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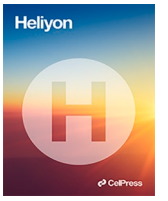

Research article

Ethnobotanical study of medicinal plants used to manage human ailments in Lay Gaint District, South Gondar Zone, Amhara Region, Northwestern Ethiopia

Yalew Yiblet

Department of Biology, College of Natural and Computational Sciences, Mekdela Amba University, P.O. Box 32, Tuluawlia, Ethiopia

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ABSTRACT

The aim of this work is to document and record the use of medicinal plants to treat various ailments in the study area. A total of 84 informants, consisting of 54 men and 30 women, between 35 and 80 years of age were chosen. Additionally, 20 key informants were deliberately selected for their expertise. Data were collected through face-to-face interviews, group discussions, and guided field walks using semi-structured interview questions. Ethnobotanical data were analyzed using quantitative analytical tools such as preference ranking, direct matrix ranking, fidelity level and informant consensus factor. Forty-six medicinal plants belonging to 41 genera and 33 families were collected and identified. Brassicaceae, Ranunculaceae, and Polygonaceae had the highest abundance of medicinal plants used to treat various diseases in the study area. Most of the medicinal plants were herbs (43 %), followed by shrubs (35 %). The study revealed that leaves (45.7 %) were the most frequently used plant parts in the preparation of remedies. The most common mode of administration was oral ingestion (61 %), followed by dermal application (30 %). *Zingiber officinale* Roscoe and *Allium* sativum L.had the highest preference rank, whereas *Croton macrostachyus* Hochst. ex Delile was identified as the most popular medicinal plant due to its multipurpose use. while the value of fidelity level (FL) for medicinal plants in the study ranged from 34 % to 94 %. The study also identified several threats to medicinal plants in the study area, including charcoal production, overgrazing, and agricultural expansion. To prevent the eradication of these medicinal plants, the involvement of local communities in the management and conservation of plant resources is crucial.

1. Introduction

Many indigenous populations in Africa use traditional herbal medicine made from plant forms as a readily available substitute for allopathic treatments [1]. In Ethiopia, more than 800 plant species are used for therapeutic purposes, and additional new species of medicinal plants are being discovered [2]. Studies have shown that 80 % of people in underdeveloped countries receive their medical care from traditional medicine, which primarily uses plants [3].

Traditional medicine is widely used and its affordability, effectiveness, and greater accessibility are among its main advantages. The development of numerous plant systems and languages has benefited from the knowledge gathered from traditional medicine [4]. According to the assessment, nearly 80 % of Ethiopians still rely mainly on traditional medicine made from plants [5]. In the primary

E-mail address: yalewyiblet@gmail.com.

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healthcare system in many areas of the country, traditional medicine is the most conveniently accessible and reasonably priced form of therapy [6]. However, the vast body of knowledge accumulated over thousands of years in traditional medicine is seriously in danger of being lost due to a number of factors, including deforestation, environmental degradation, overexploitation, agricultural land development, acculturation, and the limited application of its documentation [7].

Ethiopia has tried, mainly in the last 40 years, to record medicinal plants used by various populations, aware of the importance of traditional medicine as well as the challenges facing the knowledge and practices associated with them. Some notable works are those by Teklay et al. [8] in Tigray Region, Nigussie et al. [9] in southern part, Teklehaymanot and Giday [10] in northwestern, Teshome et al. [11] in North Shewa Zone of Amhara Regional State, Wendimu et al. [12] in the Tropical Rift Valley, Awoke et al. [13] in Somali Region, and Chekole et al. [14] in Libo Kemkem South Gondar Zone Amhara region, Ethiopia. However, these efforts are not all inclusive, so national efforts must be coordinated to capture this important knowledge for improved application and preservation.

Oral transfer of indigenous knowledge about medicinal plants also closes documentation and record keeping gaps on the topic in general. Therefore, the aim of this work is to document medicinal plants and associated indigenous knowledge with specific objectives; (1) To identify the species of medicinal plants that are used in the district to treat human ailment; (2) To identify plant parts used to remedy preparation; (3); To identify threats to medicinal plants and (4) To compile and record indigenous knowledge of the people on medicinal plants in the study area. This work serves as a starting point for further phytochemical investigation and conservation of medicinal plants.

2. Materials and methods

2.1. Description of the study area

The study was carried out in Lay Gaint District, South Gondar Zone, Amhara Region, Ethiopia (Fig. 1). The latitude and longitude of the area are 11^0 04 to 12^0 10′ N and 38^0 12′ to 38^0 38′ E, respectively. Lay Gaint is one of the eleven districts of the South Gondar Zone in the Amhara Region, located 185 km from Woldia, 175 km from Bahir Dar, and 729 km from Addis Ababa. Lay Gaint was surrounded

