ADDIS ABABA UNIVERSITY

COLLEGE OF NATURAL AND COMPUTATIONAL SCIENCES

DEPARTMENT OF PLANT BIOLOGY AND BIODIVERSITY MANAGEMENT

Ethnobotanical study of medicinal and wild edible plants in Dibatie district, Metekel zone, western Ethiopia, and evaluation of the antimicrobial, nutritional, antioxidant and phytochemical profiles of selected plants

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Supervisors:

1. **Ermias Lulekal (Asso. Prof.)**
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PROGRAM OF GRADUATE STUDIES

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Declaration

I, the undersigned, declare that this dissertation is my original work and has not been presented at other universities, colleges, or institutes for a degree or other purpose. All sources of the materials used in the thesis have been suitably acknowledged.

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Abbreviations

ANOVA	Analysis of variance
ATCC	American Type Culture Collection
ETH	National Herbarium of Ethiopia
DPPH	2,2-diphenyl-1-picrylhydrazyl
Fi	Familiarity index
FL	Fidelity level index
FRAP	Ferric reducing antioxidant power
IC_{50}	50% inhibition concentration
ICF	Informant consensus factor
ICPC	International Classification of Primary Care
JCS	Jaccard's coefficient of similarity
MIC	Minimum inhibitory concentration
NTFPs	Non-timber forest products
PCA	Principal Component Analysis
POWO	Plants of the World Online
SPSS	Statistical Package for the Social Sciences
TSS	Total soluble solids
UV	Use value
UV-Vis	Ultra-Violet Visible
WEPs	Wild edible plants

Abstract/Summary

Human beings rely on plant resources to meet their day-to-day lives. Ethiopia is rich in plant diversity, multilanguistic, diverse ethnic groups, and indigenous knowledge to use the plant resources for various purposes, such as herbal medicines, foods, spices, stimulants, forages, construction, home furnishings, fuel wood, ritual ceremonies, beverages, oil, gum, shade, perfumes, artifacts, fences, and other commercial values. Yet limited research was conducted on the traditional use, product development, value addition, commercialization, and conservation of the plant resources in the Dibatie district, Metekel zone, western Ethiopia, as well as the country as a whole. Thus, this study was aimed at investigating the ethnobotany of medicinal and wild edible plants in the Dibatie district of the Metekel zone, western Ethiopia, with an evaluation of the antimicrobial activity, nutritional value, antioxidant potential, and phytochemicals of selected plants.

The ethnobotanical data (for **Papers I and III**) were collected using a semi-structured interview, field observation, focus group discussions, a market survey, and the ranking of selected plants. Voucher specimens were collected, identified, and preserved at the National Herbarium of Ethiopia. The ethnobotanical data (for **Papers I and III**) were analyzed through descriptive statistics (percentage and frequency), ranking, comparison, and quantitative ethnobotanical techniques such as informant consensus factor, fidelity level index, familiarity index, Jaccard's similarity index, and use value index. The selected medicinal plants (in **Paper II**) were collected, shade dried, pulverized, extracted with 80% ethanol, and subjected to antibacterial, antioxidant, and phytochemical tests. The minimum inhibitory concentration (MIC) was determined using 96-well microplates and nutrient broth microdilution. Antioxidant activity was evaluated using the 2,2-diphenyl-1-picrylhydrazyl (DPPH) free radical scavenging assay. Phytochemical screening was conducted using standard test methods. The juices of selected wild edible plants (in **Paper IV**) were used to determine the pH, acidity, and total soluble solids (TSS). Their lyophilized powders were analyzed to determine vitamin C, proximate composition, minerals, functional properties, anti-nutritional factors, antioxidant activity (DPPH assay and ferric reducing power), and quantitative phytoconstituents.

In **Paper I**, a total of 170 medicinal plants were recorded to treat about 79 human and 29 livestock ailments. A large percentage (35.88%) of the medicinal plants were herbs, and the majority

(79.41%) of them were from wild sources. Many (41.17%) medicinal plants had multiple remedy parts and were often prescribed freshly. The remedies were mostly applied orally (52.20%), followed by dermal (17.62%) routes. Out of the examined medicinal plants in **Paper II**, the extract of *Polystachya steudneri* Rchb.f. pseudobulb was the most active against gram-negative and gram-positive bacterial strains. The extracts of *Gnidia involucrata* Steud. ex A.Rich. stems and roots were effective antioxidants, with respective IC_{50} values of 168.68 and 181.79 µg/mL compared to ascorbic acid (IC_{50} = 53.76 µg/mL). The studied plants (in **Paper II**) contained alkaloids, anthocyanins, anthraquinones, cardiac glycosides, coumarins, flavonoids, phenols, saponins, steroids, tannins, and terpenoids. Ethnobotanically, 54 wild edible plants (in **Paper III**) were identified, of which 38.90% were trees and mainly contained edible fruits (72.20%). They were usually consumed raw as complementary foods frequently in the months December to May. About 98% of the recorded plants had additional uses beyond their nutritional values. Out of the analyzed wild edible plants in **Paper IV**, *Saba comorensis* (Bojer ex A.DC.) Pichon fruit had the highest ($p < 0.05$) acidity, vitamin C, TSS, water solubility, oxalates, and tannins. The evaluated plants were rich in carbohydrates (59.63–68.83%), energy (267.75–324.08 kcal/100g), and minerals like calcium (522.27–995.04 mg/100g), iron (19.80–111.94 mg/100g), magnesium (923.25–1592.18 mg/100g), and potassium (591.69–1357.71 mg/100g). *Dioscorea praehensilis* Benth. tuber had the highest bulk density, water absorption, water holding, foaming, and foam stability, and *Syzygium guineense* (Wild.) DC. subsp. *macrocarpum* (Engl.) F.White fruit was significant in oil absorption. *Saba comorensis* fruit contained the highest ($p < 0.05$) total phenolics, flavonoids, and alkaloids and was found to be a substantial source of antioxidant, followed by *S. guineense* subsp. *macrocarpum* fruit.

The study area was rich in a diversity of potential medicinal and wild edible plants, along with the associated indigenous knowledge. The plants support the native people in food security, agriculture, medicine, energy sources, construction, ecological services, aesthetics, income generation, and household utensils. However, medicinal and wild edible plants are recently threatened owing to the appearance of various anthropogenic factors in the study area. Thus, appropriate conservation actions and careful utilization are crucial to counteract the increasing effect of anthropogenic factors and ensure the sustainability of important plants with the related indigenous knowledge. In addition, experimental validation should be employed to evaluate the pharmaceutical and nutritional benefits of the identified medicinal and wild edible plants in the

study area. The investigated medicinal plants (in **Paper II**) were confirmed as vital sources of antibiotics, antioxidants, and bioactive phytochemicals. Hence, further investigations were suggested to obtain bioactive lead compounds for the development of novel drugs. The examined wild edible plants (in **Paper IV**) were verified as good sources of valuable nutrients and phytochemicals with substantial functional, anti-nutritional, and antioxidant properties. As a result, they need to be conserved and wisely used in the form of various food products in the future.

Keywords: Antibacterial, Antioxidant, Anti-nutritional factors, Ethnobotanical study, Medicinal plants, Nutritional values, Phytochemicals, Wild edible plants

CHAPTER ONE

1. General Introduction

1.1. Background of the study

Plants play an important role in the daily lives of human beings, still now, through a variety of ways in that they produce oxygen, serve as food, sources of fibers, building materials, fuel, medicine, beauty flowers, dyes, perfumes, plant resins, and so on (Van Der Veen, 2018). In the Ethiopian context, plant resources are reported to be used as traditional medicines, foods, spices, stimulants, forages, construction raw materials, household apparatuses (e.g., beds, mats, etc.), firewood, ritual ceremonies, beverages, oil, gum, shade, perfumes, artifacts, fences, and commercial values (Dalle et al., 2005; Tebkew et al., 2014; Teketay et al., 2010).

It is believed that 60% of the world population and about 80% of African people are dependent on traditional medicinal plants for their primary healthcare (Bogale et al., 2023). Ethiopia is a rich source of medicinal plants and associated indigenous knowledge due to the diversity of ethnic groups, wide range of geographic variation, and long history of using traditional medicines (Tahir et al., 2023b). Thus, traditional medicinal plants have been used for a long time to treat different human and livestock ailments in Ethiopia (Zemede et al., 2024). Medicinal plants are one of the potential sources for the discovery of biologically active compounds (Siraj et al., 2020), which play essential roles in the healing of different human and animal diseases. Several biochemical substances derived from medicinal plants have significant antibacterial activities (Teka et al., 2015). The antibacterial activities of medicinal plants depend on the constituents of secondary metabolites, such as alkaloids, flavonoids, glycosides, tannins, terpenoids, and so on (Sisay et al., 2019). Besides, medicinal herbs and spices have potential antioxidant, anti-infammatory, antimutagenic, and anticancer effects owing to a variety of phenolic compounds (Nigussie et al., 2023).

Moreover, a number of wild food plants can be found in Ethiopia due to the diverse climatic and edaphic characteristics of the country (Masresha et al., 2023). Wild edible plants are integral parts of the feeding cultures in most rural communities of Ethiopia (Abera & Belay, 2022), supplementing the staple food staff and filling the seasonal food shortages (Hankiso et al., 2023). Hence, they are appreciated for fighting against food insecurity, especially during lower productivity of the cultivated crops (Asfaw et al., 2023). Some wild edible plants are chief sources of diet diversity and are rich in dietary fiber, fat, protein, energy, and minerals like calcium, iron, and zinc, among others (Yimer et al., 2023a). In addition, wild edible plants have health benefits in traditional medicines (Giday & Teklehaymanot, 2023; Hankiso et al., 2023) and serve as natural antioxidants due to phytoconstituents such as phenols, flavonoids, vitamin C, and carotenoids (Yimer et al., 2023b).

Today, antimicrobial resistance is having major effects because of the treatment failures associated with microorganisms that are resistant to multiple drugs (Dinbiso et al., 2022). As a result, there is a need for safe and effective alternative plant-based medicines to treat various infectious diseases. Additionally, natural antioxidants of plant origin are attracting the attention of food and pharmaceutical companies and concerned researchers owing to the adverse effects of synthetic antioxidants, for example, butylated hydroxyl toluene, butylated hydroxyl anisole, propyl gallate, and tributyl hydroquinone (Yimer et al., 2023b). In Ethiopia, despite their indispensable roles in healthcare and food security, medicinal and wild edible plants are declining along with indigenous knowledge due to overexploitation, population growth, agricultural expansion, overgrazing, fuel wood collection, and charcoal production (Tadesse & Teka, 2023; Yiblet & Adamu, 2023). Besides, the related indigenous knowledge was overlooked as it has been transmitted through oral methods from generation to generation (Megersa et al., 2023; Tahir et al., 2023a). This calls for in-depth investigation and documentation of medicinal and wild edible plants throughout the country.

