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Ethnomedicinal plants used to treat human ailments in the prehistoric place of Harla and Dengego valleys, eastern Ethiopia

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Abstract

Background: Traditional medicines remained as the most affordable and easily accessible source of treatment in the primary health care system among diverse communities in Ethiopia. The Oromo community living in the prehistoric Harla and Dengego valleys has long history of ethnomedicinal know-how and practice against human and livestock ailments. However, this rich ethnomedicinal knowledge had been remained unexplored hitherto. This study focus on the comprehensive ethnomedicinal investigation in an attempt to safeguard the deteriorating ethnomedicinal knowledge that can be used as a steppingstone for phytochemical and pharmacological analysis.

Methods: Fifty five (44 male and 11 female) systematically selected informants including ten traditional herbalists (key informants) were participated in the study. Semi-structured interviews, discussions and guided field walk constituted the data collection methods. Factor of informant consensus (*Fic*), frequency of citation (*F%*), and binomial test were employed in data analysis. Medicinal plant specimens were collected, identified and kept at Herbarium of Haramaya University (HHU).

Results: A total of 83 traditional medicinal plant species against human ailments in 70 genera and 40 Families were recorded. Twelve medicinal plants were marketable in open market places of the nearby towns. Formulations recorded added to 140 remedies for 81 human ailments. Concoction accounts 50.7% of the total preparations followed by fluids extraction (10.7%) and infusion (6.4%). Fifteen different plant parts were used for remedies preparation wherein leaves accounted 46.4%, stem 9.2%, fruits and roots each 7.8%. Most of the remedies (90.7%) were prepared from single plant species like, aphrodisiac fresh rhizome of *Kleinia abyssinica* (A. Rich.) A. Berger chewed and swallowed few hours before sexual performance for a man having problem of erectile dysfunction. The *Fic* value ranges between 1.0 (gastritis and heartburn/pyrosis) and 0.77 (swollen body part). *Aloe harlana* Reynolds was reported to be used for the highest number of ailments treating swollen body part locally called GOFLA, colon cleaner, snake bite, liver swelling, spleen swelling/splenomegaly, fungal infections and inflammation of skin.

Conclusion: Such documentation of comprehensive ethnomedicinal knowledge is very valuable and needs to be scaled-up so that it could be followed up with phytochemical and pharmacological analyses in order to give scientific ground to the ethnomedicinal knowledge.

Keywords: Dengego valley, Eastern Ethiopia, Ethnomedicinal knowledge, Harla, Traditional medicinal plants

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Background

Knowledge of the medicinal plants of Ethiopia and their uses provide wide and vital contribution to human and livestock healthcare needs throughout the country [1-5]. These wide and vital uses of traditional medicine in the country could be attributed to cultural diversity and acceptability, psychological comfort, economic affordability, and perceived efficacy against certain type of diseases as compared to modern medicines [6,7]. In Ethiopia, about 80% of the human population and 90% of livestock is said to be dependent on traditional medicine for primary healthcare services and most of this comes from plants [8,9]. That is why there are considerable number of research works on the various aspects on traditional medicinal plants [2,5-7,9-17] even some were developed to the pharmaceutical industries like, *Phytolacca dodecandra* L'Herit. [18,19]. However, many more medicinal plants of Ethiopia which are found in lesser studied areas still anticipate scientific studies.

The reviewed literatures show that studies on medicinal plants of Ethiopia have so far concentrated in the south, southwest, central, north and north-western parts of the country [2,5-7,9-13,15,16,20-33]. There were little data that quantitatively assess the resource potential, indigenous knowledge on the use and management of medicinal plant species from eastern Ethiopia [34,35] as well as none are there from the present study area.

The Oromo people who currently inhabit the prehistoric Harla and the entire catchments might be the descendants of the former Harla people of the Harla kingdom which had been ruled between 13th to 16th centuries (Patacini D, Berehanu K: Notes on Harla: a preliminary report, Unpublished). They are expected to be the guardians of valuable indigenous knowledge on the use of traditional medicinal plants of their surroundings, which they use for treating human and livestock ailments. Scientific investigations indicated that there is an endemic plant species named after this prehistoric place called *Aloe harlana* Reynolds [36] due to its availability only in Harla locality. It has been traditionally used by the Oromo people in Harla for the treatment of various infectious and inflammatory diseases [17]. The latex and isolated compounds of *A. harlana* possess promising antimicrobial activity particularly against the Gram-negative bacterial strains such as *Escherichia coli*, *Salmonella typhi* and *Vibrio cholerae* [17]. Unpublished documents suggested that there are many more potential medicinal plants in this unique geographic setting and complex landscape areas.

Even one of the translations of the eastern port town of Ethiopia known as Dire Dawa is "plain of medicine" in Oromo language. Dire Dawa is only 15 kms far from Harla and this study also covers 5 to 25 kms distant areas from this village believing that most of the

traditional medicinal plants which are marketable in Dire Dawa are coming from these study areas (Harla and Dengego valleys and the entire catchments of Dire Dawa). In addition, given the diversity of plant species in the Dengego Mountains and valley complex, and the ancient history and civilization of the vanished Harla Kingdom, the share of medicinal plants and the value of the associated indigenous knowledge of the current Oromo communities of the area, who might be descendants of the lost Harla people, is expected to be high.

However, except few archaeological studies [23,37], this prehistoric place and people, Dire Dawa and entire Dengego mountain and valley complex are ethnobotanically unexplored and there is no comprehensive account of the traditional medicinal practices. Therefore, the objectives of this study were to (1) assess, identify and document the traditional medicinal plant species potential; (2) investigate comprehensive information on associated indigenous knowledge of medicinal plants; (3) generate baseline ethnomedicinal information on medicinal plants for human ailments for further investigation. Thus, the output of this study can be used as a stepping-stone for conservation of medicinal plant species, preservation of ethnomedicinal knowledge, and phytochemical and pharmacological analysis.

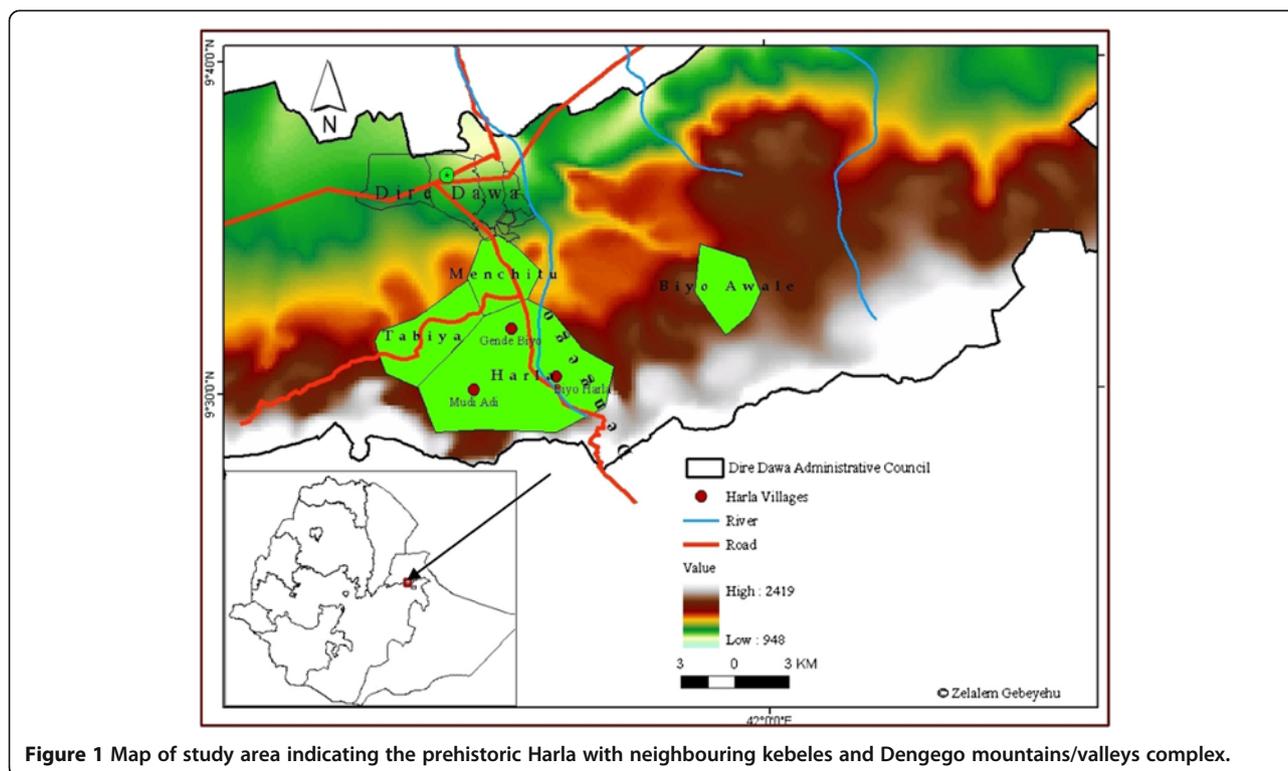
Methods

Study area

The study area covers Harla upto Biyo Awale and Dengego Mountains and Valleys complex which is found under Dire Dawa administrative council. It extends 5 to 25 kms distance SE of Dire Dawa town in eastern Ethiopia which is located at 515 kms east of Addis Ababa and 311kms west of Djibouti.

