generally known by the communities as buangkirakira (a local name). Aside from being a malaria medicine, mangroves had benefits as a cosmetic ingredient and natural dye in traditional drinks. Specifically, the utilization of fruits and flowers compromises the species of mangrove plants from *L. littorea*, *R. mucronata*, *S. hydrophyllacea*, and *S. alba* species known as Soki in the local language were used as a source of malaria medicine (Figure 3). The local ethnics lived in small islands with long coastlines and mangrove vegetation. *L. littorea* and *S. hydrophyllacea* plants were taken during the flowering season in May-August 2018 and May-September 2019. In addition to its use for malaria treatment, red *L. littorea* flowers (Figure 3) were used as a sleeping therapy with additional ingredients of sweet liquid from enau [*Arenga pinnata* (Wurmb) Merr., Family: Arecaceae] plants.

The benefit of mangrove species

Data of fidelity level utilization analysis value based on ethnic groups indicated that Bacan, Buton, Gorap, Maba, Ternate, and Tidore had utilized mangrove plants of *X. granatum* as the raw material of malaria medicines with an FL value of 74.48%, followed by *X. moluccensis* of 60.20%, *S. alba* of 51.02%, *R. mucronata* of 43.88%, *S. hydrophyllacea* of 28.57% and *L. littorea* of 27.55% (Table 3; Figure 4). Maba and Buton ethnic groups mostly used *X. granatum* and *X. moluccensis* as essential malaria medicines. Bacan and Maba ethnic groups were the highest in utilizing mangrove species of *S. alba*, whereas Buton ethnic group preferred *R. mucronata* to cure malaria. Mangrove with the lowest fidelity level included *L. littorea* and *S. hydrophyllacea*.

The traditional use by the communities of the six ethnic groups was a pearl of local wisdom original from communities' oral tradition, spoken for generations. Local knowledge of mangrove plants as a medicine was the characteristic of the community's ability to adapt to their living environment. The environment adaptation was closely related to a social and cultural transformation in the community. The consumption pattern of traditional medicine continued to evolve from herbal medicines to chemical drugs. If it continued, the community's local knowledge of medicinal plant utilization would vanish in

the future. One of the efforts to eliminate the loss of the community's local knowledge was through ethnic-based education.

The use of rinds and barks of mangrove from *X. granatum* and *X. moluccensis* species by the local ethnic groups were in the high category since these species were the main ingredients in malaria treatment (Figure 4). *S. alba* flowers and *R. mucronata* fruits were the second options for medicines when the first options were not found. Parts of the plant, such as flowers from *L. littorea* and *S. hydrophyllacea* fruits, were the alternative ingredients if the main ingredients were not found.

Informants from all age groups explained that children, teenagers, and adults often experienced malaria symptoms such as high fever and chills, fatigue, sweating, headache, nausea and vomiting, diarrhea, and muscular pain. Actions conducted by Gorap, Makian, Ternate, and Tidore ethnics to treat malaria was by making *Rarano* by taking the rinds and barks of *X. granatum* and *X. moluccensis* and boiling them, and taking the potion twice a day after meals. Bacan and Maba ethnics preferred to use *S. alba* by taking its flower and adding *L. littorea* flowers and *R. mucronata* fruits. These three plant parts were mixed and soaked in hot water and allowed to cool and taken twice a day after meals.

Table 1. Distribution of informants' gender and age

Ethnic groups	Age Groups	Gender		No. of persons	Percentage
		Male	Female		
Bacan	40-49	1	1	2	14.28
	50-59	2	2	4	28.57
	60-69	1	4	5	35.71
	70-79	1	1	2	14.28
	80-89+	0	1	1	7.14
Buton	40-49	1	1	2	14.28
	50-59	0	3	3	21.42
	60-69	4	1	5	35.71
	70-79	1	3	4	28.57
	80-89+	0	0	0	0
Gorap	40-49	0	1	1	7.14
	50-59	1	3	4	28.57
	60-69	2	5	7	50
	70-79	0	2	2	14.28
	80-89+	0	0	0	0
Maba	40-49	1	1	2	28.57
	50-59	2	4	6	28.57
	60-69	1	1	2	14.28
	70-79	1	1	2	14.28
	80-89+	1	1	2	14.28
Makian	40-49	2	1	3	21.42
	50-59	2	3	5	35.71
	60-69	2	2	4	28.57
	70-79	0	2	2	14.28
	80-89+	0	0	0	0
Ternate	40-49	1	0	1	7.14
	50-59	3	2	5	35.71
	60-69	3	4	7	50
	70-79	1	0	1	7.14
	80-89+	0	0	0	0
Tidore	40-49	1	3	4	28.57
	50-59	2	2	4	28.57
	60-69	1	1	2	14.28
	70-79	1	1	2	14.28
	80-89+	1	1	2	14.28
	Total	40	58	98	