Particularly, the Dibatie district of Metekel zone, Benishangul Gumuz Regional State, western Ethiopia, contains different ethnic groups (Agaw, Amhara, Gumuz, Oromo, and Shinasha), linguistics, cultures, and a diversity of plants. The local people have a vast indigenous and local knowledge of medicinal and wild edible plants. The local community interaction with their plant resources needs to be documented for the purpose of conservation strategies and sustainable use of plants. Therefore, this study was aimed at assessing the ethnobotany of medicinal and wild edible plants used in Dibatie district of Metekel zone, western Ethiopia, with an evaluation of the antimicrobial activity, nutritional value, antioxidant potential, and phytochemical constituents of the selected plants.

1.2. Concise literature review

1.2.1. Traditional medicinal plants in Ethiopia

In Ethiopia as well as other developing countries, medicinal plants serve as a prominent supplementary medicine where access to modern healthcare is limited or unaffordable for most people (Dalle et al., 2005). Ethiopia is particularly a center for plant diversity and multiple languages, cultures, and beliefs that contribute to the practice of various traditional knowledge, including the use of medicinal plants (Giday et al., 2003). The different parts of medicinal plants, such as roots, stems, leaves, fruits, seeds, flowers, bark, buds, twigs, latex, and bulbs, are utilized locally to treat human and livestock illnesses (Giday et al., 2016; Wondimu et al., 2007).

However, the harvesting of whole plant parts and roots of medicinal plants can pose adverse effects on their survival and continuity in the future (Damtie & Mekonnen, 2016; Kefalew et al., 2015; Lulekal et al., 2008). The use of rhizomes, bulbs, flowers, bark, and stems may also cause destructive effects relative to the harvesting of leaves (Asnake et al., 2016; Belayneh et al., 2012). For example, *Thymus schimperi* and *Thymus serrulatus* are threatened due to harvesting of the whole plant parts, including roots (Damtie & Mekonnen, 2016); and *Hagenia abyssinica* is endangered owing to overexploitation of its roots, bark, and inflorescences (female flowers) for traditional medicine (Assefa et al., 2010). Moreover, the extensive use of plants by the local communities, with a high rate of deforestation, can put the medicinal plants under the burden of extinction unless wise use and conservation of the forest ecosystem are made to ensure the existence of these plants to a large extent (Giday et al., 2016).

1.2.2. Preparation methods and administration routes of medicinal plants

The methods used to prepare medicinal plants include grinding, crushing, chewing, pounding, powdering, chopping, decocting, exudation, concoction, soaking, infusing, squeezing, filtering, rubbing, cooking, roasting, boiling, smoking, burning, heating, fumigating, and consuming the remedy parts (Chekole, 2017; Tefera & Kim, 2019; Tolossa et al., 2013). The remedy preparation is mostly carried out from a part of a single species, although different parts of a single plant are also used to treat the same type of ailment (Belayneh et al., 2012). On the other hand, herbal remedies could be prepared from a mixture of more than one plant species to treat a particular human or livestock ailment. This is because certain traditional healers believe that the mixing of two or more species has synergistic effects for healing diseases (Tolossa et al., 2013; Yigezu et al., 2014). In addition, traditional healers practice poly-herbal preparation to avoid the side effects of powerful plants due to their various constituents (Kefalew et al., 2015; Suleman & Alemu, 2012).

The traditional medicinal plants are applied through different routes of administration, such as oral, topical, dermal, nasal, optical, vaginal, and auricular routes (Alemayehu et al., 2015a; Chekole, 2017). Additionally, traditional remedies are applied by tying on the body, steam or smoke fumigation, surgical implantation, and washing the solution (Chekole et al., 2015). Oral administration is reported to be the most commonly used in various parts of Ethiopia (Chekole, 2017; Demie et al., 2018; Eshete et al., 2016). However, pregnant women and children under 6 months old are not treated through internal prescription in some areas of the country (Tahir et al., 2023b). The repellant medicinal plants are mainly applied by smoking to the vectors, although some remedies could be hung around the bedroom, door, and windows (Tefera & Kim, 2019).

1.2.3. Possible side effects and antidotes of herbal medicine in Ethiopian

The majority of traditional medicinal plants in Ethiopia are reported to be free from adverse effects (Mekonnen et al., 2022; Yimam et al., 2022). Herbal medicines are sometimes preferable over conventional drugs due to their lower side effects, greater efficacy, and multiple activities (Aschale et al., 2023). Like any other treatment, however, herbal remedies may have unfavorable consequences. In this sense, the most common adverse effects of orally applied traditional medicines include nausea, vomiting, diarrhea, stomachaches, bad breath, appetite loss, perspiration, fever, bloating, sleeping, sneezing, eye redness, farting, and recurrent urine (Agize et al., 2022; Teshome et al., 2023; Yimam et al., 2022). For instance, herbal remedies orally taken to treat hepatitis, gonorrhea, and rabies are reported to cause nausea, vomiting, headache, diarrhea, gastric pain, weight loss, and short-term unconsciousness. Whereas, topically or dermally applied medicinal plants against hemorrhoids, wounds, and skin infections are indicated to cause temporary irritation or burning (Mekonnen et al., 2022). Traditional healers counteract the negative effects of herbal medicines by giving antidotes such as milk, honey, coffee, meat, and a local beer called ‘Tella’ (Megersa & Tamrat, 2022; Zemede et al., 2024).

1.2.4. Dosage determination and additives of herbal medicine in Ethiopia

The amount of herbal medicine administered by local healers varies from location to location and healer to healer, even to treat the same ailments (Mekonnen et al., 2022). Dosage is one of the limitations of traditional medicine in the country owing to the lack of a reliable standard (Zemede et al., 2024). It is necessary to be aware of the dosage issue, as it plays a crucial role in deciding whether or not a small amount is therapeutic, and an excessive amount can have harmful or fatal consequences (Oda et al., 2024). The appropriate dosage determination can be dependent on the age, sex, physical state, degree of illness, and pregnant status of the treated human or livestock (Oda et al., 2024; Teshome et al., 2023). Besides, the dosage issue requires more attention during oral applications than dermal, as it may lead to serious internal complications (Tahir et al., 2023b). Traditional healers usually determine the dosage through traditional methods such as finger strips, glass, coffee cups, tea spoons, and hand palms (Megersa et al., 2023; Zemede et al., 2024).

Traditional healers use certain additives to enhance the taste, boost the effectiveness, and decrease the negative effects of herbal medicines (Bekele et al., 2022; Mekonnen et al., 2022). Local healers usually use additives such as coffee, food, milk, honey, water, salt, tea, red teff powder, sugar, oil, and butter with traditional medicines (Agize et al., 2022; Megersa et al., 2023). Additionally, local people apply herbal remedies with butter and oil to treat cutaneous diseases and use coffee, honey, and local beverages like 'Tela' and 'Areke' to avoid the bitterness of certain medicinal plants (Getaneh & Girma, 2014).

1.2.5. Marketability of medicinal plants in Ethiopia

Most traditional medicinal plants in Ethiopia are not commercially viable for use as medicine (Tadesse & Teka, 2023; Tamene et al., 2023; Teshome et al., 2023). Traditional remedies made by local healers from plants or plant parts are often sold at home rather than on the open market, according to the habits of some local communities in Ethiopia (Agize et al., 2022; Eshete & Molla, 2021; Megersa et al., 2023). Instead of purchasing medical plants from the market, native people choose to either go straight to traditional healers for treatments or gather medicinal plants on their own from the available places to prepare the remedies (Teshome et al., 2023). However, certain medicinal plants are vended in the local markets, and the majority of them are sold for other values such as uses as spice, food, local drink, construction, and firewood (Abebe, 2022; Tadesse & Teka, 2023). For instance, medicinal plants such as *Artemisia afra, Hagenia abyssinica, Lepidium sativum, Polygala sadebeckiana, Satureja abyssinica,* and *Silene macrosolen* in the Gurage and Silti zones (Teka et al., 2020) and *Echinops kebericho* in the Sheka Zone (Kassa et al., 2020) are vended for their medicinal uses. Whereas other medicinal plants like *Allium sativum, Allium cepa, Artemisia abyssinica, Brassica carinata, Brassica nigra, Capsicum annuum, Carica papaya,* *Citrus limon, Coriandrum sativum, Cucurbita pepo, Lepidium sativum, Linum usitatissimum, Nigella sativa, Ocimum basilicum, Trigonella foenum-graecum*, and *Zingiber officinale* in Zuway Dugda district are stated to be sold primarily for values other than medicinal purposes (Megersa et al., 2023).

1.2.6. Antimicrobial activities of medicinal plants

The extracts of traditional medicinal plants are reported to have antibacterial, antifungal, antimalarial, antiviral, anti-parasitic, anti-inflammatory, and antioxidant properties (Ogbole et al., 2018; Prakash et al., 2016). Regarding the antibacterial activities, extracts of medicinal plants are potent against both gram-negative (e.g., *Escherichia coli, Pseudomonas aeruginosa, Salmonella enterica, and Shigella sonnei*) and gram-positive (e.g., *Bacillus cereus, Streptococcus faecalis, Listeria innocua, and Micrococcus luteus*) bacterial pathogens (Baloyi et al., 2019; Panda et al., 2019). The antimicrobial activity of the plants could be ensured either by inhibiting the growth of bacteria or by disturbing the cell-to-cell communication system between the bacteria as anti-quorum sensing (AQS), in which the latter is currently preferable, especially against antibiotic-resistant bacteria (Baloyi et al., 2019). The presence of phytoconstituents such as alkaloids, flavonoids, phenols, terpenoids, steroids, cardioglycosides, and amino acids may account for the antibacterial properties of certain medicinal plants (Padayachee & Baijnath, 2020). For example, multi-solvent extracts of *Aerva lanata* have been recognized to inhibit the growth of *Pseudomonas aeruginosa*, *Staphylococcus aureus, Escherichia coli,* and *Enterobacter aerogenes,* among other bacterial strains, due to the constituents of phytochemicals like flavonoids, glycosides, tannins, steroids, saponins, phenolics, terpenoids, and alkaloids (Al-Ansari et al., 2019). Additionally, the crude extracts of *Datura metel*, *Spermacoce hispida*, and *Withania somnifera* have been shown to have considerable inhibitory activity against the growth of *Bacillus cereus* and *S. aureus* (Mohotti et al., 2020).