This area is delimited with coordinates of 9°27' and 9°39'N latitude and 41°38' and 42°20'E longitude. Its elevation ranges between 950–2260 meters a.s.l. (Figure 1). The physiographic feature includes mountain ranges, hills, valleys, river terraces and flat plains. The geology of the area consists of precambrian metamorphic rocks (Gneisses, pegmatites and diorites), mesozoic sedimentary rocks (Adigrat sandstone, Hamanlei limestone and Amba Aradam sandstone), Tertiary volcanic (basalts) and quaternary sediments (alluvial sediments, travertine and river sand deposits) [38].

The mean annual temperature is about 22.8°C, ranging from a mean minimum of 16.2°C to mean maximum of 30.4°C. May to June are the hottest months of the area; whereas, November to January are the coldest months. The mean annual rainfall in the surrounding areas ranges from about 1,000 mm on the south to about 500 to 600 mm in the north lowland. Almost all of the catchments receive less than 900 mm year⁻¹ of rainfall. Rainfall is bimodal, occurring from February to April



(short rainy season) and June to September (long rainy season). The mean annual runoff values estimated for different watersheds ranges from 12.4 Mm³ to 100.13 Mm³ [39].

The human population of the rural area is about 125,800 (Male 63,000 and 62,800 female) in which the livelihood depends mainly on smallholder agriculture and livestock production [38]. The vegetation of the area includes few grass lands and wood lands, scrubland and bush lands dominated by species like *Acacia brevispica* Harms, *A. bussei* Harms ex Sjostedt, *A. etbaica* Schweinf, *A. seyal* Del., *Aloe megalacantha* Baker, *A. harlana* Reynolds, *Balanites aegyptiaca* (L.) Del. *Euclea racemosa* Murr., *Euphorbia bergeri* M. Gilbert, *Ficus salicifolia* Vahl. *Opuntia ficus-indica* (L.) Miller, and *O. stricta* Haworth.

Harla is probably a 13th C village. As the finding of the site indicated, it has a long time commercial link with the middle and Far East through the port of Zeila between 13th and 16th C (Patacini D, Berehanu K: Notes on Harla: a preliminary report, Unpublished). The whole village was buried beneath the surface and covered with ashes and pumice. The current Harla is built on top of the old one. The current inhabitants use ready rectangular stone blocks from the old village, which they have uncovered while digging below the surface, to build their homes, fences, and farm land terraces (Pers. Observation and communication).

There are very limited written documents on the history of the Harla kingdom. Due to limitation of published works on the prehistoric Harla, we are unable to

mention many references in this study except for a few indicated issues that may attract field professionals for future investigations. Of course, there are certain archaeological findings collected by different social anthropologists and archaeologists that are kept for visitors in the small museum at the centre of Harla village. Archaeological findings and collections of the site include coins written in Arabic and Chinese, pieces of glasses, ornaments, tools for knitting, pottery fragments and a stone moon calendar with two geographical coordinates, etc. which are available in some homes of the residents and in the small museum at the centre of Harla village (Pers. observation).

Data collection methods

Participatory Rural Appraisal (PRA) techniques were employed to collect data, as recommended by Martin [40] and Cunningham [41]. Employing this methodology, an ethnobotanical data were collected in two different rounds, from October to December 2012 and May 2013 from six sampling sites which were identified from the study areas namely Biyo Harla, Gende Biyo, Mudi Adi, Tabiya, Menchitu and Biyo Awale. The first three sites were villages in Harla kebele and the other three sites were purposively selected as neighbouring kebeles (the smallest political administrative unit in Ethiopia) of the prehistoric Harla to represent Dengego valley complex. Ethnobotanical information was collected from 55 informants (44 male and 11 female). Among the 55

informants, 10 key informants (traditional healers) were selected with the assistance of community leaders, elderly people and members of the local community. Purposive sampling technique was used for selecting key informants (all were male and above 55 age) while stratified random sampling was employed to select others (34 male and 11 female). Households of selected study sites were registered and stratified into three age groups. Then fifteen informants were randomly selected from each stratum (age group) to see how the knowledge varies with age. The three age groups were young (25–40), adult (41–60) and elderly (above 60).

Before carrying out the interviews and group discussions, a traditional ceremonial and blessing of the Oromo culture conducted and an oral Prior Informed Consent (PIC) was confirmed from every respondent. Furthermore, participants collectively endorsed the research by giving oral blessings in their usual traditional style. Semi-structured interviews with 55 informants and group discussions (total of 9 groups discussed with average members of 11 per group) were administered in the local language (Afan Oromo) to collect basic information on the local name(s) and traditional description of the medicinal plant species, diseases treated or controlled, parts used, conditions and method of preparations, routes of remedial administration, dosages used, major drawbacks, and locally marketable medicinal plants. Besides, practical observation sessions in preparation of remedies and some observation of traditional treatment given to the patients by traditional healers were conducted. In addition, guided field walks with key informants were employed to collect voucher specimens of each medicinal plant species with additional notes. Photographic cameras were used for graphic documentation. Additional interviews with key informants were carried out in the field in order to avoid the risk of confusing identity of plant species by repeated inquiries. This was done for at least three times with the same and different informants so as to confirm the validity and reliability of the recorded information. Specimens were collected and numbered on the spot, later identified using taxonomic keys in the relevant volumes of the Flora of Ethiopia and Eritrea and through visual comparisons with authenticated plant specimens kept at the Herbarium of Haramaya University (HHU) where voucher specimens of the medicinal plants were deposited. The authentication of identified plant species was done by a renowned plant taxonomist, Mr. Melaku Wondafraash (National Herbarium of Addis Ababa University).

Data analysis

The data were filled in Excel sheet in a way that makes the analysis very suitable. Total number of traditional medicinal plant species used for human ailments along

with their Family and genus distribution; growth habit in percentage; part used versus number of remedies prepared; number of human ailments treated; methods of preparation, and route of administration were all analyzed using both qualitative and quantitative methods following Martin [40] and Cotton [42]. The informant consensus factor (*Fic*) of each medicinal plant, the proportion of informants who independently reported its use against a particular disease/disease category, was calculated using the formula: $Fic = n_{ur} - n_t / n_{ur} - 1$ [43,44], where, n_{ur} is the “number of use-reports” in each disease category and n_t is the “number of taxa used”. The *Fic* values range from 0 to 1, with high values (i.e. close and equal to 1) indicating that relatively few plants are used by a large proportion of informants, while low values (<0.5) indicate that informants do not agree on the plant species to be used to treat a category of ailments.

Frequency of citation (*F*) of each medicinal plant species was calculated using the formula:

$$F (\%) = \frac{\text{No. of informants who cites the species}}{\text{Total No. of informants}} \times 100.$$

Binomial test was run in SPSS 18.0 to evaluate the depth of knowledge with age categories in which pair wise age category test was considered and for comparison of gender wise depth of knowledge. P-value of less than 0.05 was taken as statistically significant difference. MS Excel Spreadsheet was used to generate bar graphs.