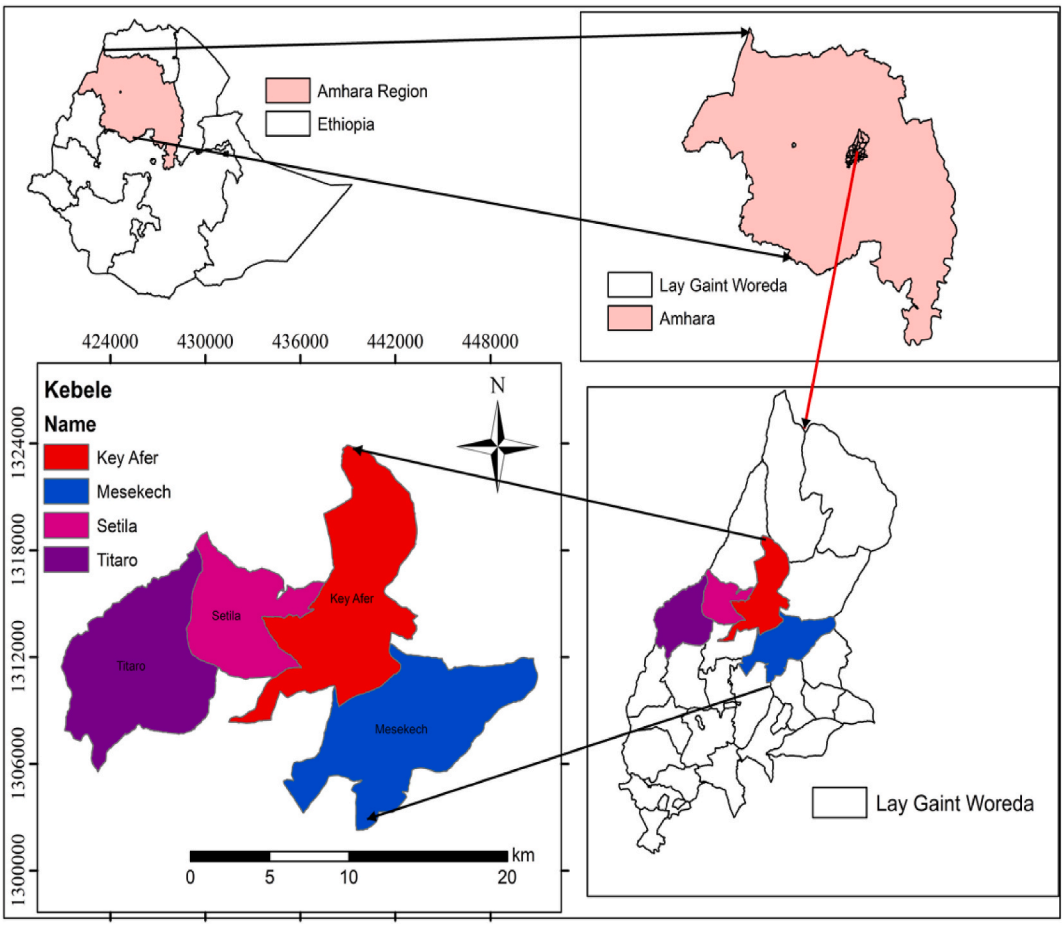

Fig. 1. Map of the study area Lay Gaint District.

by the Siemen Wollo Zone on the east, Tach Gayint and Simada on the south, Misraq Este on the south west, Farta on the west, and Ebenat on the north. The district has a total of 28 kebeles administrations and a total population of 201,787 with 102,109 men and 99,678 women. Among these population, 97.47 % were Orthodox Christians, and 2.47 % followed Muslim religion. The three primary agroclimatic zones of the Lay Gaint district are Kola (low land), Woyina dega (mid land), and Dega (highland), with an elevation range of 1500 to 3100 m above sea level. Rainfall ranges between 400 and 1100 mm every year and average minimum and maximum temperatures range from 5 to 20.5 °C, respectively [15].

2.2. Reconnaissance survey and site selection

A reconnaissance survey evaluation of the study area was carried out from September 10 to September 30, 2021, and four study sites Mesekech, Setila, Key afer, and Titaro were identified. The study locations were selected based on the availability of traditional medicinal practices and suggested by elders and local authorities in the Lay Gaint district. The selection of the study locations (kebeles) also took into consideration the three agroclimatic zones.

2.3. Selection of informants

A total of 84 informants (54 men and 30 women) were selected from four kebeles with age between 35 and 80 years. Sixty-four general informants were chosen using the systematic random sampling method of the total informants who lived 5 years in the study area. Twenty key informants were purposefully chosen based on the recommendations of local authorities, elders, and religious leaders. Key informants are individuals who have specialized knowledge, experience, or unique insight into a particular medicinal plant or herb. Of the 20 key informants, the top 10 key informants were chosen for preference and direct matrix ranking based on their in-depth knowledge of traditional medicine and asked to rank medicinal plants for their potential use in treating a particular disease [16]. General informants, on the other hand, are individuals who may have some knowledge or information related to medicinal plants, but may not possess the same level of expertise or specialized insights as key informants (Table 1).

2.4. 2.4. ethnobotanical data collection

2.4.1. Semi-structured interviews

Following Alexiades [17], semi-structured interviews were conducted to collect ethnobotanical data on medicinal plant species, common ailments, preparation techniques, dosage, administration routes, local names, parts of plants used, conservation concerns, and threats to medicinal plants. A researcher conducted all interviews in Amharic, the language of the area. To confirm the precision of ethnobotanical data, each informant was visited twice in the study period.

2.4.2. Guided field walks

To collect medicinal plant specimens and collect essential ethnobotanical information, guided field walks were conducted with the help of local guides and interviewees at the study sites. During these walks, all relevant information about specific medicinal plant species was recorded, including its vernacular name, parts used, and diseases treated.

2.4.3. Group discussion

Before collecting ethnobotanical data, a quick group discussion was conducted with the informants in each kebele to obtain their consent and explain that their participation would be very helpful in collecting medicinal plants in the area of study. At each study site, groups of seven to ten informed traditional healers participated in group discussions to gather information on local topography, threats to medicinal plant species, indigenous vegetation classification, and conservation efforts.

2.5. Specimen collection and identification

During field walks, the reported medicinal plants had been collected from and around natural woods; the habits, local name, date of collection, and collector's name were registered. The collected plant samples were taken to botanical experts and the databases of the World Flora Online Plant List and the Global Biodiversity Information Facility were used to verify the botanical names and families of the reported medicinal plant species [18].

Table 1
Study location, number of informants, and sociodemographic characteristics of the data.

Name of kebeles	Number of households	Key informants		General informants		Total informants		
		Men	Women	Men	Women	Men	Women	Total
Mesekech	850	2	1	9	5	11	6	17
Setila	540	3	1	6	6	9	7	16
Key afer	756	4	2	12	7	16	9	25
Titaro	610	4	3	14	5	18	8	26

2.6. Data analysis

The ethnobotanical data on the reported medicinal plants and associated indigenous knowledge were analyzed using a descriptive statistical approach, percentage, frequency, and the Statistical Package for the Social Sciences (SPSS). Preference ranking, fidelity level and informant consensus were calculated to assess the relative effectiveness of particular medicinal plants compared to the most prevalent illnesses in the area. For multipurpose medicinal plants that healers frequently reported, a direct matrix ranking of applications considered dangers to medicinal plants and a priority ranking of elements considered threats to medicinal plants were carried out based on their degree of detrimental effects (values 1–3).