1.2.7. The wild edible plants in Ethiopia

The habit of eating wild edible plant products has been continued by most agricultural societies instead of depending only on staple crops (Lulekal et al., 2011). Thus, wild edible plants play a critical role in guaranteeing food security in many communities throughout the world, as they form a component of diets both during times of food scarcity and as a source of nutritional balance (Teketay et al., 2010). Additionally, they provide a variety of ecosystem services that support ecological balance and cultural heritage preservation, in addition to having economic, medicinal, and foraging values (Feyssa et al., 2012). In Ethiopia, the rural populations have a rich knowledge of wild edible plants (Teklehaymanot & Giday, 2010). However, wild edible plant species are very marginalized to document and conserve owing to the changes in food habits, lifestyles, and expansion of cultivated food, oil, and industrial crops in current Ethiopia (Dandena, 2010; Feyssa, 2012). Moreover, the consumption of wild edible plants has often been considered an indication of poverty in some Ethiopian communities due to a lack of knowledge about their nutritional benefits (Addis et al., 2013).

1.2.8. Role of wild edible plants in food and nutritional security

Wild edible plants serve as sources of food both during times of abundance and scarcity of normal food supplies (Addis et al., 2005). They could be used during periods of ample food production as supplementary to staple foods or as famine foods to fill the gap of seasonal food shortages (Ashagre et al., 2016). People consume wild edible plants during periods of food shortages owing to crop failure, protracted drought, starvation, social instability, or conflict (Bahru et al., 2013). Hence, they function as famine foods primarily in times of chronic food shortages and when preferred alternatives are unavailable (Bahru et al., 2013; Balemie & Kebebew, 2006). However, when food shortages become severe, local people tend to consume plants of less acceptable taste and nutritional quality under normal conditions (Addis et al., 2013; Aragaw et al., 2021). *Amaranthus graecizans, Balanites aegyptiaca, Balanites rotundifolia, Carissa spinarum, Cordia africana, Dioscorea prahensilis, Dobera glabra, Ferula communis, Garcinia livingstonei, Hypolepis sparsisora, Manilkara butugi, Portulaca oleracea, Rubus apetalus, Rumex abyssinicus, Syzygium guineense, Vitex doniana,* and *Ximenia americana* are among the significant species during periods of food shortage in various parts of Ethiopia (Aragaw et al., 2021; Kidane et al., 2014; Meragiaw et al., 2015; Teklehaymanot, 2017).

Indigenous fruits and vegetables can contribute positively to food and nutritional security (Aragaw et al., 2021). This is because indigenous vegetables have potential nutritional values and are cheap sources of vitamin A, vitamin C, and minerals like calcium, iron, and phosphorous (Dandena, 2010). Thus, the use of green leafy vegetables as part of main dishes or supplementary food helps to alleviate malnutrition (Addis et al., 2013). For instance, green leafy vegetables such as *Amaranthus graecizans, Portulaca oleracea*, *Hypelopis sparsisora,* and *Solanum nigrum* are good sources of protein, while fruit plants like *Carissa spinarum*, *Syzygium guineense*, and *Tristemma mauritianum* are found to be higher in energy, and vitamins A and C are rich in the fruits of *Rubus apetalus* and *Syzygium guineense* (Aragaw et al., 2021). Additionally, *Mimusops kummel*, *Ziziphus spina-christi*, and *Diospyros mespiliformis* are rich in vitamin C, phosphorus, and iron, respectively. However, local people are unaware of the nutritional components of wild edible plants, which they consume as famine and snack foods (Fentahun & Hager, 2009).

Wild edible shrub and tree species can mitigate the problems of hunger, food shortages, and malnutrition since they adapt better to the local environments and overcome the extreme effects of climate change (Kebebew & Leta, 2016). This is due to the innate resilience of wild species to water-deficit environments, which makes wild edible plants more crucial for local communities compared to exotic species (Feyssa et al., 2011a). On the other hand, the harvesting periods of wild edible plants could be varied, resulting in year-round fruit availability, owing to intra-species variation in fruit ripening time, climatic variation, and differences in inter-site fruiting season (Fentahun & Hager, 2009). Additionally, leafy vegetables help to fulfill the food needs of several households during the rainy season, while wild fruits are consumed in large quantities during the dry season. Therefore, wide-scale wild edible fruit, tuber, and leafy vegetable growing, scaled production, and commercialization may help diversify diets and boost resistance to climate change-related problems (Aragaw et al., 2021).

1.2.9. Indigenous mode of consuming wild edible plants in Ethiopia

In Ethiopia, wild edible plants are traditionally used as cabbage, refreshing fruit or fruit juice, hot drinks, alcoholic or non-alcoholic drinks, boiled or roasted grain, and tubers (Balemie & Kebebew, 2006; Fentahun & Hager, 2009; Yimer et al., 2021). The majority of wild edible plants (many of them fruits) are consumed raw, while others need to be processed through various food preparation techniques such as frying, boiling, roasting, fermenting, and cooking (Aragaw et al., 2021; Fentahun & Hager, 2009). Many wild edible plants, which are consumed raw, are eaten outdoors in agricultural fields, during cattle herding, traveling, coffee berry collection, and firewood collection (Addis et al., 2013; Ashagre et al., 2016; Teklu & Abduljabar, 2019). It is perceived that the raw consumption of wild edible fruits is often useful to reduce the loss of crucial nutrients upon cooking, boiling, or roasting (Abera & Belay, 2022; Giday & Teklehaymanot, 2023; Masresha et al., 2023). However, some wild edible plants are poisonous if consumed raw. For instance, the fruits of *Boscia angustifolia* and the tubers of *Dioscorea prahensilis* need to be eaten boiled or roasted by hunters, honey gatherers, miners, and travelers. This is due to the fact that cooking reduces the toxicity effects of certain compounds (Aragaw et al., 2021; Assefa & Abebe, 2011; Masresha et al., 2023). Nevertheless, some others could be consumed both cooked and uncooked, as in the case of *Arisaema schimperianum* (Ashagre et al., 2016).

Some wild edible plants, for example, the refreshing juices of *Carissa spinarum*, *Tamarindus indica, Cordia africana,* and *Ziziphus spina-christi,* are consumed with additives such as water, sugar, and honey (Fentahun & Hager, 2009). Additionally, indigenous people in the Melokoza woreda of southern Ethiopia use the seeds of *Vepris dainellii* as additive in coffee drinks (Denu & Desissa, 2013). Most leafy edibles are also consumed after being processed in the form of unleavened or leavened bread and local drinks with maize, sorghum, or barely flour, salt, and butter (Balemie & Kebebew, 2006).

On the other hand, ease of access, ease of processing, flavor, availability, and harvesting effort all influence how much wild edible plant is consumed (Assefa & Abebe, 2011). For instance, it takes all day to cook *Dobera glabra* fruits, and it is exceedingly labor-intensive to dig *Dioscorea praehensilis* tubers (Balemie & Kebebew, 2006).

1.2.10. Seasonal availability of wild edible plants in Ethiopia

The local communities have enough knowledge on the fruiting and ripening periods of wild edible fruit species (Fentahun & Hager, 2009). Local communities could have access to the edible plant parts at various times if they are available at different periods of the year (Masresha et al., 2023). For example, *Ficus* spp. are harvested within a short time, *Rosa abyssinica* becomes wider in harvesting periods (Fentahun & Hager, 2009), and *Syzygium guineense* and *Ximenia americana* are consumed within one to two months (Balemie & Kebebew, 2006). The harvesting periods and abundance of wild edible plants vary from plant to plant and place to place owing to the variation in species, ecological diversity, and climatic conditions (Balemie & Kebebew, 2006; Fentahun & Hager, 2009). In this regard, many wild edible plants are reported to be consumed during the periods of March-May (Tahir et al., 2023a; Yimer et al., 2021), January-August (Fentahun & Hager, 2009), and September-November (Giday & Teklehaymanot, 2023) in various parts of Ethiopia.

However, wild and semi-wild fruit species are mainly harvested during the dry season and at the beginning of the rainy season in some areas of the country (Kidane et al., 2014; Yimer et al., 2021). On the other hand, most green vegetables are abundant during the rainy season (May to September), although they sometimes exist in irrigated areas during the dry season (Aragaw et al., 2021; Balemie & Kebebew, 2006). For example, edible fruit species such as *Syzygium guineense* and *Ximenia americana* are harvested between March and April, while vegetable species like *Corchorus olitorius*, *Corchorus trilocularis*, *Amaranthus caudatus*, *Amaranthus graecizans*, and *Portulaca quadrifida* are mainly collected between July and September (Balemie & Kebebew, 2006).

1.2.11. Adverse effects of wild edible plants in Ethiopia

Although the majority of wild edible plants lack adverse effects during their collection, preparation, and consumption, some are mentioned for the incidence of abdominal pain, hallucinogenic symptoms, diarrhea, and constipation when they are eaten unripe or taken excessively (Kebebew & Leta, 2016). For example, excessive consumption of *Cordia africana*, *Ficus platyphylla,* and *Tamarindus indica* was reported to cause diarrhea, stomachaches, and vomiting (Kidane et al., 2014). In addition, the direct contact with the exudate of *Arisaema schimperianum* stem causes skin, tongue, and throat irritation (Ashagre et al., 2016), while the consumption of *Manilkara butugi* aggravates wounds (Kidane et al., 2014). In order to reduce or avoid such adverse effects, local people practice various preparation and/or consumption methods, such as taking considerable care during preparation, prolonged cooking, roasting, drinking coffee, and adding salt or lime to remove the disgusting effect during ingestion (Ashagre et al., 2016; Kebebew & Leta, 2016; Kidane et al., 2014). On the other hand, some wild edible plants have side effects on domestic animals. For instance, seeds of *Syzygium guineense* (Kebebew & Leta, 2016) and fruits of *Lepisanthes senegalensis* are stated to cause the death of goats, and leaves of *Pentarrhinum inspidum* are found to be fatal to cattle (Balemie & Kebebew, 2006).

