ORIGINAL RESEARCH

Ethnobotanical Assessment and Physicochemical Properties of Commonly Used Medicinal Plants in Jimma Zone, Southwest Ethiopia: Traditional Healers Based Cross-Sectional Study

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Background: The demand for traditional herbal medicine is increasing and about 85% of the world population use herbal medicines for the prevention and treatment of diseases. More than 62.5% of the forest areas in Ethiopia are found in the southwest region, which have been used as a source of traditional medicine to treat different human and livestock ailments. The aim of this study was the investigation of the ethnobotanical and physicochemical properties of commonly used medicinal plants in Jimma zone, southwest Ethiopia.

Materials and Methods: A cross-sectional study was conducted in the district of Jimma zone from June 1 to 30, 2017. The ethnobotanical data were collected from traditional healers through semi-structured questionnaires. Specimens collected from various habitats were taken into Jimma University, Herbarium laboratory, dried, and prepared using standard herbarium specimen techniques for identification. Physicochemical analysis was done for selected medicinal plants.

Results: A total of 72 medicinal plants categorized under 61 genera and 39 families were stated by the respondents for the treatment of different human and livestock ailments. Herbs constitute the largest category (28 species, 38.89%) followed by shrubs (21 species, 29.17%), trees (20 species, 27.78%) and climbers (3 species, 4.17%). Leaves (39.19%) were the most commonly used plant parts followed by roots (27%) and seeds (10.81%). Traditional healers reported processing remedies mainly through crushing (46.91%), powdering (18.52%), pounding (11.11%), and pressing (9.88%). The water-soluble extractive value of the selected medicinal plants were between 1.825 to 18.507%w/w and the alcohol-soluble extractive value were between 0.143 to 1.107%w/w. The moisture content (%LOD) of *Barleria argentea* Balf. f. was higher than the recommended standard which consisted of 21.063% w/w and followed by high %LOD of *Crateva adansonii* D.C. Prodr (8.143%w/w) and *Euphorbia abbyssinica* J.F. Gmel. (16.347%w/w). The highest total ash value was registered in *Dioscorea quartiniana* A.Rich. species which consisted of 18.563%w/w and followed by *Crateva adansonii* D.C. Prodr (16.033%w/w) and *Barleria argentea* Balf. f. (15.648%w/w). High acid-insoluble ash value (7.227%w/w) and water-soluble ash (6.731%w/w) was recorded in *Euphorbia abbyssinica* J.F. Gmel.

Conclusion: The study revealed that the water-soluble extractive value of the selected medicinal plants indicates the presence of water-soluble components such as sugar, acids, and inorganic compounds. In the future, these characters can be used to check the genuine nature of the crude drug; thus, it plays an important role in preventing the possible steps of adulteration.

Keywords: botanical diversity, extractable matter, ash values, moisture content, medicinal plants

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Introduction

Medicinal plants have become an alternative source of remedy for many people all over the world and serve as one of the potential sources for discovery of various active compounds. Pharmaceutical importance of plants has led to exploration of plant extracts which are commonly used in traditional medicine.[1] Approximately 85%[2] of the population use medicinal plants for avoidance and management of diseases, and the demand is increasing in developed and developing countries. Drugs containing compounds obtained from higher plants account for 25%. Only 10% of medicinal plant species are cultivated today while the majority are at risk in the wild.[3]

In many parts of the world where herbal medicines are widely used, certain factors have militated against their inclusion in the mainstream health-care system include poor dosage form design and standardization of products.[4] In recent times there has been an upsurge in the use of herbal medicines, which has become more conventional due to improvement in regulation, analytical and quality control tools as well as advances in clinical research showing great value in general health-care and management of certain diseases in which conventional medicines have not done too well.[5]

Herbal medicines are frequently considered to be safer than conventional medicines because of their better tolerance. But there are reports of side effects and adverse reactions that have been related to herbal medicines.[6] Some of these side effects and adverse reactions are due to the intrinsic bioactive secondary metabolites present in the herbal materials. In addition, poor quality of the products is attributed to contamination (with chemicals, pesticides, microorganisms, and heavy metals), adulteration with pure drug compounds and poor quality control measures. Therefore an acceptable herbal product must be safe, stable and presented in a suitable dosage form and package.[7]

Ethiopia is endowed with diverse biological resources including about 6,500 species of higher plants, with approximately 12% endemic, hence making it one of the six highest plant biodiversity rich regions. More than 62.5% of its forest areas are found in the southwest region of Ethiopia where most of the medicinal plants are confined and have been used as a source of traditional medicine to treat different human and livestock ailments.[3]

Strict quality control of traditional medicine is based largely on the empirical measurement of a few nonspecific physical properties such as pH, viscosity, density etc. But quality control by specific methods still requires authenticity. This problem lies in the process of manufacture of the traditional drugs. According to the WHO cited by Annan et al. 2013, to ensure reproducible quality of herbal plants (or preparations), physicochemical and phytochemical characterizations are required to be carried out for establishing their identity, purity, and quality standards.[8] Physicochemical standards were generally used for deciding the identity, purity and strength of the drug source. These parameters were also used to detect the adulterants if present in the plant material. Physicochemical information could form the basis for further research towards drug discovery and development from medicinal plants.

Therefore, there is a need for documentation of physicochemical investigations for profiling the quality control parameters of medicinal plants/plant-derived crude/herbal drugs. It was revealed that no reports were available on the physicochemical quality of medicinal plants in Ethiopia. Thus, the aim of the current study was investigation of ethnobotanical and physicochemical properties of commonly used medicinal plants in Jimma zone, southwest Ethiopia.

Materials and Methods
Study Area and Study Design

The plant materials were obtained from the Jimma zone, southwest Ethiopia. A map of Jimma zone, Oromia Regional State is presented in Figure 1. Traditional healers found in these zones were identified and selected through contacting community leaders and the administrative staff of the zone. The traditional healers were interviewed to identify the most commonly used medicinal plants/parts/preparation. The plant samples were collected and transported to Jimma University Herbarium laboratory for species identification. Physicochemical analyses of samples were conducted at Jimma University Laboratory of Drug Quality (JULaDQ) and Jimma University, School Pharmacy, Pharmacognosy Laboratory.

A cross-sectional study was conducted in selected district of Jimma Zone from June 1 to 30, 2017. The study sites and kebeles (neighborhoods) were selected based on the prior information gathered from community leaders, knowledgeable elders, especially indigenous resourceful elder people greater than 40 years, health workers, and a number of traditional healers in the area.
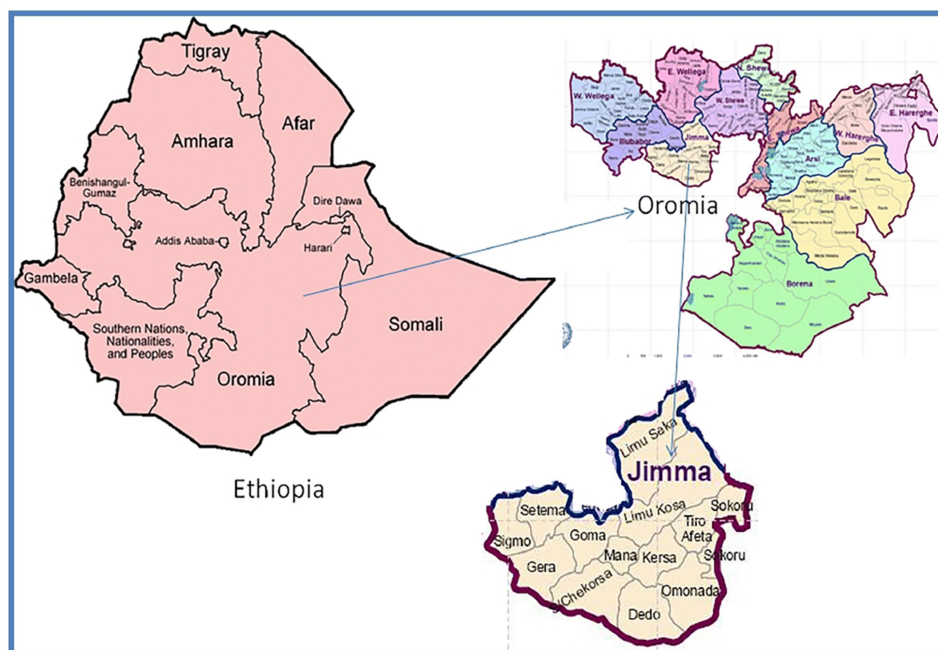
Figure 1 The Map of Jimma zone, Oromia Regional State.
Note: Adapted from Copyright ©2019 Belew S, Suleman S, Mohammed T, et al. Quality of fixed dose artemether/lumefantrine products in Jimma Zone, Ethiopia. *Malar J.*2019;18:236. doi:10.1186/s12936-019-2872-1. [9]

