

# An Ethnobotanical Study of Medicinal Plants in Kelala District, South Wollo Zone of Amhara Region, Northeastern Ethiopia

Mesfin Woldearegay (✉ [mesfinwa@gmail.com](mailto:mesfinwa@gmail.com))

Department of Biology, College of Natural and Computational Sciences, Debre Birhan University, Ethiopia. P. O. Box 445, Debre Birhan University, Debre Birhan, Ethiopia. <https://orcid.org/0000-0003-2140-0874>

**Yimer Assen**

Debre Berhan University

**Abeba Haile**

Debre Berhan University

---

## Research

**Keywords:** Ethnobotany, Fidelity, Indigenous knowledge, Kelala District, Medicinal plants

**Posted Date:** September 15th, 2020

**DOI:** <https://doi.org/10.21203/rs.3.rs-75536/v1>

**License:**  This work is licensed under a Creative Commons Attribution 4.0 International License.

[Read Full License](#)

---

# Abstract

**Background:** Plants have a long history of being used for medicinal purposes, and a large proportion of people in the developing world still rely on traditional medicines to meet their primary health care requirements. Medicinal plants are the major components of the traditional health care system. The objective of this study was to record and document the medicinal plants and associated indigenous plant use knowledge of the local people in Kelala District of Amhara Region, Ethiopia.

**Methods:** Ethnobotanical data were collected by conducting pre-prepared semi-structured interview items with 60 informants. Focus group discussion and guided field walk were also used. Data were analyzed using basic analytical tools and descriptive statistics. Determination of Informant Consensus Factor, Fidelity level, and ranking was performed.

**Results:** A total of 82 medicinal plants distributed in 79 genera and 45 families were collected. Of these plants, 43 species were used to treat human ailments, and 33 species were used to treat livestock ailments and the remaining 6 species were used to treat both human and livestock ailments. The majority of medicinal plants were harvested from the wild environments. The family Solanaceae occupied the first rank with seven species followed by Fabaceae, Asteraceae, Cucurbitaceae, Apiaceae, and Euphorbiaceae with four species each. The most frequently used plant parts were leaves (42.2 %) followed by seeds (15.2 %), roots (8.1 %), and fruits (7.6%). Freshly harvested plant parts (72.68 %) were mostly used for remedy preparation than dried forms (24.74 %) whereas crushing, which accounted for (41.12%), and powdering (24.37%) were the most widely used methods of remedy preparation in the study area.

**Conclusion:** Higher number of medicinal plants recorded in the study area indicates the depth of medicinal plant resources and associated indigenous knowledge of the local people. However, the expansion of farmlands by cutting trees heavily threatens medicinal plants and therefore, needs due attention. High ranking medicinal plants are good candidates for further research in drug discovery and development.

## Background

Plants have a long history of being used for medicinal purposes. About 80% of the developing world's population still depends on traditional medicines to meet their primary health care requirements [1] and many of the modern drugs were derived from traditional uses [2]. Factors like accessibility, availability, and cultural acceptability of the health care service generally affect the use of traditional medicines [3]. Particularly, in most rural areas of developing countries, medicinal plants serve as major sources of medicines to meet primary health care needs [4–5].

Ethiopia is an important regional center of biological diversity and endemism due to its wide ranges of altitude and geographical diversity with high and rugged mountains, flat-topped plateaus and deep gorges, incised river valleys, and rolling plains [6]. This geographical diversity coupled with the multiplicity of ethnic groups and complex cultural diversity makes the country the home for the high diversity of

traditional knowledge, practice, and uses of traditional medicine [7–9]. The practice of traditional medicine in the country is not only concerned with the curing of diseases but also with the protection and promotion of human physical, spiritual, social, mental, and material wellbeing [10].

The flora of Ethiopia is very heterogeneous and is estimated to contain about 6,027 species of vascular plants of which about 10% are endemic [6]. The cultivation and use of medicinal plants in Ethiopia have a long history [11]. Traditional plant remedies are still the most important and sometimes the only sources of therapeutics for nearly 80% of the people in the developing countries [1]. For instance, nearly 80% of the population in Africa fulfills their primary healthcare requirements by using traditional medicines. Similarly, about 90% of the population in Ethiopia use traditional medicine as their first line of healthcare requirements [12]. The deep-rooted culture of using medicinal plants in Ethiopia led the people to be acquainted with the knowledge of medicinal properties of many plants used in treating numerous human and livestock ailments [13]. However, the knowledge on traditional medicinal plants which was developed for millennia is now subjected to loss since it is transferred by word of mouth from generation to generation, basic information about the use of the plants and the part used, drug preparation methods, route of administration, the diseases treated and others may be lost and discarded in the knowledge transfer process [13]. Besides, other factors such as deforestation, overexploitation of natural resources, overgrazing, habitat destruction, and fragmentation, as well as agricultural land expansion heavily threaten the Ethiopian traditional medicinal plant resources and associated indigenous knowledge [8]. Therefore, it is important to identify and document medicinal plants and the indigenous wisdom associated with the use of plants to strengthen the medicinal plant database of the country. Such research also provides the opportunity for recognition, promotion, management, and protection of indigenous knowledge of a community on medicinal plants as a vital part of a nation's heritage, to carry out drug research, further to calling policymakers, natural resource managers, other stakeholders and cultural practitioners for conservation actions. Thus, the present study was initiated to record and document the medicinal plants and associated indigenous plant use knowledge of the people in Kelala district.

## Methods

This study aimed to record and document medicinal plants and associated indigenous knowledge of the people in Kelala district northeastern Ethiopia. Kelala district is located in the south Wollo administrative zone of Amhara Regional State, which is 561 km far away from Addis Ababa. The geographical coordinates of the district lie between 10° 28' N and 38° 48' E (Fig. 1). The district has an altitudinal variation that ranges from 500–2300 m a.s.l. and it covers a total surface area of 143,433 ha [14]. The study area has a unimodal rainfall with a long rainy period from June to October and small rain from March to May [15]. The mean annual rainfall of the study area is 988 mm. The mean annual temperature of the study area is 17 °C ranging from the mean annual minimum of 6.2 °C to the mean annual maximum of 29.2 °C [16].