Results and discussion

Medicinal plant species richness and part used for remedial preparations

This study revealed that the prehistoric Harla and Dengego Mountains and Valleys complex harbour about 83 traditional medicinal plant species against 81 human ailments which are distributed across 70 genera and 40 Families (Table 1). About 57.8% of these traditional medicinal plant species belong to ten Families. Asteraceae had the largest number of plant species (10, 12%), followed by Fabaceae (8, 9.6%), Euphorbiaceae (6, 7.2%) and Cucurbitaceae (5, 6%). Aloaceae and Lamiaceae had each 4 plant species, Asclepiadaceae, Boraginaceae and Capparidaceae each has 3 species, and Apocynaceae has 2 species. About 71% of these medicinal plant species were reported by different authors who conducted researches on traditional medicinal plants in the different parts of Ethiopia [4-7,9-13,15,16,21,22,24,25,27-32,34,45] wherein about 44% of them were reported for similar ailments. The number of medicinal plant species reported in this study is considerable, though application of long-term participant observation techniques could add more medicinal plant species to the present list, given the floristic richness and the strongly plant-based bio-cultural

Table 1 List of traditional medicinal plant species used to treat human ailments in the prehistoric Harla and Dengego valleys

| Voucher No. | Scientific name | Family | Vernacular name | Habit | Disease treated | PU | Method of preparation & part administered |
|-------------|---|---------------|-------------------|-------|--|--------------------------|--|
| AHU167 | <i>Abutilon bidentatum</i> (Hochst.) A. Rich. | Malvaceae | Muka Adi | HA | Headache Rh disease Mineral deficiency in children | L L L | Boiled in HOJA and served like a tea Decoction taken orally Infusion taken oral |
| AHU212 | <i>Acacia nilotica</i> (L) Willd. ex Del. | Fabaceae | Serkema | T | Bad breath/halitosi | B | Chew and spit |
| AHU197 | <i>Acalypha fruticosa</i> Forssk. | Euphorbiaceae | Dhirii | Sh | Heart disease Kidney infection/Nephropathy | L L | Decoction is taken oral Decoction is taken oral |
| AHU171 | <i>Acanthospermum hispidum</i> DC. | Asteraceae | Kumutu Adi | HA | Itching skin | Ap | Concoction is drenched |
| AHU33 | <i>Acokanthera schimperi</i> (A. DC.) Schweinf. | Appocynaceae | Qarari | Sh | Tonsillitis Malaria | St, L Ap | Concocted, gargling and rinsing the throat Dried & smoke is used as mosquito repellent |
| AHU117 | * <i>Aloe harlana</i> Reynolds | Aloaceae | Hargesa | Sh | Snake bite, liver swelling & spleen swelling/Splenomegaly Colon cleaner Skin fungus, hair fungus & skin inflammation | L Sa J, L Sa, J | Crushed and filtrate taken oral in all cases Crystallized, powdered and juice taken oral Concocted together and used as ointment and wash the hair |
| AHU161 | * <i>Aloe mcloughlinii</i> Chris. | Aloaceae | Hargesa | Sh | Eye infections | Sa | Extract the sap and drop in the eye |
| AHU162 | <i>Aloe megalacantha</i> Baker | Aloaceae | Hargesa Guracha | Sh | Colon cleaner | J, Sa | Crystallized & Juice made/SIBRI, taken oral |
| AHU160 | <i>Aloe retrospiciens</i> Reynolds & Bally | Aloaceae | Hargesa Adi | Sh | Colon cleaner | J, Sa | Crystallized & Juice made/SIBRI, taken oral |
| AHU153 | <i>Asparagus africanus</i> Lam. | Asparagaceae | Hida Sere | Sh | Swelling and infection on the head (KOROKOR) | L | Crushed and put on hot plate and applied on the head while warm |
| AHU201 | <i>Asparagus racemosus</i> Willd. | Asparagaceae | Hida Sero Guracha | Sh | Body burning feeling and mentally disturbed Itching the whole skin | Br R | Concocted and taken oral and drenched Crushed and the filtrate is drenched |
| AHU213 | <i>Azadirachta indica</i> A. Juss. | Meliaceae | Kinina | T | Malaria Intestinal parasites | S, L S, L | Mixture of leaf infusion and oil extracted from seed taken oral Mixture of leaf infusion and oil extracted from seed taken oral as anthelmintics |
| AHU207 | <i>Bidens pilosa</i> L. | Asteraceae | Xiye | HA | Difficulty of blood clotting | St, L | Crushed and bandaged on bleeding part |
| AHU112 | <i>Cadaba rotundifolia</i> Forssk. | Capparidaceae | Delensisa | Sh | Extended flow of menstruation/ Menometrorrhagia | B, L | Concocted together with <i>Withania somnifera</i> and a cup of filtrate is taken oral |

Table 1 List of traditional medicinal plant species used to treat human ailments in the prehistoric Harla and Dengego valleys (Continued)

| | | | | | | | |
|---------|--|------------------|-------------|----|--|------|--|
| AHU178 | <i>Cadia purpurea</i> (Picc.) Ait. | Fabaceae | Cheeka | Sh | Gastritis | N | Collect from the flower and taken oral |
| | | | | | Heartburn/Pyrosis | N | Sucked from flower and used as carminative |
| AHU146 | <i>Capparis tomentosa</i> Lam. | Capparidaceae | Gemora | CP | Nipple pores remain closed after birth | R, L | Concoction taken oral to facilitate opening of nipple pores |
| AHU111 | <i>Caralluma speciosa</i> N.E. Br. | Asclepiadaceae | Ya'ii Bera | HP | Skin cyst & tumour locally known as KELEDO | St | Crushed with <i>Gloriosa superba</i> and put on the tumour |
| | | | | | Gangrene | St | Powdered with <i>Gloriosa superba</i> and turtle bone then put on the starting point |
| | | | | | Swollen body part-GOFLA | St | Crushed and bandage on swollen part |
| | | | | | Anti poison | Sa | Diluted sap taken orally |
| | | | | | Wound | Sa | Sap extracted and used as ointment |
| | | | | | Itching skin | Sa | Sap extracted and used as ointment |
| AHU154 | <i>Carissa spinarum</i> L. | Apocynaceae | Agamsa | Sh | Premature ejaculation | F | Decoction of unripened fruit is served as a tea and wash the body with the infusion |
| AHU199 | <i>Cissampelos mucronata</i> A. Rich. | Menispermaceae | Bal-Toke | CP | Sudden illness locally called DINGETEGNA | R | Chew & swallow to stop sudden vomiting, abdominal pain and discomfort |
| AHU204 | <i>Coccinia</i> sp. Burger | Cucurbitaceae | Hanchota | CH | Kidney disease | Tu | Infusion taken oral |
| AHU214 | <i>Commelina stephaniniana</i> Chiov. | Commelinaceae | Hola gebis | HA | Skin fungus around the neck and face | Sa | Extract creamy sap and use as an ointment |
| AHU187 | <i>Commicarpus sinuatus</i> Meikle | Nyctaginaceae | Kontom | HP | Gonorrhoea | L | Concoction with leaf and fruit of <i>Cucumis dipsaceus</i> and taken oral |
| | | | | | Skin fungus around the neck and face | L | Leaf paste mixed with oil and used as ointment |
| AHU184 | <i>Craterostigma plantagineum</i> Hochst. | Scrophulariaceae | Roba Enjire | HA | Liver disease | R, L | Concoction taken oral |
| | | | | | Diarrhoea | R, L | Concoction taken oral |
| AHU158 | <i>Croton macrostachyus</i> Del. | Euphorbiaceae | Bekenisa | T | Liver disease/Jaundice | B | Concocted with bark of <i>Terminalia brownii</i> and drink a cup of infusion |
| AHU108 | <i>Cucumis dipsaceus</i> Ehrenb. ex Spach | Cucurbitaceae | Hare Goge | CH | Gonorrhoea | F, L | Concocted with <i>Commicarpus sinuatus</i> leaf and taken oral |
| | | | | | Urinary retention/Ischuria | L | Crushed and filtrate taken oral |
| | | | | | Skin fungus | F | Rub the affected part with warm fruit |
| AHU108B | <i>Cucumis ficifolius</i> A. Rich. | Cucurbitaceae | Hare Goge | CH | Swelling due to poisonousthorn | F | Put on hot plate and bandage on the swollen part while warm |
| AHU217 | <i>Cucumis prophetarum</i> L. | Cucurbitaceae | Hidi | CA | Wound and Swollen body part | F | Make it warm and bandage on wound/ swollen part while warmth |
| AHU114 | <i>Cynoglossum coeruleum</i> Hochst. ex A. DC. | Boraginaceae | Mexene Tiro | HA | Kwashiorkor | Ap | Concocted with <i>Verbascum sinaiticum</i> and taken oral |