Data Collection and Analysis

Purposeful sampling technique was used for sample survey selection. A total of 82 informants (traditional healers), individuals in the age range of 40 and above (52 male and 30 female), were randomly selected from 12 districts and out of these, 10 key informants (6 male and 4 female medicinal plant practitioners) were selected purposefully with the help of local administrators and community leader from each district. The ethnobotanical data were collected from traditional healers through a semi-structure questionnaire. Group discussion and field observation were also employed to collect ethnobotanical information. Group discussions were conducted to obtain details of the popular medicinal plants, preservation methods, and method of preparation of medicinal plants in the study area. Every traditional healer was asked to list the main diseases he/she treated and the plants used in the treatment, preparation methods, parts used and route of applications. Field walks with traditional healers were employed to collect specimens of each medicinal plant species. Medicinal plant samples were collected from traditional healers' own gardens as well as from field (wild). Based on ethnobotanical information provided by informants, specimens were collected, numbered, pressed, and dried for identification. The completeness of the data was

checked. Errors related to inconsistency were verified using cross tabulation and other data exploration methods. The data were exported to Microsoft Excel, then recoded, categorized and sorted to facilitate analysis. The data were analyzed using Microsoft Excel.

Plant Collection

The reported medicinal plants were collected from natural vegetation (forest) or home gardens with the help of the traditional healers. The collected plant specimens were dried, identified, and deposited at Jimma University Herbarium. Identification of plants were performed by taxonomists using standard procedures. The specimens were identified by comparison with already identified specimens and using taxonomic literatures. All plant names were authenticated using www.worldfloraonline.org or the plantlist.org.

Preference Ranking

Preference ranking was used to rank the popular medicinal plants and medicinal plants used in the treatment of particular ailments in the study area. Each variable was ranked by 10 selected informants. All informants were oriented on each variable and asked to mark the highest value (10) for most preferred and the lowest value (1) for the least

preferred on preparation methods, degree of popular medicinal plants and the healing potential of individual medicinal plants. Finally, the values was summed up, ranked and illustrated using tables.

Fidelity Level Index

Fidelity level index (FL) is used to quantify the importance of a given species for a particular purpose in a given cultural group. In this study, FL was used to determine the relative healing potential of 22 medicinal plants against 4 human ailments based on the proportion of informants' agreement on the use of a given medicinal plant against a given ailment category. The formula used was as follows:

$$FL\% = \frac{Ip}{Iu} \times 100$$

FL% is Percentage of Fidelity Level; Ip is the number of informants that indicated the use of a specific plant to treat a disease category; Iu represents the total number of informants that have confirmed the use of the plant for any category of diseases. High fidelity value is indicative of the frequency of use of a particular plant to treat a specific disease.[10]

Informant Consensus Factor (ICF)

ICF was calculated according to the previously described method[11] and used to determine the similarity of the types of plants used by herbal practitioners in treating various categories of diseases. An ICF value close to 0 or 1 indicates that the choice of plant for a diseases category is random or that the majority of herbal practitioners agree on the use of plants for a particular disease, respectively.

ICF=Nur-Nt/Nur-1

Where Nur is the number of uses reported for a particular disease category, Nt indicates the number of taxa used for a particular disease.

Physicochemical Investigations

Based on the degree of agreement on ranking of 10 medicinal plants and the principle that the plant species are widely known and frequently used for the treatment of a particular ailment among the local community, six medicinal plants were selected for further processing for physicochemical investigation. Physicochemical investigations of each prepared sample was carried out for the determination of total ash, water-soluble ash, acid-insoluble ash, water- and alcohol-soluble extractive values and moisture content which was determined by loss on drying (LOD) method. Physicochemical investigations were performed using WHO standard procedures.[12] Each study was performed in triplicate and mean values with standard deviation (SD) were calculated.

Results
Botanical Diversity

A total of 72 medicinal plants were stated by the respondents for the treatment of different human and livestock ailments and their specimens were collected from the traditional healers' own gardens and from forests. The collected specimens were identified based on herbal standard preparation procedures and categorized under 61 genera and 39 families (Table 1). Family Fabaceae was the largest medicinal plant family used for the treatment of different diseases in the study area, and represented 11 species (15.28%). Family Euphorbiaceae was the second most used group of medicinal plants by the community next to the Fabaceae and consisted of five species (6.94%), followed by Lamiaceae, and Asteraceae which consisted of four species each (5.56%) (Table 2). The presence of such a large number of medicinal plant species and associated ethnomedicinal knowledge in the zone indicates that the area has a very high diversity of medicinal plant species and is a site for varied indigenous knowledge. Analysis of growth forms of these medicinal plants revealed that herbs constitute the largest category (28 species, 38.89%) followed by shrubs (21 species, 29.17%), trees (20 species, 27.78%), and climbers (3 species, 4.17%).

Plant Parts Used

The medicinal plant parts used widely to treat human and livestock ailments include leaves, root, stem, and others. The most commonly used medicinal plant parts for the preparations of the medicines into different dosage forms in the study area were leaves which consisted of 39.19% (n=29) followed by roots and seeds which represented 27% (n=20) and 10.81% (n=8), respectively (Figure 2). Leaves were the most commonly used plant parts by the traditional healers in the herbal preparations which represented 39.19%. This could be due to ease of preparation of medicinal remedies[13] and the presence of more biologically active components in leaves developed in response to phytophagous organisms.[14]

Methods of Preparation, Route of Administration and Application

The traditional practitioners used different methods of preparation and administration for the treatment of different types of human and livestock ailments. The

Table 1 Botanical Identification of Medicinal Plants Collected from Traditional Healers in Jimma zone, Southwest Ethiopia

