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Diversity and use of traditional medicinal plant species in Bantimurung-Bulusaraung National Park, Indonesia

IIN PERTIWI A. HUSAINI[1,3], RISMA ILLA MAULANY[2,♥], NASRI NASRI[2], PUTU OKA NGAKAN[2]

[1]Faculty of Forestry, Universitas Hasanuddin. Jl. Perintis Kemerdekaan Km. 10, Makassar 90245, South Sulawesi, Indonesia. Tel./fax.: +62-411-588566, ♥email: risma.maulany@unhas.ac.id

[2]Forest Conservation Department, Forestry Faculty, Universitas Hasanuddin. Jl. Perintis Kemerdekaan Km. 10, Makassar 90245, South Sulawesi, Indonesia

[3]Research Center for Plant Conservation, Botanic Gardens and Forestry-National Research and Innovation Agency. Jl. Ir. H. Juanda No.13, Bogor 16122, West Java, Indonesia

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Abstract. *Husaini IPA, Maulany RI, Nasri N, Ngakan PO. 2022. Diversity and use of traditional medicinal plant species in Bantimurung-Bulusaraung National Park, Indonesia. Biodiversitas 23: 5539-5550.* The people of Minasatene (Pangkep District) in Bantimurung-Bulusaraung National Park, South Sulawesi (Indonesia) have used traditional medicinal plants for many centuries. However, this local knowledge has not been recorded. This study aims to examine the diversity of plant species used to treat various ailments in the area. A set of semi-structured questionnaires was distributed to 60 respondents, consisting of traditional healers, elderly people, herb sellers and local people of Minasatene. This was used to obtain a demographic profile, vernacular names of plants and their uses, plant parts used, modes of preparation and methods of application. The diversity and use of the medicinal plant species in a traditional context were descriptively analyzed. The data were further extrapolated using *Use Value* (UV) to analyze the relative importance of plant species based on the number of uses; *Fidelity Level* (FL) to determine the specific uses of each plant species and preference over other species, and *Informant Consensus Factor* (ICF) to investigate an agreement between each group of diseases and related remedies. The study reveals that there were 74 species of medicinal plants belonging to 65 genera and 44 families being used as traditional medicines, which have been known to treat 54 ailments. Among the plant species, soursop (*Annona muricata*) had the highest UV (0,95), while the fig tree species, *Ficus septica* (100%) had the highest FL with the most frequent citation. From the data gained, it was found that skeletomuscular disorders had the highest ICF value (0,92).

Keywords: Bantimurung-Bulusaraung National Park, diversity, ethnobotany, Minasatene, traditional medicinal plants

INTRODUCTION

Indonesia is a mega-biodiversity country known for its rich flora with 30,000-40,000 species identified (Ministry of National Development Planning 2016; Atik et al. 2019). Of these, only tiny percentages are known for their potential and benefits to the community, of which, medicinal herbs are the one. About 6,000 plant species in Indonesia are known to have potential as herbal medicine (Elfahmi et al. 2014). Recently, the use of medicinal plants has been increasing in the community and has become one of the alternative treatments (Rahayu et al. 2020). People tend to use medicinal plants due to the lack of negative side effects (Karimi et al. 2015) and their accessibility and low cost (Mahomoodally 2013; Malini et al. 2017), compared to modern drugs.

Medicinal plants have been found as an important contributor to the pharmaceutical, agricultural and food industries (Krishnan 2016). Plants were used as a basis of some of the most important drugs, such as diuretic activity in *Mangifera indica*, antiparasitic activity in *Carica papaya*, and anti-inflammatory activity in *Curcuma longa* (Yudharaj et al. 2016). During the COVID-19 pandemic, medicinal plants were also chosen as one of many interventions and explored across the world to find an effective as well as a complimentary cure for the disease alongside conventional treatments (Lim et al. 2021). Many studies have revealed that the use of medicinal plants for COVID-19 cases has assisted in prevention, reducing the severity of the disease and alleviating its effects (Chan et al. 2020; Panyod et al. 2020; Vellingiri et al. 2020). Here, the role of medicinal plants should not be underestimated.

Ethnobotany knowledge about medicinal plants has long been inherited from generation to generation (Yuan et al. 2016; Zikri et al. 2018; Li et al. 2020; Rastogi et al. 2020). But this traditional knowledge is currently facing the threat of disappearance due to loss of use in a society competing with modern drugs. This shift is related to changes in communities going through modernization (Malini et al. 2017), the death of the holders of knowledge of medicinal plants, which belongs only to older persons (>60 years) and traditional shamans or healers (Silalahi et al. 2015), as well as the lack of people who cultivate medicinal plants (Syamsiah et al. 2016).

Many people around the world still depend on the use of medicinal plants for their primary healthcare, in particular around Africa, some parts of Asia and Central and South America (Allkin 2017). Different tribes across the world have different medicinal plant species. This has caused differences in procedures for the utilisation of

medicinal plants, species of plants used as medicinal herbs, parts of plants used, diseases treated, plant processing and application (Syamsiah et al. 2016). As many have attempted to open doors for the use of medicinal plants, few plant species have been identified and explored. Like other regions, people in Sulawesi (Indonesia) also have a traditional medicine system known as *Lontaraq Pabbura* (Lukman et al. 2014). And, people in Sulawesi use plants from the forest as traditional medicines to maintain their health and treat a number of diseases (Mustofa et al. 2020; Azis et al. 2020; Pandiangan et al. 2019). However, there has been no documented data that reports on TMPs being used treating ailments among the people of Minasatene.

Bantimurung-Bulusaraung National Park is located in the unique karst formation and is known as the second-largest karst area after China, with a width of more than 40,000 ha. The national park was established in 2004 by the Ministry of Forestry (Siburian 2010). The presence of a karst ecosystem has become a distinct feature of this region (Puspitaningtyas 2017). It is also known for the diversity, uniqueness and beauty of its plants; there are 709 species of plants derived from 100 families that have been identified (Ministry of Environment and Forestry 2016). As one potential habitat for medicinal plants, the national park has not been widely explored. This study aims to examine the diversity and use of traditional medicinal plants by the local community living adjacent to Bantimurung-Bulusaraung National Park. It is expected that the results of the study will provide essential answers related to the knowledge and use of medicinal plants for curing certain diseases by the locals obtained in the forest but these could also be further used to initiate and promote forest conservation efforts in the area through community empowerment.