According to KDARDO [17], the dominant soil types occurring in the area are clay (17.4%), clay loam (0.6%) and clay to clay-loam (63.5%), loam to clay (0.7%) and silt clay (17.8%). Among these soil types, clay to clay-loam is the most abundant and suitable for cultivation of cereal crops. The vegetation of the study area belongs to dry single-dominant Afromontane forest and this type of forest is known to occur on the plateau of Tigray, Gonder, Wollo, and Harerge regions with an annual rainfall distribution between 500 and 1500 mm. The typical dominant species in the upper storey of these forests is *Juniperus procera* and *Olea europea* Subsp. *cuspidata*. Sometimes the juniper trees can be rather scattered and the forest is characteristic of *Juniperus* woodland with discontinuous evergreen undergrowth [18].

Based on the 2007 national population and housing census, Kelala district had a total population of 136,545 where 67,929 were men and 68,616 women. The majority of the people (94.4%) lives in the rural area by directly obtaining their means of subsistence from agriculture and associated activities while 5.6% of the people are urban inhabitants. More than 95% of the inhabitants were Muslims whereas 4% of the population practiced Christianity [19].

In the district, the major ten human diseases are dyspepsia, diarrhea (non-bloody), acute febrile illness, acute upper respiratory infection, infection of the skin and subcutaneous tissue, disease of the musculoskeletal system and connective tissue, pneumonia, urinary tract infection, helminths and trauma (injury, fracture, etc.). The most important livestock diseases in the district include sheep and goat pox, pasteurellosis (ovine and obivne), mange mites, blackleg, anthrax, African horse sickness, contagious eczema, lice, and fleas' infection and rabies [20].

## Site and informant selection

A reconnaissance survey of the study area was conducted from September 20 to October 10, 2017, and resulted in the identification of eleven study sites, namely Abet wuha, Lugama, Senbo, Kelela, Yimerina rebortu, Deger, Tirtira, Qorki, Aleltu, Gumero, and Mukech. These study sites were selected based on the presence of traditional medicinal practitioners and the recommendations of elders, kebele administrators, and health workers. Also, accessibility of the sites and agro-climatic zones of the district were considered to select the study sites (kebeles).

A total of 60 (41 males and 19 females) informants were selected from the population following Martin [21]. Out of these, 40 general informants were selected randomly and 20 key informants were selected purposively based on the recommendations of knowledgeable elders, local authorities, and health workers by taking 1–2 individuals from each study kebele. The informants were aged between 20–91 years.

## Data collection

Qualitative and quantitative ethnobotanical data were collected from informants using a pre-prepared semi-structured interview method [21, 22]. Focus group discussion, participant observation, and guided field walk were also applied. Ethnobotanical data collection sheet was prepared in English and translated

to Amharic language ahead of time to be used during ethnobotanical information retrieval from informants. Information was carefully recorded during an interview with an informant including local names of the medicinal plants, habitat of the plant, disease the plant treats, parts used, methods of remedy of preparation, ingredients added, dosage prescriptions, and routes of administration [21, 22]. Before data collection, written permission was obtained from the culture and tourism office of the district as well as permission from the local administration of each selected kebele. Following this, the purpose of the study was briefly explained to each informant and prior verbal consent was obtained.

## Focus group discussion and guided field walk

Discussions were conducted to gather further information on medicinal plant knowledge at the community level, ways of transferring their knowledge, major threats on medicinal plants, and indigenous conservation practices. The method of guided field walk with the help of local guides from each study site was applied to make notes on the habit, habitat, morphological features, and association of the medicinal plants with other species. Moreover, it allowed seeing, smelling, and tasting the medicinal plants under investigation to understand the unique features of the species. The local field guides also played a crucial role in identifying the medicinal plants found in the field by proving their vernacular names. Voucher specimen collection was made from the wild and home gardens. Preliminary identification of the specimens was made at the field and the collected specimens were dried, pressed, and taken to the National Herbarium (ETH) in Addis Ababa University. Specimen identification was carried out by using taxonomic keys in the Flora of Ethiopia and Eritrea and comparing with authenticated specimens at ETH.

## Data analysis

Ethnobotanical data were analyzed using basic analytical tools following Martin [21] and descriptive statistical methods such as frequency and percentage. Informant Consensus Factor (ICF) was computed to identify potentially effective medicinal plant species in the respective disease categories [23]. Thus,

$$ICF = \frac{n_{ur} - n_t}{(n_{ur} - 1)}$$

where, ICF = informants consensus factor,  $n_{ur}$  = number of use citations in each category,  $n_t$  = number of times a species used. Preference ranking and direct matrix ranking exercises [21, 24] were computed to recognize use-preference and/or use diversity of medicinal plants by the key informants. Values given by key informants on use-preference and/or use diversity of medicinal plants were added and ranked to get the outputs of the preference ranking and direct matrix ranking. The relative healing potential of each reported medicinal plant used against human diseases was computed as fidelity level

(FL) [24].  $FL = \frac{I_p}{I_u} \times 100$ , where  $I_p$  = the number of informants who independently cited the importance of a species for treating a particular disease and  $I_u$  = the total number of informants who reported the medicinal plant for any given disease [24].

## Results

# Diversity of medicinal plants

Eighty-two species of medicinal plants, belonging to 79 genera and 45 families, were used by the local people to treat different human and livestock diseases in Kelala district. From the total eighty-two medicinal plants, 43 (52.44%) species were used to treat human ailments whereas 33 (40.24%) species were used to treat livestock ailments and 6 (7.32%) species were used to treat both human and livestock ailments. The family Solanaceae had the highest number of medicinal plant representation (seven species, 8.54%) followed by Fabaceae, Asteraceae, Cucurbitaceae, Apiaceae, and Euphorbiaceae (four species each, 4.88%) and Lamiaceae and Poaceae (three species each, 3.67%). Eleven families were represented by two species each (2.44%) whereas the remaining 26 families had single-species representation (1.22%). The growth forms of the medicinal plants indicated that herbs (30 species, 36.6%) had the highest proportion than shrubs (28 species, 24.1%), trees (18 species, 22%), and climbers (6 species, 6.5%) (Fig. 2). The medicinal plants were harvested from the wild, home gardens, and both the wild and home gardens. Of all the medicinal plants recorded in the study area, large proportions of the medicinal plant species (53, 64.6%) were harvested from the wild followed by home gardens (24, 29.3%), and the remaining species (5, 6.1%) were collected from both the wild and home gardens.