Family	Scientific Name	Local Names	Growth Habit	Voucher No
Acanthaceae	*Asystasia guttata* (Forssk.) Brummitt	Baquli	Herb	JS101
Acanthaceae	*Barleria argentea* Balf. f.	Hokto	Shrub	JS79
Acanthaceae	*Barleria eranthemoides* R.	Shishi	Shrub	JS80
Alliaceae	*Allium sativum* L.	Qullubbii	Herb	JS75
Aloaceae	*Aloe monticola* Reynolds	Hernias	Herb	JS 3
Aloaceae	*Aloe macrocarpa* Tod	Dheri	Herb	JS 76
Amaranthaceae	*Amaranthus caudatus* L.	Iyyaasuu	Herb	JS102
Amaranthaceae	*Achyranthes aspera* L.	Jibir	Herb	JS70
Apocynaceae	*Carissa edulis* Vahl	Akama	Shrub	JS 16
Apocynaceae	*Carissa spinarum* L.	Hagamsa	Shrub	JS 24
Asteraceae	*Acmella caulirhiza* Del.	Gutichaa	Herb	JS 21
Asteraceae	*Artemisia abyssinica* Sch.Bip.ex.Rich/	Ariti	Herb	JS 35
Asteraceae	*Echinops kebericho*, Mesfin	Qabarichoo	Herb	JS 77
Asteraceae	*Guizotia scabra* (Vis.) Chiov.	Adaa	Shrub	JS 53
Balanitaceae	*Balanites aegyptica* (L.) Del.	Badanna	Tree	JS83
Boraginaceae	*Cynoglossum amplifolium* Hochst. ex DC.	Karchaba	Herb	JS103
Brassicaceae	*Coronopus didymus* (L.) Sm	Surumaa	Shrub	JS 25
Cactaceae	*Opuntia ficus-indica* (L.) Mill.	Nimi	Tree	JS 38
Capparidaceae	*Crateva adansonii* D.C. Prodr	Qolladii	Shrub	JS 04
Capparidaceae	*Ritchiea albersii* Gilg	Arbuu	Tree	JS 27
Capparidaceae	*Cadaba farinose* Forssk.	Galee	Shrub	JS05
Celasteraceae	*Catha edulis* (Vahl)	Chati	Tree	JS112
Chenopodiaceae	*Chenopodium ambroisoides* L.	Ajo	Herb	JS105
Combretaceae	*Combertum paniculatum* Schinz	Baggii	Shrub	JS 07
Crassulaceae	*Kalanchoe densiflora* Rolfe	Endahula	Herb	JS 61
Cucurbitaceae	*Coccinia grandis* (L.) Voigt	Gale	Herb	JS111
Cucurbitaceae	*Cucumis dipsaceus* Ehrenb. ex Spach	Kurera	Herb	JS89
Cucurbitaceae	*Cucurbita pepo* L.	Buqqee	Herb	JS 06
Dioscoreaceae	*Dioscorea quartiniana* A. Rich.	Gishu	Tree	JS104
Dracenaceae	*Sansevieria ehrenbergii* Schweinf. ex Bak.	Muka koricha	Herb	JS114
Euphorbiaceae	*Croton macrostachyus* Del.	Bakkannisa	Tree	JS 38
Euphorbiaceae	*Euphorbia abbyssinica* J.F. Gmel.	Adaamii	Tree	JS36
Euphorbiaceae	*Euphorbia dumalis* S. Carter	Dargu adi	Shrub	JS115
Euphorbiaceae	*Euphorbia heterophylla* L.	Ananole	Herb	JS123
Euphorbiaceae	*Justicia schimperiana* (Nees) T. Anderson	Loomii	Tree	JS 42
Fabaceae	*Acacia abyssinica* Hochst ex.Benth.	Laaftoo	Tree	JS 26
Fabaceae	*Acacia hockii* De Wild	Chaqkent	Shrub	JS 62
Fabaceae	*Acacia mellifera* (Vahl) Benth.	Dille	Shrub	JS72
Fabaceae	*Albizia anthelmintica* Brongn.	Dheta	Tree	JS69
Fabaceae	*Albizia schimperiana* Oliv.	Imalaa	Tree	JS 65
Fabaceae	*Caesalpinia volkensii* Harms	Sidika	Climber	JS107
Fabaceae	*Calpurnia subdecandra* (L'Herit.) Schweick.	Ceeqa	Shrub	JS 28
Fabaceae	*Erythrina abyssinica* Lam. Ex. DC.	Beroo	Tree	JS 63
Fabaceae	*Indigofera dauensis* Gillett	Korsa Birti	Herb	JS08
Fabaceae	*Pterolobium stellatum* (Forssk.)	Kejima	Climber	JS119
Fabaceae	*Taverniera abyssinica* A. Rich.	Dingatagna	Shrub	JS 18
Lamiaceae	*Ajuga integrifolia* Buch.-Hamn.	Armaguusa	Herb	JS 29
Lamiaceae	*Clerdendrum myricoides* Hochst	Maraasisa	Shrub	JS 32
Lamiaceae	*Ocimum gratissimum* L.	Damakase	Shrub	JS11
Lamiaceae	*Ocimium lamifolium* Hochst. Ex. Benth.	Hancabbii	Herb	JS 15
Lauraceae	*Cassytha filliformis* L.	Korsa buda	Climber	JS122

(*Continued*)

Table 1 (Continued).

Family	Scientific Name	Local Names	Growth Habit	Voucher No
Loganiaceae	*Buddleja polystachya* Fresen.	Hanfaaree	Tree	JS 31
Melianthaceae	*Bersama abyssinica* Fresen.	Lolchiisaa	Shrub	JS 12
Moraceae	*Ficus sycomorus* L.	Odaa	Tree	JS 85
Muluginaceae	*Glinus lotoides* L.	Mataharree	Herb	JS81
Myrsinaceae	*Maisa lanceolata* Forssk.	Abbayii	Tree	JS90
Myrtaceae	*Eucalyptus globules* labing	Bargamoo Adii	Tree	JS 48
Poaceae	*Cynodon dactylon* L. Pers.	Coqorsa adii	Herb	JS 30
Poaceae	*Cynodon nlemfuensis* Vanderyst	Coqorsa gurraacha	Herb	JS 46
Phytolaccaceae	*Phytolocca dodecandra* L 'Hert.	Andoodee	Herb	JS 34
Plumbaginaceae	*Plumbago zeylanica L.*	Martus	Herb	JS 41
Polygalaceae	*Rumex neppalensis* Spreng	Tult	Herb	JS 10
Polygalaceae	*Securidica longipedunculata* Fresen	Etsamanaay	Tree	JS 13
Ranunculaceae	*Nigella sativa* L.	Gurra	Shrub	JS 22
Rocaceae	*Prunus africana* (Hook. f.) Kalkman	Hoomii	Tree	JS 37
Rubiaceae	*Coffee arabica* L.	Buna	Tree	JS20
Rutaceae	*Clausena anisata* (Wild.) Benth.	Ulumaa'i	Tree	JS 39
Rutaceae	*Ruta chalepensis* L.	Cilaattama	Herb	JS 44
Simarobouceae	*Brucea antidysentrica* J.F.Mill.	Qomonyo	Shrub	JS47
Solanaceae	*Datura stramonium* L.	Asaangira	Shrub	JS 56
Solanaceae	*Withania somnifera* L. Dunal	Kumo	Shrub	JS 55
Zingibiraceae	*Zingiber officinale* Roscoe	Zinjibila	Herb	JSI7

preparation and administration systems differ based on the type of condition treated and the location of the disease. In this study, oral route of administration is the most commonly used route of application of the medicinally important plant parts in the study area which consisted of 47 herbal remedies and this was followed by topical and nasal routes of administration which represented 14 and 4 herbal therapies, respectively (Table 3). During group discussion sessions, most informants reported that they preserved the plant material that they could not find in the dry or rainy season in various ways like pounding and saving the powder or hanging the intact plant material in the kitchen. Traditional healers reported processing remedies mainly through crushing (46.91%), powdering (18.52%), pounding (11.11%), and pressing (9.88%) (Table 4). Pounding and powdering are effective for the complete extraction of the potential content of the plant and increase the curative power of the medicine or its efficacy, as both increase the healing power of the remedy through faster physiological reaction.

