



RESEARCH ARTICLE

An ethnobotanical study of medicinal plants used by the Tengger tribe in Ngadisari village, Indonesia

Nurul Jadid ^{*}, Erwin Kurniawan, Chusnul Eka Safitri Himayani, Andriyani, Indah Prasetyowati [†], Kristanti Indah Purwani, Wirdhatul Muslihatin, Dewi Hidayati, Indah Trisnawati Dwi Tjahjaningrum

Department of Biology, Institut Teknologi Sepuluh Nopember, Surabaya, Indonesia

* nuruljadid@bio.its.ac.id



Abstract

The people of Tengger, Indonesia have used plants as traditional medicine for a long time. However, this local knowledge has not been well documented until recently. Our study aims to understand the utilization of plants in traditional medicine by the people of Tengger, who inhabit the Ngadisari village, Sukapura District, Probolinggo Regency, Indonesia. We conducted semi-structured and structured interviews with a total of 52 informants that represented 10% of the total family units in the village. The parameters observed in this study include species use value (SUV), family use value (FUV), plant part use (PPU), and the relative frequency of citation that was calculated based on fidelity level (FL). We successfully identified 30 species belonging to 28 genera and 20 families that have been used as a traditional medicine to treat 20 diseases. We clustered all the diseases into seven distinct categories. Among the recorded plant families, Poaceae and Zingiberaceae were the most abundant. Plant species within those families were used to treat internal medical diseases, respiratory-nose, ear, oral/dental, and throat problems. The plant species with the highest SUV was *Foeniculum vulgare* Mill. (1.01), whereas the Aloaceae family (0.86) had the highest FUV. *Acorus calamus* L. (80%) had the highest FL percentage. The leaves were identified as the most used plant part and decoction was the dominant mode of a medicinal preparation. Out of the plants and their uses documented in our study, 26.7% of the medicinal plants and 71.8% of the uses were novel. In conclusion, the diversity of medicinal plant uses in the Ngadisari village could contribute to the development of new plant-based drugs and improve the collective revenue of the local society.

OPEN ACCESS

Citation: Jadid N, Kurniawan E, Himayani CES, Andriyani, Prasetyowati I, Purwani KI, et al. (2020) An ethnobotanical study of medicinal plants used by the Tengger tribe in Ngadisari village, Indonesia. PLoS ONE 15(7): e0235886. <https://doi.org/10.1371/journal.pone.0235886>

Editor: Khawaja Shafique Ahmad, University of Poonch Rawalakot, PAKISTAN

Received: August 18, 2019

Accepted: June 23, 2020

Published: July 13, 2020

Copyright: © 2020 Jadid et al. This is an open access article distributed under the terms of the [Creative Commons Attribution License](https://creativecommons.org/licenses/by/4.0/), which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

Data Availability Statement: All relevant data are within the manuscript and its Supporting Information files.

Funding: This work is financially supported by Kementerian Riset Teknologi dan Pendidikan Tinggi Republik Indonesia (Contract no. 890/PKS/ITS/2019 and contract no. 1204/PKS/ITS/2020). NJ received grant from Ministry of Research, Technology and Higher Education of the Republic of Indonesia. The funders had no role in study

Introduction

The interaction between humans and plants has been long described as one of the factors influencing human civilization, especially in medicinal fields [1]. Documentation of the medicinal use of plants through ethnobotanical studies enables the development of contemporary drugs and treatments as well as for plant conservation [2, 3]. Many ethnobotanical studies around

design, data collection and analysis, decision to publish, or preparation of the manuscript.

Competing interests: The authors have declared that no competing interests exist.

the world, including in Indonesia, report the use of herbal plants for the healing process, which has been in use for several generations in their respective societies [4, 5]. Though the cultural diversity in Indonesia contributes to the extensive traditional knowledge [6], access to this is limited. Traditional knowledge is usually passed on orally and often person-specific [7]. Therefore, the knowledge is often owned by tribal leaders, village heads, elders, heads of *kampung* (small village), or traditional healers in the particular community or tribe [8].

Indonesia has around 40,000 different plant species, of which approximately 6,000 are used for traditional healing processes [4], especially in certain tribal areas including Bromo Tengger Semeru National Park (BTSNP) [9]. BTSNP is designated as a national park because of its fascinating vegetation (about 600 floral species) and is home to the unique Tengger tribe. Some plants have been cultivated for daily consumption and trading whereas others are naturally found and used for particular purposes such as tribal ceremonies and medicinal uses [9]. People of Tengger are distributed in buffer zone villages around the BTSNP including Ngadisari village [10].

The Tengger people use plants from the BTSNP for traditional ceremonies [11], as well as medicinal applications [12], industrial materials, food sources, and building materials in some buffer village areas [13]. However, there are no reports regarding the ethnobotanical aspect of medicinal plants used in these buffer village areas in the BTSNP by the Tengger people. The present study documents the medicinal plant species and traditional knowledge of the Tengger tribe who inhabit the Ngadisari village in the BTSNP, Indonesia.

Materials and methods

Study area

This study was carried out in Ngadisari village, which belongs administratively to the Sukapura district in Probolinggo Region of the Republic of Indonesia. It is located at 7° 55' 18" S 112° 57' 21" E around the Bromo Tengger Semeru National Park (BTSNP) (Fig 1). Ngadisari village is situated at an altitude of 1800–1950 meters above sea level. The total area of the study comprised 4,993 km². Like other regions in Indonesia, Ngadisari village has only two seasons; dry and rainy. The rainy season spans the months of November–May, whereas the dry season spans June–October. The present study was conducted from 2018–2019. Most inhabitants belonged to the Tengger tribe and rely on agriculture. According to the Indonesian Statistics Bureau (BPS) data, the Ngadisari village has a population of 1,543 inhabitants or about 507 family units (households) [14]. The population consists of 742 males and 801 females. The Welsh onion (*Allium fistulosum* L.), potato (*Solanum tuberosum* L.), cabbage (*Brassica oleracea* L.), carrot (*Daucus carota* L.) and corn (*Zea mays* L.) are examples of plants that contribute to the income of these communities [9].

Data collection

This study was authorized (SK No. 091650/IT2.VII/HK.00.02/2018) by the Institute of Research and Community Service (LPPM) of the Institut Teknologi Sepuluh Nopember (ITS), Surabaya, Indonesia. Verbal informed consent was obtained from each informant before conducting the interview process.

Data collection was obtained through semi-structured and structured interviews with informants who knew or used plants as medicine. This technique is commonly used in ethnobotanical studies [16]. Interviews were conducted with selected informants including about 10% of the total heads of family units (52 informants) to determine and explore the traditional knowledge regarding the utilization of medicinal plant species, their usefulness, the utilized part,

mode of preparation, or method of processing the plants. All of the head family units were males since norms, values, and local wisdom are based on patriarchal culture [17]. The age of the informants ranged from 25 to more than 45 years, where four were between the ages of