## Medicinal plant parts used and condition of preparation

Although the traditional healers mentioned many plant parts to be used for remedy preparation, leaves occupied the highest proportion (42.2%) followed by seeds (15.2%), roots (8.1%), and fruits (7.6%) (Fig. 3). Most of the herbal medicine preparation involved the use of a single plant part (95%) whereas the uses of mixing different parts (5%) were not commonly practiced in the study area. The majority of remedies were prepared from freshly harvested plant parts (72.68%) followed by dried form (24.74%) and the remaining (2.58%) were prepared both from fresh and dried parts of medicinal plant species.

## Modes of remedy preparation, dosage and application

The major modes of remedy preparation from medicinal plant materials were crushing (41.12%) followed by powdering (24.37%) and decoction (13.2%) (Table 1). The traditional healers do not have any standardized doses for herbal remedies prescribed and given to patients. However, approximate dosages were used based on gender, age, pregnancy status, and physical appearance of the patient. Some medicinal plant preparations were measured using small cups (locally called SINI), handful, plastic jug, finger length, and spoon. Different routes of administration of medicinal plant preparations were used to treat various human and livestock ailments in the study area. The most commonly used route of administration was an oral application (52.8%) followed by dermal application (35.5%). Other routes of administration include nasal (3.6%), oral or nasal (3.6%), external (2%), and eye or dermal (1%).

Table 1  
Modes of preparation of herbal medicine in the study area

Modes of preparation	Number of preparations	Percentages
Crushing	81	41.12
Powdering	48	24.37
Decoction	26	13.2
Chewing, taking the sap	11	5.58
Extracting juice, latex	8	4.06
Boiling, inhaling the smoke	7	3.55
Others	16	8.12

## Informant consensus factor (ICF)

Results of the analysis of ICF showed that some medicinal plants are effective in treating a certain disease. These medicinal plants are well known by the informants also have higher ICF values. Accordingly, the category with the highest ICF value was gastrointestinal disorder and parasitic infection (0.77) followed by respiratory diseases (0.70) (Table 2).

Table 2  
Informant consensus factor values by disease category in the study area

No	Disease category	No of species	% all species	Use citations	% all use citations	ICF
1	Gastrointestinal and parasitic infections	29	35.37	125	25.25	0.77
2	Respiratory diseases	7	8.54	21	4.24	0.70
3	Dermatological	30	36.59	90	18.18	0.67
4	Febrile illness	17	20.73	46	9.29	0.64
5	Livestock parasitic diseases	14	17.07	35	7.07	0.62
6	Livestock diseases	24	29.27	57	11.52	0.59
7	Organ malfunctioning	15	18.29	33	6.67	0.56
8	Internal diseases	15	18.29	31	6.26	0.53
9	Snakebite, scorpion bite	12	14.63	24	4.85	0.52
10	Others	15	18.29	33	6.67	0.56

# The relative healing potential of medicinal plants, fidelity level

The highest fidelity level (100%) was recorded for *Zehneria scabra* followed by *Ocimum lamiifolium* (94.44%), *Impatiens rothii* (92.5%), *Eucalyptus globulus* (84.38%), *Cordia Africana* (81.25%), and *Otostegia tomentosa* (80%) (Table 3). The highest fidelity level scores recorded for *Zehneria scabra*, *Ocimum lamiifolium*, *Eucalyptus globulus*, and *Cordia africana* were found under Febrile illness disease category. Conversely, the highest fidelity level values of *Impatiens rothii* and *Myrtus communis* were found in the dermatological disease category.

Table 3  
Fidelity level values of medicinal plants against a given human disease category

No	Scientific name	Disease category	Ip	Iu	FL (%)
1	<i>Zehneria scabra</i>	Febrile illness	32	32	100
2	<i>Ocimum lamiifolium</i>	Febrile illness	34	36	94.44
3	<i>Impatiens rothii</i>	Dermatological	37	40	92.5
4	<i>Eucalyptus globulus</i>	Febrile illness	27	32	84.38
5	<i>Cordia africana</i>	Febrile illness	13	16	81.25
6	<i>Otostegia tomentosa</i>	Gastrointestinal and parasitic infections	20	25	80.00
7	<i>Myrtus communis</i>	Dermatological	11	14	78.57
8	<i>Foeniculum vulgare</i>	Internal diseases	7	10	70.00
9	<i>Artemisia afra</i>	Gastrointestinal and parasitic infections	4	6	66.67
10	<i>Laggera tomentosa</i>	Gastrointestinal and parasitic infections	7	11	63.64
11	<i>Nicotiana tabacum</i>	Respiratory diseases	8	13	61.54
12	<i>Artemisia afra</i>	Respiratory diseases	3	6	50.00

## Preference ranking

Results of analysis of preference ranking on medicinal plants that were reported to be used against stomachache in humans indicated that *Nigella sativa* was the most-preferred species to treat the disease followed by *Allium sativum* and *Zingiber officinale* (Table 4).

Table 4

Preference ranking results of five medicinal plants used for treating stomachache

Medicinal Plants	Respondents (R1-R7)							Total	Rank
	R1	R2	R3	R4	R5	R6	R7		
<i>Zingiber officinale</i>	4	3	4	5	4	3	4	27	3 <sup>rd</sup>
<i>Nigella sativa</i>	4	5	4	5	4	5	4	31	1 <sup>st</sup>
<i>Allium sativum</i>	4	4	4	4	5	4	4	29	2 <sup>nd</sup>
<i>Ruta chalepensis</i>	3	3	5	4	4	3	4	26	4 <sup>th</sup>
<i>Lepidium sativum</i>	4	3	4	4	3	4	3	25	5 <sup>th</sup>

**NB:** The numbers in the table indicate the ranks given by informants to medicinal plants based on their healing power. The highest score (5) is given for the medicinal plant most effective in treating stomachache and the lowest score (1) is for the least effective plant.

## Direct matrix ranking

The results of direct matrix ranking exercise on five multipurpose medicinal plants indicated that *Cordia africana* was ranked first followed by *Acacia abyssinica* and *Olea europaea* Subsp. *cuspidata* (Table 5). This finding showed that these species are more exploited for purposes other than their medicinal uses in the study area.