MATERIALS AND METHODS

Study area

This study focused on the community living in the buffer area of Bantimurung-Bulusaraung National Park. The Minasatene area, as part of the national park, is a buffer area and is located in the Pangkajene Kepulauan (Pangkep) District, South Sulawesi Province, Indonesia (Figure 1). The area is situated between 4° 47'33" to 4° 53'24" south latitudes and 119° 33'30" to 119° 40'55" east longitudes. The distance between the study area and the capital city of South Sulawesi Province (Makassar) is approximately 55 km. The total area of Minasatene is 79.15 km^2 and is the district with the highest population density compared to other buffer areas of the national park, with 39,364 people (Ministry of Environment and Forestry, 2016).

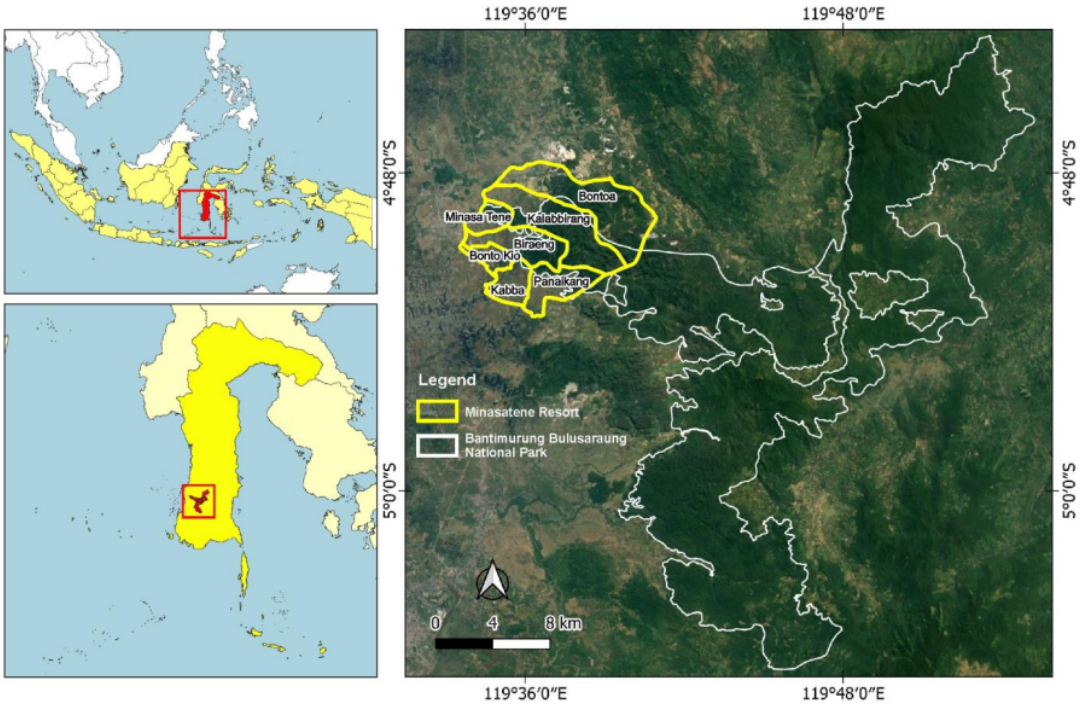

Figure 1. Location of Minasatene Resort, Bantimurung Bulusaraung National Park, South Sulawesi, Indonesia

Procedures

In this study, 60 respondents were interviewed, consisting of traditional healers, elderly people, herb sellers, and local people of Minasatene in Bantimurung-Bulusaraung National Park. A traditional healer is a person who uses traditional medicine to cure people who are ill or injured. An elderly person is a person 60 years of age or older who understands the use of medicinal plants. A herb seller is a person who sells herbs, especially medicinal herbs. Local people in this study are defined as the people who live in Minasatene Resort, are aged 30-80 years old and have used medicinal plants. Informant selection, in particular the healers, was based on the snowball sampling technique. The subsequent informants are determined by the directions given by the previous respondents.

Ethnobotanical data were collected from November 2021 to January 2022 using semi-structured interviews. The collected ethnobotanical data included the demographic profiles of respondents, diversity of plant species (vernacular names of plants), use of medicinal plant species (type of ailments, plant parts used, modes of preparation, and methods of application) and plant origins. The scientific name and family of each medicinal plant mentioned were later checked using different websites of plant databases such as http://www.theplantlist.org, and http://www.powo.science.kew.org.

Medicinal plants reported by the respondents were grouped into seven categories, according to Jadid et al. (2020). The seven categories were 1) gastrointestinal disorders (ulcers, constipation, flatulence, nauseous, diarrhea, food poisoning and worm infection); 2) dermatological diseases (wounds, bruises, scars, smallpox, hair care, ringworm, skin rash, boils and burns); 3) urogenital and gynecological problems (menstrual cramps, urinary tract infection, kidney disease, leucorrhoea and aphrodisiacs); 4) skeletomuscular disorders (gout, muscle pain, rheumatism, arthritis, back pain and bone pain); 5) internal medical diseases (high cholesterol, cancer, fever, malaria, dengue fever, chills, hemorrhoids, diabetes, hypertension, liver, typhus and heart disease); 6) respiratory, nose, ear, oral, eye and throat problems (coughs, colds, toothache, sprue, sore eyes, asthma, bronchitis, tonsils, stye, mumps and oral thrush); and 7) other (magical and spiritual problems, body odor issues, increase in appetite and breast milk booster).

Data analysis

The demographic profiles of respondents were processed using Microsoft office excel to find the number of medicinal plant species known to each respondent. The respondents who knew >20 medicinal plant species and respondents who knew ≤20 medicinal plant species were compared based on their gender, age, education, and occupation using chi-square tests (*p*-values).