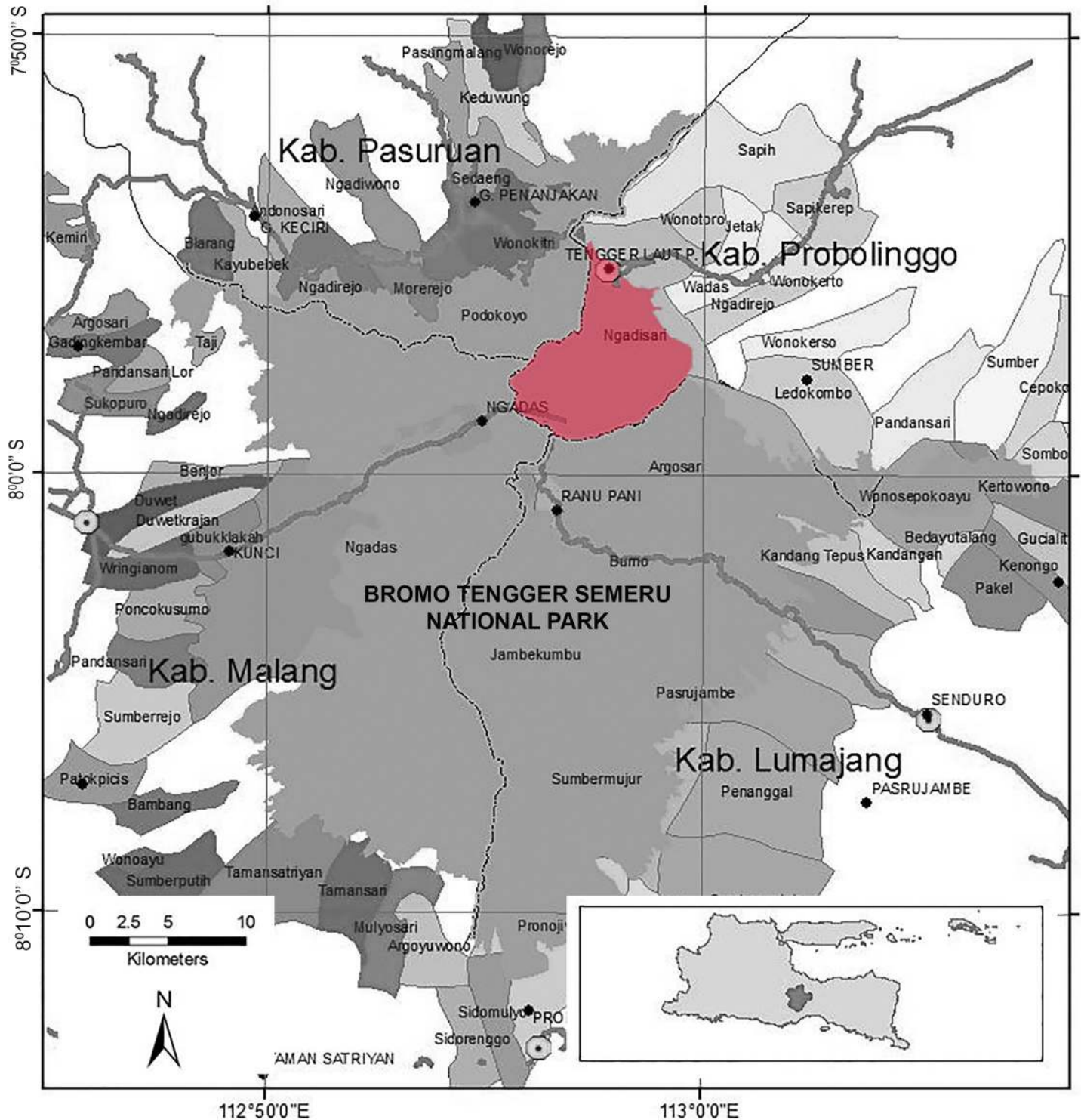


Fig 1. Location of the study area. Ngadisari village (A, red color) is located within the Bromo Tengger Semeru National Park Indonesia. This figure is similar but not identical to the original image obtained from [15] under a CC BY license and is used for illustrative purposes only.

<https://doi.org/10.1371/journal.pone.0235886.g001>

25–30, sixteen were ranging from 31–35, eighteen were between 36–40, nine were ranging from 41–45, and five informants were older than 45 years. The interview activities were carried out in their entirety using a questionnaire. Informant selection was based on the Snowball Sampling technique, by determining the key person. A key-person is one who possesses strong power within society. The subsequent informants are determined by the direction of the previous respondents.

Taxonomical identification and herbarium

Taxonomical identification was conducted to verify the samples that were raised during the interviews. An herbarium was also prepared to obtain dry specimens supporting the taxonomical identification. However, the herbarium method was used only for unknown species. Photo documentation and herbarium of medicinal plants were then identified by Christin Risbandini under the laboratory of plant bioscience and biotechnology, Institut Teknologi Sepuluh Nopember, Indonesia using key dichotomy and some references [18, 19].

Disease classification and grouping

Diseases that commonly occur in the Indonesian region were grouped into seven categories including gastrointestinal disorders (GI) (diarrhea, nausea, vomiting, stomach ache, gastric problems, loss of appetite, colic, flatulence, dysentery); dermatological diseases (DO) (skin burns, skin spots, skin rashes, boils, cut, wounds, hair problems, ectoparasites); urogenital and gynecological problems (UGP) (sexual problems including frigidity, lack of libido, infertility, gonorrhea, diuretic, aphrodisiac, menstrual disorders); skeletomuscular disorders (SD); internal medical diseases (IM) (diabetes, cancers, and tumors, hypertension, piles/hemorrhoids); respiratory-nose, ear, oral/dental, throat problems (RT) (asthma, nose bleeding, sinusitis, ear-ache, throat sore, dental problems); and others (OT) (motion sickness).

Data analysis

Fidelity Level (FL). The relative frequency of citation was calculated using the fidelity level (FL) formula according to Friedman *et al.* [20] and Ouedraogo *et al.* [21]. FL is the percentage of informants who claim to use certain plant species for particular healing processes. This reflects the preference of people for a specific plant species in a particular medicinal treatment. It was calculated using the following equation:

$$FL (\%) = \frac{Np}{N} \times 100 \quad (1)$$

Where Np is the number of informants who mentioned or claimed the use of plant species for a particular healing process/medicinal treatment. N is the total number of informants who cited the plant species for various kinds of medicinal treatment.

Species Use Value (SUV). SUV signifies the value of a medicinal plant species used by the people from Ngadisari village. It is calculated as the sum of the informant species use values (UV_{is}) for a particular medicinal species divided by the total number of informants (N_i). The SUV was calculated according to Hoffman and Gallaher [22] as follows:

$$SUV = \frac{\sum UV_{is}}{(n_i)} \quad (2)$$

Family Use Value (FUV). FUV was calculated as described by Phillips and Gentry [23], signifying the use value of a given plant family that is used as medicine by the people from

Ngadisari village. The calculation follows the below equation:

$$FUV = \frac{\sum UV_s}{(n_s)} \quad (3)$$

Where $\sum UV_s$ represents the sum of the use values for all species belonging to a particular family divided by the total number of species in the same family.

Plant Part Value (PPV). The plant part value is presented as the percentage of utilized parts of plants (stem, leaves, root, fruit, bark, and flower) that are used as medicinal biore-sources. The PPV is calculated according to Gomez-Beloz [24] as follows:

$$PPV(\%) = \frac{\sum RU_{(plant\ part)}}{\sum RU} \times 100 \quad (4)$$

Where $\sum RU_{(plant\ part)}$ and $\sum RU$ represent the sum of the cited plant parts and the total number of cited uses for a given plant, respectively.

Results and discussion

Utilization of plant species as traditional medicine by Tengger tribe in Ngadisari village

The people of Tengger receive their knowledge of traditional medicine from their ancestors. This knowledge is inherited and subsequently preserved across generations [12]. We found 30 plant species that are used in traditional medicine. Among them, eight plants (26.7%) were recorded for the first time, compared with the previous study [9, 11, 12]. They were *Mandevilla sanderi* (Hemsl.) Woodson, *Jatropha curcas* L., *Cymbopogon nardus* (L.) Rendle), *Microsorium buergerianum* (Miq.) Ching., *Paederia foetida* L., *Solanum muricatum* Ait., *Zingiber zerumbet* (L.) Sm., and *Senna alata* (L.) Roxb. Also, different medicinal uses for known plants (71.8%) were observed in the present study, compared to the study conducted by Batoro [9] (Table 1).

The highest number of species in one category was found in the category of IM with 12 species, followed by nine species in RT and six species in DD (Table 1). We also observed that five species found in this study were used to treat more than one disease in distinct categories. For instance, fennel, locally named *Adas* (*Foeniculum vulgare* Mill.) has been used to treat urticaria/hives (DD), cough (RT), and to overcome motion sickness (OT). Betelvine (*Piper betle* L.) has also been used for more than one disease including leucorrhoea (UGP), hives or urticaria (DD), and worm disease (GI). This demonstrated that the use value of these species is quite high compared with that of other medicinal plants [22].

Species and family use value

Species use value demonstrates the value of a medicinal plant species used by the people from Ngadisari village. Our results revealed that the SUV of the reported plants varied from 0.01 to 1.01 (Fig 2). Five species showed the highest SUV: *Foeniculum vulgare* Mill. (1.01), *Aloe vera* (L.) Burm. f. (0.86), *Acorus calamus* L. (0.8), *Apium graveolens* L. (0.76), and *Allium fistulosum* L. (0.71). Previous studies also demonstrated that fennel is frequently used as medicinal plants in Indonesia [12, 25] and is abundantly present in this region [9]. Our data showed that *F. vulgare* is categorized as a plant used to treat dermatological problems (DO). People of Tengger inhabiting Ngadisari village use *F. vulgare* to treat urticaria, hives, or itching. Our results are also in accordance with other studies that revealed *F. vulgare* as a traditional medicine for people suffering from itching or other dermatitis problems [26].

Table 1. Disease categories, health-related problems, and medicinal plants used in Ngadisari village.