According to the discussions made with traditional healers the preparations made were drawn from mixtures of different plant species with different additive substances such as honey, sugar, teff flour, butter, soda ash, salt, ground honey, soil, and charcoal ash for the treatment of

single ailment (data not given). These additive substances had been reported to have a double function i.e. to improve flavour and reduce adverse effects such as vomiting and diarrhea, and enhance the efficacy and healing conditions.

In addition to the medicinal plants commonly used by the traditional healers for the treatment of different diseases, there were also reports of different diseases that the medicinal plants were prescribed for. The most common disease in which the herbal preparations were prescribed for were gonorrhea in which a total of six different medicinal remedies were prescribed and treated by the traditional healers. This was followed by remedies for diarrhoea and evil spirit which consisted of five medicinal plants reported as effective means of treatment of these cases. Also, four medicinal floras were reported as effective means of treatment of malaria.

Preference Ranking
The degree of agreement on ranking of 10 medicinal plants based on the principle that the plant species are widely known and frequently used for the treatment of a particular ailment among the local community is indicated in Table 5. *Barleria argentea* Balf. f. scored the highest points and ranked first followed by *Dioscorea quartiniana* A.Rich. and *Euphorbia abbyssinica* J.F. Gmel. species as

Table 2 Medicinal Plant Families in the Study Area with the Corresponding Numbers of Species

S. No	Families	Numbers of the Species	Percentage of the Species
1	Acanthaceae	3	4.17%
2	Alliaceae	1	1.39%
3	Aloaceae	2	2.78%
4	Amaranthaceae	2	2.78%
5	Apocynaceae	2	2.78%
6	Asteraceae	4	5.56%
7	Balanitaceae	1	1.39%
8	Boraginaceae	1	1.39%
9	Brassicaceae	1	1.39%
10	Cactaceae	1	1.39%
11	Capparidaceae	3	4.17%
12	Celasteraceae	1	1.39%
13	Chenopodiaceae	1	1.39%
14	Combretaceae	1	1.39%
15	Crassulaceae	1	1.39%
16	Cucurbitaceae	3	4.17%
17	Dioscoreaceae	1	1.39%
18	Dracenaceae	1	1.39%
19	Euphorbiaceae	5	6.94%
20	Fabaceae	11	15.28%
21	Lamiaceae	4	5.56%
22	Lauraceae	1	1.39%
23	Loganiaceae	1	1.39%
24	Melianthaceae	1	1.39%
25	Moraceae	1	1.39%
26	Muluginaceae	1	1.39%
27	Myrsinaceae	1	1.39%
28	Myrtaceae	1	1.39%
29	Poaceae	2	2.78%
30	Phytolaccaceae	1	1.39%
31	Plumbaginaceae	1	1.39%
32	Polygalaceae	2	2.78%
33	Ranunculaceae	1	1.39%
34	Rocaceae	1	1.39%
35	Rubiaceae	1	1.39%
36	Rutaceae	2	2.78%
37	Simarobouceae	1	1.39%
38	Solanaceae	2	2.78%
39	Zingibiraceae	1	1.39%
	Total	72	

widely known by the large local community and even prepared and used at family level.

Traditional Healers' Consensus on Treating Different Human Ailments

High degree of consensus (ICF = 0.87) was observed among the traditional healers in treating malaria; this disease was treated by employing *Allium sativum* L., *Carissa spinarum* L., *Cadaba farinose* Forssk., *Croton macrostachyus* Del., and *Withania somnifera* (L.) Dun. (Table 6). Traditional healers agreed more in the treatment of diarrhea (ICF = 0.78), gonorrhea (ICF = 0.65) and evil spirit (ICF = 0.44). The species with the highest level of fidelity (FL = 100%) is in treatment of malaria. The highest fidelity level was recorded on the use of *Carissa spinarum* L., *Cadaba farinose* Forssk., *Coffea arabica* L., *Dioscorea quartiniana* A.Rich., *Catha edulis* (Vahl), *Cucurbita pepo* L., *Artemisia abyssinica*, *Taverniera abyssinica* A. Rich, by traditional healers of the study area to treat malaria, diarrhea, gonorrhea and evil spirit, respectively.

Physicochemical Analysis

Based on the degree of agreement on ranking of 10 medicinal plants and the principle that the plant species are widely known and frequently used for the treatment of a particular ailment among the local community, the top six medicinal plants were selected for further processing for physicochemical investigation (Table 7). The plant parts were dried, powdered, and passed through a sieve and appropriate amounts of the sample were taken to undergo analysis.

Determination of Extractable Matter

The average concentration of water-soluble extractive value and alcohol-soluble extractive value of the extracted medicinal plants included in this study is summarized in Table 8. Accordingly, water-soluble extractive value of *Euphorbia abbyssinica* J.F. Gmel. was higher than the rest at 18.53%w/w and followed by *Dioscorea quartiniana* A.Rich. and *Barleria argentea* Balf. f. which represented 18.507 and 16.217%w/w average concentration of water-soluble extractive value, respectively. A lower average concentration of water-soluble extractive value was detected in *Cadaba farinose* Forssk. (1.825%w/w). These results show the presence of water-soluble additives like sugar, acids, and inorganic compounds, etc. The average concentration of alcohol-soluble extractive value of *Cadaba farinose* Forssk. was high at 1.107%w/w and followed by *Crateva adansonii* D.C. Prodr and *Dioscorea quartiniana* A.Rich. with 0.33 and 0.329%w/w, respectively. These indicates the presence of contents such as phenols, alkaloids, steroids, glycosides, and flavonoids. Comparing the water-soluble and alcohol-soluble
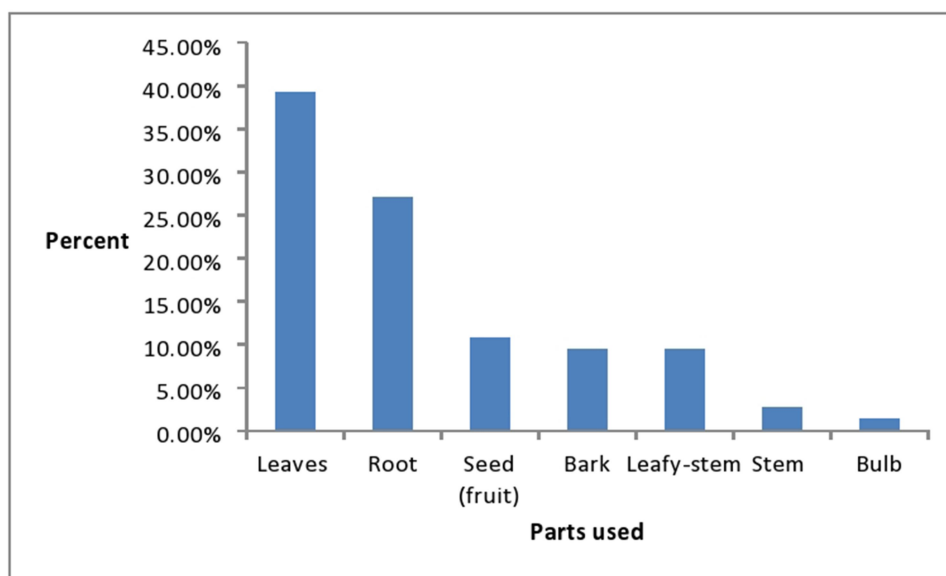
Figure 2 The medicinal plant parts used widely to treat human and livestock ailments.

extractive values of the medicinal plants, it was concluded that the percent water-soluble extractive values were higher than the alcohol-soluble extractive values; these indicates presence of more amounts of water-soluble contents in the plants.