Table 2. Level of education of the informants

Ethnic groups	Level of education	No. of individuals	Percentage
Bacan	Illiterate	0	0
	Primary	1	7.14
	Middle	5	35.71
	Secondary	6	42.86
	University	2	14.29
Buton	Illiterate	1	7.14
	Primary	1	7.14
	Middle	3	21.43
	Secondary	7	50
	University	2	14.29
Gorap	Illiterate	1	7.14
	Primary	1	7.14
	Middle	4	28.57
	Secondary	7	50
	University	1	7.14
Maba	Illiterate	0	0
	Primary	0	0
	Middle	1	7.14
	Secondary	11	78.57
	University	2	14.29
Makian	Illiterate	0	0
	Primary	0	0
	Middle	6	42.86
	Secondary	4	28.57
	University	4	28.57
Ternate	Illiterate	0	0
	Primary	2	14.29
	Middle	2	14.29
	Secondary	9	64.29
	University	1	7.14
Tidore	Illiterate	0	0
	Primary	0	0
	Middle	2	14.29
	Secondary	7	50
	University	5	35.71

Table 3. Fidelity level values of mangrove species utilization based on ethnic groups

Mangrove plant species	Family	Voucher no.	Ethnic groups						
			Bacan	Buton	Gorap	Maba	Makian	Tidore	Ternate
Lumnitzera littorea (Jack) Voigt	Combretaceae	TACO1	42.86	42.86	14.29	35.71	14.29	28.57	14.29
Rhizophora mucronata Poir.	Rhizophoraceae	TARH1	50	78.57	35.71	50	42.86	21.43	28.57
Scyphiphora hydrophyllacea C.F.Gaertn.	Rubiaceae	TARU1	28.57	28.57	14.29	50	14.29	50	14.29
Sonneratia alba Sm.	Lythraceae	TALY1	64.29	64.29	57.14	85.71	42.86	14.29	28.57
Xylocarpus granatum J.Koenig	Meliaceae	TAME1	78.57	92.86	50	92.86	35.71	85.71	85.71
Xylocarpus moluccensis (Lam.) M.Roem.	Meliaceae	TAME2	78.57	92.86	35.71	85.71	28.57	85.71	14.29