The diversity and use of medicinal plant data were also processed by excel software and the obtained results were processed by quantitative ethnobotanical indices consisting of *Use Value* (UV), *Fidelity Level* (FL), and *Informant Consensus Factor*s (ICF). These three indices are further elaborated on:

UV (Use Value)

To further analyze the relative importance of a medicinal species based on the variety of recorded uses, the UV index was deployed using the formula:

$$UV = \sum Ui / N$$

Where: Ui is the number of different uses mentioned by each respondent for a given species and N is the total number of participants (Zenderland et al. 2019).

Fidelity Level (FL)

FL determines the specific uses of each plant species and its preference over other species. Meanwhile, a limitation of this index is that if a plant species has a low number of uses (one use), the FL can be high (100%). In contrast, a plant species with a higher number of uses may have a low FL (Ceto and Heinrich 2011). In this study, we used frequency of citation (FC) to determine the number of informants who mention the use of a plant species. The resulting FC value can then be correlated with FL to identify a species with high fidelity. FLs were calculated using the following equation:

$$FL = \sum Np / n$$

Where: Np is the number of respondents who mentioned the use of the given species for medicinal treatment and n is the total number of respondents who cited the plant species for any medicinal treatment (Jadid et al. 2020).

Informant Consensus Factor (ICF)

ICF was determined to investigate the agreement between each group of diseases and reported remedies. ICF was calculated as follows:

$$ICF = Nur - Nt / Nur - 1$$

Where: Nur is the number of valuable reports in each ailment category and Nt is the number of species used for this ailments category (Heinrich et al. 1998).

RESULTS AND DISCUSSION

Demographic profile of study respondents

This study involved 60 respondents, consisting of 19 traditional healers, 7 elderly people, 4 herb sellers, and 30 local people of Minasatene in Bantimurung-Bulusaraung National Park. These respondents were categorized based on their socio-demographic data (Table 1). Among the 60 respondents, 58% were female and 60% were over 50 years old and 40% were below 40 years old. Most respondents had graduated from high school (31%). The respondents consisted of 25% traditional healers, 22% unemployed/housewives, 13% laborers/farmers, 13% civil servants, 10% private employees and 17% sellers/traders.

Table 1. Demographic profile of study respondents (n=60)

Characteristic	No. of respondents	
	Frequency	%
Gender		
Male	25	42
Female	35	58
Age group (years old)		
31-40	8	13
41-50	16	27
51-60	18	30
61-70	9	15
71-80	9	15
Education		
Uneducated	6	10
Elementary	13	22
Secondary school	13	22
High school	19	31
University	9	15
Main occupation		
Traditional healer	15	25
Unemployment/housewife	13	22
Laborer/farmer	8	13
Civil servant	8	13
Private employee	6	10
Seller/trader	10	17
Respondents		
Traditional healer	19	32
Elderly	7	12
Herb seller	4	6
Local people	30	50

Table 2. Families of medicinal plants with two or more species

Families	Number of species
Acanthaceae	3
Amaryllidaceae	2
Anacardiaceae	2
Annonaceae	2
Asteraceae	4
Euphorbiaceae	4
Fabaceae	4
Lamiaceae	2
Moraceae	3
Myrtaceae	3
Oxalidaceae	2
Phyllanthaceae	3
Piperaceae	2
Poaceae	3
Rubiaceae	2
Rutaceae	2
Zingiberaceae	4
Others	27

Diversity of medicinal plants

The result shows that in Minasatene (Bantimurung-Bulusaraung National Park), there were 74 plant species belonging to 65 genera and 44 families listed as medicinal plants among the Minasatene people were reported. Out of these, 61 species of plants had more than one usage, while the remaining had just one usage.

Out of the 44 plant families, 17 had more than one species of medicinal plant (Table 2). The top families mentioned by respondents belonged to the families of Asteraceae, Euphorbiaceae, Fabaceae and Zingiberaceae, with four species in each, followed by species belonging to families Acanthaceae, Moraceae, Myrtaceae, Phyllanthaceae and Poaceae with three plant species. The plant genus with the highest number of mentioned species was Jatropha, with three species of medicinal plant.

A total of 54 medicinal uses (remedies) were recorded in this study. Thirteen ailments were reported to be treated by a single medicinal plant, while the remaining were by at least two medicinal plants. Various ailments with five or more plant species can be seen in Figure 2 Diabetes is treated by 11 species, including *Andrographis paniculata, Tinospora crispa,* and *Vernonia amygdalina,* which have a bitter taste. Followed by coughs and hypertension by 9 species, hypertension by 7 species. This high number of species was used to treat fairly common ailments, such as diarrhea, fever, ulcers, diabetes and respiratory problems (colds and coughs). Some medicinal plants used to treat respiratory problems, such as ginger and lemongrass, are also believed to treat COVID-19.

This study recorded 12 different usable parts (Figure 3A) with leaves as the most dominant part used (47%) followed by fruits (11%). Barks and whole parts (8% each), rhizomes and sap (6% each) were also used to treat human ailments. Seeds (5%), stems (3%), bulbs and roots (2%, each) and flowers and shoots (1%, each) were parts that were occasionally used. The results showed that the majority of remedies were prepared through decoction (51%), and this method was reported to have a higher level of efficacy (Penecilla and Magno 2011). Prior to the application of medicinal plants, turning plants and parts into pastes (16%) and juices (10%), brewing (4%), creating powders (3%) and cooking (2%) were also reported as other processing methods. A few plant species (14%) were identified to be directly consumed without prior handling and processing. However, the application methods of obtained TMPs in this study varied with the type of disease treated. The most frequently reported mode of administration was oral intake (68%), followed by an external application (24%) and rubbing (7%), while only one species (1%) were given by inhalation. Among all the plant species in this study, 46 of them (62%) were collected from the wild, 19 species (26%) from cultivated land and 9 species (12%) from both wild and cultivated land.