Determination of Moisture Contents

The results of the moisture content determinations are presented in Table 8. The moisture content (%LOD) of *Barleria argentea* Balf. f. was higher than the recommended standard at 21.063%w/w and followed by high %LOD of *Crateva adansonii* D.C. Prodr and *Euphorbia abbyssinica* J.F. Gmel. which represented 18.143 and16.347%w/w, respectively (Table 8). This shows that the drugs developed high moisture contents after being properly dried and stored. Only one medicinal plant has normal moisture content, this being *Cadaba farinose* Forssk. (4.876%w/w). Moisture content (%LOD) is mainly used to regulate the pleasantness of herbal preparations. The pharmacopoeial monographs limit the water content material in vegetable sources to between 8% and 14%.

Determination of Ash Contents

The purity of herbal extracts can also be assessed by determination of ash values which constitute the content of foreign matter together with inorganic salts or silica present as a shape of adulterant within the drug sample. In this study, the highest total ash value was registered in

Dioscorea quartiniana A.Rich. species which consisted of 18.563%w/w and followed by *Crateva adansonii* D.C. Prodr and *Barleria argentea* Balf. f. with 16.033 and 15.648%w/w, respectively (Figure 3). This shows the presence of physiological ash that is derived from the plant tissue itself, and non-physiological ash.

The acid-insoluble ash value of *Euphorbia abbyssinica* J.F. Gmel. was higher than the rest at 7.227%w/w and followed by the acid-insoluble ash value of *Croton macrostachyus* Del. *and Dioscorea quartiniana* A.Rich. with 7.217 and 6.975%w/w (n=3), respectively. This indicates the presence of sand and siliceous earth. The amount of water-soluble ash was approximately equal to the acid-insoluble ash value with the highest result frequently observed for *Euphorbia abbyssinica* J.F. Gmel. species with 6.731%w/w (n=3). The average concentration of water-soluble ash for *Dioscorea quartiniana* A.Rich. species was relatively equal with the value of *Euphorbia abbyssinica* J.F. Gmel. with 6.398%w/w (n=3). The results of acid-insoluble ash values and water-soluble ash values of the selected medicinal plants are summarized in Figure 3.

Discussion

This study revealed that 72 medicinal plants were stated by the respondents for the treatment of different human and livestock ailments and their specimens were collected from the traditional healers' own gardens and from forests. The collected specimens were identified based on herbal

Table 3 Uses, Preparation Method and Route of Administration of Medicinal Plants Commonly Used in the Study Area

Scientific Name	Preparation Method	Uses	Human/ Livestock	Route of Application
Asystasia guttata (Forssk.) Brummitt	Fresh or dry root of this plant is crushed and homogenized in water and the patient drinks it	Diarrhea	Human	Oral
Barleria argentea Balf. f.	Fruit is crushed and mixed with water and the patient drinks it	Diarrhea	Human	Oral
Barleria eranthemoides R.	Root is crushed, boiled and the patient drinks it	Stabbing pain	Human	Oral
Allium sativum L.	Bulb of this plant is powdered and consumed with honey	Malaria	Human	Oral
Aloe monticola Reynolds	Root is powdered and mixed with water and the patient drinks it	Anthrax	Human	Oral
Aloe macrocarpa Tod	Leaf of this plant is milled and mixed with honey and consumed by the patient	Wart	Human	Oral
Amaranthus caudatus L.	Leaf is crushed and boiled with water and drunk by the patient	Diarrhea	Human	Oral
Achyranthes aspera L.	Leaf is crushed, boiled and drunk by the patient	Itching sore	Human	Oral
Carissa edulis Vahl	Roots are boiled with water. A concentrated substance of the roots is used to treat malaria	Malaria	Human	Oral
Carissa spinarum L.	Fresh root of this plant is powdered and mixed with local alcohol and the patient drinks it	Impotence Stomach-ache Gonorrhea, Headache	Human	Oral
Acmella caulirhiza Del.	Flower of this plant is chewed and spitted for tonsillitis	Tonsillitis	Human	Sublingual
Artemisia abyssinica Sch.Bip.ex. Rich/	Fresh root of this plant is milled and mixed with water and the patient smells and drinks it	Evil spirit	Human	Oral+Nasal
Echinops kebericho, Mesfin	Dry root of this plant is crushed and mixed with coffee and the patient drinks and brushes teeth with it	Toothache Vomiting Headache	Human	Oral +Sublingual
Guizotia scabra (Vis.) Chiov.	Leaf of this plant is pressed and drops are prepared and applied on the wound	Wound	Human	Topical
Balanites aegyptica (L.) Del.	Fresh or dry root of this plant is crushed and solubilized in water and the patient smells and drinks it	Evil spirit	Human	Oral+Nasal
Cynoglossum amplifolium Hochst. ex DC.	Fresh leaf of this plant is crushed and mixed with water and the patient smells it	General malaise	Human	Nasal
Coronopus didymus (L.) Sm	Leafy-stem of this plant is dried in sunlight, crushed and mixed with ingredient and the patient drinks it	Bone fracture	Human	Oral
Opuntia ficus-indica (L.) Mill.	Leaf of this plant is crushed and smoked in places where mosquitoes are present	Insecticidal	Human	Smoking
Crateva adansonii D.C. Prodr	Dry root of this plant is milled and solubilized with water and the patient drinks it	Gonorrhea	Human	Oral
Ritchiea albersii Gilg	The seed of this plant is powdered and mixed with hot water and drunk	Cough	Human	Oral
Cadaba farinose Forssk.	Young leaves are crushed and the juice drunk to treat malaria	Malaria	Human	Oral

(*Continued*)

Table 3 (Continued).

Scientific Name	Preparation Method	Uses	Human/ Livestock	Route of Application
Catha edulis (Vahl)	Fresh leaf is crushed and boiled with water and the patient drinks it	Gonorrhea	Human	Oral
Chenopodium ambroisoides L.	Dry leaf or stem of this plant is crushed, mixed with water and creamed on the hair	Dandruff	Human	Topical
Combertum paniculatum Schinz	Bark latex of this plant is powdered and mixed with table salt and creamed on affected skin	Ringworm	Human	Topical
Kalanchoe densiflora Rolfe	Fresh leaves of this plant are pressed, and drops are applied on the wound	Gonorrhea	Human	Topical
Coccinia grandis (L.) Voigt	Fresh or dry root of this plant is crushed and homogenized with water and applied to the infected site	Kidney infection	Human	Topical
Cucumis dipsaceus Ehrenb. ex Spach	Fresh fruit of this plant is crushed and extracted and drunk by the patient	Meningitis Hemorrhoids Rabies	Human	Oral
Cucurbita pepo L.	Seed powder is mixed with water and filtered and the patient drinks it. Fresh leaves of this plant are crushed and homogenized with water and drunk by cattle	Gonorrhea Epilepsy in cattle	Human Livestock	Topical Oral
Dioscorea quartiniana A. Rich.	Fresh or dry root of this plant is crushed and homogenized with water and the patient drinks it. Fresh root of this plant is crushed and boiled with water and the cattle drink it	Vomit & diarrhea Kidney infection Side pain	Human Livestock	Oral Oral
Sansevieria ehrenbergii Schweinf. ex Bak.	Fresh or dry root or bark of this plant is crushed and tied on the swelling part	Swelling	Human	Topical
Croton macrostachyus Del.	Leafy-stem of this plant is crushed, mixed with water and butter and applied to the infected area and wound. The powder is mixed with water and the patient drinks it for the treatment of malaria	Wound Gonorrhea Malaria	Livestock Human Human	Topical Oral
Euphorbia abbyssinica J.F. Gmel.	Fresh bark of this plant is concentrated after being boiled with water and the patient drinks it	Gastrointestinal, Gonorrhea	Human	Oral
Euphorbia dumalis S. Carter	Fresh root of this plant is powdered and mixed with water and the patient drinks it	Liver case	Human	Oral
Euphorbia heterophylla L.	Fresh stem of this plant is crushed and extracted, part is applied on the hair	Dandruff	Human	Topical
Justicia schimperiana (Nees) T. Anderson	Dry or fresh seed of this plant is crushed and mixed with water and taken by the patient	Rabies	Human	Oral
Acacia abyssinica Hochst ex. Benth.	Fresh leaf of this plant is crushed and the juice is made by mixing with honey or sugar and the patient drinks it	Goitre	Human	Oral
Acacia hockii De Wild	The leaves are crushed and mixed with water and drunk by animals	Livestock medicines	Livestock	Oral
Acacia mellifera (Vahl) Benth.	Fresh leaf of this plant is powdered and dissolved with ingredients and then applied to the infected area	Body infection	Human	Topical