2.6.1. Informant consensus factor (ICF)

To determine the informant consensus factor on reported cures for the group of diseases listed below, the informant consensus factor (ICF) was calculated for each category [19]. The ICF was determined using the following formula:

$$\mathrm{ICF} = \frac{Nur - Nt}{Nur - 1}$$

Where ICF is the informant consensus factor, Nur is the number of individual plant use reports for a particular illness, and Nt is the total number of species used by all informants for this category.

2.6.2. Fidelity level (FL)

The preference of people for a certain species of medicinal plant for a given disease is shown in the fidelity level (FL) [20]. The following equation was used to calculate it: Fl (%) = Np/N × 100, where N is the total number of informants who cited plant species for various types of medicinal use and Np is the number of informants who used plants as a medicine.

2.6.3. Preference ranking

Furthermore, according to the method described by Faruque et al. [21] the five traditional medicinal plant species used to prevent stomachaches were ranked in preference by ten experienced key informants who were deliberately chosen. Given that stomachaches are deadly and becoming more common in society, they were given priority for ranking. The medicinal plants with the highest level of value (5) were considered the most capable of curing the disease, while the lowest level (1) was assigned to the plants with the lowest level of capability. The value was totaled and the entire score was used to determine the rank for each species. As a result, it was simpler to determine which medicinal plants natives used to treat their ailments.

2.6.4. Direct matrix ranking

The direct ranking matrix was used to compare the different types of medicinal plants based on information obtained from informants. The multifunctional species were selected from among all medicinal plants. Ten randomly chosen key informants were asked to assess the utility of each species after listing the uses of these plants. Use values (5: Excellent, 4: Very Good, 3: Good, 2: Less used and 1: Least used) were requested from each key informant. The average value of each use value for a species was determined using data from informants, and the values for each species were then totaled and ranked.

3. Results

3.1. Indigenous knowledge of medicinal plants in different social groups

The findings presented in Table 2 indicate that there were correlations between demographic characteristics and the knowledge reported about medicinal plants. Specifically, men mentioned significantly more herbal plants than women respondents. The number of medicinal plants reported by informants from the young to middle age (35–50 years) and the older (65–80 years) informants were significantly different ($P < 0.05$) (Table 2). Key informants reported a higher number of medicinal plants than young and general informants.

Table 2
Independent *t*-test and statistical test of significance on the number of medicinal plant use reported by informants in Lay Gaint District.

Parameters	Informants groups	N	Mean ± SD	t-value	P – value
Gender	Men	54	7.65 ± 5.6	−3.51	0.01
	Women	30	3.83 ± 2.7		
Aged	35–50	22	3.18 ± 2.66	−3.13	0.01
	>50	62	6.95 ± 5.08		
Literacy level	Literate	38	3.08 ± 2.4	−3.80	0.00
	Illiterate	46	6.83 ± 5.6		
Informant category	General informant	64	7.03 ± 5.4	−4.23	0.00
	Key informant	20	15.20 ± 12.2		

* Significance difference ($P < 0.05$), **t (0.05) (two tailed), Degree of freedom = 82; N = number of respondents.

3.2. Diversity of medicinal plants in the study area

In the study areas, 46 species of medicinal plants were identified from 41 genera and 33 families that are used to treat human illnesses were identified. Three species were identified from each of the plant families Brassicaceae, Ranunculaceae, and Polygonaceae. There are two species of each of the Alliaceae, Lamiaceae, Rhamnaceae, Euphorbiaceae, Asteraceae and Oleaceae (Table 3).

3.3. Growth forms of medicinal plant species

The most commonly encountered life forms used as medicinal plants in the study area were herbs, which comprise 20 species (43 %) followed by shrubs, 16 species (35 %), trees, 8 species (17 %) and climbers, 2 species (4 %), in that order (Fig. 2**).** The results showed that herbs account for the highest proportion.

3.4. Plant part used and sources of medicinal plants

Different parts have reportedly been used as medicines, according to data concerning parts of plants. Fig. 3 shows that leaves, which make up the majority of plant parts 21 (45.7 %), were followed by seeds 8 (17.4 %) and bark 4 (8.7 %) (Fig. 3).

3.4.1. Sources of medicinal plants

Locals collected medicinal plants from different habitats such as wild, home gardens, and farmlands. The wild was found to be the main source of medicinal plants accounted for 28 (60.9 %) followed by the home garden 12 (26.1 %) (Fig. 4).

3.4.2. Method of preparation

The local healers in the study area prepared medicinal plants in a variety of ways to cure human diseases. In the study area, 14 (30 %) of the traditional medicinal herbs were made in powder form, followed by 10 (22 %) in crushing and chewing form, 6 (13 %) (Fig. 5).

3.4.3. Route of administration

People around them usually give traditional medicine in the study area orally. Oral accounts (61 %), dermal (30 %) and tooth (4 %), respectively (Fig. 6). In addition, locals said that other chemicals were used when traditional medicine was administered.

3.5. Ranking of medicinal plants

3.5.1. Preference ranking on stomachache

Residents at the study site prefer one plant over another when treating a particular disease for which several treatments are recommended. *Zingiber officinale* Roscoe was the most popular medicinal plant to treat stomachaches, followed by *Allium sativum* L. This shows that five potentially effective medicinal plants were frequently used by residents of the study area (Table 4). This choice may result from the perceived efficacy of a medicinal plant for the indicated foods.

3.5.2. Direct matrix ranking

Direct matrix analysis can be used to evaluate medicinal plant species that are used for a variety of purposes. The community used medicinal plants in the study area for a variety of purposes, and six use categories were given for ten key informants to assign use values to each species. According to, the direct matrix ranking exercise *Cordia africana* Lam. was ranked first due to the multipurpose role for the community and this was followed by *Croton macrostchyus* Hochst. ex Delile (Table 5).

3.5.3. Informant consensus factor (ICF)

The present study has shown that diseases that are common in the study area have a higher value of informant consensus (IFC) (0.92) and the lowest value (0.63). Medicinal plants with a higher informant consensus factor are well known in the local population and effective in treating specific diseases (Table 6).

3.5.4. Fidelity level index

Table 7 shows the level of precision of eight commonly cited medicinal plant species, ranging from 34 % to 94 %. For treating wounds and malaria, respectively, *Zingiber officinale* Roscoe (66 %) and *Zehneria scabra* (L.f.) Sond. (55 %) showed the highest Fidelity level, while *Allium sativum* L. had the highest Fidelity level for malaria (95 %). When it comes to curing dandruff, *Datura stramonium* L. received the lowest score (24 %) from Fidelity level (Table 7).