No	Disease Categories	Specified disease name	Plant family	Plant species	Common name	Local name	Plant part used	Mode of preparation
1	Internal medical diseases	Hypertension	Apiaceae	<i>Apium graveolens</i> L.	Celery	<i>Seledri</i>	Leaves	Eaten raw, decoction
			Solanaceae	<i>Physalis angulata</i> L.	Cutleaf ground cherry	<i>Keciplukan</i>	Leaves	Decoction
			Solanaceae	<i>Solanum muricatum</i> Ait.	Pepino dulce, sweet cucumber	<i>Buah Melodi</i>	Fruit	Eaten raw
			Zingiberaceae	<i>Zingiber zerumbet</i> (L.) Sm.	Bitter ginger	<i>Lempuyang</i>	Rhizome	Eaten raw
		Fever	Acoraceae	<i>Acorus calamus</i> L.	Sweet flag, calamus	<i>Dringu</i>	Leaves	Pounded
			Liliaceae	<i>Allium cepa</i> L.	Onion	<i>Bawang merah tengger</i>	Bulb	Burned
			Poaceae	<i>Cymbopogon nardus</i> (L.) Rendle	Citronella grass	<i>Serai</i>	Leaves	Squeezed
			Poaceae	<i>Saccharum officinarum</i> L.	Sugarcane	<i>Tebu merah</i>	Stem	Burned
			Zingiberaceae	<i>Curcuma domestica</i> Val.	Curcuma	<i>Kunyit</i>	Rhizome	Shredded
		Nose bleeding	Asteraceae	<i>Artemisia vulgaris</i> L.	common wormwood	<i>Ganjan</i>	Leaves	Rolled up
		Hemorrhoid	Myrtaceae	<i>Psidium guajava</i> L.	Guava	<i>Jambu klutuk</i>	Leaves	Pounded
			Solanaceae	<i>Physalis angulata</i> L.	Cutleaf Ground Cherry	<i>Keciplukan</i>	Leaves	Decoction, pounded
			Clusiaceae	<i>Garcinia mangostana</i> L.	Mangosteen	<i>Manggis</i>	Stem bark	Burned
2	Urogenital and gynecological problems	Leucorrhea	Piperaceae	<i>Piper betle</i> L.	Betelvine	<i>Sirih</i>	Leaves	Decoction
			Rubiaceae	<i>Paederia foetida</i> L.	Stinkvine	<i>Kesimbukan</i>	Leaves	Decoction
3	Dermatological diseases	Hair problems	Arecaceae	<i>Cocos nucifera</i> L.	Coconut	<i>Kelapa</i>	Fruit	Decoction
			Aloaceae	<i>Aloe vera</i> (L.) Burm. f.	Barbados aloe	<i>Lidah Buaya</i>	Leaves	Smear
		Urticaria/hives	Apiaceae	<i>Foeniculum vulgare</i> Mill.	Fennel	<i>Adas</i>	Leaves	Decoction, Pounded
			Piperaceae	<i>Piper betle</i> L.	Betelvine	<i>Sirih</i>	Leaves	Decoction
			Polypodiaceae	<i>Microsorium buergerianum</i> (Miq.) Ching.	Microsorium	<i>Pangotan, paduka aji</i>	Leaves	Decoction
		Ringworm	Fabaceae	<i>Senna alata</i> (L.) Roxb.	Candle bush	<i>Ketepeng</i>	Leaves	Pounded, decoction
		Skin burn	Aloaceae	<i>Aloe vera</i> (L.) Burm. f.	Barbados aloe	<i>Lidah buaya</i>	Leaves	Smear
4	Respiratory-nose, ear, oral/dental, throat problems	Cough	Liliaceae	<i>Allium fistulosum</i> L.	Welsh onion	<i>Bawang prei</i>	Leaves	Burned
			Apiaceae	<i>Foeniculum vulgare</i> Mill.	Fennel	<i>Adas</i>	Leaves	Decoction
			Rutaceae	<i>Citrus aurantium</i> L.	Lime	<i>Jeruk Nipis</i>	Fruit	Squeezed
			Zingiberaceae	<i>Zingiber officinale</i> Rosc.	Ginger	<i>Jahe</i>	Rhizome	Pounded, decoction
			Zingiberaceae	<i>Kaempferia galanga</i> L.	Chinese ginger, aromatic ginger	<i>Kencur</i>	Rhizome	Burned
		Mouth ulcer, sprue	Euphorbiaceae	<i>Jatropha curcas</i> L.	Jatropha	<i>Jarak Pagar</i>	Stem	Smear
		Asthma	Poaceae	<i>Cymbopogon nardus</i> (L.) Rendle	Citronella grass	<i>Serai</i>	Leaves	Decoction
		Heatiness	Poaceae	<i>Imperata cylindrica</i> (L.) P. Beauv.	Cogon grass	<i>Alang-alang</i>	Leaves	Decoction
		Eye Irritation	Apocynaceae	<i>Mandevilla sanderi</i> (Hemsl.) Woodson	Brazilian jasmine	<i>Bunga Terompet</i>	Gum	Dropped

(Continued)

Table 1. (Continued)

No	Disease Categories	Specified disease name	Plant family	Plant species	Common name	Local name	Plant part used	Mode of preparation
5	Skeleto-muscular disorders	hyperuricemia	Euphorbiaceae	<i>Jatropha curcas</i> L.	Jatropha	<i>Jarak Pagar</i>	Leaves	Decoction
		Muscle soreness	Poaceae	<i>Dendrocalamus asper</i> (Schult. f.) Backer ex Heyne	Dragon bamboo, giant bamboo	<i>Bambu betung</i>	Stem	Pounded
6	Gastrointestinal disorders	Diarrhea	Apiaceae	<i>Coriandrum sativum</i> L.	Coriander	<i>ketumbar</i>	Stem	Burned
			Convolvulaceae	<i>Ipomoea paniculata</i> Burm. f.	Bindweed	<i>Tirem</i>	Leaves	Decoction
			Myrtaceae	<i>Psidium guajava</i> L.	Guava	<i>Jambu klutuk</i>	Fruit	Eaten raw
		Constipation	Brassicaceae	<i>Brassica</i> sp.	Mustard	<i>Sawi Tengger</i>	Leaves	Decoction
		Worm disease	Piperaceae	<i>Piper betle</i> L.	Betelvine	<i>Sirih</i>	Leaves	Decoction
7	Others	Motion sickness	Apiaceae	<i>Foeniculum vulgare</i> Mill.	Fennel	<i>Adas</i>	Leaves	Squeezed

<https://doi.org/10.1371/journal.pone.0235886.t001>

Similar medicinal uses of *Aloe vera* (L.) Burm. f., *Acorus calamus* L., *Apium graveolens* L., and *Allium fistulosum* L. have been reported in previous ethnobotanical studies. For example, Reimers *et al.* [27] and Salehi *et al.* [28] reported the use of *Aloe vera* to treat hair problems. Meanwhile, the use of *Acorus calamus* L. to treat fever has been reported by Rajput *et al.* [29]. Also, *A. graveolens* and *A. fistulosum* L. have been used by traditional Chinese and Indonesian people to reduce blood pressure and cough, respectively [30, 31]. Finally, nine species were reported to have low SUV (0.01) in the present study (Fig 2). High or low SUV may be due to extensive or minimum ethnobotanical uses of the reported species, respectively. Similar results were also reported by Hussain *et al.* [32], where the highest SUV represents the most exploited medicinal plants used to treat a specific ailment.

In total, 30 medicinal plant species have been recorded in our study. All belong to 20 different families, with Poaceae and Zingiberaceae being dominant in the study area (each consisting of four species) followed by Apiaceae (three species). The remaining families were represented by one or two species (Table 2). Poaceae and Zingiberaceae were the most representative medicinal plant families in our study. This finding might be due to the high accessibility of these species in that region. This further supports that dominant plant families and species are commonly used by local people for disease treatment [32]. Moreover, most of the species within both families are cultivated by people of Tengger in the Ngadisari village. The occurrence of dominant plant species and families in the study area is also related to favorable climate and environmental conditions [33, 34]. As a result of the abundance, these species are commonly used as a basic ingredient of *Jamu*—an Indonesian traditional medicine [35]. Sharifi-Rad *et al.* [36] also described that plants from the Zingiberaceae family are a potential source of bioactive phytochemical.