1.2.12. Marketability of wild edible plants in Ethiopia

In addition to their nutritional purpose, some wild edible plants are marketable in various parts of Ethiopia to support household incomes (Ashagre et al., 2016; Assefa & Abebe, 2011). These wild food plants are mostly collected and sold by children and sometimes mothers (Addis et al., 2013; Bahru et al., 2013; Balemie & Kebebew, 2006). The marketing is carried out in the villages, on the roadside, and in the nearest local markets (Bahru et al., 2013). *Adansonia digitata, Opuntia ficus-indica, Ziziphus spina-christi, Balanites aegyptiaca, Diospyros abyssinica, Grewia villosa, Grewia mollis, Tamarindus indica, Arisaema schimperianum, Leptadenia hastata, Syzygium guineense subsp. guineense, Sclerocarya birrea, Saba comorensis*, and *Ximenia americana* are among the marketable wild edible plants in different parts of Ethiopia (Ashagre et al., 2016; Bahru et al., 2013; Balemie & Kebebew, 2006; Hassen, 2021; Tebkew et al., 2018). Additionally, some wild edible plants are exported to neighboring countries; for example, the fruits of *Adansonia digitata*, *Balanites aegyptiaca*, and *Tamarindus indica* are sold to Sudan (Masresha et al., 2023; Tebkew et al., 2018), and the dried leaves of *Corchorus olitorius* are sent to Djibouti (Dandena, 2010).

As food sources, wild edible plants are vended mostly for their edible fruits and rarely for edible leaves and gum (Bahru et al., 2013; Balemie & Kebebew, 2006). The market chain is short since it occurs only between collectors and buyers without middlemen (Kidane et al., 2014). Some wild edible plants are marketed for other uses, such as timber, agricultural tools, construction and firewood (Balemie & Kebebew, 2006; Kebebew & Leta, 2016). However, many wild edible plants are not marketable due to their limited access and low habits of consumption (Alemneh, 2020; Feyssa et al., 2011a).

1.2.13. Nutritional composition of wild edible plants

Domesticated and non-domesticated green leafy vegetables are crucial for numerous dietary and health benefits for human beings (Getachew et al., 2013). The composition of "primary metabolites" (such as carbohydrates, fats, proteins, vitamins, and minerals like Ca, Mg, Fe, and Zn) and "secondary metabolites" (such as ultratrace and trace elements, phenolic compounds, terpenoids, glycosides, alkaloids, and various antioxidants) determines the "nutritional quality" of food (Jain & Ramawat, 2013). In addition to the essential nutrients and energy needed to maintain the body's proper physiological homoeostasis, wild edibles offer the body additional sources of vitamins (C, B1, B2, B3, B5, B6, and B9) and minerals like Ca, Mg, Cu, Mn, Fe, Zn, Na, and K (Datta et al., 2019).

Wild edible plants are good sources of dietary nutrients in the rural communities of Ethiopia (Yimer et al., 2023a). The wild edible plants of southern Ethiopia are, for instance, acknowledged to contain a considerable amount of nutrients such as protein, crude fiber, carbohydrate, moisture, essential minerals (e.g., Ca, Mg, Mn, Fe, and Zn), and total energy content (Getachew et al., 2013). It is reported that wild edibles like *Amaranthus graecizans*, *Portulaca oleracea*, and *Solanum nigrum* are rich in proteins and minerals such as calcium, iron, and zinc, while *Rubus apetalus* and *Syzygium guineense* are found to be rich in vitamins A and C, respectively (Aragaw et al., 2021). Additionally, *Vigna membranacea*, *Dioscorea praehensilis*, and *Trilepisium madagascariense* are good sources of energy (Yimer et al., 2023a). Moreover, wild edible plants such as *Euclea racemosa*, *Ficus sur*, *Rosa abyssinica*, *Rhus natalensis*, and *Rhus vulgaris* are reported to be good in nutritional composition (Yiblet, 2024).

1.2.14. Anti-nutritional factors in wild edible plants

In edible plants, oxalic acid occurs in the form of water-soluble (Na and K) or water-insoluble (Ca, Mg, Fe, and Zn) salts, especially as an insoluble complex of calcium oxalate (Kristanc & Kreft, 2016), which reduces the bioavailability of dietary calcium (Amalraj & Pius, 2015). For example, water spinach, Chinese wolfberry, black glutinous rice, dragon fruit, rice bean, abalone fruit, and Chinese torreya fruit are considered high-oxalate foods (Ruan et al., 2013). As a result, the consumption of high-oxalate-containing foods is forbidden owing to the risk of oxalate stones, which cause kidney damage in susceptible humans (Bong et al., 2017; Pinela et al., 2017).

On the other hand, phytic acid and tannins may chelate minerals (e.g., Ca and Fe) toughly and potentially reduce their bioavailability (Kiewlicz & Rybicka, 2020; Wu et al., 2018). This may result in nutritional deficiency diseases such as anemia, osteoporosis, and problems with physical growth (Johnson & Thavarajah, 2013). In contrast, the presence of tannins can contribute to the therapeutic properties of medicinal plants, especially against diabetes and pathogenic microorganisms (Padayachee & Baijnath, 2020; Sunilkumar, 2011). Moreover, saponin-containing plant foods have both beneficial and adverse effects, as they reduce membrane cholesterol levels and their bitter taste decreases food consumption (Muzquiz et al., 2012; Podolak et al., 2010). However, phytic acid, tannins, and saponins are heat-stable and can be reduced through dehulling, soaking, germination, and fermentation (Muzquiz et al., 2012).

1.2.15. Nutraceutical plants

Nutraceuticals are defined as any compounds that are regarded as foods and portions of them that have health or medicinal advantages and may be used to cure or prevent illnesses (Cabrera-De La Fuente et al., 2018). Nutraceutical plants, therefore, have dual functions in that they benefit the community by providing nutrition and traditional medicine (Wondimu et al., 2006). In this case, the concept of food is changing, from a past emphasis on health maintenance to the promise of promoting better health and preventing chronic diseases (Devasagayam et al., 2004).

Nutraceutical plants are very important in human nutrition since the same phytochemicals, vitamins, antioxidants, and trace minerals that plants use to adapt and protect against stressful environments can also be used to defend or stabilize cellular components in humans (Cabrera-De La Fuente et al., 2018). These foods and medicinal plants are known as "functional foods" since they provide consumers with both basic nutrition and physiological advantages (Devasagayam et al., 2004). For example, the fruits of *Balanites aegyptiaca* and *Cordia africana* are acknowledged to relieve abdominal pain and diarrhea, respectively, in addition to their use as food for people around Nech Sar National Park, southern Ethiopia (Kebebew & Leta, 2016). Moreover, some edible spices, fruits, and staple food crops such as *Allium sativum*, *Ruta chalepensis, Brassica carinata, Cicer arietinum, Carica papaya, Citrus aurantifolia, Citrus aurantium, Coffea arabica, Cucurbita pepo, Linum usitatissimum, Mimusops kummel, Persea americana, Prunus persica, Punica granatum, Zea mays, Eragrostis tef, Capsicum annuum,* and *Vicia faba* are commonly used as homemade traditional medicine to treat various human as well as livestock ailments (Chekole et al., 2015).

1.2.16. Free radicals and antioxidant compounds

Free radicals (FR) are, chemically, any molecules that contain a single, unpaired electron (McCord, 2000) or substances that derive from incompletely oxidized compounds that have undergone partial burning and have, structurally, oxygen groups that are capable of initiating aggressive oxidation reactions at the surface of the cell membranes or even within the cells (Butnariu & Samfira, 2012). Reactive oxygen species (ROS) and reactive nitrogen species (RNS) are examples of free radicals that can have both positive and negative effects on a living system. At lower concentrations, they can interfere with immune function (e.g., defense against pathogenic microbes), multiple cellular signaling pathways, the mitogenic response, and redox regulation. At higher concentrations, they cause oxidative stress and nitrosative stress, which can damage biomolecules (Phaniendra et al., 2015). Such damage to biomolecules can impair cell functions and even lead to cell death, eventually resulting in several diseases (Devasagayam et al., 2004).

The free radical-susceptive (or targeted) biomolecules are membrane lipids, nucleic acids, proteins, and enzymes (Mohammed et al., 2015). The ROS radicals include superoxide (O_2^{*-}), hydroxyl (OH^*), alkoxyl radical (RO^*), and peroxyl radical (ROO^*), while the RNS radicals are nitric oxide (NO^*) and nitrogen dioxide (NO_2^*) (Phaniendra et al., 2015). Free radicals can be produced endogenously by the body through normal cellular metabolic reactions and exogenously by exposure to harmful physicochemical, environmental, or pathological agents, including air pollution, cigarette smoking, UV rays, radiation, hazardous chemicals, over nutrition, and advanced glycation end products (AGEs) associated with diabetes (Devasagayam et al., 2004; Mohammed et al., 2015).

The different degrees of antioxidant defense in a normal, healthy human body efficiently check the development of pro-oxidants in the form of ROS and RNS (Devasagayam et al., 2004). For this reason, the antioxidant chemicals become very reactive, changing the structure and function of several cellular constituents, including carbohydrates, DNA, RNA, lipoproteins, and cell membranes (McCord, 2000). Antioxidant phenolic compounds scavenge free radicals by donating hydrogen atoms to free radicals, preventing the oxidation of cellular components and forming stable, harmless molecules like phenoxyl radicals (Alu'datt et al., 2018). Consequently, they help to decrease the risk of chronic diseases such as diabetes, some cancers, cardiovascular and gastrointestinal diseases, and act as antiviral, antibacterial, antifungal, laxative, and anti-inflammatory (Han et al., 2007). For instance, *Doronicum macrolepis*, *Aerva lanata*, *Adinandra nitida*, *Apocynum venetum*, and *Cyclocarya paliurus* are important antioxidant plants due to their possession of phytochemicals such as phenolics, flavonoids, flavonols, tannins, steroids, saponins, proanthocyanidins, α-glucosidase inhibition, and glucose consumption activities (Al-Ansari et al., 2019; Chen et al., 2019; Özcan, 2020).

1.2.17. Threats to medicinal and wild edible plants in Ethiopia

Forest plants are currently declining in Ethiopia due to the appearance of several threatening factors. The major threats to economically important forest plants include human settlement, agricultural expansion, forest burning, overgrazing, fuel wood collection, overexploitation, multipurpose use, harvesting of whole plant parts, tree cutting for construction materials, construction of new roads, charcoal production, encroachment by invasive species, habitat destruction, seasonal drought (climate change), and lack of attention from humans (Ashagre et al., 2016; Assefa & Abebe, 2011; Bahru et al., 2013; Damtie & Mekonnen, 2016). Some food and medicinal plants, for example, *Cordia africana*, *Syzygium guineense* subsp. *guineense*, *Olea europaea* subsp. *cuspidata, Acacia prasinata,* and *Acacia negrii,* are threatened as a result of overexploitation for medicine, food, fodder, firewood, construction, charcoal, fencing, and furniture (Ashagre et al., 2016; Bahru et al., 2013). In addition, *Thymus schimperi* and *Thymus serrulatus* are reported to be threatened due to overgrazing, agricultural expansion, overharvesting of the whole plant, and a lack of awareness about their management (Damtie & Mekonnen, 2016).