(*Continued*)

Table 3 (Continued).

Scientific Name	Preparation Method	Uses	Human/ Livestock	Route of Application
Albizia anthelmintica Brongn.	Dry bark of this plant is pounded and mixed with honey and coffee and eaten by the patients	Tape worm	Human	Oral
Albizia schimperiana Oliv.	Fresh root of this herb is dried, pounded and put on a fire and the smoke is used by the patient. Root of *A. schimperiana* is powdered and the powder is rolled in clean cloth and tied to the neck of equines.	Evil eye Swelling	Human	Nasal
Caesalpinia volkensii Harms	Dry seed of this plant is crushed and dissolved with water and the patient drinks it	Infertility problem in females	Human	Oral
Calpurnia subdecandra (L'Herit.) Schweick.	Fresh leaf of this vegetable is crushed and applied on the inflamed area	Skin diseases	Human	Topical
Erythrina abyssinica Lam. Ex. DC.	Fresh bark of this herb is powdered and mixed in water and the patient drinks it	Abdominal distension, and cramp	Human	Oral
Indigofera dauensis Gillett	Dry or fresh root of this shrub is crushed and tied on the body of the patient	Evil eye	Human	Topical
Pterolobium stellatum (Forssk.)	Fresh leaf of this plant is crushed and the patient drinks it with water. Fresh or dry root of this plant is crushed and boiled with water and the patient drinks it	Sore throat, Sharp pain	Human	Oral Oral
Taverniera abyssinica A. Rich,	Dry root of this plant is smoked close to the patient	Spiritual disease	Human	Nasal
Ajuga integrifolia Buch.-Hamn.	Dry leaf of this herb is milled and mixed with fat and the patient drinks it	Internal Parasite Epilepsy	Human	Oral
Clerdendrum myricoides Hochst	Fresh leaf of this vegetable is extracted by the process of maceration and the patient drinks it	Constipation General malaise	Human	Oral
Ocimum gratissimum L.	Fresh leaf of this herbal is pressed and drops are applied to the inflamed area	Allergic	Human	Topical
Ocimium lamifolium Hochst. Ex. Benth.	Fresh leaf of this plant is crushed and smelled	Headache	Human	Nasal
Cassytha filliformis L.	Fresh or dry root of this plant is crushed and the patient inhales and drinks with water	Evil eye	Human	Nasal+ oral
Buddleja polystachya Fresen.	Fresh leaf of this shrub is squashed and spat on cattle's eyes	Eye disease	Livestock	Topical
Bersama abyssinica Fresen.	Fresh leafy-stem of this plant is pressed and applied on the affected area	Wound	Human	Topical
Ficus sycomorus L.	Fluid is collected from bark surface of this plant and applied on inflamed area	Hepatitis	Human	Topical
Glinus lotoides L.	Leafy-stem of this herb is powdered and their juice is prepared by mixing with sweetening agent and the patient drinks it	Tape worm	Human	Oral

(*Continued*)

Table 3 (Continued).

Scientific Name	Preparation Method	Uses	Human/ Livestock	Route of Application
Maisa lanceolata Forssk.	Fresh or dry bark of this plant is milled and mixed with fat and applied to the affected area	Elephantiasis	Livestock	Oral
Eucalyptus globules labing	Fresh leaf of this plant is crushed and boiled in water and the patient drinks it	Influenza Allergic	Human	Oral
Cynodon dactylon L. Pers	Fresh leafy-stem is collected and given to cattle	Bone fracture	Livestock	Oral
Cynodon nlemfuensis Vanderyst	Fresh leaf stem is crushed by teeth	Tonsillitis	Human	Oral
Phytolocca dodecandra L 'Hert.	Fresh leaf is pressed and juice is prepared and the patient drinks it	Sinus Anemia	Human	Oral
Plumbago zeylanica L.	Fresh leaf is pressed and juice is prepared and the patient drinks it	Cancer	Human	Oral
Rumex neppalensis Spreng	Dry or fresh root is powdered and mixed with coffee and the patient drinks it	Stomach pain	Human	Oral
Securidica longipedunculata Fresen	Dry and fresh root is milled and homogenized with water and the patient drinks it	Intestinal parasite	Human	Oral
Nigella sativa L.	Dry seed of this plant is powdered and mixed with water and the patient drinks it	Headache	Human	Oral
Prunus africana (Hook. f.) Kalkman	Fresh bark of this plant is extracted with water and juice is made and the patient drinks it	Prostate gland hypertrophy	Human	Oral
Coffee arabica L.	The seed of coffee is roasted and milled and mixed with honey and consumed by the patient	Diarrhea	Human	Oral
Clausena anisata (Wild.) Benth.	Fresh leaf of this plant is crushed and applied to the irritated area	Skin irritation	Human	Topical
Ruta chalepensis L.	Fresh leaf of this plant is crushed and drunk by the patient with alcohol	Stomach-ache	Human	Oral
Brucea antidysentrica J.F.Mill.	Fresh leaf of this plant is powdered and homogenized with water	Parasite	Human	Topical
Datura stramonium L.	Fresh leafy-stem is pressed and droplets are prepared with fat	Wart, Toothache	Human	Sublingual
Withania somnifera L. Dunal	Fresh of leaf is pounded, and juice is prepared and the patient drinks it	Malaria	Human	Oral
Zingiber officinale Roscoe	Fresh leafy-stem of this herb is powdered and mixed with gargle and other ingredients and drunk by the patient	Influenza, Internal Parasite	Human	Oral

standard preparation procedures and categorized under 61 genera and 39 families. Family Fabaceae was the largest medicinal plant family used for the treatment of different diseases in the study area, representing 11 species (15.28%). This finding was similar to the ethnobotanical studies reported from different areas of Ethiopia which also showed that family Fabaceae is the largest medicinal family mostly used by the local healers for healing common diseases.[3,15,16] This could be attributed to their wider spreading, abundance, and rich bioactive constituents of medicinal plants in Ethiopia. Family Euphorbiaceae was the second most used group of medicinal plants by the

Table 4 Mode of Preparation of Medicinal Plants

Methods of Preparation	Frequency	Percentage (%)
Pounding	9	11.11
Crushing	38	46.91
Powdering	15	18.52
Chewing	2	2.47
Burning and inhaling	2	2.47
Extraction	5	6.17
Boiling	2	2.47