The total number of species within a given family has been calculated to obtain their FUV. Our results showed that Aloaceae had a high FUV (0.86), followed by Acoraceae (0.80), Piperaceae (0.69), and Euphorbiaceae (0.65). Other families represented low FUV (< 0.60) (Table 2). High values of FUV might be because the plant species were cited by a large number of people in the study area. In addition, some reports have described similar results. For example, *A. vera* or locally named as crocodile's tongues has been frequently used in some regions such as Southern Africa [37], Asia [38], Nigeria [39], and India [40] to treat dry skin, for improving skin integrity, and to decrease the appearance of acne, skin burn, and wrinkles.

A. calamus is also cited by other ethnobotanical studies around the world including China [41], India [42], Nepal [43] to treat fever, diarrhea, bronchitis, tumors, skin diseases, and

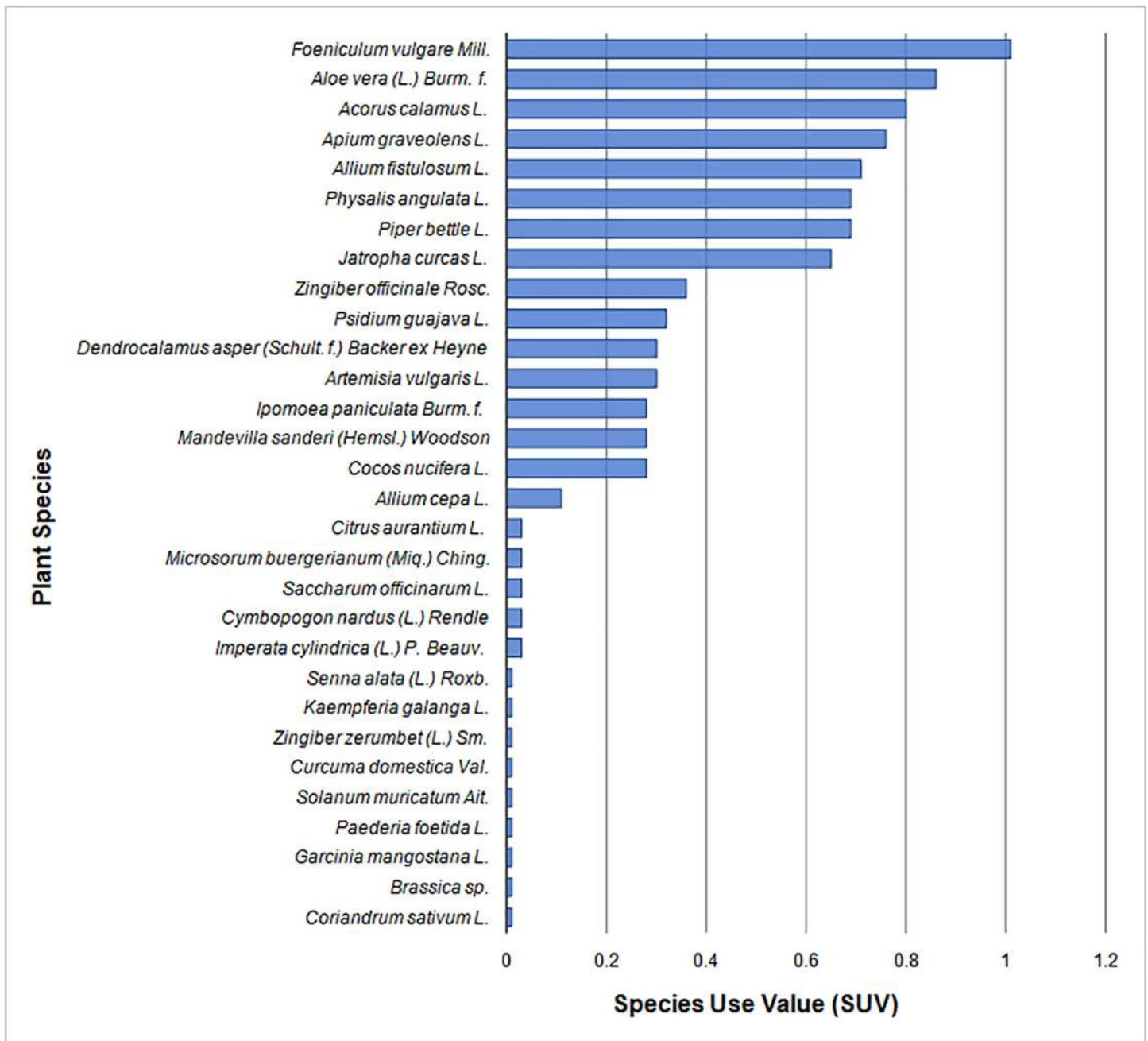


Fig 2. Species Use Value (SUV) of medicinal plants found in the Ngadisari village, Indonesia.

<https://doi.org/10.1371/journal.pone.0235886.g002>

cough treatment [29]. Reported species from Piperaceae has also highly cited in the previous study [11]. Finally, another high FUV in this study was obtained by Euphorbiaceae with only one species (*Jatropha curcas*). The Tengger people use this Barbados nut species to treat mouth ulcers and hyperuricemia. Our data supports other studies; for example, Abdelgadir and Staden [44] reported that its latex is used for ailments such as headache, toothache, mouth ulcers, cold, and cough. Abu Bakar *et al.* [45] also reported that *J. curcas* is potentially used to treat hyperuricemia.

Table 2. Family Use Value (FUV) of medicinal plants found in Ngadisari village, Indonesia.

No.	Plant Family	FUV	Number of Species	Local name (Plant species)/voucher number
1	Apiaceae	0.59	3	Adas (<i>Foeniculum vulgare</i> Mill.) / NAD-003
				Sledri (<i>Apium graveolens</i> L.) / NAD-005
				Tumbar (<i>Coriandrum sativum</i> L.) / NAD-001
2	Acoraceae	0.8	1	Dringu (<i>Acorus calamus</i> L.) / NAD-030
3	Arecaceae	0.28	1	Kelapa (<i>Cocos nucifera</i> L.) / NAD-019
4	Asteraceae	0.30	1	Ganjan (<i>Artemisia vulgaris</i> L.) / NAD-021
5	Aloaceae	0.86	1	Lidah buaya (<i>Aloe vera</i> (L.) Burm. f.) / NAD-006
6	Apocynaceae	0.28	1	Bunga trompet (<i>Mandevilla sanderi</i> (Hemsl.) Woodson) / NAD-029
7	Brassicaceae	0.01	1	Sawi tengger (<i>Brassica</i> sp.) / NAD-002
8	Clusiaceae	0.01	1	Manggis (<i>Garcinia mangostana</i> L.) / NAD-023
9	Euphorbiaceae	0.65	1	Jarak Pagar (<i>Jatropha curcas</i> L.) / NAD-015
10	Liliaceae	0.41	2	Bawang prei (<i>Allium fistulosum</i> L.) / NAD-010
				Bawang merah Tengger (<i>Allium cepa</i> L.) / NAD-009
11	Myrtaceae	0.32	1	Jambu (<i>Psidium guajava</i> L.) / NAD-014
12	Piperaceae	0.69	1	Sirih (<i>Piper betle</i> L.) / NAD-008
13	Poaceae	0.1	4	Serai (<i>Cymbopogon nardus</i> (L.) Rendle) / NAD-017
				Bambu betung (<i>Dendrocalamus asper</i> (Schult. f.) Backer ex Heyne) / NAD-022
				Tebu merah (<i>Saccharum officinarum</i> L.) / NAD-018
				Alang-alang (<i>Imperata cylindrica</i> (L.) P. Beauv.) / NAD-016
14	Polypodiaceae	0.03	1	Pangotan (<i>Microsorium buergerianum</i> (Miq.) Ching.) / NAD-012
15	Rutaceae	0.03	1	Jeruk nipis (<i>Citrus aurantium</i> L.) / NAD-013
16	Rubiaceae	0.01	1	Kesimbukan (<i>Paederia foetida</i> L.) / NAD-024
17	Solanaceae	0.35	2	Keciplukan (<i>Physalis angulata</i> L.) / NAD-011
				Buah melody (<i>Solanum muricatum</i> Ait.) / NAD-025
18	Convolvulaceae	0.28	1	Tirem (<i>Ipomoea paniculata</i> Burm. f.) / NAD-020
19	Zingiberaceae	0.10	4	Jahe (<i>Zingiber officinale</i> Rosc.) / NAD-004
				Kunyit (<i>Curcuma domestica</i> Val.) / NAD-028
				Lempuyang (<i>Zingiber zerumbet</i> (L.) Sm.) / NAD-007
				Kencur (<i>Kaempferia galanga</i> L.) / NAD-026
20	Fabaceae	0.01	1	Ketepeng (<i>Senna alata</i> (L.) Roxb.) / NAD-027

<https://doi.org/10.1371/journal.pone.0235886.t002>

Fidelity level

According to Imran *et al.* [46], the fidelity level (FL) is useful to determine the level of species importance in relation to a particular disease. FL shows the percentage of respondents who mention the use of a plant species for the same main purpose. Ouedraogo *et al.* [21] reported that relative frequency of citation could also be counted based on FL. This is designed to measure species importance for specific purposes. Our results showed that FL of the 30 plant species ranged from 1.92 to 80% (Table 3). *A. calamus* demonstrated the highest FL for fever (80%), followed by *A. graveolens* (76.92%) and *A. fistulosum* (71.15) for treating hypertension and cough, respectively. Based on a previous study, plants with a high percentage of FL are more frequently used as bio-pharmacological resources [47] and should be considered for further conservation program [48] bioassays and phytopharmacological investigation [49, 50].