1.2.18. The conservation strategies of medicinal and wild edible plants in Ethiopia

It is necessary to preserve forest plant resources using both scientific approaches to plant conservation strategies and traditional knowledge. The native conservation techniques might be used in a variety of contexts. When implemented correctly, the Gada System (the Oromo indigenous administration system) increases the willingness of the people to conserve economically significant plants, hence preventing the cleansing of neighboring vegetation (Feyssa et al., 2011c). The protection habits or norms of native people prevent the cutting of valuable plants for charcoal production unless special permission is given by the clan chiefs (Bahru et al., 2013) and inhibit the cutting of big trees, edible, medicinal, and beehive-hanging trees (Assefa & Abebe, 2011). Some domesticated plants are managed by cultivation on farmlands and/or home gardens (Chekole et al., 2015; Wondimu et al., 2006). Conservation of forest patches can also occur in and around churches, monasteries, graveyards, mosques, and other sacred sites (Bongers et al., 2006; Klepeis et al., 2016). On the other hand, scientific (modern) conservation methods are found to be performed through *in-situ* (on-site), e.g., a national park (Bahru et al., 2013), and *ex-situ* (off-site), e.g., seedling distribution (Chekole et al., 2015) conservation strategies.

1.3. Research questions

The following research questions were set for this research:

- What are the traditional medicinal plants used to treat various human and livestock ailments in the Dibatie district of the Metekel zone, western Ethiopia?
- To what extent do the selected medicinal plants inhibit the growth of certain pathogenic bacterial strains?
- What are the wild edible plants traditionally consumed by local communities in the Dibatie district of the Metekel zone, western Ethiopia?

- Which nutrients and anti-nutritional factors are dominant in the selected wild edible plants of the study area?
- What are the techno-functional properties of the edible parts of the selected wild edible plants in the study area?
- How can the selected medicinal and wild edible plants in the study area perform as antioxidants?
- What are the phytochemical constituents of the selected medicinal and wild edible plants in the study area?
- What are the threats to and conservation status of medicinal and wild edible plants in the study area?

1.4. Objectives of the study

1.4.1. General objective

- To investigate the traditional use of medicinal and wild edible plants in Dibatie district of Metekel zone, western Ethiopia, along with the evaluation of the antimicrobial activity, nutritional value, antioxidant capacity, and phytochemical constituents of the selected plants.

1.4.2. Specific objectives

- To document the traditional medicinal plants and associated indigenous knowledge of the people in Dibatie district, Metekel zone, western Ethiopia
- To evaluate the antibacterial activity of the selected medicinal plants in the study area
- To document the wild edible plants and associated indigenous knowledge of the people in Dibatie district, Metekel zone, western Ethiopia
- To determine the nutrients, minerals, and anti-nutritional factors in the selected wild edible plants of the study area
- To assess the techno-functional properties of the edible parts of the selected wild edible plants in the study area
- To evaluate the antioxidant activities of the selected medicinal and wild edible plants in the study area
- To determine the phytochemical profiles of the selected medicinal and wild edible plants in the study area

- To assess the threats to and conservation status of medicinal and wild edible plants in the study area

1.5. Significance of the Study

This study is helpful to explore the traditional medicinal and marginalized wild edible plants in the Dibatie district of the Metekel zone, western Ethiopia, for sustainable use and conservation priority. It is also important to document the medicinal and wild edible plants of Dibatie district, along with the associated indigenous knowledge, including the antimicrobial activity, nutritional value, antioxidant, and phytochemical profiles of selected plants. Plants with good antimicrobial activity, antioxidant capacity, and phytochemical constituents would be recommended for sustainable use by the local communities and drug industries. Besides, nutritionally rich wild edible plants would be recommended for the community, food processing industry, food policy of the country, and other concerned bodies. Furthermore, this study is a baseline for other researchers to investigate more of the medicinal and wild edible plants of Dibatie district in terms of ethnobotany, ecology, pharmacology, nutrition, and other related fields of study.

1.6. Scope of the study

This study emphasized the ethnobotanical study of medicinal and wild edible plants traditionally used by native people in the Dibatie district of the Metekel zone, western Ethiopia. Additionally, it was restricted to the antibacterial activity, antioxidant potential, and qualitative phytochemical screening of seven medicinal plants, as well as the nutritional values, techno-functional properties, antioxidant ability, and quantitative phytochemical contents of three wild edible plants in the study area.

1.7. Limitations of the study

The major limitation of this study was the security issue that appeared due to the ethnic conflict in the Dibatie district of the Metekel zone during data collection. Thus, Gumuz ethnic group was not participated in the ethnobotanical data delivery. The other limitation was that not all parameters of nutritional analyses were conducted in the Center for Food and Nutrition Laboratory at Addis Ababa University. Hence, the time for the completion of laboratory work was extended due to searching for the appropriate laboratory places.

1.8. Structure of the dissertation

The structure of this study was outlined, including the chapters and publication status of each paper, as follows:

Title: Ethnobotanical study of medicinal and wild edible plants in Dibatie district, Metekel zone, western Ethiopia, and evaluation of the antimicrobial, nutritional, antioxidant and phytochemical profiles of selected plants

Abstract: a summary of whole dissertation

Chapter 1: General introduction

Chapter 2: Paper I - Ethnobotanical study of medicinal plants in Dibatie district, Metekel zone, Benishangul Gumuz Regional State, western Ethiopia (under review by Journal of Ethnobiology and Ethnomedicine)

Chapter 3: Paper II - Ethnomedicine, antibacterial activity, antioxidant potential and phytochemical screening of selected medicinal plants in Dibatie district, Metekel zone, western Ethiopia (published on BMC Complementary Medicine and Therapies)

Chapter 4: Paper III - Ethnobotanical study of wild edible plants in Dibatie District, Metekel Zone, Benishangul Gumuz Regional State, western Ethiopia (published on Journal of Ethnobiology and Ethnomedicine)

Chapter 5: Paper IV - Nutritional values, functional properties, antioxidant activity and phytochemicals of three commonly consumed wild plants by Dibatie people, western Ethiopia (under review by PLOS ONE)

Chapter 6: General discussion/conclusions and recommendations

CHAPTER TWO

Paper I

2. Ethnobotanical Study of Medicinal Plants in Dibatie District, Metekel Zone, Benishangul Gumuz Regional State, Western Ethiopia

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Abstract

Background: Herbal medicine has been used for the treatment of human and livestock ailments since ancient times. Numerous rural and urban communities in Ethiopia practice traditional medicine and transfer the knowledge verbally from generation to generation. Thus, this study was conducted to document the traditional medicinal plants and associated indigenous knowledge in Dibatie district, Metekel zone, Benishangul Gumuz Regional State, western Ethiopia.

Methods: Three hundred seventy-four (374) informants from 11 kebeles (the smallest administrative units) were selected using Cochran's (1977) formula and participated in the study. The data collection was carried out using semi-structured interviews, preference ranking, direct-matrix ranking, field observation, market surveys, and focus group discussions, including voucher specimen collections. The ethnobotanical data were analyzed using descriptive statistics (frequency and percentage), ranking, comparison, and quantitative ethnobotanical techniques such as informant consensus factor, fidelity level index, Jaccard's coefficient of similarity, and use value index.

Results: A total of 170 plant species that have been used to treat 79 human and 29 livestock ailments were recorded. Fabaceae (with 20 species) and Asteraceae (with 18 species) were the most dominant medicinal plant families in the area. Most remedial plants were herbs (61 species, 35.88%), followed by shrubs (39 species, 22.94%). Most (135 species, 79.41%) medicinal plants were harvested from wild sources. Many (70 species, 41.17%) medicinal plants possessed multiple remedy parts that are usually prescribed in fresh form (60.13%). The herbal medicines were mostly administered orally (52.20%), followed by dermal (17.62%) application. *Embelia schimperi* Vatke and *Glinus lotoides* L. had 100% fidelity to cure tapeworm, and *Haplosciadium abyssinicum* Hochst., *Mucuna melanocarpa* Hochst. ex A. Rich., and *Phragmanthera macrosolen* (Steud. ex A. Rich.) M.G.Gilbert also had 100% fidelity level values against snake venom, tick infestation, and general malaise, respectively.

Conclusion: The study area was rich in the diversity of potential medicinal plants and associated indigenous knowledge. Thus, appropriate conservation actions and careful utilization are essential to counteract the rise of anthropogenic threats and to ensure the continuity of plants with the related indigenous knowledge. Additionally, the medicinal plants should be validated through experimentation to integrate local knowledge with modern medications.

Keywords: Dibatie district, Ethnobotanical study, Herbal medicine, Indigenous knowledge, Medicinal plants

2.1. Background

Traditional medicine has been widely used worldwide since ancient times. Traditional medicine is the use of any plant, animal, or mineral product, either independently or in combination, for the treatment of human or animal ailments (World Health Organization, 2019). Approximately 60% of the world's population is estimated to use traditional medicine for the treatment of various health problems (Aschale et al., 2023). Especially, there has been an increase in the demand for herbal medicines in some developed and developing countries, owing to different reasons such as their biological and pharmacological activities, high safety, and low costs (Nakibuuka & Mugabi, 2022). For this purpose, the wide use of herbal medicine has been concerned with multi-herbal formulations or herbal interactions with conventional drugs, which may have synergistic or antagonistic effects on efficacy (Enioutina et al., 2016).

In developing countries, where the practice of modern medicine is rare, traditional medicine is a crucial resource for the population to meet their primary healthcare needs (Oyebode et al., 2016). Like other developing countries, most Ethiopians (about 80%) (Aragaw et al., 2020; Hailu et al., 2020) and about 90% of their livestock (Abebe, 2022; Moges & Moges, 2020) are treated using traditional medicine, of which more than 95% is prepared from plant products (Abebe, 2022). The reason is due to the lack of adequate modern health services (Chekole, 2017; Demie et al., 2018), habits of cultural interaction, ease of accessibility, relative efficacy against certain diseases, and low cost of using traditional medicines (Aschale et al., 2023; Tolossa et al., 2013). Hence, many rural populations in Ethiopia use several medicinal plants for the treatment of various human as well as livestock ailments (Demie et al., 2018; Tolossa et al., 2013). Additionally, some urban populations employ traditional medicinal plants for their healthcare, although urbanization poses a great impact on the use of traditional medicine and associated indigenous knowledge (Teshome-Bahiru, 2006).