Relationship between knowledge of medicinal plants and socio-demographic factors

To describe the relationship between knowledge of medicinal plants gained by the community and socio-demographic factors, a test of chi-square was applied. The result revealed there is no significant correlation between knowledge of medicinal plant species and gender (p = 0,700), age (p = 0.669), education (p = 0.845) or occupation (p = 0.794) of respondents.

Use Value (UV)

The UV of each medicinal plant was determined to assess the commonness in the use of each plant in the study area. Results of the study revealed that the UV ranged from 0.02 to 0.95. The 10 highest values of UV are indicated in Figure 4, including *Annona muricata* (0.95), *Chromolaena odorata* (0.93), *Curcuma longa* (0.90), *Zingiber officinale* (0.82), *Orthosiphon aristatus* (0.77), *Phyllanthus niruri* and *Ficus septica* (0.72 for each), *Carica papaya, Lannea coromandelica* and *Psidium guajava* (0.70 for each).

Fidelity Level (FL)

To determine the highly preferred medicinal plant species for specific uses FL was employed and the results showed that the FL for each plant species ranged from 35% to 100% (Table 3). Information provided by informants on a particular plant's medical usefulness was regarded as a frequency of citation (FC). Plant species with the highest FL and FC can be seen in Figure 5. *Ficus septica* (tobo-tobo) had the highest value based on the number of respondents who indicated the use of this plant species (mentioned by 43 out of 60 respondents).

Informant Consensus Factor (ICF)

The 54 medicinal uses (remedies) were classified into seven ailment categories (Table 4). The ICF was calculated to determine the level of homogeneity among respondents that used plants to treat each ailment category. This study indicated ICF values ranging from 0,86 to 0,92 per each ailment category that showed a high level of consensus among the 60 respondents in the multiple uses of the 74 medicinal plant species. The highest ICF value was found in skeletomuscular disorders (0,92), while internal medical diseases were the most frequently treated ailments, with 501 reported from the answers given by the interviewed respondents and 50 medicinal plant species. Meanwhile, the lowest ICF values (0,86) was other diseases (magical and spiritual problems, body odor issue, decrease in appetite and breast milk booster). N_{ur} refers to the number of use reports per ailment, while N_t is explained as the number of plant species that were reported to address a particular plant-use category.

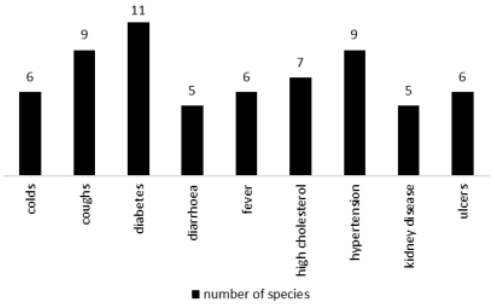

Figure 2. Various ailments with five or more species of medicinal plants in Minasatene (Bantimurung-Bulusaraung National Park), South Sulawesi, Indonesia

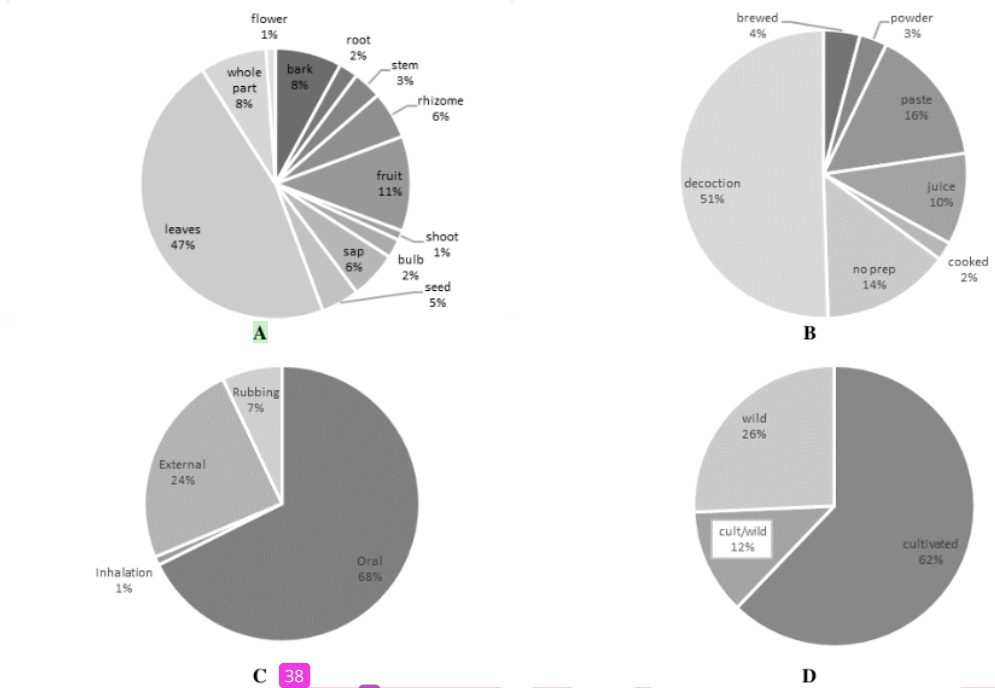

Figure 3. Summary of information on medicinal plants used by the local people in Minasatene, Bantimurung-Bulusarung National Park, South Sulawesi, Indonesia based on: A. Plant parts used; B. Modes of preparation; C. Methods of application, and D. Plant origins

Table 3. Medicinal Plants used for treating various ailments in Minasatene-Bantimurung Bulusaraung National Park, South Sulawesi, Indonesia. (Ba: bark; Bu: bulb; Fl: flower; Fr : fruit; Le: leaves; Rh: rhizome; Ro: root; Sa: sap; Se: seed; Sh: shoot; St: stem; Wp: whole part; Bre: brewed; Coo: cooked, Dec: decoction; Jui: juice; Pas: paste; Raw: no preparation; Ext: external application; Inh: inhalation; Ora: oral intake; Rub: rubbing; C: cultivated; W: wild; MoP: mode of preparation; MoA: method of application; UV: *Use Value*; FL: *Fidelity Level*; Ori: Plant's origins)