Some species have low percentage of FL (1.92%) related to various diseases (Table 3). Examples include, *S. muricatum*, *Z. zerumbet*, *C. nardus*, *C. domestica*, *P. guajava*, *G. mangostana*, *P. foetida*, *S. alata*, *K. galanga*, *C. sativum*, *Brassica* sp. Low fidelity levels might also explain the low abundance of plant species in this region. Furthermore, it might also indicate that there is little information about the use of this medicinal plant among the people of Tengger in the

Table 3. Fidelity Level (FL) of medicinal plants in Ngadisari village, Indonesia.

Disease categories	Plant Species	Specified disease name	Fidelity level (%)
Internal medical diseases	<i>Apium graveolens</i> L.	Hypertension	76.92
	<i>Physalis angulata</i> L.	Hypertension	38.46
	<i>Solanum muricatum</i> Ait.	Hypertension	1.92
	<i>Zingiber zerumbet</i> (L.) Sm.	Hypertension	1.92
	<i>Acorus calamus</i> L.	Fever	80
	<i>Allium cepa</i> L.	Fever	11.50
	<i>Cymbopogon nardus</i> (L.) Rendle	Fever	1.92
	<i>Saccharum officinarum</i> L.	Fever	3.84
	<i>Curcuma domestica</i> Val.	Fever	1.92
	<i>Artemisia vulgaris</i> L.	Nose bleeding	30.76
	<i>Psidium guajava</i> L.	Hemorrhoid	1.92
	<i>Physalis angulata</i> L.	Hemorrhoid	30.76
	<i>Garcinia mangostana</i> L.	Hemorrhoid	1.92
Ureno-genital and gynaecological problems	<i>Piper bettle</i> L.	Leucorrhoea	42.30
	<i>Paederia foetida</i> L.	Leucorrhoea	1.92
Dermatological diseases	<i>Cocos nucifera</i> L.	Hair problems, hair nourishment	28.84
	<i>Aloe vera</i> (L.) Burm. f.	Hair problems, hair nourishment	65.38
	<i>Foeniculum vulgare</i> Mill.	Itchy, urticaria/hives	36.53
	<i>Piper bettle</i> L.	Itchy, urticaria/hives	3.38
	<i>Microsorium buergerianum</i> (Miq.) Ching.	Itchy, urticaria/hives	3.84
	<i>Senna alata</i> (L.) Roxb.	Ringworm	1.92
	<i>Aloe vera</i> (L.) Burm. f.	Skin burn	21.15
Respiratory-nose, ear, oral/dental, throat problems	<i>Allium fistulosum</i> L.	Cough	71.15
	<i>Foeniculum vulgare</i> Mill.	Cough	42.30
	<i>Citrus aurantium</i> L.	Cough	3.84
	<i>Zingiber officinale</i> Rosc.	Cough	36.54
	<i>Kaempferia galanga</i> L.	Cough	1.92
	<i>Jatropha curcas</i> L.	Sprue, mouth ulcer	65.38
	<i>Cymbopogon nardus</i> (L.) Rendle	Asthma	1.92
	<i>Imperata cylindrica</i> (L.) P. Beauv.	Heatiness	3.84
	<i>Mandevilla sanderi</i> (Hemsl.) Woodson	Eye irritation	28.84
Skeleto-muscular disorders	<i>Jatropha curcas</i> L.	Hyperuricemia	3.38
	<i>Dendrocalamus asper</i> (Schult. f.) Backer ex Heyne	Muscle soreness	30.76
Gastro-intestinal disorders	<i>Coriandrum sativum</i> L.	Diarrhea	1.92
	<i>Ipomoea paniculata</i> Burm. f.	Diarrhea	28.84
	<i>Psidium guajava</i> L.	Diarrhea	32.69
	<i>Brassica</i> sp.	Constipation	1.92
	<i>Piper bettle</i> L.	Worm disease	23.07
Others	<i>Foeniculum vulgare</i> Mill.	Motion sickness	3.83

<https://doi.org/10.1371/journal.pone.0235886.t003>

Ngadisari village. Even though some plants possess low FL, these species should not be abandoned to preserve traditional knowledge of the society in treating some diseases as reported by Chaachouay *et al.* [51].

Plant part use and mode of preparation

According to Hoffman and Gallaher [22], calculating the use of plant parts (Plant Part Use) is useful to determine the dominant plant parts being used as medicinal ingredients. Plant parts

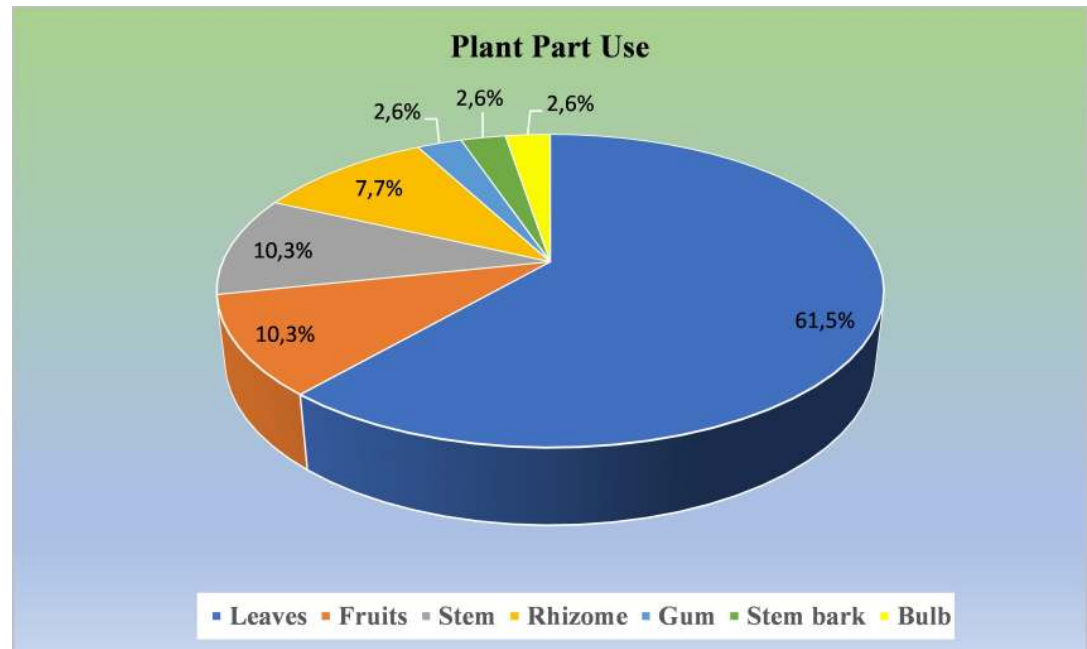


Fig 3. Percentage of medicinal plant part use for herbal preparation in Ngadisari village, Indonesia.

<https://doi.org/10.1371/journal.pone.0235886.g003>

are capable of accumulating diverse and interesting natural compounds. They attract attention because of their ability to act as factories, producing and offering important pharmaceutical potential [52]. Our results showed that leaves were the most predominantly utilized plant parts at 61.5%, while gum, stem bark and bulb represent parts that are infrequently used by people of Ngadisari (Fig 3).