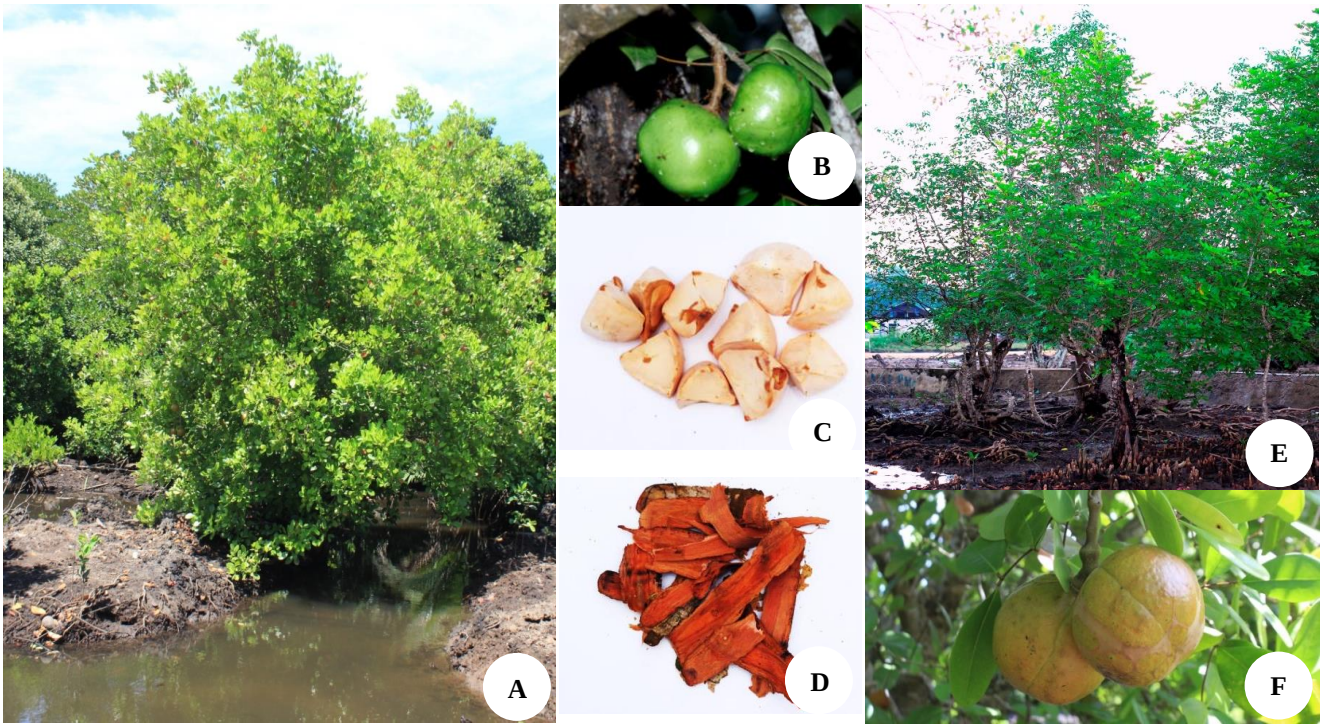

Figure 2. *Xylocarpus granatum*: A, Tree habit, B. Fruits, C. Flesh fruits, D. Barks; *Xylocarpus moluccensis*: E. Tree habit, F. Fruits

Figure 3. A. *Lumnitzera littorea* (Jack) Voigh. Flowers, B. *Scyphiphora hydrophyllacea* Gaertn. F. Fruits, C. *Sonneratia alba* J. Sm., D. *Rhizophora mucronata* Lam. propagules