Table 1 List of traditional medicinal plant species used to treat human ailments in the prehistoric Harla and Dengego valleys (Continued)

| | | | | | | | |
|--------|--|----------------|----------------------|----|---|-------|---|
| AHU149 | <i>Datura stramonium</i> L. | Solanaceae | Qamaxari | HA | Ear infections/Otitis externa & media | F, L | Dried, ground together and mix with oil and drop in the ear |
| | | | | | Worms created in the tooth gum | F | Boiled and put on the gum area |
| AHU159 | <i>Dodonaea angustifolia</i> L.f. | Sapindaceae | Edecha | Sh | Hair fungus Swelling and bursting on the head (KOROKOR) | L | Dried, powdered and mixed with oil and used as an ointment |
| | | | | | Malaria | F | Fresh fruits are eaten |
| | | | | | Intestinal parasite | L | Fresh leaf extract taken oral as anthelmintics |
| AHU164 | <i>Echidnopsis dammanniana</i> Spreng. | Asclepiadaceae | Muka Mesqa | HA | Snake bite poison | St | Crushed and tie on the snake bite |
| AHU209 | <i>Echinops macrochaetus</i> Fresen. | Asteraceae | Qore Hare | HA | Toothache | R | Crushed and put on the painful teeth |
| AHU196 | <i>Erianthemum aethiopicum</i> Wiens & Polhill | Loranthaceae | Digelo Serkema | E | Breast swelling/Mastitis | St, L | Concoction taken oral |
| AHU192 | <i>Erucastrum arabicum</i> Fisch. & Mey. | Brassicaceae | Rafu Shimbiro | HA | Skin fungus around the neck and face | P, S | Dried, powdered, mix with oil and use as an ointment |
| AHU118 | <i>Euclea racemosa</i> Murr. subsp. <i>schimperi</i> | Ebenaceae | Miesa | Sh | Snake bite poison | L | Crushed with <i>Aloe sp.</i> and filtrate taken oral |
| | | | | | Liver swelling | L | Crushed with <i>Aloe sp.</i> and filtrate taken oral |
| | | | | | Spleen swelling/Splenomegaly | L | Crushed with <i>Aloe sp.</i> and filtrate taken oral |
| AHU163 | <i>Eulophia petersii</i> Rchb.f | Orchidaceae | Shunkurta Gara, Ejji | HA | Swollen body part-GOFLA | Bu | Cooked bulb eaten |
| | | | | | Abdominal pain/KURTET | Bu | Soup made from bulb taken oral |
| AHU110 | <i>Gloriosa superba</i> L. | Colchicaceae | Harmel Kubra | Sh | Toothache | L | Crushed leaf applied on painful teeth |
| | | | | | Epilepsy | L | Crushed leaf filtrate taken oral |
| | | | | | Skin cyst & tumour/KELEDO | L | Crushed leaf is bandage on tumour/cyst |
| | | | | | Gallstone | L | Immersed in water and infusion taken oral |
| | | | | | Gangrene | L | Crushed with succulent <i>Caralluma speciosa</i> and tie on the starting point |
| AHU126 | * <i>Gomphocarpus purpurascens</i> A. Rich. | Asclepiadaceae | Ari-Yuyo | HA | Itching skin | L | Roasted and powdered leaf is mixed with oil & used as ointment |
| | | | | | Evil eye | L | A cup of Infusion taken oral & smoke bath with dry leaf |
| AHU145 | <i>Gossypium hirsutum</i> L. | Malvaceae | Jibri Boke | Sh | Small swelling with oozing pus in the vagina/Vaginitis | L | Concocted with <i>Acokanthera schimperi</i> and KURUNFUD and wash the affected part |
| AHU177 | <i>Grewia bicolor</i> Juss. | Tiliaceae | Deka | Sh | Small swelling with oozing pus/skin ulcer | L | Crushed leaf in bandage on it |
| | | | | | Epidermal drying | L | Extract is applied on skin as emollients |
| | | | | | Bad breath (Halitosis) | St | Used as a toothbrush |
| AHU144 | <i>Heliotropium aegyptiacum</i> Lehm. | Boraginaceae | Harma Deysa | HA | Leech attached on throat | L | Crushed and filtrate is used for gargling the throat |

Table 1 List of traditional medicinal plant species used to treat human ailments in the prehistoric Harla and Dengego valleys (Continued)

| | | | | | | | |
|--------|---|---------------|---------------|----|--|-------|--|
| AHU166 | <i>Heliotropium steudneri</i> Vatke | Boraginaceae | Muka Michii | HA | MICH | L | Crushed and filtrate is drenched |
| | | | | | Skin fungus | L | Fresh leaf rubbed on affected part |
| AHU169 | <i>Indigofera amorphoides</i> Jaub. & Spach | Fabaceae | Muka Adi | HP | Heart disease | Ap | Decoction taken oral |
| AHU176 | <i>Indigofera</i> sp. | Fabaceae | Muka Aroo | HA | Herpes zoster | L | Dried, powdered, roasted and mixed with oil to be used as ointment |
| AHU174 | * <i>Indigofera ellenbeckii</i> Bak. f. | Fabaceae | War | HP | Mouth infection | L | Crushed leaf filtrate is used to wash mouth |
| AHU189 | <i>Jasminum grandiflorum</i> L. | Oleaceae | Bilu | Sh | Chapped lips | L | Paste of fresh leaf used as emollient on lips |
| | | | | | Tooth gum infection/Gingivitis | L | Crushed and applied on the gum in the mouth |
| AHU152 | <i>Jatropha curcas</i> L. | Euphorbiaceae | Hambete Muluk | Sh | Constipation | S | Decoction and oily fluid taken oral as laxative |
| AHU203 | <i>Kalanchoe marmorata</i> Bak. | Crassulaceae | Chophi Gurati | HP | Eye infection | St | Extracted sap is boiled, cooled & dropped |
| | | | | | Ear infections/Otitis | St | Sap extracted, boiled, cooled & dropped |
| | | | | | Swelling with pus due to spine | St, L | Crushed with <i>Ricinus communis</i> seed and bandage on to remove the pus and spine |
| AHU200 | <i>Kleinia abyssinica</i> (A. Rich.) A. Berger | Asteraceae | Abrasha | HA | Sexual dysfunction | Rh | Aphrodisiac fresh rhizome is eaten few hours before sexual performance |
| AHU202 | <i>Kleinia odora</i> (Forsk.) DC. | Asteraceae | Luko | HP | Nerve case | L | Oily extract is boiled, mixed with <i>Cadaba rotundifolia</i> and used to massage |
| AHU205 | <i>Kleinia pendula</i> (Forsk.) DC. | Asteraceae | Afrasha | HP | Swollen body part | St | Decoction of fresh succulent is bandaged on swollen part while warm |
| AHU206 | <i>Kleinia squarrosa</i> Cufod. | Asteraceae | Luko | Sh | Intestinal parasite | St | Crush and taken oral as anthelmintics |
| | | | | | Swelling on gum and toothache | St | Used as toothbrush |
| AHU195 | <i>Lagenaria siceraria</i> (Molina) Standl. | Cucurbitaceae | Buqee | CA | Obstructed labour/Dystocia | L | Crushed and filtrate taken oral in a traditional assisted delivery |
| AHU173 | <i>Leucas minimifolia</i> Chiov. | Lamiaceae | Muka Adi | Sh | Eye diseases | L | Crushed and filtrate dropped in the eye |
| | | | | | Closing of the eye in the morning specially children | L | Crushed and filtrate dropped in the eye |
| AHU175 | * <i>Leucas stachydiformis</i> (Hochst. ex Benth.) Briq. | Lamiaceae | Muka Bofta | HA | Mouth infection | L | Decoction taken oral |
| | | | | | Nose infection | L | Decoction taken oral |
| AHU150 | <i>Lawsonia inermis</i> L. | Lytheraceae | Hina | Sh | Infection after haemorrhage & skin tumour removal | L | Crushed fresh leaf is applied external as antiseptic |
| | | | | | Fever | L | Crushed and wash the head |
| AHU148 | <i>Maerua triphylla</i> A. Rich. | Capparidaceae | Qanqalcha | Sh | Stomach GOFLA | L | Concocted and taken oral |
| AHU127 | <i>Melhania zavattarii</i> Cufod. | Sterculiaceae | Muka bira | Sh | Kidney infection | F, L | Concoction taken oral |
| AHU179 | <i>Ocimum basilicum</i> L. var. <i>thrysiflorum</i> (L.) Benth. | Lamiaceae | Rahan | HP | SIRKITA | L | Crushed and filtrate taken oral |