Family	Scientific name	Vernacular name	Type of ailments treated	Part used	MoP	MoA	UV	FL	Ori
Acanthaceae	*Acanthus illicifolius* (L.)	Kalli-kalli	Mumps	Le	Dec	Ora	0.38	52.2	C
			Worm infection	Se	Pow	Ora			
	Andrographis paniculata (Burm.f.) Ness	Sambiloto	Coughs, diabetes, colds	Le	Dec	Ora	0.37	45.5	C
	Strobilanthes crispus Blume	Keci beling	Urinary tract infection, back pain	Le	Dec	Ora	0.50	56.7	W
Acoraceae	*Acorus Calamus* (L.)	Kareango	Diarrhoea	Rh	Dec	Ora	0.08	60.0	C/W
			Magical/spiritual problems	Wp	Raw	Ext			
Amaryllidaceae	*Allium ascalonicum* (L.)	Bawang merah	Fever	Bu	Pas	Rub	0.47	75.0	C
			Colds	Bu	Pas	Inh			
	Allium sativum (L.)	Bawang putih	Hypertion	Bu	Dec	Ora	0.32	89.5	C
			Stye	Bu	Raw	Ext			
Anacardiaceae	*Lannea coromandelica* (Houtt.) Merr.	Tammate	Wounds	Ba	Jui	Ext	0.70	50	W
			Ulcers, haemorrhoids	Ba	Dec	Ora			
	Mangifera indica (L.)	Taipa	High cholesterol, diabetes	Le, Ba	Dec	Ora	0.15	66.7	C
Annonaceae	*Annona muricata* (L.)	Sirsak	High cholesterol, back pain	Le	Dec, Raw	Ora, Ext	0.95	71.9	C
			Cancer	Le	Dec, Raw	Ora			
	Annona squamosa (L.)	Serikaya	Diarrhoea	Le	Dec	Ora	0.17	55.6	C
			Hair care	Se	Pow	Rub			
Apiaceae	*Centella asiatica* (L.) Urb.	Tungke-tungke	Typhus, arthritis, bonchitis	Wp	Dec	Ora	0.32	36.8	W
Apoccynaceae	*Alstonia scholaris* (L.) R. Br.	Rita	Malaria	Ba	Dec	Ora	0.30	55.6	C
Arecaceae	*Cocos nucifera* (L.)	Kaluku	Food poisoning	Fr	Raw	Ora	0.30	72.2	C
			Hair care	32	Jui	Rub			
Asphodelaceae	*Aloe vera* (L.) Burm. f	Lidah buaya	Hair care, burns	Le	Pas	Rub	0.28	82.4	C
Asteraceae	*Chromolaena odorata* (L.) R.M.King & H.Rob.	Lahuna	Wounds	Le	Pas	Ext	0.93	83.9	W
			Ulcers	Le	Dec	Ora			
	Elephantopus scaber (L.)	Lisu-lisu tanah	Ulcers, smallpox, cancer	Wp	Dec	Ora	0.13	50	W
	Pluchea indica (L.) Less.	Lamutasa	Body odor, high cholesterol	Le	Dec	Ora, Rub	0.32	84.2	C/W
	Vernonia amygdalina Delile	Daun afrika	High cholesterol, diabetes	Le	Dec	Ora	0.47	60.7	C
Basellaceae	*Anredera cordifolia* (Ten.) Steenis	Binahong	Hypertension, ulcers	Le	Dec, Raw	Ora	0.33	35.0	C
			Bruise	Le	Pas	Ext			
Bromeliaceae	*Ananas comosus* (L.) Merr.	Nenas	Tonsils	Fr	Jui	Ora	0.07	100	C
Capparaceae	*Cleome rutidosperma* DC.	Birosa	Sore eyes	Wp	Pas	Ext	0.10	100	W
Caricaceae	*Carica papaya* (L.)	Pepaya	Dengue fever, chills	Le	Dec	Ora	0.70	66.7	C
Crassulaceae	*Bryophyllum pinnatum* (Lam.) Oken	Cocor bebek	Fever, boils	Le	Pas	Ext	0.45	74.1	C/W
Cucurbitaceae	*Momordica charantia* (L.)	Paria	Coughs	Le	Jui	Ora	0.37	68.2	C;
			Smallpox	Le	Jui	Ext			