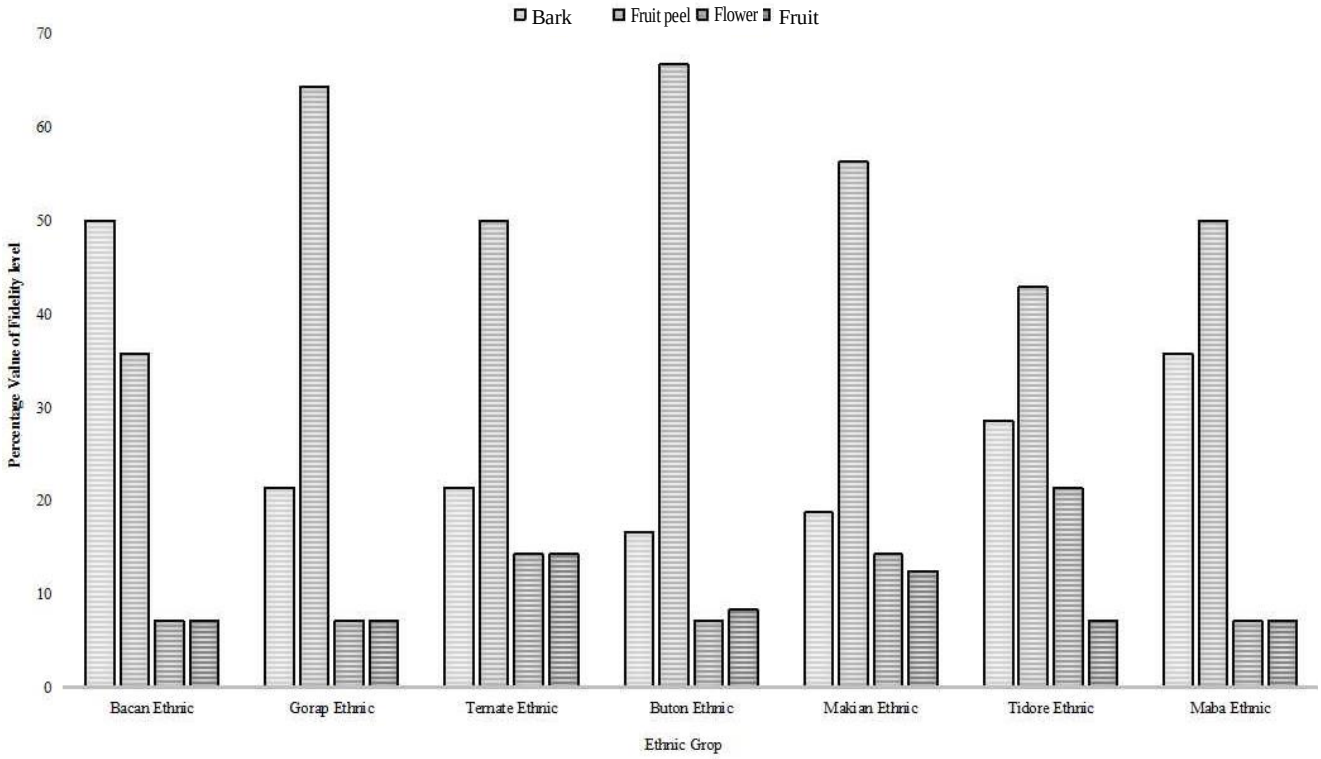

Figure 4. Fidelity level values (%) of plant parts utilization based on ethnic groups

Discussions

The formulation method of mangrove plants into *Rorano* of malaria was boiling. The communities in the five ethnic groups collected the medicinal plants and dried them to produce simplicia. It was conducted to maintain the medicine availability to be available when they got sick. The medicinal plant simplicia was dried for 1-3 weeks to remove water content in the plant organs to prevent mold fungi from growing. Only the traditional healers in the villages owned the simplicia. People who had access to chemical drug stores no longer used mangrove plants as malaria medicines. Traditional treatment was one of the best ways practiced in the community social life (Elyazar et al., 2012). The mangrove plants had cultural, ecological, and economic values (Datta et al., 2012). Traditional health treatment systems were developed from generations and practiced using mangrove plants in various disease treatment activities. People in remote villages performed therapy to cure malaria utilizing the plant's vegetative and generative parts (Bandaranayake 1998). From the locals ' perspective, the utilization of mangrove plants from generations proved that mangroves had the property to cure malaria (Lalitha et al., 2019). In X. granatum J.Koenig, four compounds were found: gedunin, photogedunin, xyloccensin-I, and palmitic acid. Gedunin and xyloccensin-I compounds found indicated suitable activities as antimalaria (Lakshmi et al., 2012).

The locals in the island areas of North Maluku used rinds, barks, fruits, and flowers of mangrove plants to make *Rorano* of malaria (Tamalene et al., 2019). Those parts of the plant were taken freshly and dried to make a potion. The locals utilized fresh leaves, seeds, bark, and fruits for malaria treatment preparation (Ngarivhume et al., 2015). Mangrove from *R. mucronata* Poir. species had potential as a safe and effective source of mosquitoes control agent to cure malaria. The community's need for medicine sources from plants is important as an agent of malaria cure (da Silva and Ricci-Júnior 2020). The use of *Jamu* (herbs) for generations has shown safety; however, further testing is required to determine the safety of potions consumed by the communities. This research only reports community knowledge on mangrove utilization as an agent to cure malaria for communities in the coastal areas of North Maluku Province in Indonesia. Mangrove has drug value since it has derivative compounds such as stigmasterol, triterpenoids, tretinoin, pyrethrins, and rubrolide-N) that could become new inhibitors for dihydrofolate reductase. The in-silico docking study also found that mangrove derivative compounds could block dihydrofolate reductase that, in turn, it could cause the inhibition of malaria parasites growth (Senthilraja et al., 2012).

At present, six mangrove species are being used by local communities of North Maluku Province Indonesia, especially ethnic peoples, as a source of malaria medicines. Traditional health treatment systems developed from generations and practiced in treatment activity and therapy to cure malaria disease used mangrove plants species from *L. littorea*, *R. mucronata*, *S. hydrophyllacea*, *S. alba*, *X. granatum*, and *X. moluccensis*. The traditional treatment that used mangrove rinds, barks, fruits, and flowers was one of the best methods practiced in the community social life. The mangrove plants have cultural, ecological, and economic values; hence, the local communities utilized and protected the plant through the socio-cultural approach.