3.6. Threats to medicinal plants and conservation practices in the study area

3.6.1. Threats to medicinal plants

The discussion with the informants revealed that several factors were considered primary threats to medicinal plants. Anthropogenic factors that affect medicinal plants in the study area were charcoal collection, agricultural expansion, deforestation, and overgrazing. Therefore, agricultural expansion is the most threatening factor (38.1 %), followed by deforestation (23 %) as reported by

Table 3
List of medicinal plants used to treat human ailments in the Lay Gaint District.

Families	Scientific name	Local name	Ha	Pu	Disease Treated	Mode of Preparation and dosage	RoA	Voucher number
Acanthaceae	*Justicia schimperiana* (Hochst. ex Nees) T. Anders	Smitha	S	Ys	Tape worm	*Dodonaea angustifolia*, *Cynodon dactylon*, and *Justicia schimperiana* shoots are crushed and submerged in water for seven days, then drink a glass of the decanted.	Oral	MU35
Alliaceae	*Allium capa* L.	Qey shinkurt	H	Bu	Kidney diseases	Grind the bulb and mix with water, then drink in a cup of tea in the morning and evening.	Oral	MU17
	Allium sativum L.	Nech shinkurt	H	Bu	Malaria	*Allium sativum* bulb and *Schinus molle* seed are ground into a powder, with a small amount of water, and consumed.	Oral	MU11
Aloaceae	*Aloe percrassa* Tod.	Eret	H	R	Caught	The root of *Aloe percrassa* is powdered mixed with honey, then boiled and the solution is drank on a finger nail for 3 days.	Oral	MU14
Amaranthaceae	*Achyranthes aspera* L.	Telenj	H	L	Wound	Crushed and tied with a piece of cotton at the fingertip	Dermal	MU10
Asclepiadaceae	*Calotropis procera* (Aiton) W.T. Aiton	Tobia	S	Lat	Hemmorrhoids	Crushed root is combined with the latex of *Calotropis procera* and then smeared.	Dermal	MU28
Asteraceae	*Artemisia abyssinica* Sch.Bip. ex A.Rich.	Chekugn	H	L	Evil eye	A burning fire is ignited with the combination of roots and leaves of *Echinops kebericho*, then the smoke is administered to the sufferer.	Dermal	MU13
	Laggera tomentosa (A. Rich.) Sch.Bip. ex Oliv. & Hiern	Shita	S	L	Stomachache	Powered *Laggera tomentosa* was boiled with a teaspoon of coffee and drink.	Oral	MU05
Boraginaceae	*Cordia africana* Lam.	Wanza	T	B	Problem of menstruation	*Cordia africana* Fresh bark is powdered and mixed with water and then a cup of tea is drinking for three successive days.	Oral	MU02
Brassicaceae	*Brassica carinata* A. Braun	Gomenzer	H	Se	Stomach ache	Add salt and green paper to *Allium sativum* before grinding and eating it.	Oral	MU15
	Brassica nigra (L.) Koch	Senafich	H	Se	Malaria	By dissolving the powered *Brassica nigra* in *Allium sativum* and consuming it with an Injera piece.	Oral	MU12
	Lepidium sativum L.	Feto	H	Se	Malaria	The crushed *Allium sativum* bulb and *Lepidium sativum* seed are eaten with a teaspoon of honey.	Oral	MU18
Burseraceae	*Combretum molle* R. Br. ex G. Don	Abalo	S	R	Abdominal pain	The powdered root of *Combretum molle* is boiled and drinks in a teaspoon.	Oral	MU09
Cactaceae	*Opuntia ficus indica* (L.) Miller	Beles	S	L	Ear infection	*Opuntia ficus-indica* leaf is squeezed and a small amount of finger strip sap is carefully poured into the ear canal.	Ear	MU20
Commelinaceae	*Commelina latifolia* Hochst. exA. Rich.	Yewof enkur	H	L	Wound	Leaf part is crushed and tied with cloth until recovery.	Dermal	MU23
Cucurbitaceae	*Zehneria scabra* (L.f.) Sond.	Aregersa	H	L	Fever/Mich	Boiled the leaf and fumigate the whole body.	Dermal	MU29
Cupressaceae	*Juniperus procera* Hochst. ex Endl.	Yeabesha Tsid	T	Re	Tooth ache	The resin is mixed with kolo and chewed for 30 min.	Tooth	MU42
Euphorbiaceae	*Croton macrostachyus* Hochst. ex Delile	Bisana	T	Ys	Amoebiasis	Grind nine young shoot tip boiled with *Ruta chalepensis* and drink with a cup of coffee.	Oral	MU04
	Ricinus communis L.	Gulo	S	Se	Headache	Powdered seed is combined with butter and attached to the skull.	Dermal	MU30
Fabaceae	*Acacia abyssinica* Benth.	Girar	T	B	Scorpion poison	The bite or poisoned part of a human is linked to the interior of the barks	Dermal	MU37
Flacourtiaceae	*Dovyalis abyssinica* (A. Rich.) Warb.	Koshim	S	F	Intestinal parasite	Every morning, the fruit is consumed before breakfast.	Oral	MU46
Lamiaceae	*Ocimum urticifolium* Roth	Damakisse	S	L	Leishmaniasis	squeezing the leaf by mixing with a cup of coffee and drink.	Oral	MU41
	Otostegia integrifolia Benth.	tingut	S	L	Hepatitis	Boiling the leaf and fumigate the entire body for seven days.	Oral	MU19
Loganiaceae	*Buddleja polystachya* Fresen.	Anfar	S	L	Eye disease	Buddleja polystachya young shoot is squeezing and spitting a drop on the eye.	Eye	MU01

(*continued on next page*)

Table 3 (*continued*)