Euphorbiaceae	*Aleurites moluccanus* (L.) Willd.	Kemiri	Constipation	Se	Dec	Ora	0.10	66.7	C
			Hair care	Se	Dec	Rub			
	Jatropha curcas (L.)	Tangan-tangan kanjoli	Toothache, sprue, oral thrush	Sa	Raw	Ora	0.68	51.2	C
			Magical/spiritual problems	St	Raw	Ext			
	Jatropha gossypiifolia (L.)	Jarak merah	Wounds	Sa	Raw	Ext	0.07	100	C
	Jatropha multifida (L.)	Pinisilin	Wounds	Sa	Raw	Ext	0.13	100	C
Fabaceae	*Mimosa pudica* (L.)	Jabe-jabe	Diabetes, aphrodisiac	Le	Dec	Ora	0.27	50.0	W
			Haemorrhoids	Ro	Pas	Ext			
	Leucaena leucocephala (Lam.) de Wit	Langtoro	Diabetes, worm infection	Ba	Dec	Ora	0.07	50	C/W
	Pterocarpus indicus Willd.	Angsana	Kidney disease	Le	Dec	Ora	0.08	60.0	C/W
			Sprue	Sa	Raw	Ext			
	Senna alata (L.) Roxb.	Kitti-kitti balanda	Ringworm	Le	Pas	Sub	0.48	100	W
Lamiaceae	*Orthosiphon aristatus* (Blume) Miq.	Kumis kucing	Urinary tract infection, gout	Le	Dec	Ora	0.77	73.9	C
	Plectranthus scutellarioides (L.) R.Br	Miana	Coughs, asthma	Le	Bre	Ora	0.50	80.0	C
Lauraceae	*Persea americana* Mill.	Alpukat	Hypertension, kidney disease	Le	Dec	Ora	0.20	58.3	C
Malvaceae	*Abelmoschus manihot* (L.) Medik	Gedi	Cancer, high cholesterol	Le	Dec	Ora	0.38	52.2	C
Meliaceae	*Swietenia macrophylla* King	Mahoni	Malaria, diabetes	Se	Pow	Ora	0.20	58.3	C
Menispermaceae	*Tinospora crispa* (L.) Hook. f. & Thomson	Tambara kaleleng	Bone pain, diabetes	St	Dec	Ora	0.25	53.3	W
Moraceae	*Artocarpus altilis* (Parkinson ex F.A.Zorn) Fosberg	Bakara	Diabetes, high cholesterol	Le	Dec	Ora	0.18	54.5	C
	Artocarpus heterophyllus Lam.	Nangka	Boils	Le	Pas	Ext	0.05	100	C
	Ficus septica Burm.f.	Tobo-tobo	Fever	Le	Raw	Ext	0.72	100	W
Moringaceae	*Moringa oleifera* Lam.	Keloro	Gout	Le	Dec	Ext	0.60	38.9	C
			Breast milk booster, eyes	Le	Coo	Ora			
Muntingiaceae	*Muntingia calabura* (L.)	Kersen	Diabetes, hypertension	Le	Dec	Ora	0.68	51.2	W
Musaceae	*Musa x paradisiaca* (L.)	Unti	Fever	Le	Pas	Ext	0.15	62.5	C/W
			Diarrhoea	Fr	Raw	Ora			
Myrtaceae	*Psidium guajava* (L.)	Jambu-jambu	Diarrhoea	Fr, Le	Raw	Ora	0.70	92.9	C
			Bronchitis	Fr, Le	Dec	Ora			
	Syzygium cumini (L.) Skeels	Coppeng	Diabetes, diarrhoe	Le,Ba	Dec	Ora	0.15	55.6	C/W
	Syzygium polyanthum (Wight) Walp.	Leko salam	Goat, hypertension	Le	Dec	Ora	0.43	57.7	C
Oxalidaceae	*Averrhoa bilimbi* (L.)	Belimbing	Fever, hypertension	Fl, Le	Dec	Ora	0.42	56.0	C/W
	Averrhoa carambola (L.)	Belimbing bintang	Heart disease	Fr	Raw	Ora	0.05	100	C
Pandanaceae	*Pandanus amaryllifolius* Roxb.	Pandan	Nauseous, menstrual cramps, rheumatism	Le	Dec	Ora	0.15	60	C
Phyllanthaceae	*Phyllanthus acidus* (L.) Skeels	Caramele	Hypertension, nauseous	Le	Dec	Ora	0.07	75.0	C
	Phyllanthus niruri (L.)	Camba-camba sibokoi	Arthritis, kidney disease	Wp	Dec	Ora	0.72	55.8	W
	Sauropus androgynous (L.) Merr.	Katu’	Breast milk booter, fever	Le	Coo	Ora	0.18	54.5	C
			Smallpox	Le	Pas	Ext			
Piperaceae	*Peperomia pellucida* (L.) Kunth	Lawi-lawi darat	Muscle pain	Wp	Dec	Ora	0.57	55.9	W
			Bruise	Wp	Pas	Ext			
	Piper betle (L.)	Sirih	Leucorrhoea, sore eyes, toothache, coughs	Le	Dec, Bre	Ora, Ext	0.67	37.5	C
Poaceae	*Bambusa vulgaris* Schrad.	Bambu kuning	Liver	Sh	Dec	Ora	0.05	100	C
	Cymbopogon citratus (DC.) Stapf	Sereh	Arthritis, flatulence, colds	St	Dec	Ora	0.52	45.2	C
	Imperata cylindrica (L.) Raeusch.	Alang-alang	Kidney disease, coughs	Ro	Dec	Ora	0.05	66.7	W

Portulacaceae	*Portulaca oleracea* L.	Alo	Skin rash	Wp	Pas	Ext	0.13	62.5	W
			Heart disease	Wp	Dec	Ora			
Rhamnaceae	*Ziziphus mauritiana* Lam.	Bidara	Colds, ulcers	Le	Dec	Ora	0.20	58.3	C
Rubiaceae	*Ixora coccinea* (L.)	Asoka	Increase in appetite, diarrhoe	Le, Ba	Dec	Ora	0.03	50	C/W
	Morinda citrifolia L.	Baja'	High cholesterol, body odor, arthritis	Fr	Dec, Jui	Ora	0.57	38.2	W
Rutaceae	*Citrus aurantiifolia* (Christm.) Swingle	Jeruk lemo	Coughs, sprue	Fr	Jui	Ora	0.23	64.3	C
	Murraya paniculata (L.) Jack	Kemuning	Rheumatism	Le	Dec	Ora	0.03	100	C
Sapindaceae	*Schleichera oleosa* (Lour.) Merr.	Ba'do	Diabetes	Le, Ba	Dec	Ora	0.02	100	
Sapotaceae	*Manilkara zapota* (L.) P.Royen	Sawo manila	Typhus	Fr	Jui	Ora	0.18	100	C
Solanaceae	*Physalis angulata* (L.)	Lappo-lappo	Kidney disease, heart disease	Fr, Le	Bre	Ora	0.17	60.0	W
Sterculiaceae	*Kleinhovia hospita* (L.)	Paliasak	Hypertension, liver	Le	Dec	Ora	0.35	52.4	C
Thymelaeaceae	*Phaleria macrocarpa* (Scheff.) Boerl.	Mahkota dewa	Colds	Fr	Bre	Ora	0.08	100	C
Verbenaceae	*Lantana camara* L.	Tai jangang	Skin rash	Le	Pas	Ext	0.55	42.4	W
			Hypertension, coughs, asthma	Le	Dec	Ora			
Zingiberaceae	*Kaempferia galanga* (L.)	Cakkuru	Increase in appetite, coughs	Rh	Jui	Ora	0.12	71.4	C
	Curcuma longa (L.)	Kunyi	Ulcers, menstrual cramps, constipation	Rh	Jui	Ora	0.90	50	C
			Scars	Rh	Pas	Ext			
	Curcuma xanthorrhiza Roxb.	Temmu	Increase in appetite, liver	Rh	Jui	Ora	0.42	64	C
	Zingiber officinale Roscoe	Jahe	Muscle pain, nauseous, coughs, colds	Rh	Dec	Ora	0.82	36.7	C