Leaves are the major plant components commonly reported to be used as herbal medicine materials in Indonesia [8, 53] and also in other countries [54–56]. Leaves are common and favorite parts used for medicinal treatment preparation because of easy handling and sustainability [57, 58]. The latter is linked to the survival rate of medicinal plants. Removing the leaves biomass within reasonable limits does not interfere with the plant life, compared to collecting the stem, root, or whole plant, which may risk the plant life [59]. Moreover, many reports have showed that leaves contain diverse plant secondary metabolites [60]. In the present study, no data have been obtained for the use of flowers as medicinal materials. This might offer other perspectives for further investigation. Furthermore, our data have also shown the use of more than one plant part from the same plant species. For instance, *J. curcas* leaves and stem have been used to treat hyperuricemia and mouth ulcer, respectively.

People from the Ngadisari village use many methods to prepare plant parts before using them as herbal medicine. The decoction is considered the main mode of preparation (40.9%), followed by pounding (15.9%) and burning (13.6%). Meanwhile, eating raw (9.1%) and smearing (6.8%) contribute and of the total mode of preparation in the present study. Other miscellaneous modes of preparations constitute the remaining 13.6% (Fig 4). Some other studies have also mentioned the same results, where the most common method of preparation is decoction [61–63]. Simple, easy handling and inexpensive are the major reasons why this mode of preparation is widely used by society [64]. Moreover, other reports also demonstrated that decoction might increase the efficiency of plant extraction and therefore increase its bioactivity [65].

Some plants can be prepared without any processing. For example, leaves of *A. graveolens* are eaten raw to reducing hypertension symptoms and leaves of *A. vulgaris* are applied directly

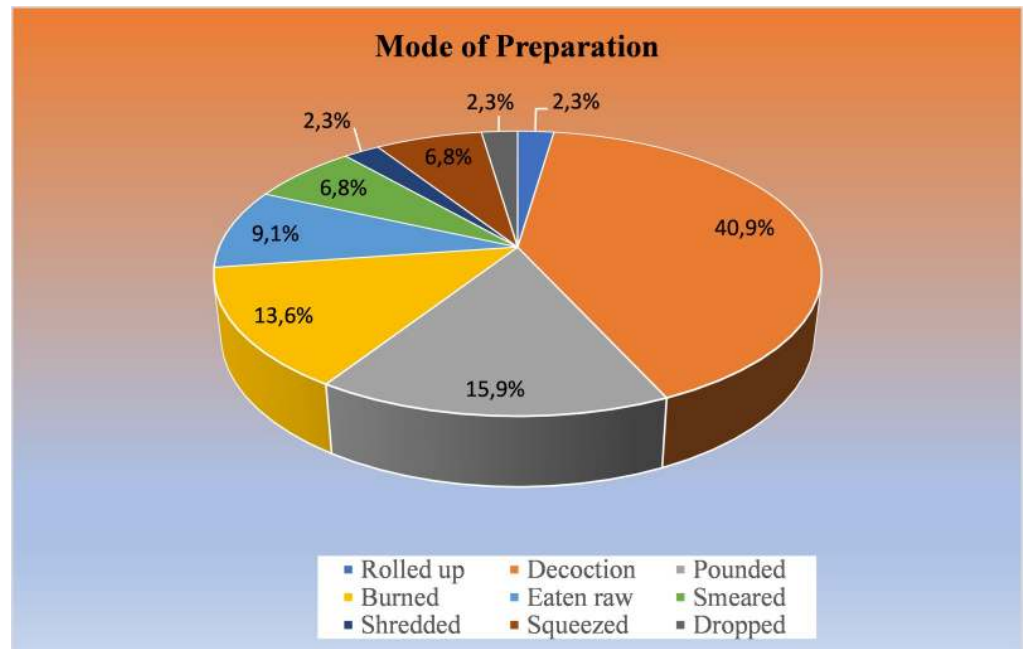


Fig 4. Mode of preparation of the medicinal plants used by the people of Tengger in Ngadisari village, Indonesia.

<https://doi.org/10.1371/journal.pone.0235886.g004>

by clogging into the nose to stop nosebleeds. All this local knowledge is preserved and applied by the people of Tengger in Ngadisari village. This practice is common in other regions in Indonesia such as in Madura and Bali [5, 66].

Conclusions

Our results highlighted the use of medicinal plants by people from the Ngadisari village, Indonesia. A total of 30 medicinal plant species were recorded in the present study. They belong to 20 different families, where Poaceae and Zingiberaceae were the most representative families. A high number of plant species were used for treating internal medical diseases, respiratory-nose, ear, oral/dental, and throat problems. Leaves were the most popular plant part used and decoction was the most common method of preparation. These findings indicated potential roles of medicinal plants used in the Ngadisari village. Furthermore, our study characterized the cultural values of the people of the Ngadisari village. The species use, family use values and fidelity levels presented here may be used to further support plant conservation and pharmacological studies for new drug discovery. Out of all the plants we reported, approximately 26.7% were novel medicinal plants. In addition, 71.8% of the plant uses we documented of medicinal species were also novel. Some highly cited species recorded in our study warrant further biochemical analyses to evaluate their bioactive substances. Moreover, *in vitro* plant tissue culture could also be used as an alternative way to conserve medicinal plants documented in this study. Finally, the information we obtained could enable the local communities to develop, market, and profit from dried herbal products, which then substantially improving the collective revenue of the local society.

Acknowledgments

We would like to thank to all people from the Ngadisari village and the people of Tengger for participating in this study and sharing all their information.

Author Contributions

Conceptualization: Nurul Jadid, Kristanti Indah Purwani.

Data curation: Erwin Kurniawan.

Formal analysis: Nurul Jadid, Chusnul Eka Safitri Himayani, Andriyani, Indah Prasetyowati, Kristanti Indah Purwani, Wirdhatul Muslihatin, Dewi Hidayati, Indah Trisnawati Dwi Tjahjaningrum.

Funding acquisition: Nurul Jadid.

Investigation: Erwin Kurniawan.

Methodology: Nurul Jadid, Erwin Kurniawan, Kristanti Indah Purwani, Wirdhatul Muslihatin, Dewi Hidayati, Indah Trisnawati Dwi Tjahjaningrum.

Supervision: Nurul Jadid.

Visualization: Chusnul Eka Safitri Himayani, Andriyani, Indah Prasetyowati.

Writing – original draft: Nurul Jadid, Erwin Kurniawan.

Writing – review & editing: Nurul Jadid.

References

1. Yeung AWK, Heinrich M, Kijjoa A, Tzvetkov NT, Atanasov AG. The ethnopharmacological literature: An analysis of the scientific landscape. *Journal of Ethnopharmacology* 2020; 250 112414.
2. Heinrich M. Ethnobotany and its role in drug development. *Phytotherapy Research* 2000; 14(7): 479–488. [https://doi.org/10.1002/1099-1573\(200011\)14:7<479::aid-ptr958>3.0.co;2-2](https://doi.org/10.1002/1099-1573(200011)14:7<479::aid-ptr958>3.0.co;2-2) PMID: 11054835
3. Calzada F and Bautista E. Plants used for the treatment of diarrhoea from Mexican flora with amoebicidal and giardicidal activity, and their phytochemical constituents. *J. Ethnopharmacology* 2020; 253: 112676.
4. Elfahmi, Woerdenbag H, Kayser O. Jamu: Indonesian traditional herbal medicine towards rational phytopharmacological use. *Journal of Herbal Medicine* 2014; 4 (2): 51–73.
5. Sujarwo W, Keim AP, Savo V, Guarrera PM, Caneva G. Ethnobotanical study of *Loloh*: Traditional herbal drinks from Bali (Indonesia). *Journal of Ethnopharmacology*. 2015; 169: 34–48. <https://doi.org/10.1016/j.jep.2015.03.079> PMID: 25861955
6. Sujarwo W., Arinasa I.B.K., Salomone F., Caneva G., Fattorini S. Cultural erosion of Balinese indigenous knowledge of food and nutraceutical plants. *Econ. Botany* 2014; 68 (4), 426–437.
7. Sabran S. F., Mohamed M., & Abu Bakar MF. Ethnomedical Knowledge of Plants Used for the Treatment of Tuberculosis in Johor, Malaysia. *Evidence-based complementary and alternative medicine*. 2016; eCAM, 2850845.
8. Supiandi MI, Mahanal S, Zubaidah S, Julung H, Ege B. Ethnobotany of traditional medicinal plants used by Dayak desa Community in Sintang, West Kalimantan, Indonesia. *Biodiversitas* 2019; 20(5): 1264–1270.
9. Batoro, J. Etnobiologi masyarakat tengger di bromo tengger semeru Jawa Timur. Doktoral Thesis, Institut Pertanian Bogor. 2012. Available from: <https://repository.ipb.ac.id>.
10. Barber CV, Johnson NC, Hafild E. *Menyelamatkan sisa hutan di Indonesia dan Amerika Serikat*. Jakarta: Yayasan Obor Indonesia; 1999.
11. Batoro J, Hakim L, Rahardi B. Traditional knowledge sacred area: Holly sites (Pedanyangan) in Tengger tribe of East Java, Indonesia. *Advances in Life Sciences* 2019; 9(1): 1–6.
12. Rohman F, Juma Y, Sulisetijono, Utomo DH, Purwanto, Lestari SR, et al. Plants diversity as a medicinal plants by the Tengger Tribe, Bromo Tengger Semeru National Park, East Java, Indonesia. *EurAsian J. Biosci.* 2019; 13: 2293–2298.
13. Rohman F, Lestari SR, Utomo DH, Purwanto, Juma Y, Arifah SN, et al. The utilization of plant diversity by Tengger Tribe around Bromo Tengger Semeru National Park, East Java, Indonesia. *IOP Conf. Series: Earth and Environmental Science* 2019; 276: 012042.
14. Badan Pusat Statistik Kabupaten Probolinggo. *Kecamatan Sukapura dalam angka*. Probolinggo: BPS Kabupaten Probolinggo; 2017.