Moreover, Ethiopian people had indigenous knowledge of how to use medicinal plants for the treatment of various communicable and non-communicable human diseases. The rural communities also use medicinal plants to treat several livestock diseases like blackleg, diarrhea, Newcastle disease, colic, listeriosis, leech, eye disease, rabies, swelling, wounds, pasteurellosis, coughing, anthrax, footrot, and so on (Abebe, 2022; Asfaw et al., 2022; Assefa & Bahiru, 2018). The people obtain indigenous knowledge of using medicinal plants through verbal transmission from parents, healers, neighbors, or friends, frequent observations, experiences, and trial-and-error practices (Moges & Moges, 2020). Medicinal plants are usually harvested from natural forests, home gardens, farmlands, coffee agroforestry, stream sides, road sides, along valleys, wetland areas, and other microhabitats (Kassa et al., 2020). The local population use medicinal plant parts such as roots, stems, leaves, fruits, seeds, flowers, bark, buds, twigs, latex, bulbs, and/or whole parts as traditional medicine alone or in combinations (Chekole et al., 2015; Kidane et al., 2018a; Wondimu et al., 2007).

In regards to the Metekel zone, different ethnic groups in the area (Agaw, Amhara, Gumuz, Oromo, and Shinasha) rely on traditional medicines, mostly in the past during the shortage of modern health centers. Even today, people in the Metekel zone widely use traditional medicines, mainly from plant sources. Recently, however, medicinal plants have declined along with the associated indigenous knowledge due to various factors such as the expansion of urbanization, settlements, agriculture, and the better availability of modern drugs, as well as a lack of awareness about their conservation. Hence, the present study was aimed at documenting the traditional medicinal plants used for the treatment of human and livestock ailments and the associated indigenous knowledge of local communities in Dibatie district of Metekel zone, Benishangul Gumuz Regional State, western Ethiopia.

2.2. Methods

2.2.1. Description of the study area

The study was conducted in Dibatie district, Metekel zone, Benishangul Gumuz Regional State, western Ethiopia (Figure 2.1). Dibatie district is one of the seven administrative districts in

Metekel zone. It is bordered by Mandura district in the north, Bulen district in the west, Kamashi zone in the south and south-east, and Amhara Regional State in the east. The district consists of 30 kebeles (the lowest administrative units), of which 5 are towns while 25 are rural kebeles. Out of these, 11 kebeles (Dibatie-02, Parzeyit, Lega-buna, Berber, Jan, Donben, Gipho, Tuski-gambela, Galessa, Qorqa, and Sombo-sire) were selected as representative study sites. There are five ethnic groups, namely Amhara, Gumuz, Shinasha, Oromo, and Agaw, in the district. These ethnic groups speak different languages, such as Amharic (which belongs to the Semitic family), Gumuzigna (which belongs to the Nilo-Saharan family), Shinashigna (which belongs to the Omotic family), and Afaan Oromoo and Agawgna (which belong to the Cushitic family), respectively. However, residents of the Gumuz ethnic group were not included in this study due to security-related problems in the area during data collection.

The study area is characterized by highland, semi-highland, and lowland agro-ecological types (Anbessa et al., 2024). The area is known for *Combretum-Terminalia* woodland vegetation, including broad-leaved deciduous woodland, *Vachellia* woodland, *Boswellia* woodland, riparian woodland, and bamboo thicket (Girmay et al., 2016).

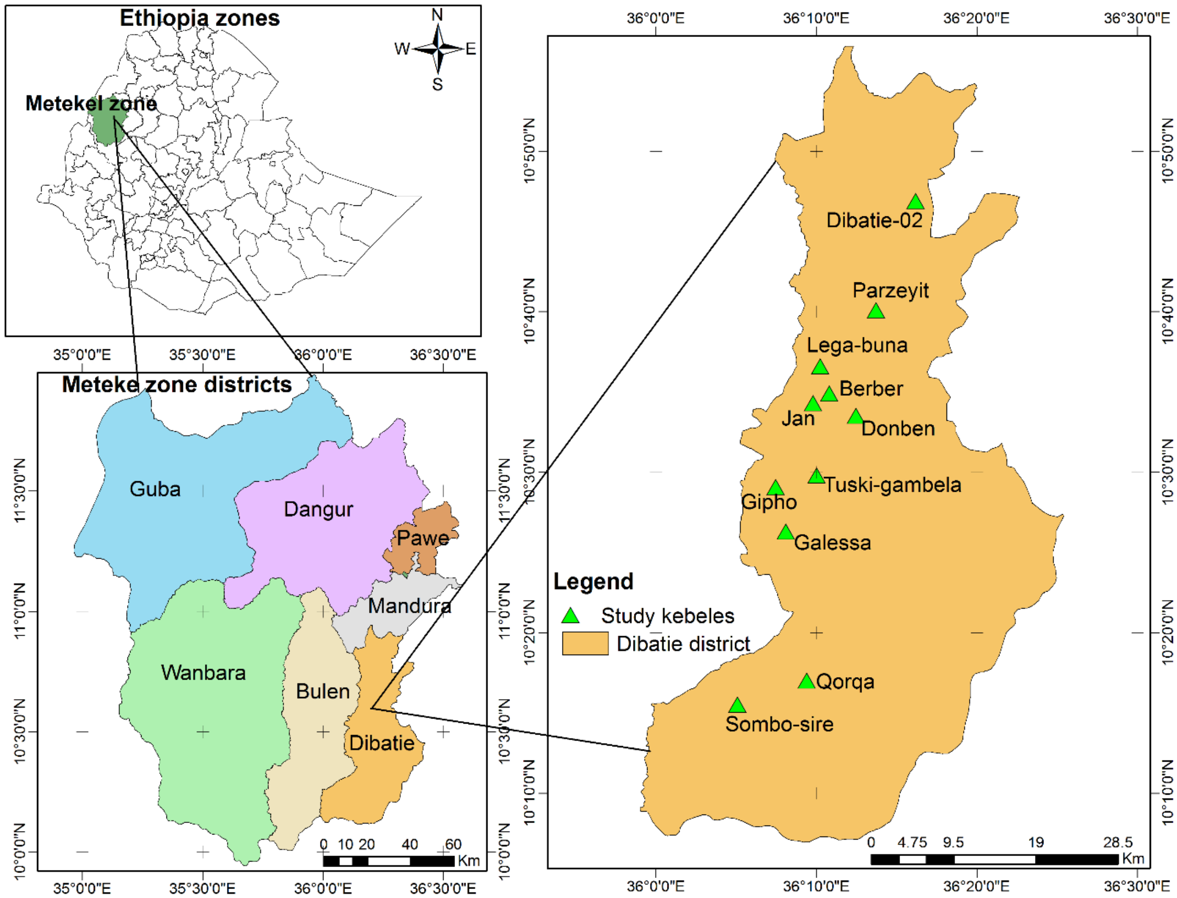

Figure 2.1. Map of the study area.

2.2.2. Sampling techniques

The study sites (kebeles) were selected purposefully based on geographic variations, native ethnic group composition, security of the area, and road access to the study site. Out of the total of 9879 households, 374 informants were selected as representative respondents using the formula developed by Cochran (1977) with a 95% confidence level and ± 5% precision. Then, 34 informants participated in the data delivery from each kebele. Households of 200 general informants were selected randomly and participated in the ethnomedicinal data collection. Besides, 174 key informants, such as knowledgeable community elders and traditional healers, were selected purposefully based on their knowledge of medicinal plants in the community.

2.2.3. Socio-demographic characteristics of informants

Household members of ages greater than 20 participated in the data delivery as representative respondents. Most (41.71%) informants in the present study were in the age range of 41-60 years. Out of 374 informants, the majority (67.38%) were males and 32.62% were females (Table 2.1).

Table 2.1: Socio-demographic profiles of informants in the Dibatie district

Demographic profile	**Category**	**Frequency (N = 374)**	**Percent (%)**
Age	20-40 years	94	25.13
	41-60 years	156	41.71
	> 60 years	124	33.16
Gender	Female	122	32.62
	Male	252	67.38
Ethnicity	Agaw	16	4.28
	Amhara	53	14.17
	Oromo	172	45.99
	Shinasha	133	35.56
Religion	Islam	34	9.09
	Orthodox	186	49.73
	Protestant	154	41.18
Occupation	Civil servants	26	6.95
	Farmers	324	86.63
	Laborers	2	0.53
	Merchants	22	5.88
Educational status	Uneducated	179	47.86
	Elementary school	147	39.30
	Secondary school	23	6.15
	Diploma or degree	25	6.68

2.2.4. Methods of data collection

The ethnobotanical data related to medicinal plants were collected using semi-structured interviews, preference ranking, direct-matrix ranking (Martin, 1995), field observation, market surveys (Alexiades, 1996), and focus group discussions as described in Teklehaymanot (2017).

Interviews were carried out in the appropriate languages of the informants, with the help of translators when required. Interview questions focused on remedy parts, types of human and/or livestock ailments treated, use condition, preparation method, additive agents, routes of administration, dosage, side effects, and additional uses of the medicinal plants (Appendix 4). Through the process, information on local names of plants, demographic characteristics (e.g., age, gender, ethnicity, religion, occupation, literacy level, and so on) of informants, marketability, threats to, and management methods of medicinal plants in the study area were collected. Besides, field surveys, guided field observation, focus group discussions, and the collection of voucher specimens for identification were conducted. Voucher specimens were identified and deposited in the National Herbarium (ETH) at Addis Ababa University. Botanical names were confirmed by experts in the herbarium and checked on the website Plants of the World Online (POWO) for taxonomic updates.

2.2.5. Methods of data analysis

The collected ethnobotanical data were analyzed through descriptive statistics (percentage and frequency distribution), ranking, and comparison. Accordingly, informant consensus factor (ICF) was calculated to differentiate the agreement of informants on the medicinal plants reported to treat ailment categories (Heinrich et al., 1998). The ailments were categorized according to the International Classification of Primary Care (ICPC-2) (Staub et al., 2015). Then the informants' consensus factor was calculated using the formula: $ICF = \frac{Nur - Nt}{Nur - 1}$ where Nur is the number of use citations for a particular ailment category and Nt is the number of medicinal plant species used to treat a particular ailment category by all informants.

Preference ranking (Martin, 1995) was conducted by 10 respondents to assess the degree of preference of 10 medicinal plant species based on their efficacy to treat hemorrhoids in humans. A direct matrix ranking was conducted according to (Martin, 1995) to compare the multiple uses of selected eight (8) medicinal plants based on the eight (8) use categories, such as beehive trees, charcoal, construction, fodder, food, fuel wood, medicine, and household utensils. For this purpose, seven (7) key informants were selected and asked to rate each plant species, assigning the use values of each attribute using integer numbers from 5 (most frequently used) to 0 (not used). At the end, the average values of each plant species were summed up and ranked.