Families	Scientific name	Local name	Ha	Pu	Disease Treated	Mode of Preparation and dosage	RoA	Voucher number
Melianthaceae	*Bersama abyssinica* Fresen.	Azamir	S	L	Ascaris	The powdered leaf twig portion is boiled with tea and drink in a glass of water.	Oral	MU25
Menispermaceae	*Stephania abyssinica* (Quart. -Dill. & A. Rich.) Walp.	Gyte arege	H	Se	Hypertension	Swallow three uncooked seeds per day.	Oral	MU27
Myrtaceae	*Eucalyptus globulus* Labill.	Nech Bahirzaf	T	L	Hepatitis	Boiling the young shoot in water and fumigate the entire body.	Dermal	MU07
Oleaceae	*Jasminum grandiflorum* L.	Hareg	Cl	R	Evil eye	Powdered portions of *Artemisia afra*, *Ruta chalepensis* and *Allium sativum* Bulb are taken in a cup of coffee and fumigated	Oral	MU32
	Olea europaea subsp. *cuspidata* (Wall. & G. Don) Cif.	Woira	T	St	Tooth-ache	The heated stem is chewed b/n teeth for 20 min.	Tooth	MU24
Phytolaccaceae	*Phytolacca dodecandra* L'Hér.	Endoded	S	Se	To control pregnancy	The juice from crushed *Phytolacca dodecandra* seed is consumed with an injera.	Oral	MU39
Poaceae	*Cynodon dactylon* (L.) Pers.	Serdo	H	St	Snake bite	Chewed and absorbed the juice.	Oral	MU16
Polygonaceae	*Rumex nepalensis* Spreng.	Yebra milase	H	L	Madiyat	The leaf is grinding and smear with honey.	Dermal	MU06
	Rumex nervosus Vahl	Embacho	S	L	Wound	Butter and dried root bark are mixed and then smeared to the wound	Dermal	MU31
	Rumex abyssinicus Jacq.	Mokemoko	H	B	Constipation	*Rumex abyssinicus* bark is powered and cooked with wheat flour, then eaten as porridge.	Oral	MU45
Ranunculaceae	*Clematis hirsute* Perro & Guill.	Nech yeazoarge	H	L	Skin infection	Crushing the leaf, combining it with butter, and applying or painting it on the skin.	Dermal	MU44
	Clematis simensis Fresen.	Azoarge	Cl	L	Cancer	Powdered of fresh leaf rolled and tied on the neck.	Dermal	MU03
	Nigella sativa L.	Tikur azmude	H	Se	Tonsillitis	The seed of *Nigella sativa* is ground into a powder and added to coffee, then drink with a cup of tea for 3–4 days.	Oral	MU33
Rhamnaceae	*Rhamnus prinoide* L'Hér.	Gasho	S	L	Tonsillitis	Chewing young leaves and drinking juice in a teaspoon.	Oral	MU36
	Ziziphus spina –christi (L) Desf.	Gaba	T	L	Dandruff	The *Zizlphus spina-christi* leaf is ground to a powder, combined with butter and then smeared.	Dermal	MU34
Rosaceae	*Hagenia abyssinica* (Bruc e ex Steud.) J. F.Gme.	Koso	T	Se	Diarrhea	Powdered seed mixing with a cup of coffee and drink.	Oral	MU40
Rutaceae	*Ruta chalepensis* L.	Tena adam	H	L	Snake bite	During bite time, the *Rumex nervosus* leaf is chewed and the solution is drunk immediately.	Oral	MU22
Santalaceae	*Osyris quadripartita* Decn.	Keret	S	St	Stomachache	Chewing on fresh stem bark and swallowing the solution.	Oral	MU21
Sapindaceae	*Dodonaea angustifolia* L. f.	Kitkita	S	L	Wound	The young shoot of *Dodonaea angustifolia* was used to tie the broken body part.	Dermal	MU08
Solanaceae	*Datura stramonium* L.	Astenager	H	L	Dandruff	After hair removal, a leaf of *Datura stramonium* is crushed and rubbed over the head.	Oral	MU47
Urticaceae	*Urtica simensis* Hochst. ex A.Rich.	Sama	H	L	Gastritis	*Urtica simensis* is eaten in the form of stew ('wot') to prevent gastritis and heart disease.	Oral	MU26
Zingiberaceae	*Zingiber officinale* Roscoe	Zingeble	H	B	Abdominal pain	The crushing bark is boiled with butter and drink it with a glass of water.	Oral	MU43

Key to abbreviations: T-tree, S-shrub, H-Herb, Cl-climber, L-leaf, R-root, Lax-latex, St-stem, F-fruit, Se-seed, B- bark, Bu-bulb, Pu-part used, Ha - Habit and RoA- Route of administration.

informants (Table 8).

3.6.2. Conservation practices of medical plants

The rural community needs plants for their living in different aspects. In this study, several factors both anthropological and natural threats affected the survival of medicinal plant species in the study area. From the interview with the informants, various factors were

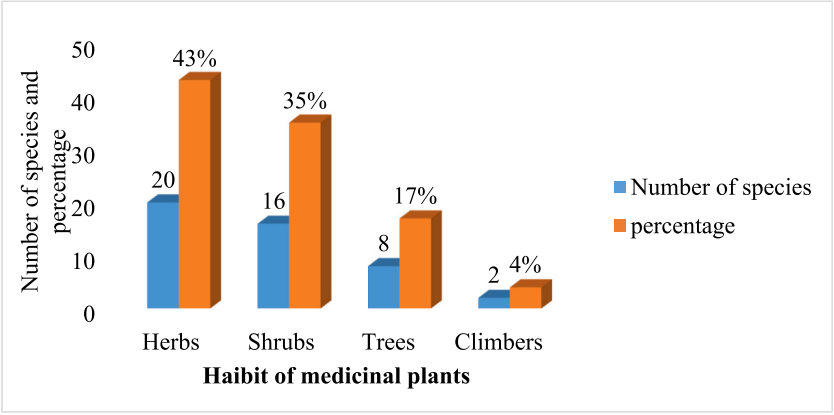

Fig. 2. Life forms of medicinal plants collected from the Lay Gaint district.