Table 5

Average direct matrix ranking score of five key informants for five multipurpose medicinal plants

Use diversity	<i>Cordia africana</i>	<i>Olea europaea subsp. cuspidata</i>	<i>Eucalyptus globulus</i>	<i>Acacia abyssinica</i>	<i>Croton macrostachyus</i>
Medicine	4	3	2	3	5
Food	1	0	0	1	0
Fuel wood	4	5	5	4	3
Charcoal	2	4	2	5	3
Construction	4	3	5	2	2
Furniture	4	2	3	2	3
Forage	4	3	2	4	2
Total	23	20	19	21	18
Rank	1	3	4	2	5

## Conservation of medicinal plants

The local community in the study area mainly depends on the natural environment for collecting medicinal plants. Despite harvesting the majority of the medicinal plants (53 species, 64.6%) from the wild environment, no remarkable effort was observed to conserve and sustainably utilize the fast-eroding medicinal plant resource of the district. Besides the observed poor experience of cultivating medicinal plants in home gardens, it was reported that most medicinal plants are under threat due to an ever-increasing anthropogenic disturbance on the natural environments of medicinal plants in the area. The major anthropogenic disturbances were agricultural expansion (20.23%), fuelwood collection (19.07%), charcoal production (17.34%), construction (14.45%) and overgrazing (13.87%). Due to the limited accessibility of some medicinal plants, some traditional healers claimed that they have to travel long distances for several hours to collect a particular medicinal plant.

## Discussion

### Medicinal plants of the study area

Eighty-two medicinal plants have been documented in this study. The number of reported medicinal plants and plant use knowledge of the local people indicated that Kelala district is rich in medicinal plant diversity and associated indigenous knowledge. In this study a relatively larger number of medicinal plants were reported compared to some other previous works like 27 species were documented in [25], 34

species in [40], 35 species in [27], 71 species in [26], and 51 species in [28] in different parts of Ethiopia. Out of these reported medicinal plants, 43 (52.44%) species were used to treat human ailments only whereas 33 (40.24%) species were used to treat livestock ailments and 6 (7.32%) species were used to treat both human and livestock ailments. Similar results were reported by [29–32] in other parts of Ethiopia. The family Solanaceae was represented by seven species followed by Fabaceae and Asteraceae which had four species each. The finding that the family Solanaceae contributed the largest number of medicinal plants in this study agrees well with a similar study conducted elsewhere in Ethiopia [33, 40] whereas various studies in Ethiopia [29, 34, 35] have reported that Fabaceae and Asteraceae are the leading families with the highest number of medicinal plants. This could be attributed to the fact that they are the largest families in the flora area of Ethiopia and Eritrea [36]. This could also be related to its efficient and successful dispersal strategies as well as better adaptation to a wide range of ecological conditions. Some medicinal plants reported in Kelala district were also used as remedies in other parts of Ethiopia. For example, 12 medicinal plants used to treat human diseases and four of the medicinal plants reported to treat both human and livestock diseases in the present study are also reported by [35]. Similarly, 19 medicinal plants reported to treat human ailments in the present study are also reported by [37], suggesting that some of the reported medicinal plants are having similar uses in other parts of the country can be taken as an indication of their pharmacological effectiveness [28]. The majority of medicinal plants were collected from the wild environment indicating that the local people have not yet started to cultivate the medicinal plants they are using for medicinal purposes around home gardens and nearby cultivated areas.

## **Habit of medicinal plants and parts used**

A large number of the medicinal plants 30 (36.6%) collected from Kelala district were herbaceous species. This indicated that most plant remedies were obtained from herbs. This could be attributed to the fact that herbs are more easily available and relatively abundant in the nearby areas than shrubs and trees which are often harvested from forest patches distantly located from their dwelling areas. Besides, herbs occupied the dominant number of species than woody plants in the Flora area. This finding is in agreement with the general pattern of dominance of herbaceous species observed in many medicinal plant inventories in Ethiopia and elsewhere [25, 29, 35, 38, 39].

This study showed that the most frequently used plant parts are leaves (42.2%) and seeds (15.2%). The usage of leaves for remedy preparation should be promoted as a more sustainable method of accessing plant materials since a certain number of leaves remain on the parent plant to carry on its life functions than the harvesting of the roots which kills the parent plant. It agrees with other ethnomedicinal studies in Ethiopia that reported leaves as the most frequently used plant parts [29, 34, 35, 41–43]. The traditional healers prepare plant remedies for treating human and livestock ailments from a single plant or plant part. Contrary to the present study, the use of multiple plants or plant parts for a single health problem was reported by previous studies in other parts of Ethiopia [35, 39]. This might be because healers mostly used multiple plants or plant parts to increase the strength and efficacy of the drug.

## **Mode of preparation, dosage and route of application**

Crushing was the most widely used method of remedy preparation in the study area. Similar findings were reported by [35, 42, 44, 45] in other parts of Ethiopia. However, [41] and [46] reported that powdering and pounding are the dominant method of preparation in Ghimbi and Chelya Districts, respectively. The majority of remedies used for treating various human ailments were prepared from freshly harvested plant parts (72.68%). This could be attributed to the wide-spread traditional belief of attaining high efficacy from fresh remedies due to the higher concentration of active ingredients in the form of secondary metabolites in the fresh plant parts. In addition, traditional healers claim that some medicinal plants lose their healing potential if not used in fresh form. Previous ethnomedicinal works [e.g., 32, 43, 47] have also indicated the wide use of fresh plant materials for various remedy preparations due to the reportedly better efficacy than when using dried plant materials. The majority of the remedies were administered orally. This finding is in agreement with other studies [43] and [34] who reported (70.5%) and (52%), respectively that oral administration of medicine was the leading route of application in other parts of Ethiopia. Even though dosages of remedies for various ailments were reported to be determined based on age, the occurrence of pregnancy, physical fitness/appearance, and gender of the patient, there were no standardized measurements or guidelines set nor shared by traditional healers. It was reported that lack of precise dosage is one drawback of traditional medicinal plants [48–49].

## **Efficacy and the relative healing potential of medicinal plants**

For this study, the highest ICF values (0.77, 0.70 and 0.67) indicated the best agreement among informants on the use of human medicinal plant species for treating gastrointestinal and parasitic infections, respiratory diseases, and dermatological diseases, respectively. High informant consensus factor values exhibit the presence of strong agreement of informants regarding the therapeutic uses of reported medicinal plant species. Conversely, low informant consensus factor values indicate strong disagreement of informants regarding the therapeutic uses of reported medicinal plant species. Medicinal plants with higher informant consensus value could reflect the important number of use reports for a particular use category. According to [23], high ICF values are important to identify plants of particular interest in the search for bioactive compounds.