15. Pusat Pengelolaan dan Penyebarluasan Informasi Geospasial; 2020 [cited 2020 May 23]. Indonesia Geospasial Portal, Rupa Bumi Indonesia [Internet]. Available from: <https://portal.ina-sdi.or.id>.
16. Pieroni A, Houlihan L, Ansari N, Hussain B, Aslam S. Medicinal perceptions of vegetables traditionally consumed by South-Asian migrants living in Bradford, Northern England. *Journal of Ethnopharmacology*. 2007; 113 (1): 100–110. <https://doi.org/10.1016/j.jep.2007.05.009> PMID: [17583457](https://pubmed.ncbi.nlm.nih.gov/17583457/)
17. Cholil M. Complexities in dealing with gender inequality: Muslim women and mosque-based social services in East Java Indonesia. *Journal of Indonesian Islam*. 2017; 11(2): 459–488.
18. Dalimartha S. Atlas Tumbuhan Obat Indonesia. Trubus Agriwidya, Jakarta. 1999.
19. Van Steenis CGGJ. Flora: untuk sekolah di Indonesia. Pradnya Paramita, Jakarta. 2013.
20. Friedman J, Yaniv Z, Dafni A, Palewitch D. A preliminary classification of the healing potential of medicinal plants, based on a rational analysis of an ethnopharmacological field survey among Bedouins in the Negev Desert, Israel. *J Ethnopharmacol*. 1986; 16:275–87. [https://doi.org/10.1016/0378-8741\(86\)90094-2](https://doi.org/10.1016/0378-8741(86)90094-2) PMID: [3747566](https://pubmed.ncbi.nlm.nih.gov/3747566/)
21. Ouedraogo K, Dimobe K, Zerbo I, Etongo D, Zare A, Thiombiano A. Traditional knowledge and cultural importance of *Gardenia erubescens* Stapf & Hutch. in Sudanian savanna of Burkina Faso. *J. Ethnobiol. Ethnomed*. 2019; 15: 28. <https://doi.org/10.1186/s13002-019-0305-4> PMID: [31234862](https://pubmed.ncbi.nlm.nih.gov/31234862/)
22. Hoffman B and Gallaher T. Importance Indices in Ethnobotany. *Ethnobotany Research and applications*. 2007; 5: 201–218.
23. Phillips O and Gentry AH. The useful plants of Tambopata, Peru: I. Statistical hypotheses tests with a new quantitative technique. *Economic Botany*. 1993; 47:15–32.
24. Gomez-Beloz A. Plant use knowledge of the Winikina Warao: The case for questionnaires in ethnobotany. *Economic Botany*. 2002; 56:231–241.
25. Nahdi MS, Martiwi INA, Arsyah DC. The ethnobotany of medicinal plants in supporting the family health in Turgo, Yogyakarta, Indonesia. *Biodiversitas*. 2016; 17(2): 900–906.
26. Badgujar SB, Patel VV, Bandivdekar AH. *Foeniculum vulgare* Mill: a review of its botany, phytochemistry, pharmacology, contemporary application, and toxicology. *Biomed Res Int*. 2014; 2014: 842674. <https://doi.org/10.1155/2014/842674> PMID: [25162032](https://pubmed.ncbi.nlm.nih.gov/25162032/)
27. Reimers EAL, Fernández EC, Reimers DJL, Chaloupkova P, Del Valle JMZ, Milella L, et al. An Ethnobotanical Survey of Medicinal Plants Used in Papatla, Veracruz, Mexico. *Plants (Basel)*. 2019; 8 (8):246.
28. Salehi B, Albayrak S, Antolak H, et al. *Aloe* Genus Plants: From Farm to Food Applications and Phyto-pharmacotherapy. *Int J Mol Sci*. 2018; 19(9):2843.
29. Rajput SB, Tonge MB, Karuppaiyl SM. An overview on traditional uses and pharmacological profile of *Acorus calamus* Linn (sweet flag) and other *Acorus* species. *Phytomedicine*. 2014; 21 (3). 268–276. <https://doi.org/10.1016/j.phymed.2013.09.020> PMID: [24200497](https://pubmed.ncbi.nlm.nih.gov/24200497/)
30. Somanadhan B, Varughese G, Palpu P, Sreedharan R, Gudiksen L, Smitt UW, et al. An ethnopharmacological survey for potential angiotensin converting enzyme inhibitors from Indian medicinal plants. *J Ethnopharmacol*. 1999; 65:103–12. [https://doi.org/10.1016/s0378-8741\(98\)00201-3](https://doi.org/10.1016/s0378-8741(98)00201-3) PMID: [10465650](https://pubmed.ncbi.nlm.nih.gov/10465650/)
31. Rosita SMD, Otih R, ER Pribadi, Hernani. Exploration and development of indigenous knowledge of ethnomedicine at gede pangrango mountain. *Bul. Littro*. 2007; XVIII (1): 13–28.
32. Hussain S, Hamid A, Ahmad KS, Mehmood A, Nawaz F, Ahmed H. Quantitative ethnopharmacological profiling of medicinal shrubs used by indigenous communities of Rawalakot, District Poonch, Azad Jammu and Kashmir, Pakistan. *Rev. Bras. Farmacogn*. 2019; 29(5): 665–676.
33. Farooq A, Amjad MS, Ahmad K, Altaf M, Umair M, Abasi AM. Ethnomedicinal knowledge of the rural communities of Dhirkot, Azad Jammu and Kashmir, Pakistan. *J Ethnobiol. Ethnomed*. 2019; 15:45. <https://doi.org/10.1186/s13002-019-0323-2> PMID: [31470868](https://pubmed.ncbi.nlm.nih.gov/31470868/)
34. Qaseem M, Qureshi R, Amjad MS, Ahmed W, Masood A, Shaheen H. Ethno-botanical evaluation of indigenous flora from the communities of rajh mehal and goi union councils of district Kotli, Azad Jammu Kashmir Pakistan. *Appl. Ecol. Environ. Res*. 2019; 17(2):2799–829.
35. Widyowati R and Agil M. Chemical constituents and bioactives of several Indonesian plants typically used in jamu. *Chem. Pharm. Bull* 2018; 66(5): 506–518. <https://doi.org/10.1248/cpb.c17-00983> PMID: [29710047](https://pubmed.ncbi.nlm.nih.gov/29710047/)
36. Sharifi-Rad M, Varoni EM, Salehi B, Sharifi-Rad J, Matthews KR, et al. Plants of the Genus Zingiber as a Source of Bioactive Phytochemicals: From Tradition to Pharmacy. *Molecules*. 2017; 22(12):2145.
37. Grace O, Simmonds M, Smith G, Van Wyk A. Therapeutic uses of aloe L.(Asphodelaceae) in southern Africa. *J Ethnopharmacol*. 2008; 119:604–614. <https://doi.org/10.1016/j.jep.2008.07.002> PMID: [18682283](https://pubmed.ncbi.nlm.nih.gov/18682283/)