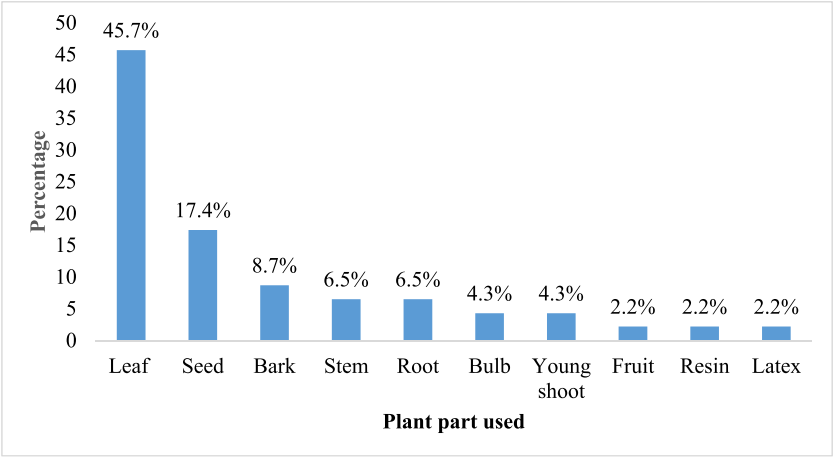

Fig. 3. Medicinal plant parts used by traditional healers for remedy preparation.

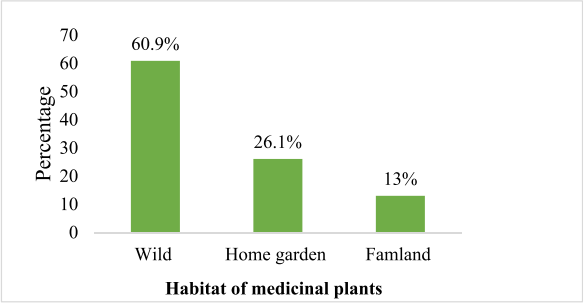

Fig. 4. Sources of medicinal plants in the study area.

recorded as the main threats to medicinal plants in Lay Gaint district. Agricultural expansion, charcoal production, overgrazing, and deforestation were reported to be factors in the decrease in natural vegetation and medicinal plants.

4. Discussion

4.1. 4.1. variation in indigenous knowledge and demographic characteristics of informants

The residents of the study district possess considerable knowledge regarding medicinal plants, which locals and traditional

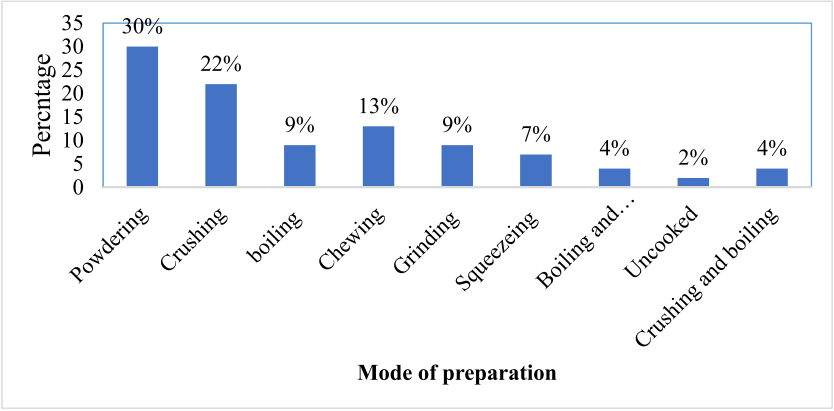

Fig. 5. Methods of preparation of herbal medicine.

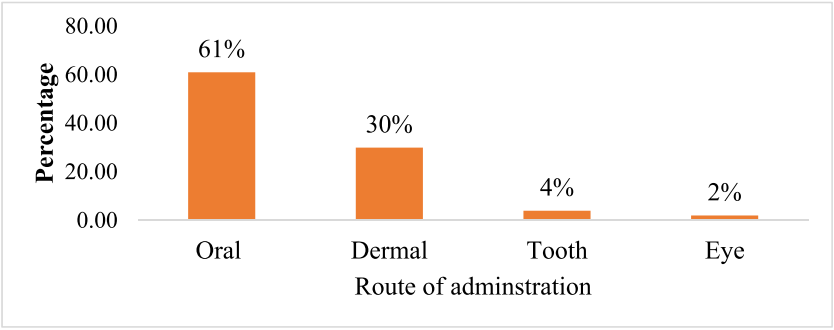

Figure: 6. Reports on the methods of administration of herbal medicines for human use.

Table 4
Ranking of the most effective medicinal plants for the treatment of stomachaches.

Medicinal Plants	Respondents (R_1–R_{10})											
	R_1	R_2	R_3	R_4	R_5	R_6	R_7	R_8	R_9	R_{10}	Total	Rank
Laggera tomentosa (A. Rich.) Sch.Bip. ex Oliv. & Hiern	3	2	3	1	3	2	4	1	2	3	24	5
Combretum molle R. Br. ex G. Don	1	3	1	2	3	2	2	2	5	5	26	3
Zingiber officinale Roscoe	3	2	5	4	5	4	3	5	4	3	38	1
Allium sativum L.	4	4	3	2	4	3	3	4	3	1	31	2
Brassica carinata A. Braun	2	1	3	4	3	2	3	2	3	2	25	4

Table 5
Direct matrix ranking score for ten medicinal plant species with additional uses based on ten key informant categories.

Plant species	Use categories							
	Respondents (R1-R10)							
	Medicine	Food	Fire wood	Construction	Fencing	Agriculture Tools	Total	Rank
Croton macrostchyus Hochst. ex Delile	3	0	3	3	4	3	16	2
Ocimum urticifolium Roth	4	1	4	2	3	0	14	4
Cordia Africana Lam.	4	3	3	5	2	5	22	1
Dovyalis abyssinica (A. Rich.) Warb.	3	2	4	1	1	2	13	5
Acacia abyssinica Benth.	3	0	4	4	4	0	15	3
Ziziphus spina-christi(L) Desf.	2	3	2	0	2	1	11	6
Allium sativum L.	4	4	0	0	0	0	8	7

herbalists employ to safeguard human health from a variety of maladies. Age, gender, and education are three demographic factors that notably influence the acquisition of this knowledge and mold peoples' perspectives on herbal plants and their uses [22]. In comparison to women, men exhibit greater familiarity with medicinal flora (Table 2). Men preferentially disseminate their information

Table 6
ICF values of medicinal plants used to treat human ailments in Lay Gaint District.