Relatively high fidelity level values were reported for *Zehneria scabra* (100%) and *Ocimum lamiifolium* (94.44%) against febrile diseases, and for *Impatiens rothii* (92.5%) against dermatological diseases could be considered a clue for the high healing potential of these plants against the corresponding diseases. Interestingly, high fidelity level values for the same disease category (Febrile illness) have been reported in Ankober district by [50]. Plants with high fidelity level values could also be targeted for further phytochemical investigation to verify the bioactive role inducing high healing results [23, 51]. Furthermore, plants with high FL values could be target species prioritized for conservation, management, and sustainable use after their bioactivities were properly evaluated and confirmed.

## **Best ranking medicinal plants**

Best ranking medicinal plants are priority species for further investigation against stomachache health problems in humans. Ranking of the top five medicinal plants by the seven key informants reveal that *Nigella sativa* stood first followed by *Allium sativum*, *Zingiber officinale*, *Ruta chalepensis*, and *Lepidium sativum*, respectively in this order as the most preferred medicinal plants for treating stomachache problem. This indicates that the aforementioned plant species were found to be culturally acceptable and important in the study area owing to their wide use by a large number of users as well as their curative properties. An ethnobotanical study carried out elsewhere in Ethiopia [37] also reported the use of *Lepidium sativum* and *Ruta chalepensis* for treating stomachache. Further investigation of these species for their bioactive ingredients that could be used for treating stomachache may produce promising results.

Direct matrix ranking exercise results showed that a number of multipurpose medicinal plants of the study area including *Cordia africana*, *Acacia abyssinica*, and *Olea europaea* Subsp. *cuspidata* ranked from first to third respectively. As indicated in Table 5 of the result section, these plants are being more exploited for their non-medicinal uses than for the reported human medicinal values. Overexploitation of multipurpose medicinal plant species for fuelwood, charcoal production, construction materials, and lumbering purposes were the factors most responsible for accelerating depletion of the species in the study area. Thus, the findings of this study call for urgent conservation measures to save the fast-eroding multipurpose medicinal plant species of the study area. This finding agrees with [47] who reported the same pattern of high exploitation of multipurpose medicinal plants for uses other than their medicinal values in southeastern Ethiopia.

## Threats to medicinal plants and conservation practices

Medicinal plants are highly threatened by the destruction of their habitats and overexploitation of well-known medicinal plants in the study area. Since most medicinal plants were harvested from wild environments, the traditional healers will not have easy access to medicinal plants and they have to travel long distances from their residential area in search of a particular medicinal plant. The effort to conserve medicinal plants by the traditional healers was found to be poor. This could be seen from the low proportion (29%) of medicinal plants harvested from home gardens as compared to those collected from the wild (65%). Traditional beliefs in the area could also have some contributions for the conservation and sustainable utilization of medicinal plants as also reported by other studies [27, 30, 52]. Informants highly agreed that agricultural expansion, firewood collection, and charcoal production are the most threatening factors for medicinal plants in the study area. Similar results were also reported by other studies in Ethiopia [42, 32, 47].

This study provides the first step to record and document medicinal plants' use and the associated indigenous knowledge of local communities in the study area, to relate this knowledge to the conservation status of the species. Promoting *in-situ* and *ex-situ* conservation of medicinal plants in Kelala district as well as assisting their conservation activities with professional guidance helps to abate the fast-eroding of medicinal plants of the study area.

## Conclusion

A considerable amount of medicinal plants recorded from the study area implies that Kelala district is a good reservoir of medicinal plant species. Most of these medicinal plants were collected from the wild environment and herbs occupied the largest proportion of medicinal plants to be utilized. The majority of the medicinal plants were harvested for their leaves and the utilization of leaves may not cause serious damage to the plant compared to those plants where their roots are used for medicinal purposes. However, the majority of plant remedies were prepared from fresh plant materials which increases the frequency of using the plant daily. This may cause overharvesting of locally rare medicinal plant species leading to local extinction. Although a large number of medicinal plants have been reported to be used for treating human and livestock ailments in the study area, they are being threatened by different anthropogenic disturbances. Cutting of trees for the expansion of farmlands was the major threat to the vegetation of the area in general and medicinal plants in particular. Combined efforts of both the district agricultural office with other stakeholders is mandatory to stop and/or reduce further loss of medicinal plants in the study area as well as to encourage and support the local communities to grow and conserve medicinal and multipurpose plants species in home gardens and nearby farmland areas.

## Declarations

### *Competing interests*

The authors declare that they have no competing interests.

### *Authors' contributions*

We have made a significant intellectual contribution to this work in data collection, data organization, plant specimen identification, data analysis, and interpretation of results, manuscript preparation, editing, and proofreading of the manuscript. All authors have read and approved the final manuscript.

### *Funding*

We are very grateful for the financial support provided by Debre Birhan University to conduct this research.

### *Ethics approval and consent to participate*

This study was approved by the joint collaboration of the Department of Biology, Debre Birhan University, and Kelala District Culture and Tourism Office.

### *Consent for publication*

Not applicable

### *Availability of data and materials*

All data generated or analysed during this study are included in this published article, and also are available from the corresponding author on reasonable request.

### ***Acknowledgments***

We are very grateful to Kelala District Administration Office for their kind corporation and assistance to carry out the research work. Department of Biology, Debre Birhan University, and the staff members are highly acknowledged. We also like to thank the local people of Kelala District for their support during data collection and sharing their knowledge and experiences unreservedly.