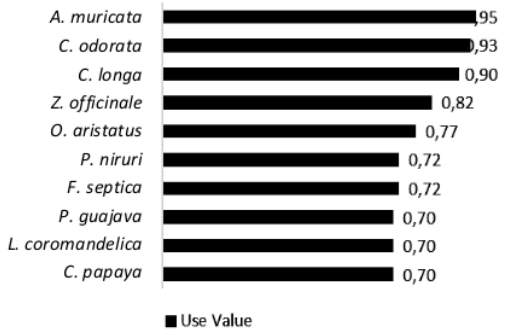

Figure 4. Medicinal plant species with the highest Use Value (UV) in Minasatene (Bantimurung-Bulusaraung National Park) , South Sulawesi, Indonesia

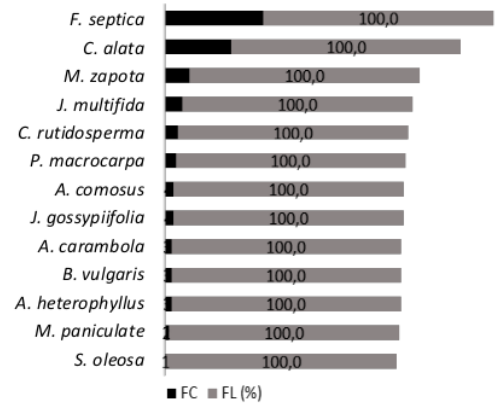

Figure 5. Frequency of citation with the highest *Fidelity Level* of plant species in Minasatene (Bantimurung-Bulusaraung National Park), South Sulawesi, Indonesia

Table 4. ICF values by categories for treating ailments in Minasatene (Bantimurung-Bulusaraung National Park), South Sulawesi, Indonesia

Ailment categories	No. of species (N_t)	No. of use reports (N_{ur})	Informant Consensus Factor (ICF)
Gastrointestinal disorders	18	155	0,89
Dermatological diseases	20	224	0,91
Urogenital and gynaecological problems	11	114	0,91
Skeletomuscular disorders	14	167	0,92
Internal medical diseases	50	501	0,90
Respiratory-nose, ear, oral, eyes, throat problems	32	258	0,88
Others	12	77	0,86

Discussion

All respondents in this study were indigenous inhabitants of Minasatene who were familiar with medicinal plants and their uses. These respondents were categorized based on their socio-demographic data. Compared with men, women were more interested in medicinal plants, which indicated women were more familiar with the knowledge and utilization of medicinal plants. This is similar to other ethnobotanical research (Nahdi and Kurniawan 2019; Nguyen et al. 2019; Chaachouay et al. 2021), where women were the majority of respondents. This is because women are usually in charge of health care in their households (Nguyen et al. 2019). The proportions in age categories indicated that older people tended to have more experience in the use of medicinal plants. Older women in the Amazon are also known to be more familiar with and use more medicinal plants compared to younger women (Wayland and Walker 2014). Most of the respondents had graduated from high school, while their occupations were traditional healers, unemployed/housewives, laborers/farmers, civil servants, private employees and sellers/traders.

Table 3 shows that there were 74 species belonging to 65 genera and 44 families listed as medicinal plants. The highest number of plants belonged to the genus *Jatropha* with three species of medicinal plants. Of these species, *J. curcas* had the most reported one for treating ailments, one of which was for magical or spiritual problems. The stem of the plant is believed to exorcise demons. Other species of the genus *Jatropha* was *J. gossypiifolia* and *J. multifidi*, which were used wound healing. The importance of Jatropha was also reported to have biological benefits such as anti-microbial, anti-infectious and healing properties by other study reports (Xavier-Santos et al. 2018; Vieira et al. 2021).

A total of 54 medicinal uses (remedies) were recorded in this study. Diabetes had the highest number of plant species because local people believed that plants with bitter tastes were effective at reducing blood sugar levels. This is similar to research by Chen et al. (2015), which stated that herbal medicines with bitter flavor and cold properties have multiple anti-diabetic mechanisms. A large number of species were used to treat respiratory problems (colds and coughs) which were believed to be symptoms of COVID-19. Respondents believe that *Zingiber officinale* (ginger) can be used to treat COVID-19 symptoms, such as colds and coughs. This is similar to another study carried out in Peru (Villena et al. 2021) and Thailand (Phumthum et al. 2021). Another medicinal plant that was used to treat COVID-19 was *Cymbopogon citratus* (lemongrass). It has

been reported to contain immune-boosting properties (Oladel et al. 2020).

In ethnobotanical studies, different plant parts are used to treat different diseases because the components in each part may have different effects (Nguyen et al. 2019). Plant parts can accumulate diverse and exciting natural components that act as factories, producing and offering substantial pharmaceutical potential (Jadid et al. 2020). Figure 3A shows that leaves were the most common plant material used in Minasatene (Bantimurung-Bulusaraung National Park). Leaves are the major plant component commonly used in herbal medicine in Indonesia (Mustofa et al. 2020; Fathir et al. 2021) and other countries (Chaachouay et al. 2020; Islam et al. 2020), as this part can be easily found in tropical regions. It's also known to be easy to handle and more sustainable compared to other parts of plants in terms of preservation. Removing the leaves within reasonable limits does not risk the plant's life compared to collecting the stem and root (Jadid et al. 2020). For some plants, only one part can be used, but for some other plants, all parts can be used. For example, the flower and leaves of starfruit (*Averrhoa bilimbi)* can be used to treat fever. Also, for *Alstonia scholaris,* the sap produced can treat toothaches, while the bark is used for treating malaria.