Table 1 List of traditional medicinal plant species used to treat human ailments in the prehistoric Harla and Dengego valleys (Continued)

| | | | | | | | |
|--------|---|----------------|----------------|----|---|-------|--|
| AHU140 | <i>Ocimum lamiifolium</i> Hochst. ex Benth. | Lamiaceae | Rahana, Riroo | Sh | MICH | L | Crush and squeeze the solution to drench and drink a teaspoon of it with tea or coffee |
| | | | | | Eye infection | L | Immerse in water and wash the eye with diluted infusion |
| AHU215 | <i>Opuntia ficus-indica</i> (L.) Miller | Cactaceae | Tini | Sh | Hair fungus | J | Extracted and wash the hair |
| AHU210 | <i>Osyris quadripartita</i> Decn. | Santalaceae | Wato | Sh | Malaria | R, L | Reddish infusion resulted after 24 hours immersion is taken oral |
| AHU105 | <i>Phyllanthus maderaspatensis</i> L. | Euphorbiaceae | Harmel Xixiqaa | HA | Heart disease | Ap | Concocted and taken oral |
| AHU147 | <i>Plumbago zeylanica</i> L. | Plumbaginaceae | Merxes | HA | Low level swelling under skin | R, L | Decoction taken oral |
| AHU216 | <i>Portulaca oleracea</i> L. subsp. <i>oleracea</i> | Portulacaceae | Merere Haree | HA | Constipation | L | Cooked and served as laxative vegetable |
| | | | | | Cough | L | Cooked and eaten as a demulcent agent |
| AHU142 | <i>Pouzolzia parasitica</i> (Forssk.) Schweinf. | Urticaceae | Dirba | HA | Infertility in female | R, L | Concoction taken oral to increase the chance of fertility |
| AHU142 | <i>Pouzolzia parasitica</i> (Forssk.) Schweinf. | Urticaceae | Dirba | HA | Diarrhoea | Tu, L | Crushed together and infusion taken oral |
| | | | | | Haemorrhage | L | Washing of anal opening with the infusion |
| | | | | | Hair fungus | Tu, L | Concocted to wash the hair |
| AHU151 | <i>Prunus persica</i> (L.) Batsch | Rosaceae | Kuki | T | Snake bite poison | L | Crushed and filtrate taken oral |
| | | | | | Liver swelling | L | Infusion taken oral |
| | | | | | Spleen swelling/Splenomegaly | L | Infusion taken oral |
| AHU208 | <i>Punica granatum</i> L. | Lythraceae | Roman (Am) | T | Swollen body part/GOFLA | F | Decoction serves like a tea |
| AHU172 | <i>Pupalia lappacea</i> (L.) A. Juss. | Amaranthaceae | Metene | HA | Urinary retention/Ischuria | Ap | Concoction taken oral |
| AHU194 | <i>Reichardia tingitana</i> (L.) Roth | Asteraceae | Wachara Haree | HA | Liver disease/swollen and create fluid sacs | L | Decoction with sugar taken like a tea |
| AHU109 | * <i>Rhynchosia erlangeri</i> Harms | Fabaceae | Harmel | Sh | Mental problem | L | Crushed leaf filtrate taken oral |
| | | | | | Heart disease | L | Concocted mix with honey and taken oral |
| AHU119 | <i>Ricinus communis</i> L. | Euphorbiaceae | Qobo | T | Constipation | S | Extracted oil taken as oral laxative |
| AHU182 | <i>Senna italica</i> Mill. | Fabaceae | Tenemeki | HA | Colon cleaner | L | Concocted with the fruit of <i>Tamarindus indica</i> and sugar and used as laxative |
| AHU181 | <i>Steganotaenia araliacea</i> Hochst. ex A. Rich. | Apiaceae | Harfetu | T | Body burning feeling and mentally disturbed | L | Concocted with <i>Grewia sp.</i> and <i>Cissampelos mucronata</i> and taken oral |
| AHU183 | <i>Tamarindus indica</i> L. | Fabaceae | Roka | T | Colon cleaner | F | Concocted with <i>Senna italica</i> and sugar and used as laxative |
| AHU155 | <i>Terminalia brownii</i> Fresen. | Combretaceae | Bireysa | T | Liver disease/Jaundice | B | Concocted with bark of <i>Croton macrostachyus</i> and drink a cup of infusion |
| AHU157 | <i>Tragia plukenetii</i> A. Rodel-Smith | Euphorbiaceae | Dobi | HA | Nipple opening remain closed after birth | R, L | Concocted and filtrate is taken oral |
| AHU185 | <i>Tribulus terrestris</i> L. | Zygophyllaceae | Qumutu Gala | HA | Heart disease | Ap | Concoction taken oral |

Table 1 List of traditional medicinal plant species used to treat human ailments in the prehistoric Harla and Dengego valleys (Continued)

| | | | | | | | |
|--------|--|------------------|-----------------------|----|--|------|--|
| AHU143 | <i>Verbascum sinaiticum</i> Benth. | Scrophulariaceae | Muka Ioni, Gura Haree | Sh | Kwashiorkor | Ap | Concocted with <i>Cynoglossum coeruleum</i> and taken oral |
| AHU156 | <i>Vernonia amygdalina</i> Del. | Asteraceae | Ebicha | T | Liver disease/Jaundice | B | Immerse in water and drink the infusion |
| AHU141 | <i>Withania somnifera</i> (L.) Dun. in DC. | Solanaceae | Hidi Bude | Sh | Extended flow of menstruation/ Menometrorrhagia | B, L | Concocted together with <i>Cadaba rotundifolia</i> & a cup of filtrate is taken oral |
| | | | | | Gallstone | R, L | Concoction taken oral |
| | | | | | Evil eye | Br | Dried and smoke bath |
| AHU188 | <i>Zinnia peruviana</i> (L.) L. | Asteraceae | Muka Ilili | HA | Depigmentation of section of skin/Vitiligo | R, L | Concocted and applied on affected part |
| AHU104 | <i>Ziziphus spina-christi</i> (L.) Desf. | Rhaminaceae | Kurkura | T | Haemorrhage | L | Crushed and bath the anal opening |
| | | | | | Headache | L | Concocted and used to wash the head |

Habit: Sh-shrub, T-tree, CA-climber/annual, CP-climber/perennial, HA-herb/annual, HP-herb/perennial, E-Epiphyte, CH- creeper herb, Part Used (**PU**), AP-All parts, B-bark, Br-branches, Bu-Bulb, St-stem, Sa-sap, J-jel, R-root, F-fruit, L-leaf, S-seed, Tu-tuber, P-Pod, Rh-rhizome and N-nectar.

*Endemic species.

background of the people. In addition, there is a potential market of traditional medicine in the nearby towns like Dire Dawa stretching to Djibouti. That is why few traditional practitioners were reluctant to give all the information since this could be detrimental to the economic benefits that come out of the traditional medicine. So, the economic benefits coming out of the traditional medicine restricted the information to some extent.