38. Foster M, Hunter D, Samman S. Herbal medicine: Biomolecular and clinical aspects. Boca Raton: CRC Press/Taylor & Francis; 2011.
39. Ezurike UF and Prieto JM. The use of plants in the traditional management of diabetes in Nigeria: pharmacological and toxicological considerations. *J Ethnopharmacol.* 2014; 155:857–924. <https://doi.org/10.1016/j.jep.2014.05.055> PMID: 24929108
40. Rajeswari R, Umadevi M, Rahale CS, Selvavenkadesh S, Kumar KS, Bhowmik D. *Aloe vera*: the miracle plant its medicinal and traditional uses in India. *J Pharmacogn Phytochem.* 2012; 1:118–124.
41. Shu H., Zhang S, Lei Q, Zhou J, Ji Y, Luo B, et al. Ethnobotany of *Acorus* in China. *Acta Soc Bot Pol.* 2018; 87(2):3585.
42. Sharma V, Singh I, Chaudhary P. *Acorus calamus* (the healing plant): a review on its medicinal potential, micropropagation and conservation. *Nat. Proc. Res.* 2014; 28: 1454–1466.
43. Acharya KP, Rokaya MB. Ethnobotanical survey of medicinal plants traded in the streets of Kathmandu valley. *Scientific World.* 2005; 3(3): 44–48.
44. Abdelgadir HA and Van Staden J. Ethnobotany, ethnopharmacology and toxicity of *Jatropha curcas* L. (Euphorbiaceae): A review. *South African Journal of Botany.* 2013; 88: 204–218.
45. Abu Bakar FI, Abu Bakar MF, Rahmat A, Abdullah N, Sabran SF, Endrini S. Anti-gout Potential of Malaysian Medicinal Plants. *Front Pharmacol.* 2018; 9:261. Published 2018 Mar 23. <https://doi.org/10.3389/fphar.2018.00261> PMID: 29628890
46. Khan I, AbdElsalam NM, Fouad H, Tariq A, Ullah R, Adnan M. Application of ethnobotanical indices on the use of traditional medicines against common diseases. *Evidence-Based Complementary and Alternative Medicine.* 2014; 2014: 1–21.
47. Ahmad KS, Hamid A, Nawaz F, Hameed M, Ahmad F, Deng J, et al. Ethnopharmacological studies of indigenous plants in Kel village, Neelum Valley, Azad Kashmir, Pakistan. *J Ethnobiol Ethnomed.* 2017; 13(1):68. <https://doi.org/10.1186/s13002-017-0196-1> PMID: 29191238
48. Kassa Z, Asfaw Z, Demissew S. An ethnobotanical study of medicinal plants in Sheka Zone of Southern Nations Nationalities and Peoples Regional State, Ethiopia. *J Ethnobiol Ethnomed.* 2020; 16(1):7. <https://doi.org/10.1186/s13002-020-0358-4> PMID: 32024539
49. Hassan-Abdallah A, Merito A, Hassan S, Aboubaker D, Djama M, Asfaw Z, et al. Medicinal plants and their uses by the people in the region of Randa, Djibouti. *J Ethnopharmacol.* 2013; 148(2):8701–13.
50. Kayani S, Ahmad M, Sultana S, Shinwari ZK, Zafar M, Yaseen G, et al. Ethnobotany of medicinal plants among the communities of alpine and sub-alpine regions of Pakistan. *J Ethnopharmacol.* 2015; 164:186–202. <https://doi.org/10.1016/j.jep.2015.02.004> PMID: 25680839
51. Chaachouay N, Benkhniq O, Fadli M, El Ibaoui H, Zidane L. Ethnobotanical and ethnopharmacological studies of medicinal and aromatic plants used in the treatment of metabolic diseases in the Moroccan Rif. *Heliyon.* 2019; 5(10):e02191. <https://doi.org/10.1016/j.heliyon.2019.e02191> PMID: 31720440
52. Jiang X, Liu Y, Li W, Zhao L, Meng F, Wang Y, et al. Tissue-Specific, Development-Dependent Phenolic Compounds Accumulation Profile and Gene Expression Pattern in Tea Plant (*Camellia sinensis*). *PLoS ONE.* 2013; 8(4): e62315. <https://doi.org/10.1371/journal.pone.0062315> PMID: 23646127
53. Grosvenor PW, Gothard PK, McWilliam NC, Supriyono A, Gray DO. Medicinal plants from Riau Province, Sumatra, Indonesia. Part 1: Uses. *J. Ethnopharmacol.* 1995; 45(2): 75–95.
54. Bradacs G, Heilmann J, Weckerle CS. Medicinal plant use in Vanuatu: A comparative ethnobotanical study of three islands. *Journal of Ethnopharmacology.* 2011; 137: 434–448. <https://doi.org/10.1016/j.jep.2011.05.050> PMID: 21679762
55. Leto C, Tuttolomondo T, La Bella S, Licata M. Ethnobotanical study in the Madonie Regional Park (Central Sicily, Italy)—Medicinal use of wild shrub and herbaceous plant species. *Journal of Ethnopharmacology.* 2013; 146: 90–112. <https://doi.org/10.1016/j.jep.2012.11.042> PMID: 23276781
56. Umair M, Altaf M, Abbasi AM. An ethnobotanical survey of indigenous medicinal plants in Hafizabad district, Punjab-Pakistan. *PLoS One.* 2017; 12(6):e0177912. <https://doi.org/10.1371/journal.pone.0177912> PMID: 28574986
57. Rehman K, Mashwani Z, Khan MA, Ullah Z, Chaudary HJ. An ethnobotanical perspective of traditional medicinal plants from the Khattak tribe of Chontra Karak, Pakistan. *J. Ethnopharmacol.* 2015; 165: 252–259.
58. Sauini T, Stern da Fonseca-Krueel V, Baptistela Yazbek P, Matta P, Cassas F, da Cruz C, et al. Participatory methods on the recording of traditional knowledge about medicinal plants in Atlantic forest, Ubatuba, São Paulo, Brazil. *PLoS ONE* 2020; 15(5): e0232288. <https://doi.org/10.1371/journal.pone.0232288> PMID: 32379779
59. Zheng X-I and Xing F-W. Ethnobotanical study on medicinal plants around Mt. Yinggeling, Hainan Island, China. *Journal of Ethnopharmacology.* 2009; 124: 197–210. <https://doi.org/10.1016/j.jep.2009.04.042> PMID: 19409476

60. Zahoor M, Yousaf Z, Aqsa T, Haroon M, Saleh N, Aftab A, et al. An ethnopharmacological evaluation of Navapind and Shahpur Virkanin district Sheikupura, Pakistan for their herbal medicines. *J Ethnobiol. Ethnomed.* 2017; 13(1):27. <https://doi.org/10.1186/s13002-017-0151-1> PMID: [28482859](https://pubmed.ncbi.nlm.nih.gov/28482859/)
61. Malik K, Ahmad M, Bussmann RW, Tariq A, Ullah R, Alqahtani AS, et al. Ethnobotany of anti-hypertensive plants used in Northern Pakistan. *Front. Pharmacol.* 2018; 9: 789. <https://doi.org/10.3389/fphar.2018.00789> PMID: [30087613](https://pubmed.ncbi.nlm.nih.gov/30087613/)
62. Shaheen H, Qaseem MF, Amjad MS, Bruschi P. Exploration of ethno-medicinal knowledge among rural communities of Pearl Valley; Rawalakot, District Poonch Azad Jammu and Kashmir. *PLoS One.* 2017; 12(9): e0183956. <https://doi.org/10.1371/journal.pone.0183956> PMID: [28886077](https://pubmed.ncbi.nlm.nih.gov/28886077/)
63. Ahmed HM. Ethnopharmacobotanical study on the medicinal plants used by herbalists in Sulaymaniyah Province, Kurdistan, Iraq. *J Ethnobiol. Ethnomed.* 2016; 12(1):8.
64. El Amri J, El Badaoui K, Zair T, Bouharb H, Chakir S, Alaoui T. Ethnobotanical study of medicinal plants in the region El Hajeb (Central Morocco). *J Res. Biol.* 2015; 4(8):1568–80.
65. Barkaoui M, Katiria A, Boubaker H, Msanda F. Ethnobotanical survey of medicinal plants used in the traditional treatment of diabetes in Chtouka Ait Baha and Tiznit (Western Anti-Atlas), Morocco. *J. Ethnopharmacol.* 2017; 198: 338–350. <https://doi.org/10.1016/j.jep.2017.01.023> PMID: [28109915](https://pubmed.ncbi.nlm.nih.gov/28109915/)
66. Jadid N, Sutikno, Dewi DS, Nurhidayati T, Abdulgani N, Muzaki FK, et al. Traditional pattern of cashew cultivation: a lesson from Sumenep-Madura, Indonesia. *AIP Conf. Proc* 2017; 1908: 040005.