Table 6 Healers' Consensus Factor and Fidelity Levels

Ailments	ICF	Species	FL
Gonorrhea	0.65	*Carissa spinarum* L.	36.5
		Crateva adansonii D.C. Prodr	48.7
		Catha edulis (Vahl)	74.3
		Kalanchoe densiflora Rolfe	21.9
		Cucurbita pepo L.	53.6
		Croton macrostachyus Del.	19.5
		Euphorbia abyssinica J.F. Gmel.	46.3
Diarrhoea	0.78	*Asystasia guttata* (Forssk.) Brummitt	74.3
		Barleria argentea Balf. f.	40.2
		Amaranthus caudatus L.	65.8
		Dioscorea quartiniana A.Rich.	80.5
		Coffea arabica L.	86.6
Evil spirit	0.44	*Artemisia abyssinica* Sch.Bip.ex.Rich/	76.8
		Balanites aegyptica (L.) Del.	28.1
		Albizia schimperiana Oliv.	65.85
		Indigofera dauensis Gillett	30.5
		Taverniera abyssinica A. Rich,	71.9
Malaria	0.87	*Allium sativum* L.	78.1
		Carissa spinarum L.	100
		Cadaba farinose Forssk.	90.2
		Croton macrostachyus Del.	75.6
		Withania somnifera (L.) Dun.	19.5

community next to the Fabaceae, consisting of five species (6.94%), followed by Lamiaceae and Asteraceae which consisted of four species each (5.56%).

The medicinal plant parts used widely to treat human and livestock ailments include leaves, root, stem, and others. The most commonly used medicinal plant parts for the preparation of medicines into different dosage forms by the traditional healers in the study area were leaves which consisted of 39.19% followed by roots and seeds which represented 27% and 10.81%, respectively. This could be due to the ease of preparation of medicinal remedies from leaves[13] and the presence of more biologically active components in leaves due to phytophagous organisms.[14] This result is agree with the study reported in other parts of Ethiopia in which leaves were most commonly used to treat various human and livestock diseases.[3,15,16]

The use of more than one species was stated by the traditional practitioners to treat human and animal diseases, which could be attributed to the additive or synergistic effects of the mixtures.[17] Similarly, a study in South Africa indicated that herbs and shrubs plant species were essential foundations for complementary and alternative

medicines.[18] Conversely, a study done in southern Ethiopia showed that 30% of documented medicinal floras were trees and in addition various authors reported that conventional medicine includes information of human and livestock ailment treatments.[19]

Traditional healers reported processing remedies mainly through crushing (46.91%), powdering (18.52%), pounding (11.11%), and pressing (9.88%). Pounding and powdering are effective for the complete extraction of the

Table 5 Ranking of 10 Medicinal Plants Known in the Study Area by the Traditional Healers as Responded by 10 Informants

Species Scientific name(s)	*R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	Total	Rank
Barleria argentea Balf. f.	10	9	8	8	9	9	10	9	9	10	108	1
Dioscorea quartiniana A.Rich.	9	8	10	8	7	7	9	7	9	8	96	2
Croton macrostachyus Del.	5	6	7	5	8	6	6	7	6	7	75	5
Phytolocca dodecandra L'Hert	4	5	6	7	5	4	3	5	4	3	57	9
Euphorbia abyssinica J.F. Gmel.	8	7	6	8	6	8	1	6	8	7	89	3
Cadaba farinose Forssk.	5	6	4	7	6	6	7	5	5	7	69	6
Coronopus didymus (L.) Sm	4	5	5	6	7	4	5	6	7	4	62	8
Ocimum gratissimum L.	6	7	5	5	6	4	6	5	5	5	65	7
Glinus lotoides L.	4	6	7	7	4	8	3	2	1	3	56	10
Crateva adansonii D.C. Prodr	6	7	7	5	8	7	6	6	5	7	76	4

*R = Respondent.

**Table 7** Selected Medicinal Plants for Further Processing for Physicochemical Investigation

S. No.	Local Name	Plant Name	Parts Used	Disease(s) Treated
1	Hokto	*Barleria argentea* Balf. f.	Fruit	Diarrhea
2	Gishu	*Dioscorea quartiniana* A.Rich.	Fresh or dry root	Diarrhea
3	Adaamii	*Euphorbia abyssinica* J.F. Gmel.	Bark	Gonorrhea
4	Qolladii	*Crateva adansonii* D.C. Prodr	Dried root	Gonorrhea
5	Bakkannisa	*Croton macrostachyus* Del.	Powdered leafy-stem	Malaria
6	Galee	*Cadaba farinose* Forssk.	Young leaves	Malaria

Table 8 Extractive Matters and Moisture Contents of the Selected Medicinal Plants in Southwest Ethiopia (Mean (%w/w) ± SD)

S. No	Plant Name	Water Extractable Values (n=3)	Alcohol Extractable Values (n=3)	Moisture Contents (n=3)
1	*Barleria argentea* Balf. f.	16.217±4.018	0.166±0.116	21.063±0.988
2	*Dioscorea quartiniana* A.Rich.	18.507±3.475	0.329±0.215	15.397±5.716
3	*Euphorbia abyssinica* J.F. Gmel.	18.53±1.19	0.143±0.067	16.347±6.829
4	*Crateva adansonii* D.C. Prodr	14.515±3.191	0.33±0.115	18.143±4.582
5	*Croton macrostachyus* Del.	15.185±2.09	0.271±0.0996	15.73±4.148
6	*Cadaba farinose* Forssk.	1.825±0.559	1.107±0.111	4.876±0.999

potential content of the plant and increase the curative power of the medicine or its efficacy, as both increase the healing power of the remedy through faster physiological reaction. The traditional practitioners used different methods of preparation and administration for the treatment of different types of human and livestock sicknesses. The preparation and administration systems differ based on the type of ailment treated and the location of the disease. In this study, oral route of administration is the most commonly used route of application of the
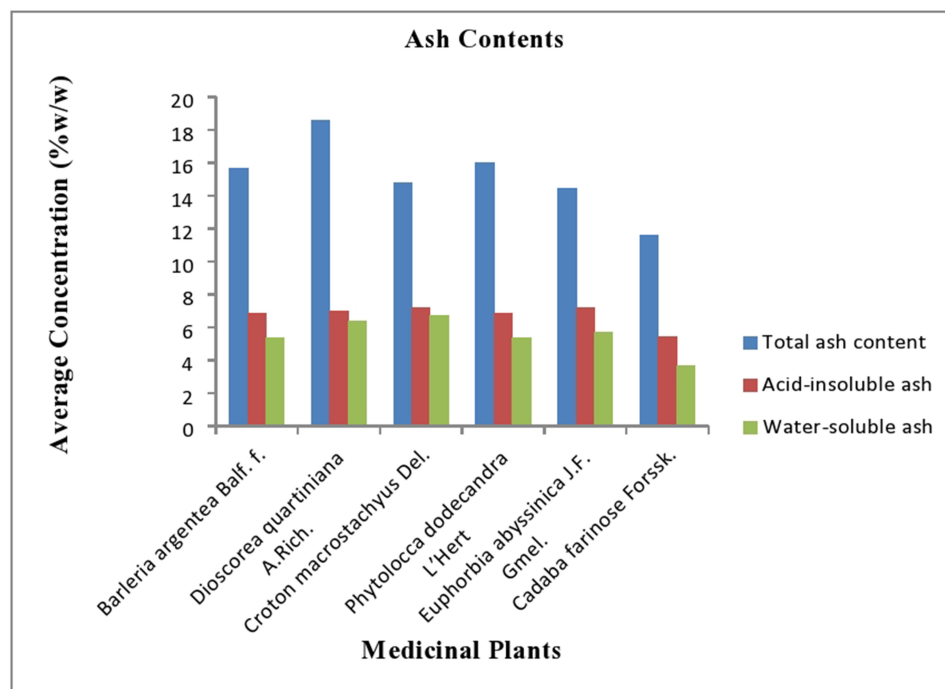
Figure 3 Total ash content, acid-insoluble ash, and water-soluble ash of the selected medicinal plants Southwest Ethiopia.