The information forms the basis of further research to test the toxicity of potions made from the mangrove plant as the primary ingredient; therefore, the local communities would obtain scientific information related to safety in consuming traditional medicine.

ACKNOWLEDGEMENTS

The authors extend their high appreciation and acknowledgment towards the local communities by providing moral support to the authors. The authors would like to thank the anonymous reviewers for reading our manuscript carefully and their many insightful comments and suggestions. This research is funded by the Ministry of Research, Technology and Higher Education, the Republic of Indonesia.

REFERENCES

A'Yunin Al-Isyrofi AQ, Widati S, Hargono R. 2021. Requirement specification to develop a digital health promotion platform for millennials and post-millennials generations in Surabaya, Indonesia. Indian J Forensic Med Toxicol 15(2): 2022-2031.

Asase A, Asafo-Agyei T. 2011. Plants are used to treat malaria in communities around the Bobiri forest reserve in Ghana. J Herbs Spices Med Plants 17(2): 85-106. DOI: 10.1080/10496475.2011.581132.

Bandaranayake WM. 1998. Traditional and medicinal uses of mangroves. Mangroves Salt Marshes 2(3): 133-148. DOI: 10.1023/A:1009988607044.

Belayneh A, Asfaw Z, Demissew S, Bussa NF. 2012. Medicinal plants are potentially used by pastoral and agro-pastoral communities in Erer Valley of Babile Wereda, Eastern Ethiopia. J Ethnobiol Ethnomed 8(1): 1-11. DOI: 10.1186/1746-4269-8-42.

da Silva MRM, Ricci-Júnior E. 2020. An approach to natural insect repellent formulations: Basic research to technological development. Acta Trop 212: 105419. DOI: 10.1016/j.actatropica.2020.105419.

Dale P, Sipe N, Anto S, Hutajulu B, Ndoen E, Papayungan M, Saikhu A, Prabowa YT. 2005. Malaria in Indonesia: A summary of recent research into its environmental relationships. Southeast Asian J Trop Med Public Health 36(1): 1-13.

Datta D, Chattopadhyay RN, Guha P. 2012. Community-based mangrove management: A review on status and sustainability. J Environ Manag 107: 84-95. DOI: 10.1016/j.jenvman.2012.04.013.

del Prado GRL, García CH, Cea LM, Espinilla VF, Moreno MFM, Márquez AD, Polo MJP, García IA. 2014. Malaria in developing countries. J Infect Dev Ctries 8(1): 001-004. DOI: 10.3855/jidc.4610.

Dossou-Yovo HO, Kindomihou V, Vodouhè FG, Sinsin B. 2021. Assessment of the diversity of medico-magic knowledge on four herbaceous species in Benin. Sci World J 2021: 1-11. DOI: 10.1155/2021/6650704.

Dossou-Yovo HO, Vodouhè FG, Sinsin B. 2017. Ethnobotanical survey of mangrove plant species used as medicine from Ouidah to Grand-Popo Districts, Southern Benin. Am J Ethnomed 4(1): 1-6.

Elyazar IR, Gething PW, Patil AP, Rogayah H, Sariwati E, Palupi NW, Tarmizi SN, Kusriastuti R, Baird JK, Hay SI. 2012. *Plasmodium vivax* malaria endemicity in Indonesia in 2010. PLoS ONE 7(5): e37325. DOI: 10.1371/journal.pone.0037325.

Gething PW, Elyazar IR, Moyes CL, Smith DL, Battle KE, Guerra CA, Patil AP, Tatem AJ, Howes RE, Myers MF, George DB. 2012. A long-neglected world malaria map: *Plasmodium vivax* endemicity in 2010. PLoS Negl Trop Dis 6(9): e1814. DOI: 10.1371/journal.pntd.0001814.

Herdiana H, Cotter C, Coutrier FN, Zarlinda I, Zelman BW, Tirta YK, Hsiang MS. 2016. Malaria risk factor assessment using active and passive surveillance data from Aceh Besar, Indonesia, a low endemic, malaria elimination setting with *Plasmodium knowlesi*, *Plasmodium vivax*, and *Plasmodium falciparum*. Malar J 15(1): 468. DOI: 10.1186/s12936-016-1523-z.

Hoffman B, Gallaher T. 2007. Importance indices in ethnobotany. Ethnobot Res Appl 5: 201-218. DOI: 10.17348/era.5.0.201-218.