Ailments category	Number of species	Number use citation	ICF
Respiratory ailments	13	44	0.72
Dermatological and oral ailments	12	145	0.92
Evil spirit diseases	11	36	0.71
Diabetics and hypertension	8	22	0.67
Dental & oral ailments	9	18	0.63
Febrile illness	16	124	0.87
Gastrointestinal tract	14	135	0.90

Table 7
Values of the integrity level of medicinal plants against the most frequently treated diseases.

Medicinal plant species	Ailment treated	Np	N	FL%
Allium sativum L.	Malaria	64	68	94 %
Artemisia abyssinica Sch.Bip. ex A.Rich.	Evil eye	24	51	47 %
Datura stramonium L.	Dandruff	16	44	34 %
Eucalyptus globulus Labill.	hepatitis	15	28	53 %
Olea europaea subsp. *Cuspidata* (Wall. & G.Don) Cif.	Tooth-ache	32	64	50 %
Ruta chalepensis L.	Snake bite	23	48	48 %
Zehneria scabra (L.f.) Sond.	Fever/Mich	18	33	55 %
Zingiber officinale Roscoe	Abdominal pain	48	72	66 %

Table 8
Major threats of medicinal plants in the study area.

Threat of medicinal plants	Number of informants	Percentage
Deforestation	20	23.8
Overgrazing	17	20.2
Agricultural expansion	32	38.1
Charcoal collection	15	17.9

to their eldest or favored sons while withholding it from their daughters, a dynamic that explains this divergence. These findings correspond to the results of prior investigations [23].

The results of the study also showed a significant difference ($p < 0.05$) in the knowledge reported about medicinal plants between the older and younger age groups. The average number of medicinal plants reported by the elder group was much higher than that of the youngest group. The reason for this discrepancy is the disapproval that younger generations have for the application of conventional medicine in the treatment of different diseases.

Similar outcomes have also been witnessed in various regions of the country as well [24]. Furthermore, the study findings revealed that non-literate people reported a notably greater number of medicinal plants than literate individuals ($p < 0.05$). This divergence can be attributed to the fact that educated persons are more inclined to prefer modern medicine over traditional therapy for all maladies. Consequently, indigenous knowledge of medicinal flora has diminished. Comparable global reports have been made [14,25].

4.2. Diversity of medicinal plants in the study area

In the current study, 46 medicinal plant species were identified for the management of human ailments distributed across thirty-three families and forty-one genera. The number of medicinal plants recorded in the Lay Giant District was lower than those from similar ethnobotanical investigations in Ethiopia, such as in the Sebeta-Awas district which listed 113 plant species [26], in Berbere District with 70 plant species [27], in the Sheka Zone of Southern Nations Nationalities and Peoples Regional State where 266 plant species were recorded [28] and in Delanta, Northwestern Wello which mentioned 133 medicinal plant species [29]. The timing and duration of data collection, as well as cultural factors, could all contribute to the variation in the quantity of medicinal plants. Brassicaceae, Ranunculaceae and Polygonaceae were the most prevalent families in terms of diversity of medicinal plant species, followed by Alliaceae, Lamiaceae, Rhamnaceae, Euphorbiaceae, Asteraceae, and Oleaceae. The existence of a number of plants from the families Brassicaceae, Ranunculaceae and Polygonaceae might be associated with the widespread distribution of the species under these families across a wide range of altitudes. In contrast, other studies found Cucurbitaceae and Lamiaceae [30] to be dominant above others.

4.3. Sources, growth forms, and plant parts used

For this investigation, more medicinal herbs were collected from wild vegetation than from home gardens. A similar finding was

reported by Mesfin et al. [31] in Wonago Woreda, SNNPR, Ethiopia. Herbs were the most reported plant species in the current study. This phenomenon may be attributable to the readily accessible nature of the herbs and associated knowledge within the community. Likewise, numerous ethnobotanical scholars across diverse regions of Ethiopia have documented the prevalence of herbal remedies in traditional medicine [9,11].

In contrast, ethnobotanical study carried out in Afar Regional State, Ethiopia, has revealed that shrubs are used more frequently to prepare traditional medicine [32]. The wider use of leaves in the study area might be due to effectiveness of bioactive substances in their parts as indicated by Tessema et al. [20,33,34] in their study area. This may be due to the fact that fresh plant components often have distinctive scents and tactile qualities that are highly beneficial in conventional medical procedures. Furthermore, the active components of the parts of fresh plants, such as flavonoids, alkaloids, and essential oils, which give them their medicinal properties [35].

4.4. Preparation of the remedy and administration route

Traditional healers in the study area prepared cures for treating human ailments using a variety of techniques. Of these techniques, powdering accounted for almost 30 % of the preparations. As other studies have also shown, traditional healers believe that powdering improves the extraction of bioactive components, enhancing the efficacy of medications against a variety of human diseases. Oral route of administration is the most frequently route followed by dermal. This result is consistent with findings [12,36,37], which also noted that oral administration was the most common. Since it is possible to self-administer pharmaceuticals in user-friendly forms, oral administration is chosen due to its simplicity, convenience, and lack of pain [10].

4.4.1. Dosage determination of medicinal plants

Traditional healers measure the dose in different ways using various techniques [38]. However, traditional healers in the Lay Giant district are well versed in treating patients; yet there is no information available on the calculation of the dosage, the mode of administration, and the associated short- and long-term adverse effects of medicinal plants [39]. Life-threatening occurrences could occur as a result of dubious validity, standardization, and side-effect problems.

This study supports the findings of [40], which assert that dosage varies according to the patient's age, sex, and physical condition.

4.4.2. Efficacy and relative healing potential of medicinal plants

In this investigation, the highest ICF values (0.92, 0.90, and 0.87) demonstrated that the highest degree of agreement between informants about the application of medicinal plants for the treatment of gastrointestinal tract, dermatological and oral ailments, and febrile diseases, respectively. High values for the informant consensus factor show that the informants strongly agree on the medical uses of known medicinal plant species. Assen et al. [19] state that it is crucial to select plants with high ICF values when searching for bioactive compounds. The available literature indicates that the highest ICF correspond to *Allium sativum* L.at 94 % against malaria, and *Zingiber officinale* Roscoe at 66 % against abdominal pain disorders. This may indicate that the relevant plants have a high potential for healing. Further phytochemical research could focus on plants with high- ICF values to confirm their bioactive involvement in the promotion of excellent healing effects [28].