The index of fidelity level (FL) was computed to determine the relative healing potential of the medicinal plants against major human ailments (Friedman et al., 1986). The percentage fidelity level (FL%) was computed for 25 medicinal plants against the most frequently reported ailments to be treated with them. It was calculated using the formula: FL% = Ip/Iu × 100, where Ip is the number of respondents who independently stated the use of a species for the same major ailments and Iu is the total number of respondents who indicated the plant for any ailments.

Jaccard's coefficient of similarity (JCS) (Hoft et al., 1999) was computed to determine the medicinal plant species use similarity between the ethnic groups of Dibatie district. The JCS was calculated using the formula: $\text{JCS} = \frac{c}{(a+b+c)}$ where JCS is the Jaccard's coefficient of similarity, *a* is the plant species used by ethnic group A, *b* is the plant species used by ethnic group B, and *c* is the common plant species used by both ethnic groups A and B. Then, the percentage of proximity was obtained by multiplying the similarity coefficient by 100 (Bekele et al., 2022).

The use value (UV) index was computed to assess the degree of importance of medicinal plant species using the formula: UV = (ΣUi)/n, modified from Phillips and Gentry (1993a, 1993b) (Albuquerque et al., 2006; Rossato et al., 1999; Zenderland et al., 2019), where Ui is the number of uses mentioned by each informant for a specific species and n is the total number of informants. The statistical analysis was carried out using Ms-Excel (version 2013), Statistical Package for the Social Sciences (SPSS) version 21.0, and R-statistical packages (ggplot2, scales, and dplyr).

2.3. Results and discussion

2.3.1. Taxonomic diversity of medicinal plants

A total of 170 medicinal plants were identified from the study area, which belong to 144 genera and 65 families. Fabaceae and Asteraceae were the most dominant medicinal plant families represented by 20 and 18 species, respectively, followed by Euphorbiaceae and Solanaceae (8 species each), Cucurbitaceae (7 species), Lamiaceae (6 species), Apocynaceae and Vitaceae (5 species each), Apiaceae, Malvaceae, Poaceae, and Rubiaceae (4 species each), Acanthaceae, Asparagaceae, Moraceae, Polygonaceae, Ranunculaceae, and Rutaceae (3 species each), and the remaining 47 families were represented by 2 or 1 medicinal plant species each (Appendix 1). Genus *Solanum* was denoted by 4 species, followed by *Cyphostemma, Echinops, Euphorbia, Ficus,* and *Rumex* genera, represented by 3 species each, and the other remaining genera had 2 or 1 medicinal plant species each.

Consistent with the current study, studies (Bekele et al., 2022; Tahir et al., 2023b; Tamene et al., 2023) conducted in different parts of Ethiopia reported the dominant diversity of medicinal plant species within the Fabaceae and Asteraceae plant families. This might be because of the phytochemicals shared among medicinal plants in the same taxonomic categories (Reinaldo et al., 2020). Hence, medicinal plants in the Fabaceae and Asteraceae families could be rich in bioactive chemical compounds that contribute to their therapeutic roles. In contrast, some researchers (Eshete & Molla, 2021; Tadesse & Teka, 2023) justified the point of view that Fabaceae and Asteraceae are the most widely abundant families in the Flora regions of Ethiopia than other plant families.

2.3.2. Growth habit of the medicinal plants

The most dominant growth habits of medicinal plants in the study area were herbs (61 species, 35.88%), followed by shrubs (39 species, 22.94%), trees (38 species, 22.35%), and climbers (22 species, 12.94%), while subshrub growth forms were found to be the least (10 species, 5.88%) (Figure 2.2). In agreement with the current study, previous studies (Megersa et al., 2023; Megersa & Tamrat, 2022; Tadesse & Teka, 2023; Tahir et al., 2023b; Tahir et al., 2021; Teshome et al., 2023) conducted in different parts of Ethiopia reported the dominance of herbaceous medicinal plants. This might be due to the more widespread distribution of herbaceous plants than plants of other growth habits (Megersa & Tamrat, 2022; Tamene et al., 2023). However, other studies in Suro Barguda district, southern Ethiopia (Eshete & Molla, 2021), and in Kebridehar and Shekosh districts, southeast Ethiopia (Wubu et al., 2023) revealed the dominance of shrub growth forms of medicinal plants. These areas are probably dominated by shrubby vegetation types situated in semi-arid or arid areas of the country.

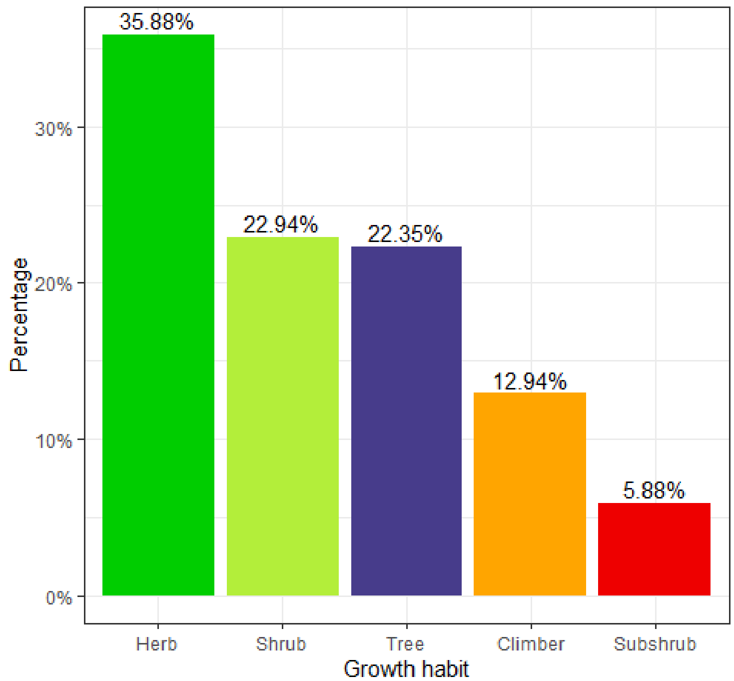

Figure 2.2. Growth forms of medicinal plants in the Dibatie district.

2.3.3. Cultivation status of medicinal plants in the study area

Results showed that most (135 species, 79.41%) medicinal plants in the current study area were harvested from wild habitats. While some (32 species, 18.82%) medicinal plants were found as cultivated plants, and a few others (3 species, 1.76%) were found to be semi-wild (Figure 2.3). This indicates that the cultivation of medicinal plants in the present study area is very low. Similarly, previous studies elsewhere in Ethiopia (Abebe, 2022; Asfaw et al., 2022; Bekele et al., 2022; Bogale et al., 2023; Mekonnen et al., 2022; Tadesse & Teka, 2023; Tamene et al., 2023) reported that medicinal plants are usually harvested from wild sources and rarely available as cultivated plants or as both cultivated and wild plants. The abundance of medicinal plants in the wild habitat increases their exposure to different threats like overexploitation (Asfaw et al., 2022; Yimam et al., 2022), deforestation, and habitat destruction (Berhanu et al., 2020). Thus, the practice of domesticating medicinal plants is important to access the plants easily and to ensure their survival in the future.

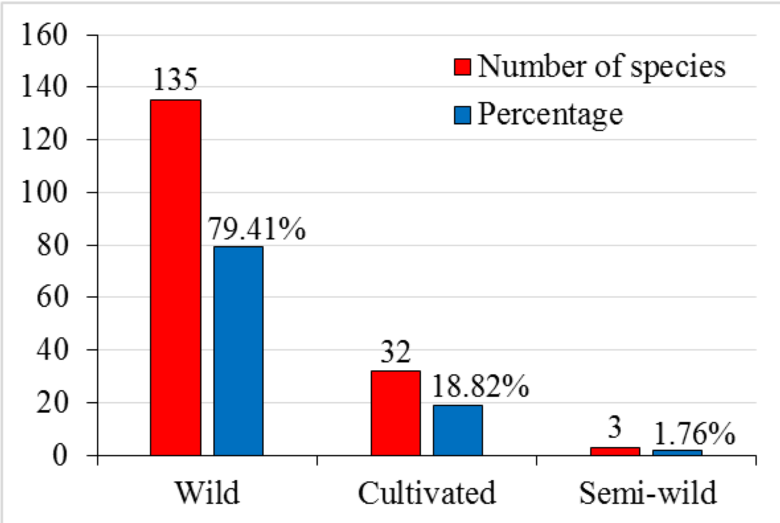

Figure 2.3. Cultivation status of medicinal plants in the Dibatie district.

2.3.4. Proportion of medicinal plants used to treat human and livestock ailments

Out of the recorded medicinal plants, 105 species (61.76%) were used to treat only human ailments, 13 species (7.65%) were used to treat only livestock ailments, and 52 species (30.59%) were used to treat both human and livestock ailments (Figure 2.4). The documented medicinal plants were traditionally used for the treatment of 79 types of human ailments and 29 kinds of livestock ailments (Appendix 1). The most commonly reported human ailments were abdominal pain, ascaris, Bell's palsy, boils, cough, diarrhea, choking, evil eye, eye disease, gastritis, general malaise, gonorrhea, hemorrhoids, hepatitis, impotency, arthritis, leishmaniasis, lymphadenitis, placenta retention, rabies, rectal prolapse, scorpion venom, snake venom, swellings, tapeworm, tinea versicolor, tonsillitis, toothache, vomiting, and wounds, among others. Whereas, the common livestock ailments were ascaris, blackleg, breast swelling, cattle thinness, colic, constipation, denying of milk, diarrhea, choking, difficulty of excretion, eye disease, febrile disease, hemorrhoids, chicken lice, leech infestation, lumpy skin, milk deficiency, mouth wound, Newcastle disease, placenta retention, rabies, respiratory disorder, snake venom, sneezing, swelling, tick, difficulty of urine flow, wound worms, and wounds.