## **References**

1. WHO. Traditional Medicine. 2008. Fact Sheet No 134. <http://www.who.int/mediacentre/factsheets/2003/fs134/en/>. Accessed 19 March 2020.
2. De LV, Salim V, Atsumi SM, Yu F. Mining the biodiversity of plants: a revolution in the making. *Science*. 2012;336:1658–60.
3. Sato A. Revealing the popularity of traditional medicine in light of multiple recourses and outcome measurements from a user's perspective in Ghana. *Health Policy Plan*. 2012;27:625–37.
4. Kasperek M, Gröger A, Schipmann U. Directory for medicinal plant conservation. IUCN/SSC Medicinal Plants Specialist Group. Bonn: German Federal Agency for Nature Conservation; 1996.
5. Van Andel T. Non-timber forest products of the northwest district of Guyana. Part 1, University of Utrecht, Tropenbos Guyana series8a, Utrecht University, The Netherlands; 2000.
6. Kelbessa E, Demissew S. Diversity of vascular plant taxa of the flora of Ethiopia and Eritrea. *Ethiopian Journal of Biological Sciences*. 2014;13:37–45.
7. Abebe D, Ayehu A. Medicinal Plants and Enigmatic Health Practice of Northern Ethiopia. B. S. P. E, Addis Ababa; 1993.
8. Asfaw Z. The role of home gardens in the production and conservation of medicinal plants. In: Zewdu M, Demissie A, editors. Proceedings of Workshop on Biodiversity Conservation and Sustainable Use of Medicinal Plants in Ethiopia. Institute of Biodiversity Conservation and Research, Addis Ababa, Ethiopia; 2001. pp. 76–91.
9. Giday M. An Ethnobotanical Study of Medicinal Plants Used by Zay People in Ethiopia. *CBM Shikrftserie*. 2001;3:81–99.
10. Bishaw M. Promoting traditional medicine in Ethiopia: a brief historical overview of government Policy. *Soc Sci Med*. 1991;33:193–200.
11. Gebrehiwot M. An ethnobotanical study of medicinal plants in Seru woreda, Arsi Zone of Oromia Region, Ethiopia, M.Sc. Thesis. Addis Ababa, Ethiopia; 2010.
12. WHO. Traditional Medicine Strategy 2002–2005. Geneva: World Health Organization (WHO); 2002.
13. Abebe D. The role of medicinal plants in healthcare coverage of Ethiopia, the possible benefits of integration. In: Zewdu M, Demissie A, editors. Proceedings of Workshop on Biodiversity Conservation

- and Sustainable Use of Medicinal Plants in Ethiopia. Institute of Biodiversity Conservation and Research, Addis Ababa, Ethiopia; 2001. pp. 6–21.
14. KDAO. Kelala District Administrative Office (KDAO), Annual Report, Kelala; 2018.
  15. Gamachu D. Aspects of climate and water budget in Ethiopia. A technical monograph. Addis Ababa University Press, Addis Ababa, Ethiopia; 1977. p. 70.
  16. NMSA. Climate data records for the study area obtained from the National Meteorological Service Agency (NMSA), Addis Ababa, Ethiopia; 2017.
  17. KDARDO. Kelala District Agricultural and Rural Development Office (KDARDO), Annual Report, Kelala; 2018.
  18. Demissew S, Friis I. Natural vegetation of the flora area. In: Hedberg I, Friis I, Persson E, editors *Flora of Ethiopia and Eritrea. Volume 8*. The National Herbarium, Addis Ababa University, Addis Ababa; 2009. pp. 28–29.
  19. CSA. The 2007 Population and Housing Census of Ethiopia. Central Statistical Authority (CSA), Addis Ababa; Ethiopia; 2007. pp. 530.
  20. KDAHD. Kelala District Animal Health Office (KDAHO), Annual Report, Kelala; 2018.
  21. Martin GJ. *Ethnobotany: A method Manual*. London: Chapman and Hall; 1995.
  22. Cotton CM. *Ethnobotany: Principles and Applications*. New York: John Wiley and Sons; 1996.
  23. Heinrich M, Ankli A, Frei B, Weimann C, Sticher O. Medicinal plants in Mexico: Healers' consensus and cultural importance. *Soc Sci Med*. 1998;47:1859–71.
  24. Alexiades MN. *Selected guidelines for Ethnobotanical Research: A Field Manual*. The New York Botanical Garden, USA; 1996.
  25. Giday M, Asfaw Z, Woldu Z. Ethnomedicinal study of plants used by Sheko ethnic group of Ethiopia. *J Ethnopharmacol*. 2010;132:75–85.
  26. Giday M, Asfaw Z, Woldu Z, Teklehaymanot T. Medicinal plant knowledge of the Bench ethnic group of Ethiopia. An ethnobotanical investigation. *J Ethnobiol Ethnomed*. 2009;5:34.
  27. Giday M, Asfaw Z, Woldu Z. Medicinal plants of the Menit ethnic group of Ethiopia: An ethnobotanical study. *J Ethnopharmacol*. 2009;124:513–21.
  28. Hailemariam T, Demissew S, Asfaw Z. An ethnomedicinal study of medicinal plants used by the local people in the lowlands of Kontal Special Wereda, Southern Nations and Nationalities and Peoples Regional State, Ethiopia. *J Ethnobiol Ethnomed*. 2009;5:26.
  29. Wondimu T, Asfaw Z, Kelbessa E. Ethnobotanical study of medicinal plants around 'Dheeraa' town, Arsi Zone, Ethiopia. *J Ethnopharmacol*. 2007;112:152–61.
  30. Mesfin F, Demissew S, Teklehaymanot T. An ethnobotanical study of medicinal Plants in Wonago Woreda, SNNPR, Ethiopia. *J Ethnobiol Ethnomed*. 2009;5:28.
  31. Teklehaymanot T, Giday M. Ethnobotanical study of medicinal plants used by people in Zegie Peninsula, Northwestern Ethiopia. *J Ethnobiol Ethnomed*. 2007;3:1–12.