Among the medicinal plants identified in this study, various parts of 12 medicinal plants species were reported to be sold in the open markets of the nearby towns like Dire Dawa. The dried and powdered sap of *Aloe harlana* and *A. megalacantha*, seeds and leaves of *Azadirachta indica*, leaves of *Gloriosa superba* and *Lawsonia inermis*; and the fresh root of *Cissampelos mucronata*, tuber of *Coccinia sp.*, leaf of *Ocimum lamii-folium*, fruits of *Punica granatum* and *Tamarindus indica* were sold in the open local market places. Similarly, ample domestic trade of Ethiopian medicinal plants was reported for diverse cultural groups in Ethiopia [6,7,16,21,23,26,34]. In contrary, none of the medicinal plants reported by some other studies were available for sale in local markets [2,5,10]. These might be related with the norm and cultural issues of diverse communities who permit and prohibit marketing of traditional medicines.

Analysis of the growth habits of the traditional medicinal plant species showed that shrubs constitute the highest number of species and epiphytes the least number of species, represented by only one species (*Erianthemum aethiopicum*/Loranthaceae) (Table 2).

The highest proportion of growth habit was covered by shrubs and herbs that constitute 68% of the total traditional medicinal plants. This can be related to the floristic composition of vegetation, which is dominated by woodland, bushland and scrubland vegetation types both in valleys and rocky mountains. Similar patterns were reported by some medicinal plant inventories work [16,24,25] where shrubs and herbs are the largest plant

growth habits but contrary to some works [6,34] where woody plant species dominated the growth form.

A total of 15 different parts of the medicinal plant species are used for remedies preparation (Figure 2). Remedial preparations made from leaves accounted for 46.4%, stem 9.2%, fruits and roots each 7.8% of the total preparations. This could be a large number of plant parts used in remedial preparation when compared with the various research reports done on traditional medicinal plants [15,21,22,28-30,34]. Such diversified use of plant parts in remedial preparation could be considered as an indicator of the deep rooted and long lasting practice and know-how of traditional medicinal plants by the community.

A total of 140 preparations were made using these 15 different parts of the medicinal plant species. The most frequently sought parts of the medicinal plant species were leaf, fruit, seed, branches, pod, and nectar that account for 60%. This may lead to the conclusion that harvesting medicinal plants poses no significant threat to the natural vegetation of the study area. Similarly, in studies conducted elsewhere in Ethiopia, leaf was indicated to be the most frequently used plant part in remedial preparations that do not cause any significant threat to the survival of individual plants when compared to other plant parts such as underground part, stem, bark and whole plant [2,15,16,34,46]. In contrast, other studies [30-32] indicated root and bark as the most commonly harvested plant part for remedial preparations. For example, study conducted in Benshangul-Gumuz of Ethiopia [30] reported that about 63% of the preparations were made from root and bark of medicinal plants. It is a mere fact that medicinal plants that are harvested for their roots, rhizomes, bulbs, bark, stem and whole part have severe effects on their survival [1,3] but this could be more important for the perennial and woody plant species.

Informant consensus factor and frequency of citation

The most common health problems of the population of the study area were identified by traditional healers based on their experience on frequency of ailments treatment. In this respect, a total of 11 ailments were reported as the most common health problem of the study area. The *Fic* value for these most important health problems of the area ranges between 0.77 and 1 (Table 3). The *Fic* is higher for gastritis and heartburn/pyrosis (1.0) and relatively lower for swollen body part locally called GOFLA (0.77). The *Fic* results could be useful in prioritizing medicinal plant species for further pharmacological studies [10,25] since efficacy of traditional medicinal plant is strongly correlated with *Fic* value, meaning pharmacologically effective remedies are expected to have greater *Fic* value and vice versa [43].

Table 2 The number of traditional medicinal plant species in each growth habit

| Growth form | No. of species | Percentage |
|---------------------|----------------|------------|
| Shrub | 29 | 34.9 |
| Herb/annual | 28 | 33.7 |
| Tree | 11 | 13.3 |
| Herb/perennial | 7 | 8.4 |
| Creepers/herbaceous | 3 | 3.6 |
| Climber/annual | 2 | 2.4 |
| Climber/perennial | 2 | 2.4 |
| Epiphyte | 1 | 1.2 |

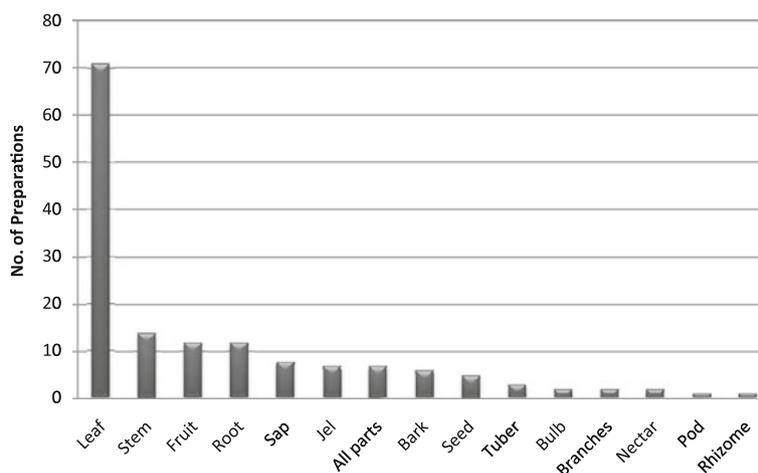


Figure 2 The use of different plant parts in remedial preparation and number of preparations per plant part.

Even if the highest value of *Fic* was for gastritis and heartburn/pyrosis indicating that there is high consensus on the treatment of these major health problems of the area, it can be concluded that there are relatively high *Fic* values for their major health problems. This will attract pharmacologists for further pharmacological investigation of the traditional plant species in this rich ethnomedicinal knowledge and practice centre. The pharmacological study done in the prehistoric place of Harla by [17] indicated that the latex and isolated compounds of *A. harlana* possess promising antimicrobial

activity particularly against the Gram-negative bacterial strains such as *Escherichia coli*, *Salmonella typhi* and *Vibrio cholerae*. Similar results were reported by [6,47] where the *Fic* value were greater than 0.5 for all clusters that may encourage interested researchers for validation of bioactivity as well as isolation and characterization of the active principles of those plant species in each category with high frequency of citation.

The frequencies of citation for medicinal plant species that are more popular and widely used by the local community were analyzed. Species having more than 20%

Table 3 Major types of human health problems of the study area, number of plant species used and informant consensus factor values

| Major health problems of the study areas | List of plant species used and no. of citation in the bracket | Total no. of use citation | Fic value |
|--|--|---------------------------|-----------|
| Gastritis and heartburn/pyrosis | <i>Cadia purpurea</i> (8) | 8 | 1 |
| Constipation | <i>Jatropha curcas</i> (10), <i>Portulaca oleracea</i> (19), <i>Ricinus communis</i> (11) | 40 | 0.95 |
| Haemorrhage | <i>Pouzolzia parasitica</i> (11), <i>Ziziphus spina-christi</i> (7) | 18 | 0.94 |
| Intestinal parasite | <i>Azadirachta indica</i> (11), <i>Dodonaea angustifolia</i> (9), <i>Kleinia squarrosa</i> (3) | 23 | 0.91 |
| Skin cyst & tumor | <i>Caralluma speciosa</i> (3), <i>Gloriosa superba</i> (4), <i>Plumbago zeylanica</i> (15), | 22 | 0.90 |
| Diarrhoea | <i>Craterostigma plantagineum</i> (4), <i>Pouzolzia parasitica</i> (5) | 9 | 0.88 |
| Kidney infections | <i>Acalypha fruticosa</i> (4), <i>Coccinia sp.</i> (12), <i>Melhania zavattarii</i> (2) | 18 | 0.88 |
| Eye and ear | <i>Aloe mcloughlinii</i> (6), <i>Datura stramonium</i> (5), <i>Kalanchoe marmorata</i> (6), <i>Leucas minimifolia</i> (3), <i>Ocimum lamiifolium</i> (7) | 27 | 0.81 |
| Wound and external infections | <i>Asparagus africanus</i> (5), <i>Caralluma speciosa</i> (3), <i>Cucumis prophetarum</i> (7), <i>Dodonaea angustifolia</i> (4), <i>Gossypium hirsutum</i> (3), <i>Grewia bicolor</i> (3), <i>Jasminum grandiflorum</i> (5), <i>Kalanchoe marmorata</i> (4), <i>Leucas stachydiformis</i> (4), <i>Lawsonia inermis</i> (6) | 44 | 0.79 |
| Skin itching, fungus, inflammation | <i>Acanthospermum hispidum</i> (4), <i>Aloe harlana</i> (8), <i>Asparagus africanus</i> (3), <i>Caralluma speciosa</i> (3), <i>Commelina stepheliniana</i> (5), <i>Commicarpus sinuatus</i> (4), <i>Cucumis dipsaceus</i> (7), <i>Dodonaea angustifolia</i> (2), <i>Erucastrum arabicum</i> (2), <i>Gomphocarpus purpurascens</i> (3), <i>Grewia bicolor</i> (3), <i>Heliotropium steudneri</i> (3), <i>Opuntia ficus-indica</i> (10), <i>Pouzolzia parasitica</i> (4) | 61 | 0.78 |
| Swollen body part locally called GOFLA | <i>Aloe harlana</i> (6), <i>Kleinia pendula</i> (3), <i>Caralluma speciosa</i> (3), <i>Cucumis ficifolius</i> (13), <i>Cucumis prophetarum</i> (4), <i>Euclea racemosa</i> (3), <i>Eulophia petersii</i> (5), <i>Erianthemum aethiopicum</i> (3), <i>Kleinia squarrosa</i> (3), <i>Maerua triphylla</i> (2), <i>Prunus persica</i> (2), <i>Punica granatum</i> (3), <i>Richardia tingitana</i> (4), | 54 | 0.77 |