4.4.3. Best-ranking of medicinal plants

Zingiber officinale Roscoe and *Allium sativum* L. rank first and second, respectively, among the top five medicinal plants recommended by the 10 key informants for the treatment of stomachaches. This suggests that due to their widespread usage by a large number of users and their therapeutic qualities, the aforementioned plant species were found to be significant and culturally acceptable in the study area. The result of the current study was recorded as comparable results by Ref. [36] reported in Dalle District, Sidama Zone, Ethiopia. Several medicinal plants that are versatile and used for a range of purposes were discovered in the study area. The direct matrix ranking revealed that *Croton macrostachyus* Hochst. ex Delile was the most popular medicinal plant among the locals, who used it for a variety of purposes. The results are consistent with a previous study [36], which found that among different users in the district. As indicated in Table 5 in the results section, the purported medicinal properties of these plants are not as often used as their nonmedical purposes.

4.4.4. Mechanism of bioactive compounds in medicinal plants against pathogens

Secondary metabolites of medicinal plants can be broadly classified into three groups: alkaloids, terpenes, and phenolic chemicals. Several investigations have shown that medicinal plant extracts and their active constituents have therapeutic benefits (Fig. 7). *Allium sativum* L.is mainly attributed to cysteine sulfoxides and other sulfur-containing substance [41,42]. Previous studies [43] indicated that *Hypericum species* are recorded as traditional herbal medicines to treat aliments, including hepatitis, malaria, hemorrhage, irregular menstruation, and wounds. The *Datura stramonium* L. leaf extract showed an antifungal activity [44]. According to scenario [22] reported that the medicinal plant was used as a mosquito repellent. Due to the large number of species, *Eucalyptus globulus* Labill. oils have a very broad range of applications. Traditionally, *Eucalyptus globulus* Labill. species have been used to relieve sore muscles after exercise and to support a healthy respiratory system [45]. As literatures [46] indicated that *Azadirachta indica* A. Juss. leaf extract possesses biological characteristics that include antibacterial, antioxidant, anticancer, and anti-inflammatory properties and prevent the host from being exposed to bacterial toxins.

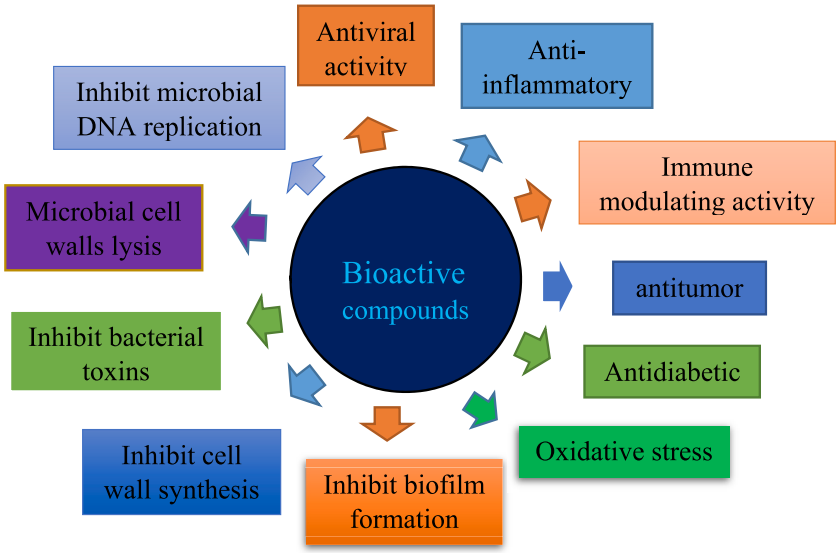

Fig. 7. Anti-microbial activity of medicinal plant bioactive compounds.

5. Threats to medicinal plants

In Lay Gaint District, various factors that were considered as main threats to medicinal plants were recorded by interviewing informants. The main factors claimed were agricultural expansion (38.1 %) followed deforestation (23.8 %). Other research on threats to medicinal plants used by the Mana Angetu District, southeastern Ethiopia [47] indicates similar investigation.

5.1. Conservation practice of medical plants

It is obvious that careful consideration of their protection is required given their widespread use for purposes other than medicine. The amount of natural flora has decreased significantly as a result of agricultural development, deforestation, overgrazing, charcoal production and firewood, collection. Despite their modest efforts, some people have begun to preserve medicinal plants by growing them in backyard gardens [13]. In fact, in order to maintain these valuable undertakings, the entire spectrum of organizations and stakeholders involved in the production, management, preservation and use of medicinal plants must take the appropriate steps and implement the necessary adjustments. Since initiatives to conserve and use medicinal plants sustainably require the participation of multiple sectors and more public support, it is imperative that ongoing efforts be made to raise public knowledge [48].

6. Conclusions

In Lay Gaint District, medicinal plants continue to play an important role in the management of a variety of human diseases despite widespread environmental deterioration and repeated drought. In the district, leaves were the most frequently used parts of plants to prepare cures. Among the recorded medicinal plants, herbs accounted for a higher percentage, which may indicate that they are more abundant than other types of life. There have been reports that the medicinal plant component of the study area is seriously threatened by agricultural expansion. Despite this, in the district, not much work is done to manage or grow medicinal plants. Therefore, it is necessary to increase the awareness of locals about the sustainable use and management of plant resources. To prevent additional damage to the District's medicinal plants, ex situ and in situ conservation measures should be implemented. A particular focus should be placed on the medicinal plants identified as the most vulnerable by a direct matrix rating and preference ranking study. It is recommended to involve local populations in plant resource management and conservation initiatives to reduce the eradication of these valuable resources.

Data availability

The author states that all additional data supporting the study findings are included in the article.

CRediT authorship contribution statement

Yalew Yiblet: Writing – review & editing, Writing – original draft, Methodology, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

I am the sole author of this manuscript. To the best of my knowledge this manuscript contains no material previously published by any other person except where due acknowledgement has been made. This manuscript contains no material which has been accepted as part of the requirements of any other academic degree or non-degree program, in English or in any other language. I declare that there is no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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