32. Lulekal E, Kelbessa E, Bekele T. An ethnobotanical study of medicinal plants in Mana Angetu District, South Eastern Ethiopia. *J Ethnobiol Ethnomed.* 2008;4:10.
33. Tadesse Beyene. Ethnobotany of medicinal plants in Erob and Gulomeheda Districts, Eastern Zone of Tigray National Regional State, Ethiopia. PhD Theses, Addis Ababa University, Addis Ababa, Ethiopia; 2015.
34. Teka A, Asfaw Z, Demissew S, Van Damme P. Traditional medicinal plant use of indigenous communities in Gurage Zone, Ethiopia. *Ethnobotany Research Applications.* 2020;19:41. <http://dx.doi.org/10.32859/era.19.41.1-31>.
35. Chekole G, Asfaw Z, Kelbessa E. Ethnobotanical study of medicinal plants in the environs of Tara-gedam and Amba remnant forests of Libo Kemkem District, northwest Ethiopia. *J Ethnobiol Ethnomed.* 2015;11:4.
36. Hedberg I, Edwards S, editors. *Flora of Ethiopia and Eritrea, Volume 3, Pittosporaceae to Araliaceae.* The National Herbarium, Addis Ababa University, Ethiopia and Uppsala University, Sweden; 1989.
37. Amsalu N. An ethnobotanical study of medicinal plants in Farta Woreda, South Gondar Zone of Amhara Region, Ethiopia. M. Sc. Thesis, Addis Ababa University, Ethiopia; 2010.
38. Tabuti JRS, Lye KA, Dhillon SS. Traditional herbal drugs of Bulamogi, Uganda: plants, use and administration. *J Ethnopharmacol.* 2003;88:19–44.
39. Muthu C, Ayyanar M, Raja N, Ignacimuthu S. Medicinal plants used by traditional healers in Kancheepuram District of Tamil Nadu, India. *J Ethnobiol Ethnomed.* 2006;2:43.
40. Giday K, Lenaerts L, Gebrehiwot K, Yirga G, Verbist B, Muys B. Ethnobotanical study of medicinal plants from degraded dry Afromontane forest in northern Ethiopia: Species, uses and conservation challenges. *Journal of Herbal Medicine.* 2016;6:96–104.
41. Abera B. Medicinal plants used in traditional medicine by Oromo people, Ghimbi District, Southwest Ethiopia. *J Ethnobiol Ethnomed.* 2014;10:40.
42. Yineger H, Yewhalaw D. Traditional medicinal plant knowledge and use by local healers in Sekoru District, Jimma Zone, Southwestern Ethiopia. *J Ethnobiol Ethnomed.* 2007;3:24.
43. Gebre T. Ethnobotanical study of traditional medicinal plants and the associated indigenous knowledge of Gamo people: the case of Bonke Woreda, Southern Ethiopia. *Ethiop J Biol Sci.* 2018;17(1):57–77.
44. Getaneh S. Ethnobotanical Studies of Medicinal Plants in Debre Libanos Wereda, North Shewa Zone of Oromia Region, Ethiopia. M. Sc. Thesis. Addis Ababa University; 2009.
45. Yirga G. Assessment of indigenous knowledge of medicinal plants in Central Zone of Tigray, Northern Ethiopia. *Afr J Plant Sci.* 2010;4(1):6–11.
46. Amenu E. Use and Management of Medicinal Plants by Indigenous People of Ejaji area (Chelya Woreda), West Shoa, Ethiopia. An Ethnobotanical Approach. M. Sc. Thesis. Addis Ababa University; 2007.

47. Yineger H, Kelbessa E, Bekele T, Lulekal. E.Plants used in traditional management of human ailments at Bale Mountains National Park, Southeastern Ethiopia. *Journal of Medicinal Plants Research*. 2008;2(6):132–53.
48. Abebe D. Traditional medicine in Ethiopia. The attempts being made to promote it for effective and better utilization. *SINET Ethiop J Sci*. 1986;9:61–9.
49. Getahun A. Some common medicinal and poisonous plants used in Ethiopia folk medicine. Addis Ababa: Addis Ababa University; 1976.
50. Lulekal E. Plant diversity and ethnobotanical study of medicinal plants in Ankober District, North Shewa zone of Amhara Region, Ethiopia. Ph. D. Dissertation, Addis Ababa University; 2014.
51. Trotter RT, Logan MH. Informants consensus: a new approach for identifying potentially effective medicinal plants. In: Etkin NL, editor. *Plants in Indigenous Medicine and Diet*. New York: Redgrave Publishing Company, Bedford Hill;; 1986. 91–112 pp.
52. Megersa M, Asfaw Z, Kelbessa E, Beyene A, Woldeab B. An ethnobotanical study of medicinal plants in Wayu Tuka District, East Welega Zone of Oromia Regional State, West Ethiopia. *J Ethnobiol Ethnomed*. 2013;9:68.

## Figures

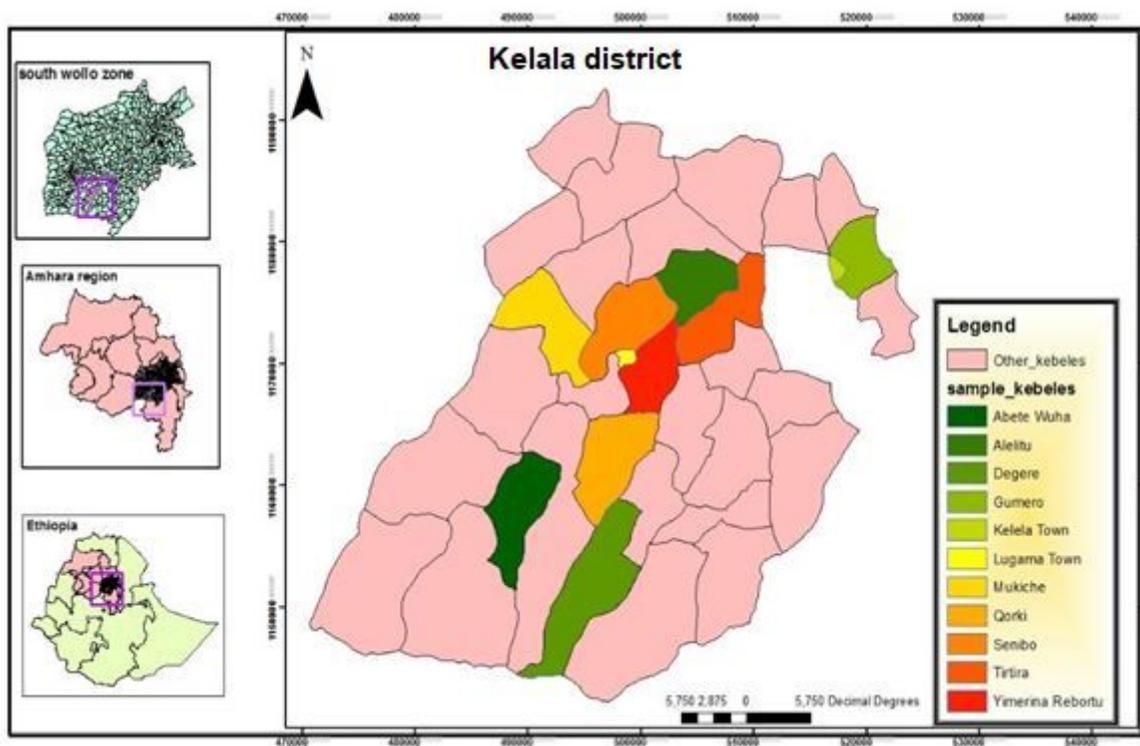
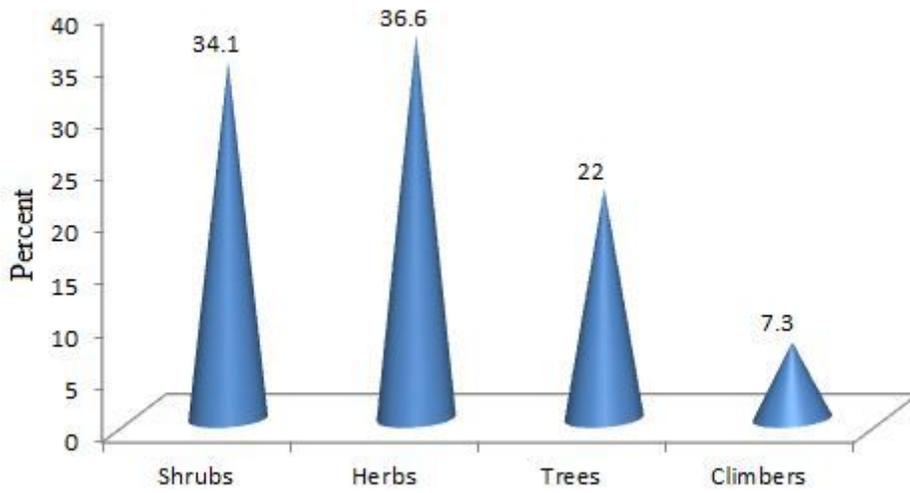