frequency of citation are given in Table 4. A total of 18 plant species showed high frequency of citations ranging from 21.8–87.3 percent. *Aloe megalacantha* has the highest frequency of citation (87.3%) which was used as colon cleaner and a remedy made from it locally called SIBRI is sold in the local open market places, followed by *Cissampelos mucronata* (85.5%), *Aloe harlana* (78.2%), *Ocimum lamiifolium* (76.4), etc. (Table 4). This can show substantial level of agreement on the therapeutic worth of the traditional medicinal plant species in the study area. The greatest independent citations a particular species receives for treatment of a certain illness category is, the greatest its cultural importance [34].

Table 4 Plant species with the highest frequency of citation based on overall effectiveness to treat the corresponding human ailments

| Species name | Disease (s) treated | F(%) |
|----------------------------------|---|------|
| <i>Aloe megalacantha</i> | Colon cleaner | 87.3 |
| <i>Cissampelos mucronata</i> | Sudden illness locally called "DINGETEGNA" | 85.5 |
| <i>Aloe harlana</i> | Swollen body part locally called GOFLA, snake bite, liver swelling, spleen swelling, colon cleaner, skin fungus, hair fungus, skin inflammation | 78.2 |
| <i>Ocimum lamiifolium</i> | "MICH", eye infection | 76.4 |
| <i>Portulaca oleracea</i> | Constipation, cough | 70.9 |
| <i>Tamarindus indica</i> | Colon cleaner | 70.1 |
| <i>Withania somnifera</i> | Extended flow of menstruation/ menometrorrhagia, gallstone, evil eye | 69.1 |
| <i>Cadia purpurea</i> | Gastritis, heartburn/pyrosis | 67.3 |
| <i>Azadirachta indica</i> | Intestinal parasite, malaria | 56.4 |
| <i>Lawsonia inermis</i> | Infection after hemorrhage removal, infection after skin tumor removal, fever | 49.1 |
| <i>Pouzolzia parasitica</i> | Diarrhoea, hemorrhage, hair fungus | 47.3 |
| <i>Kleinia abyssinica</i> | Sexual dysfunction | 41.8 |
| <i>Terminalia brownii</i> | Liver disease/jaundice | 38.2 |
| <i>Caralluma speciosa</i> | Skin cyst & tumor locally known as KELEDO, gangrene, swollen body part, anti poison, wound, itching skin | 34.5 |
| <i>Cucumis ficifolius</i> | Swollen body part locally called GOFLA | 23.6 |
| <i>Gomphocarpus Purpurascens</i> | Itching skin, evil eye | 32.7 |
| <i>Plumbago zeylanica</i> | Skin cyst & tumor locally called KELEDO | 27.3 |
| <i>Coccinia sp.</i> | Kidney infections | 21.8 |

F = frequency of citation.

Aloe harlana was reported to be used for the highest number of ailments that treat swollen body part locally called GOFLA, anti-poison for snake bite, liver swelling, spleen swelling, colon cleaner, skin and hair fungus and skin inflammation. Another study [17] on *A. harlana* indicated that the Oromo people in Harla have been used it for the treatment of various infectious and inflammatory diseases. It has a considerable role in the primary healthcare system of the community. It is an endemic plant species known only in this study area and the specific epithet "*harlana*" refers to the prehistoric Harla, locality of type specimen. Until the time of this study, the community in Harla didn't know that the famous and endemic traditional medicinal plant known as *A. harlana* is only found in their vicinity and nowhere else. Its sap extraction was dried, crystallized and powdered for the preparation of a popular traditional colon cleaner locally known as SIBRI (Oromo language), a product name on local market places. Indeed, this result will encourage local communities to further conserve and safeguard such valuable medicinal plant species within their ongoing wide scale conservation activities. A study conducted in Arsi zone of Ethiopia [29,33] indicated that paying special attention to high value medicinal plants could help to strengthen the role of those plant species in healthcare and environmental protection.

Plant species such as *Aloe megalacantha*, *Cissampelos mucronata*, *Ocimum lamiifolium*, *Tamarindus indica*, *Lawsonia inermis* and *Withania somnifera* scored high frequency of citations greater than 50 percent among the medicinal plant species which were marketable in the open market places. The higher frequency of citation of these species indicates their importance for local communities and attracts more attention for conservation in the study area.

The result on depth of comprehensive ethnomedicinal knowledge among different age groups indicated that elderly people (above 60 years) had much profound knowledge (binomial test, $p = 0.002$). Whereas, an ethnomedicinal knowledge test in the age group ranging from 25 to 40 showed the least value (binomial test, $p = 0.008$). There is a significant difference in the depth of ethnomedicinal knowledge between age category ranging from 25 to 40 and age category above 60 ($p > 0.05$). It was observed that many young people in the study area are less knowledgeable about the variety and value of indigenous medicinal plants. This might be attributed to the current expansion of education and health centres to kebele level which has resulted in the young generation focusing on modern medicines. Similar results were reported in some other cultural groups in Ethiopia [15,26] that showed the deterioration of indigenous knowledge on medicinal plants throughout the generations. A study

conducted in Bale region of Ethiopia witnessed that western style health care services provided by government and NGOs seem to have contributed to a decline in traditional knowledge on medicine [28]. Therefore, documentation and communication of findings on knowledge and use of traditional medicinal plants in the present study area and beyond is very valuable in safeguarding the deterioration of indigenous knowledge on medicinal plants. Such findings need to be scaled-up followed by phytochemical and pharmacological analyses in order to give scientific ground to the ethnomedicinal knowledge.

In addition, the binomial test on ethnomedicinal knowledge between men and women showed that men have much more profound knowledge (binomial test, $p = 0.001$) than women (binomial test, $p = 0.009$) which is significantly different ($p > 0.05$). Similar results were reported by [9-11,34] where men have more profound knowledge than women in many parts of Ethiopia. This might be related with the local tradition of restricting traditional medical practices mostly to men and resulted in least number of women representation in the informant sampling of this stud. All the key informants (traditional healers) selected in this study were men, as it is also largely true for many other parts of Ethiopia. In contrast, [48] have reported women have more specialized knowledge on medicinal plants than men since they are often called upon to diagnose and treat certain types of diseases. It was also reported that men and women who are traditional medicine practitioners have relatively equivalent medicinal plants knowledge [26].

Methods of preparation and routes of administration

The informants reported that 140 different preparations were made from 83 medicinal plant species. These were cited in the traditional healing system for use in 81 different human ailments. Out of the total preparations 50.7% are prepared in the form of concoction followed by fluids extraction (10.7%) and infusion (6.4%) (Table 5). Most of the remedies are prepared from a single species; mixtures are used infrequently. Out of total preparations, 127 were prepared from single plant species and the rest 13 were from two or more plant species. A number of sources [2,10,11,27,45,49] reported similar results stating that monotherapy preparation made from single plant species was used more frequently than mixtures for remedy preparations. This contrasts with the report by [9,15] where mixtures of different species were used to treat ailments than the use of single species.