There were various modes of preparation before using plants as remedies in Minasatene. Plants were brewed, cooked, made into decoctions, juices, pastes and powders or as fresh. The results showed that the majority of remedies were prepared from decoction (Figure 3B). This method has been reported to have a higher level of efficacy due to its fast absorption process (Penecilla and Magno 2011). Some people ingested decoctions orally, but some were smeared on the body. A unique mode of preparation was recorded for *Cleome rutidosperma*. The plant parts were kneaded or crushed and the resulting paste was put in a bottle and brought close to the eye. The plants would secrete oil that would heal the eyes, according to respondents. This method was also reported in Sumatra (Ministry of Environment and Forestry, 2015).

The application methods in this study varied with the type of disease treated. The most frequent was oral ingestion (Figure 3C). This is similar to previous studies (Nguyen et al. 2019; Chaachouay et al. 2021; Fathir et al. 2021). *Allium cepa* was discovered to be inhaled to treat colds. Extracts of *A. cepa* have been shown to have relieving effects on obstructive respiratory diseases (Beigoli et al. 2021).

The plant species in Minasatene were collected from the wild, cultivated or a combination of both (Figure 3D). Medicinal plants collected in the wild, such as from forests, fields and ponds, were available to any local people who wanted to use them. However, medicinal plants obtained from yards or home gardens were grown for respondents' own use. This is similar to another study in Vietnam, where the medicinal plants obtained from home gardens (cultivated) were primarily grown for food preparation and for marketing, such as stimulants and ornaments (Nguyen et al. 2019).

In this study, there was no significant relationship between socio-demographic factors and knowledge of medicinal plants. This might be related to the length of exposure to experiences, where most respondents had inherited knowledge of medicinal plants from using them in the same ways as their ancestors. Therefore, data was not differentiated in terms of gender, age, education and occupation. In contrast, however, several studies have indicated that gender (Bano et al. 2014; Wiryono et al. 2019), age (Bano et al. 2014; Pérez-Nicolás et al. 2017; Wiryono et al. 2019), education (Bano et al. 2014; Pérez-Nicolás et al. 2017; Rahayu et al. 2020) and occupation (Moke et al. 2021; Rahayu et al. 2020) do influence the transmission of traditional knowledge about medicinal plants' therapeutic uses in many ethnic communities.

The plant species with the highest UV was commonly known and available in the study area, while plants had lower UVs if respondents had less knowledge about them. In the study area, *A. muricata* is used to treat high cholesterol, back pain and cancer. Its extracts and phytochemicals have been characterized as antioxidant, anti-microbial, anti-inflammatory, insecticidal, larvicidal and cytotoxic to cancer cells (Gavamukulya et al. 2017). *Curcuma longa* is used to treat wounds and ulcers. The leaves of this plant are a rich source of flavonoids and have been proven to help enhance wound-healing activities. Therefore, its activity as a wound-healing agent for superficial and internal wounds, such as ulcers, should be further investigated (Bhuyan et al. 2019). *Curcuma longa* or turmeric is one species in the genus *Curcuma*, widely known as a valuable material in modern pharmacy. Curcumin is the main phenolic constituent of the genus, especially in the turmeric rhizome. It has anti-inflammatory, anti-mutagenic, anti-bacterial, anti-cancer, expectorant hepatoprotective properties (Gupta et al. 2012; Krup et al. 2013; Mondal et al. 2015). This study found that local people use turmeric to treat ulcers, menstrual cramps, constipation and scars. We also found that people in Minasatene use *Z. officinale* for respiratory disease (colds and coughs), nausea and muscle pain. It has been reported to have similar use in Yogyakarta and Vietnam (Nahdi and Kurniawan 2019; Nguyen et al. 2019). The use of *O. aristatus* to treat urinary tract infections is in line with the research of Nisa et al. (2021), who found that *O. aristatus* is the plant most often used to treat urinary tract infections in several areas of eastern Indonesia.

Fidelity Level is useful in determining which plants are most commonly utilized to treat specific diseases (Khan et al. 2014). The higher the FL, the more people can be said to trust a medicinal plant to treat specific diseases; on the other hand, the lower the FL, the fewer people seem to trust medicinal plants. Figure 5 shows that *Ficus septica* (tobo-tobo) gets the highest value, based on the number of respondents who indicated the use of a plant species (mentioned by 43 out of 60 respondents). Respondents believe tobo-tobo can treat fever. Huang et al. (2017) described a variety of uses for tobo-tobo, including treating dengue fever.

The *Informant Consensus Factor* was used to evaluate the homogeneity of the use of medicinal plants. Higher values suggested that respondents utilized certain plant species to treat a particular disease, whereas low values indicated low agreement on plant use for a specific disease (Elfrida et al. 2021). The highest ICF value was found in skeletomuscular disorders. This is quite different from other study results, where gastrointestinal was the most cited disease category (Nguyen et al. 2019; Bhagawan and Kusumawati 2021).

In summary, the present ethnobotanical study of medicinal plant species among traditional healers, elderly people, herb sellers and local people in Minasatene (Bantimurung Bulusaraung National Park) reveals a rich diversity of medicinal plants. The people in the area reported using 74 species of medicinal plants derived from 65 genera and 44 families. The plant species were believed to treat 54 different ailments in seven categories. Leaves were the most popular plant part used. The most common methods of preparation and application of medicinal plants were decoction and oral intake. During data analysis, it was discovered that the application of ethnobotanical indices such as *Use Value* (UV), *Fidelity Level* (FL), and *Informant Consensus Factor* (ICF) validated the effectiveness of the ethnobotanical practices of local people; as such, they may be used to further support plant conservation and pharmacological studies for new drug discovery. Furthermore, medicinal plants with high scores of UV and FL in this study warrant future additional biochemical analysis to determine their bioactive substances, whereas those with low scores can be promoted more. Finally, the information we gathered may assist local communities in producing, market and profit from medicinal plants, thereby significantly increasing the local society's collective revenue.

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