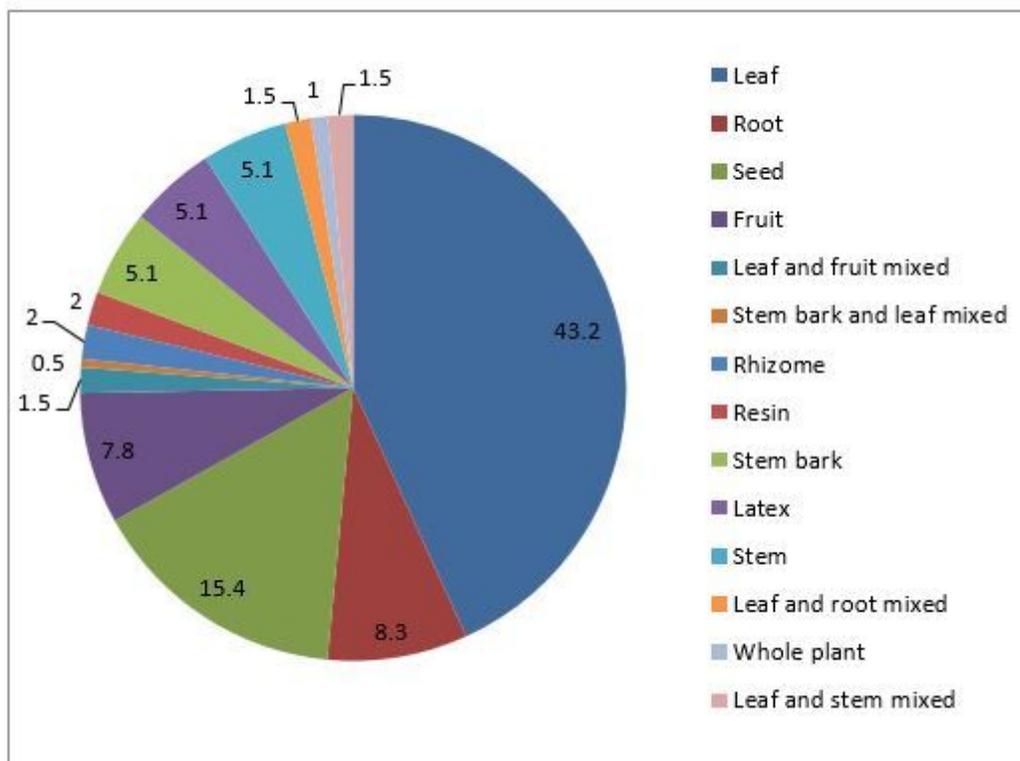
Figure 1

Map of Ethiopia showing the study area



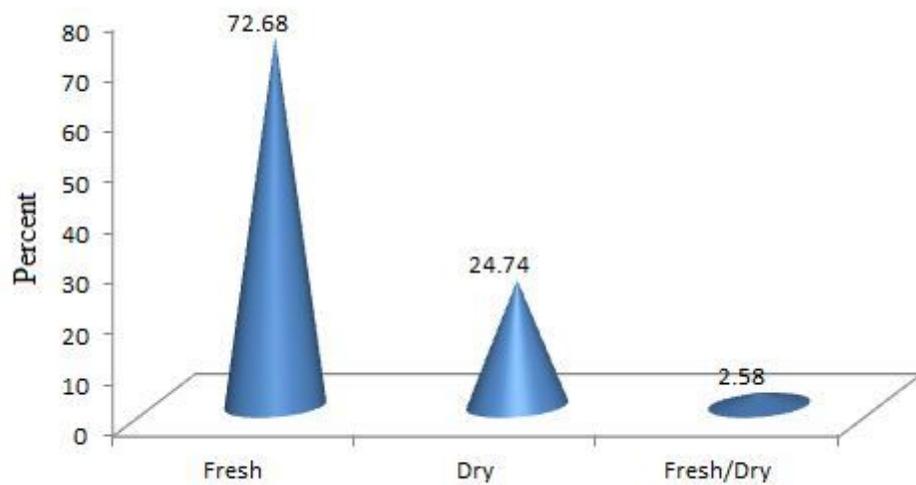
**Figure 2**

Growth form distribution of medicinal plants



**Figure 3**

Percentage distribution of medicinal plant parts used in the study area



**Figure 4**

Condition of medicinal plant preparation