medicinally important plant partswhich consisted of 47 herbal remedies and this was followed by topical nasal routes of administration which represented 14 and 4 herbal therapies, respectively. Similar results were reported in other parts of Ethiopia in which oral route of administration is the most commonly used route for application of herbal preparations by the traditional practitioners.[3,16]

In addition to the medicinal plants commonly used by the traditional healers for the treatment of different diseases, there were also report of different diseases that the medicinal plants were prescribed for. The most common disease in which the herbal preparations were prescribed for were gonorrhea in which a total of six different medicinal remedies were prescribed and reported by the tradition healers. Similar results were reported from the study done on ethnobotany of medicinal plants in southeastern Ethiopia in which the major and most widespread diseases according to the informants include gonorrhea, jaundice, kidney infection, and general malaise.[20] These are followed by diarrhea and evil spirit for which five medicinal plants were reported as effective means of treatment. Also, four medicinal flora were reported as effective means of treatment of malaria.

Quality management of herbal extracts/preparations relates to the physicochemical assessment of crude drugs covering the aspects such as choice and dealing with the crude material, safety, efficacy and balanced evaluation of completed product.[21] Physicochemical standards had been usually used for assessing the identity, purity, and strength of the drug supply. These parameters were also used to identify any adulterants if existing in the plant substance.[22]

In this study, water-soluble extractive value of *Euphorbia abbyssinica* J.F. Gmel. was higher than the rest at 18.53%w/w and followed by *Dioscorea quartiniana* A.Rich. and *Barleria argentea* Balf. f. with 18.507 and 16.217%w/w of average concentration of water-soluble extractive value, respectively. A low average concentration of water-soluble extractive value was detected in *Cadaba farinose* Forssk. (1.825%w/w). These results showthe presence of water-soluble additives such as sugar, acids, and inorganic compounds, etc. A lower extractive value indicates addition of exhausted material, adulteration or incorrect processing during drying, storage or formulation. The average concentration of alcohol-soluble extractive value of *Cadaba farinose* Forssk. was high at 1.107%w/w and was followed by *Crateva adansonii* D.C. Prodr and *Dioscorea quartiniana* A.Rich. at 0.33 and 0.329%w/w, respectively. This indicates the presence of contents such

as phenols, alkaloids, steroids, glycosides, and flavonoids. This result is relatively similar with the study conducted on the leaves of *Carallia brachiate* in India which showed that their water-soluble extractive value of the leaves was 11.63 ±0.60 (%w/w) and a higher alcohol-soluble extractive value was reported (3.96 ±0.12%w/w) compared with the present study.[23]

In this study, the moisture content (%LOD) of *Barleria argentea* Balf. f. was higher than the recommended standard at 21.063%w/w and followed by high %LOD of *Crateva adansonii* D.C. Prodr and *Euphorbia abbyssinica* J.F. Gmel. with 18.143 and 16.347%w/w, respectively. This shows that the drug absorbed moisture after being properly dried and stored. Only one medicinal plant had normal moisture content, this being *Cadaba farinose* Forssk. (4.876%w/w). Moisture content (%LOD) is mainly used to regulate the pleasantness of herbal preparations. The pharmacopoeial monographs limit the water content material in vegetable sources at 8% and 14%.

High moisture content corresponds frequently to an excessive amount of free water which could alter various physicochemical properties of merchandise which is intended for use or stored dry; it also assists the growth of dangerous bacteria, yeasts, and molds.[24] The European Agency for the evaluation of medicinal products recommended that the moisture content must be included within the listing of comprehensive specifications for herbal materials and finished natural merchandise which can be solids, since the influence of water content on the stability and safety of crude drugs is significant.[25] To manipulate moisture in herbal merchandise, the USP prescribes storage under a relative humidity of below 60% RH.

The purity of herbal extracts can also be assessed by determination of ash values which constitute the content of foreign matter together with inorganic salts or silica present as adulterants within the drug sample. In this study, the highest total ash value was registered in *Dioscorea quartiniana* A.Rich. species at 18.563%w/w and followed by *Crateva adansonii* D.C. Prodr and *Barleria argentea* Balf. f. at 16.033 and 15.648%w/w, respectively. This shows the presence of physiological ash that is derived from the plant tissue itself, and non-physiological ash. This is similar with a study conducted in India that documented the total ash to be 17.83±0.20%w/w.[26]

In this study, the acid-insoluble ash value of *Euphorbia abbyssinica* J.F. Gmel. was higher than the rest at 7.227% w/w and followed by the acid-insoluble ash value of *Croton macrostachyus* Del. *and Dioscorea quartiniana*

A.Rich. at 7.217 and 6.975%w/w (n=3), respectively. This indicates the presence of sand and siliceous earth. The amount of water-soluble ash was approximately equal with the acid-insoluble ash value with the highest result frequently observed for *Euphorbia abbyssinica* J.F. Gmel. species at 6.731%w/w (n=3); the average concentration of water-soluble ash for *Dioscorea quartiniana* A.Rich. species was relatively equal to the value of *Euphorbia abbyssinica* J.F. Gmel. at 6.398%w/w (n=3). The ash content gives an idea of the inorganic content of powdered leaves under investigation and thus the standard of the drugs is often assessed. This result is comparably similar with a study from India which showed that the amounts of acid-insoluble and water-soluble ash were 8.26±0.23 and 7.3 ±0.28 (%w/w), respectively.[26]

Conclusions

This finding reveals that there is a rich indigenous knowledge of medicinal plant use in the study area. Leaves were the most commonly used plant parts by the traditional healers in the herbal preparations. High degree of consensus was observed among the traditional healers in treating malaria. The most common diseases for which the herbal preparations were prescribed were gonorrhea, diarrhea, evil spirit, and malaria. The moisture content of all the medicinal plants studied was high enough to potentially compromise stability. The study also revealed that the water-soluble extractive value of the selected medicinal plants indicates the presence of water-soluble components such as sugar, acids and inorganic compounds, etc. and also the alcohol-soluble extractive value indicates the presence of constituents such as phenols, alkaloids, steroids, glycosides, and flavonoids. In the future, these characteristics can be used to check the genuine nature of the crude drug, thus these results play an important role in preventing the possible steps of adulteration and can also be used in the standardization of medicinal plants/crude drugs. It is essential to establish nationally recognized guidelines for assessing their quality and establishing monographs for herbal products.

Abbreviations

LOD, Loss on Drying; TS, Test Solution; WHO, World Health Organization.

Data Sharing Statement

All data generated or analyzed during this study are included in this manuscript. However, raw data are available from the corresponding author.

Ethics Approval and Consent to Participate

Verbal informed consent was approved by the Ethical Review Board of Jimma University.

This research was approved by the Ethical Review Board of Jimma University, Health research and post graduate director. Before starting the questionnaire, all participants who ultimately completed the questionnaire were informed of the purpose, content and other details of our study. Verbal informed consent was obtained from Traditional Healers prior to the interview. Confidentiality and privacy of the information was assured and maintained.

Disclosure

The authors declare that they have no conflict of interests.

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