Husain F, Wahidah BF, Prasetyo KB, Massholeh MA. 2019. Traditional knowledge of medicinal plants among sellers of Jamu Gendong in Wonolopo, Indonesia. First International Conference on Advances in Education, Humanities, and Language. Malang, 23-24 March 2019. DOI: 10.4108/eai.23-3-2019.2284999. [Indonesian]

Kasmawati H, Ruslin IS, Yamin MD, Elafita WO. 2019. Ethnomedicine studies of traditional medicinal plants of the Muna tribe in Bungi southeast Sulawesi Province of Indonesia. Int J Sci Res 8(11): 1882-1887.

Lakshmi V, Srivastava S, Mishra SK, Srivastava MN, Srivastava K, Puri SK. 2012. Antimalarial activity in *Xylocarpus granatum* J. Koenig. Nat Prod Res 26 (11): 1012-1015. DOI: 10.1080/14786419.2010.535000.

Lalitha P, Sachithanandam V, Swarnakumar NS, Sridhar R. 2019. Review on anti-inflammatory properties of mangrove plants. Asian J Pharm Res 9(4): 273-288. DOI: 10.5958/2231-5691.2019.00045.5.

Manning L, Laman M, Law I, Bona C, Aipit S, Teine D, Warrell J, Rosanas-Urgell A, Lin E, Kiniboro B, Vince J. 2011. Features and prognosis of severe malaria caused by *Plasmodium falciparum*, *Plasmodium vivax*, and mixed *Plasmodium* species in Papua New Guinean children. PloS ONE 6(12): e29203. DOI: 10.1371/journal.pone.0029203.

Martin GJ. 2014. Ethnobotany: A Methods Manual. Springer, UK.

McClatchey W, Gollin LX. 2005. An ethnobotany research training workshop in Madagascar. Ethnobot Res Appl 3: 309-328. DOI: 10.17348/era.3.0.309-328.

Medinaceli A. 2018. Taking an early step in ethnobiological research: A proposal for obtaining prior and informed consent from indigenous peoples. Ethnobiol Lett 9 (1): 76-85. DOI: 10.14237/ebl.9.1.2018.1054.

Ngarivhume T, Van't Klooster CI, de Jong JT, Van der Westhuizen JH. 2015. Traditional healers use medicinal plants to treat malaria in the Chipinge district in Zimbabwe. J Ethnopharmacol 59: 224-237. DOI: 10.1016/j.jep.2014.11.011.

Qu SQ, Dumay J. 2011. The qualitative research interview. Qual Res Account Manag 8(3): 238-264. DOI: 10.1108/11766091111162070.

Sen UK, Bhakat RK. 2020. Assessment of psammophytic medicinal plant diversity used among the rural communities in coastal East Midnapore, West Bengal, India. J Herbs Spices Med Plants 26(3): 219-247. DOI: 10.1080/10496475.2019.1707736.

Senthilraja P, Sunil KS, Kathiresan K. 2012. Potential of mangrove derived compounds against dihydrofolate reductase: An in silico docking study. J Comput Biol Bioinform Res 4: 23-27. DOI: 10.5897/JCBBR11.028.

Sukarno S. 2016. The South China Sea: An impact to Indonesia mangrove at the human perspective on ecosystem, function, services, and benefit. Malaysian J Sci 35(2): 73-106. DOI: 10.22452/mjs.vol35no2.2.

Suwonkerd W, Ritthison W, Ngo CT, Tainchum K, Bangs MJ, Chareonviriyaphap T. 2013. Vector biology and malaria transmission in Southeast Asia. In: Manguin S (eds). Anopheles Mosquitoes-New Insights into Malaria Vectors. Intech Open Publishers, London. DOI: 10.5772/56347.

Tamalene MN, Bahtiar S, Nadra WS, Syahdar SA, Vianti E. 2019. Rorano Malaria: Utilization and preservation of malaria-based medicinal plants local culture. CV. Human Scholar.

WCVP. 2021. World Checklist of Vascular Plants, version 2.0. It was facilitated by the Royal Botanic Gardens, Kew. Published on the Internet; http://wcvp.science.kew.org/ 29 June 2021.

WHO. 2012. Summary of the World Malaria Report 2012. http://www.who.int/malaria/publications/world_malaria_report_2012/en/index.html.