The preparations made from mixture of two plant species were like, the bark of *Croton macrostachyus* and *Terminalia brownii* were crushed, concocted and taken orally to treat jaundice. The stem and leaf of *Kalanchoe marmorata* and the seeds of *Ricinus communis* were crushed together and bandaged to treat small skin

Table 5 Method of preparation

| Method of preparation | Number of preparations | Percentage |
|--------------------------------------|------------------------|------------|
| Concoction | 71 | 50.7 |
| Fluids extraction | 15 | 10.7 |
| Infusion | 9 | 6.4 |
| Crushed and pounded | 8 | 5.7 |
| Decoction | 6 | 4.3 |
| Ointment | 5 | 3.6 |
| Cooked as a soup | 4 | 2.9 |
| Dried and powdered | 4 | 2.9 |
| Make it warm/hot | 4 | 2.9 |
| Small cut of fresh part to be rubbed | 3 | 2.1 |
| Dried for smoke bath | 2 | 1.4 |
| Small cut of fresh part to be chewed | 2 | 1.4 |
| Small cut of fresh part to be eaten | 2 | 1.4 |
| Small cut of stick for brushing | 2 | 1.4 |
| Syrup | 2 | 1.4 |
| Pulverized and filtered | 1 | 0.7 |

swelling with pus resulting due to poisonous spines. The bark and leaf of *Cadaba rotundifolia* and *Withania somnifera* were concocted together to treat extended flow of menstruation. Fruit and leaf of *Cucumis dipsaceus* and *Commicarpus sinuatus* were concocted together and taken orally to treat gonorrhoea. An oily extract from the leaf of *Kleinia longiflora* was boiled and mixed with crushed fresh leaf of *Cadaba rotundifolia*. It is used to massage paralyzed body part every morning and evening to improve nerve function. It was also reported that the fresh leaf of *Gloriosa superba* was crushed with succulent stem of *Caralluma speciosa* and applied on the starting point of gangrene so as to prevent its' spreading to the rest of the body.

The fresh leaves of three plants i.e. *Steganotaenia araliacea*, *Grewia bicolor*, and *Cissampelos mucronata* were concocted together and taken orally for a person having mental disturbance and body burning feeling. This was the only remedy made from mixture of three plant species. According to traditional healers' report this remedy has body cooling effect, giving good sleep and mental stability when a small cup of solution is taken in the evening. Some of the traditional healers mentioned that the use of multiple therapies in traditional remedial preparation could increase the efficacy of traditional medicine for the corresponding health problem. According to [50], the use of more than one plant species to prepare a remedy for ailments is attributed to additives or synergistic effects during ailment treatment.

In addition, different plant parts from a single species were prepared in similar ways to treat different types of

ailments. For example, the infusion from fresh leaf and seed of *Azadirachta indica* is taken orally to treat malaria and intestinal parasites; the leaf and root of *Craterostigma plantagineum* were concocted together and taken orally to treat liver disease and diarrhoea; leaf and jel of *Aloe harlana* were concocted together and used as an ointment to treat skin and hair fungi. Some remedial preparations need admixture like oil, honey and sugar. These could increase the adhesive nature of remedies particularly for dermal ailments. They also reduce some side effects like bitterness, vomiting; and improve the taste of remedies. Other studies [5,11,23,25,27] also reported about the use of admixtures in remedial preparations for same effects.

Both internal (55.1%) and external (44.9%) routes were used for application of the medicines. For internal application, the most common route was oral that accounted for 45.7% and that of external was dermal ointment which accounted for 12.1% (Table 6). Though, more diversified usage was reported for external use (nine different ways), oral route of administration accounts the highest percentage. Some more studies reported that oral route of administration is the most common [15,25-27,34].

There was no consensus on the dosage used and frequency of medication among the traditional healers. Most of them reported that the dose given to patients depended on age, physical and health conditions. For example, a small piece of an aphrodisiac fresh rhizome of *Kleinia abyssinica* can be enough if properly chewed and swallowed few hours before sexual performance to increase sexual performance of physically weak and less weighted person/man whereas considerably large sized rhizome is needed for same effect for stronger and heavy weighted person/man having problem of sexual dysfunction. Lack of precision and standardization was mentioned as a global drawback of traditional healthcare system [4,27,45]. Similarly, in this study where internal route of application accounts 55.1%, lack of precision can be taken as the major drawback.

Overdose of remedies was also reported to bring adverse effects like, diarrhoea, vomiting, abdominal pain, unconsciousness, and fainting of the patient. During such incident, the traditional healers use different antidotes for reversing adverse effects like, "HOJA" a local hot beverage prepared from milk and pericarp of coffee berry, coffee, honey and milk. The same pattern of using antidotes was reported for other cultural groups elsewhere in Ethiopia [5,9,11,26,45].

Conclusion

Overall, this comprehensive ethnomedicinal study showed that the community in Harla and Dengego Valleys rely on considerable number of traditional medicinal plant species to treat wide spectrum of human ailments and are knowledgeable about the identities and applications of medicinal plants. The majority of medicinal plant species were harvested for their leaves so poses no significant threat to the natural vegetation of the study area. Out of the total ethnomedicinal plant species identified in this study some were endemic plant species like, *Aloe harlana*, *Aloe mcloughlinii*, *Gomphocarpus purpurascens*, *Indigofera ellenbeckii* and *Rhynchosia erlangeri*. Among these endemic medicinal plant species, *Aloe harlana* was found only in this study area. It had been named after the prehistoric Harla. It was the first time for the local community to get this information. They were highly excited and encouraged to further conserve and safeguard such valuable medicinal plant species within their wide scale conservation activities.

Plant species like, *Aloe megalacantha*, *Cissampelos mucronata*, *Ocimum lamiifolium*, *Tamarindus indica*, *Lawsonia inermis* and *Withania somnifera* scored a high frequency of citations (>50%) among the medicinal plant species which were marketable in the open market places. Such benefits of plants in the primary healthcare system, income generation and higher frequency of citation could be considered as a good opportunity for the support of their livelihood. Therefore, the out put of this

Table 6 Routes of administration

| Internal | No. of preparations | Percentage | External | No. of preparations | Percentage |
|------------------|---------------------|---------------|-----------------|---------------------|---------------|
| Oral drink | 64 | 45.7 | Dermal ointment | 17 | 12.1 |
| Oral eaten | 6 | 4.3 | Dermal bandage | 16 | 11.4 |
| Eye/internal | 4 | 2.9 | Buccal cavity | 11 | 7.9 |
| Ear/internal | 2 | 1.4 | Herbal bath | 9 | 6.4 |
| Vaginal/Internal | 1 | 0.7 | Drenched | 4 | 2.9 |
| Total | 77 | 55.10% | Dermal rubbing | 2 | 1.4 |
| | | | Smoke bath | 2 | 1.4 |
| | | | Steam bath | 1 | 0.7 |
| | | | Massage | 1 | 0.7 |
| | | | Total | 63 | 44.90% |

comprehensive ethnomedicinal knowledge will encourage the community to conserve, manage and sustainable use the medicinal plant species.

The binomial test on the depth of ethnomedicinal knowledge between younger and elderly informants showed a significant difference. Many young people were less knowledgeable about the variety and value of traditional medicinal plants. This showed the level of deterioration of ethnomedicinal knowledge in this prehistoric study area. It is, therefore, necessary to preserve this indigenous knowledge on traditional medicines by proper documentation, identification of plant species, herbal preparation and dosage. In addition, it should be followed with phytochemical and pharmacological analyses in order to give scientific ground to the ethnomedicinal knowledge.

Competing interests

We declare that we do not have competing interests.

Authors' contributions

AB carried out the field study, identified the medicinal plant species, analyzed the data and wrote the manuscript. NB carried out the field study with AB, revised the manuscript, and provided considerable input. Both of us read the final manuscript and agreed on its submission.

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