The number of human ailments traditionally treated by the medicinal plants in the present study area was comparable to the number of human ailments (81) reported in Asagirt district, northeastern Ethiopia (Tahir et al., 2023b). The number of human ailments stated to be treated in the present study was greater than those of other earlier studies (Agize et al., 2022; Jima & Megersa, 2018; Kidane et al., 2018a; Mekonnen et al., 2022; Tadesse & Teka, 2023; Tahir et al., 2021; Tefera & Kim, 2019; Teshome et al., 2023) in different regions of Ethiopia. On the other hand, the number of livestock ailments reported to be treated by the medicinal plants in the current study exceeds those of previous findings (Abebe, 2022; Asfaw et al., 2022; Assefa & Bahiru, 2018; Kidane et al., 2018a; Mekonnen et al., 2022; Tahir et al., 2021; Tefera & Kim, 2019), but is exceeded by the study (Feyisa et al., 2021) conducted in the Adea Berga district of West Shewa zone, central Ethiopia. The current results showed that multiple ailments could be treated by a single plant species, and more than one plant species could also be used to treat a single ailment, in line with the previous reports (Kidane et al., 2018a; Tahir et al., 2023b) in Ethiopia. The results clearly indicated the rich medicinal plant diversity and strong relationships between the plants and local communities in the current study area with respect to human and livestock healthcare. This might be because of the predominance of mixed agriculture (crop cultivation and animal husbandry) and the remoteness of the area for access to modern healthcare.

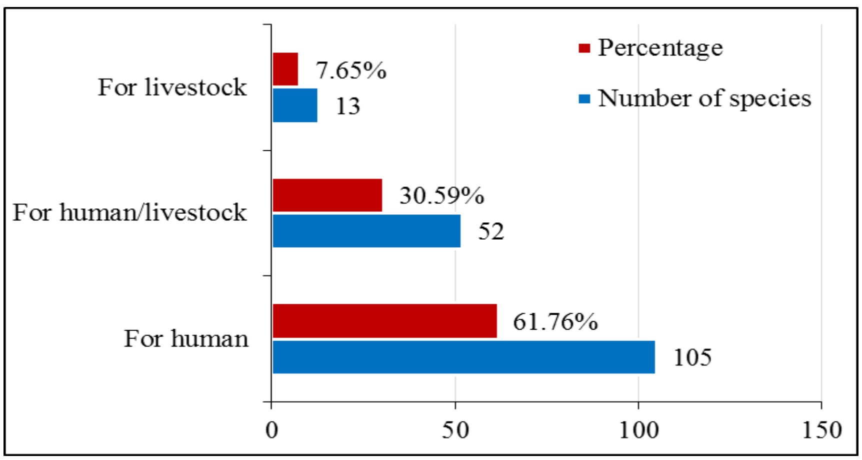

Figure 2.4. Proportions of medicinal plants used to treat human or livestock diseases.

2.3.5. Medicinal parts of the plants in the study area

In the study area, 70 medicinal plant species (41.17%) provide multiple medicinal parts from a single plant, followed by medicinal plants with leaves (29 species, 17.06%), roots (19 species, 11.18%), bark (14 species, 8.24%), tubers (11 species, 6.47%), seeds (8 species, 4.71%), and whole plants (8 species, 4.71%) as the common remedy parts. The others contribute fruits (4 species, 2.35%), exudate (3 species, 1.76%), aerial parts (2 species, 1.18%), and stems (2 species, 1.18%) medicinal parts (Figure 2.5).

The current results showed that multiple plant parts were prepared as remedies from a single species, consistent with studies in other countries (Hani et al., 2022; Jadid et al., 2020) and less frequently in Ethiopia (Bekele et al., 2022; Giday et al., 2007; Tadesse & Teka, 2023). This indicates the pharmaceutical potential of the plants due to the presence of bioactive phytocompounds in many parts. Besides, the present study revealed that most (29 species) medicinal plants have leaves as remedy parts next to plants with more than one remedy part (70 species). Similarly, leaves were reported as the most commonly used medicinal plant parts in different regions of Ethiopia (Bogale et al., 2023; Osman et al., 2020; Tadesse & Teka, 2023; Tahir et al., 2023b; Tahir et al., 2021; Yimam et al., 2022) and other countries (Axiotis et al., 2018; Hani et al., 2022; Jadid et al., 2020). The regular use of leaves as traditional medicine might be due to the ease of preparations and the excess of bioactive compounds that promote their efficacy (Hani et al., 2022; Teshome et al., 2023). The use of leaves instead of other plant parts can minimize risks related to the loss of medicinal plants (Bogale et al., 2023). Nevertheless, frequent utilization of whole plants (Bai et al., 2022; Hu et al., 2020; Huang et al., 2022) and roots (Jin et al., 2022; Megersa et al., 2019; Ndhlovu et al., 2023; Tshikalange et al., 2016; Wubu et al., 2023) has been reported in different parts of the world, including in Ethiopia. However, extensive use of whole plants and roots of medicinal plants can pose adverse effects on their survival and continuity in the future (Hani et al., 2022; Kefalew et al., 2015; Lulekal et al., 2008) though the use of rhizomes, bulbs, flowers, bark, and stems may also cause destructive effects relative to the harvesting of leaves (Asnake et al., 2016; Belayneh et al., 2012; Teshome et al., 2023).

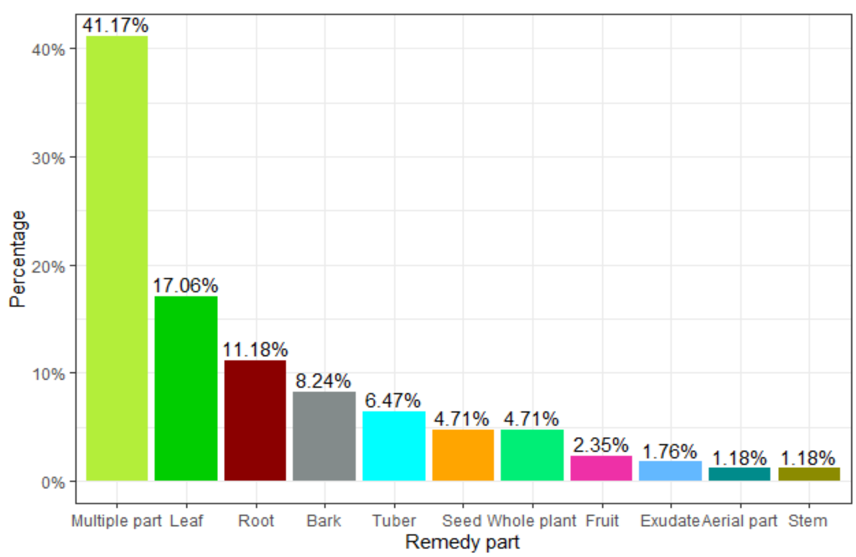

Figure 2.5. Remedy parts of medicinal plants in the Dibatie district.

2.3.6. Use conditions of the medicinal plants

The medicinal plant parts in the present study were mostly used in fresh form (60.13%), followed by either fresh or dry condition (31.28%), and sometimes utilized in dry state (8.59%) (Figure 2.6). Likewise, several researchers (Bogale et al., 2023; Megersa & Tamrat, 2022; Mekonnen et al., 2022; Tadesse & Teka, 2023; Tahir et al., 2023b; Teshome et al., 2023; Yimam et al., 2022) reported the fresh preparation of traditional medicinal plants elsewhere in the country. A fresh prescription was often performed to give a remedy immediately to the patient. Utilization of fresh medicinal plants may have the advantage of reducing the loss of bioactive phytochemicals upon drying and thus enhancing their efficacy (Tahir et al., 2021). However, the frequent use of fresh remedies has been considered one of the threats to medicinal plants since they are not preserved for later usage (Eshete & Molla, 2021). The current finding also verified that some medicinal plants were prescribed in dry conditions and could be stored for months or a year with efficacy in healing. This might be due to the fact that dry remedy preparation increases the shelf life of the medicine (Teshome et al., 2023).

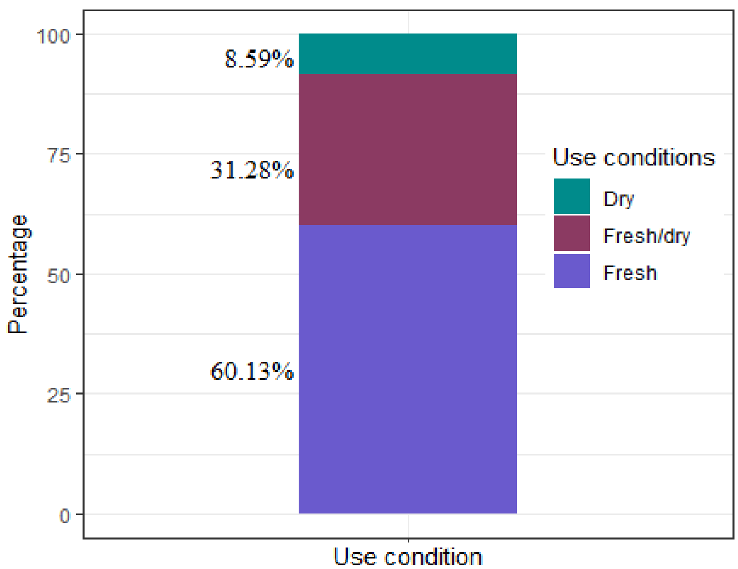

Figure 2.6. The use conditions of medicinal plant parts in the Dibatie district.

2.3.7. Preparation methods of the medicinal plants

Results showed that local communities prepare herbal remedies mostly by crushing (25.49%), followed by pounding (19.12%), chewing (11.11%), powdering (8.50%), squeezing (8.17%), heating (6.54%), boiling (4.58%), rubbing (4.41%), exuding (3.92%), cutting/slicing (2.61%), burning (2.12%), roasting (1.63%), and sousing (0.98%), and there was also unprocessed part consumption (0.82%) of some medicinal plants (Figure 2.7). The present findings agreed with numerous ethnobotanical studies (Bekele et al., 2022; Bogale et al., 2023; Demie et al., 2018; Jima & Megersa, 2018; Megersa & Tamrat, 2022; Mekonnen et al., 2022; Siraj et al., 2020; Tadesse & Teka, 2023; Tahir et al., 2023b; Wubu et al., 2023), which reported crushing of medicinal plants as a common means of traditional remedy preparation in many areas of the country. However, other studies reported grinding (Tefera & Kim, 2019), pounding (Eshete & Molla, 2021; Teshome et al., 2023; Yimam et al., 2022), and squeezing (Abebe, 2022) as the most commonly employed methods of remedy preparation in their respective study areas in different parts of Ethiopia. The remedy preparation method might vary depending on the nature of medicinal plant parts and ease of processing (Tahir et al., 2023b; Tahir et al., 2021), as well as the kind of illness and its site on the body parts (Wubu et al., 2023). For instance, the remedies taken orally and those applied topically may require different processing mechanisms to be administered safely. Additionally, fresh and dried medicinal plant parts may not need similar preparation methods. That is, dry plant materials are suitable for grinding or powdering, while fresh plant parts are good for crushing, pounding, and squeezing.

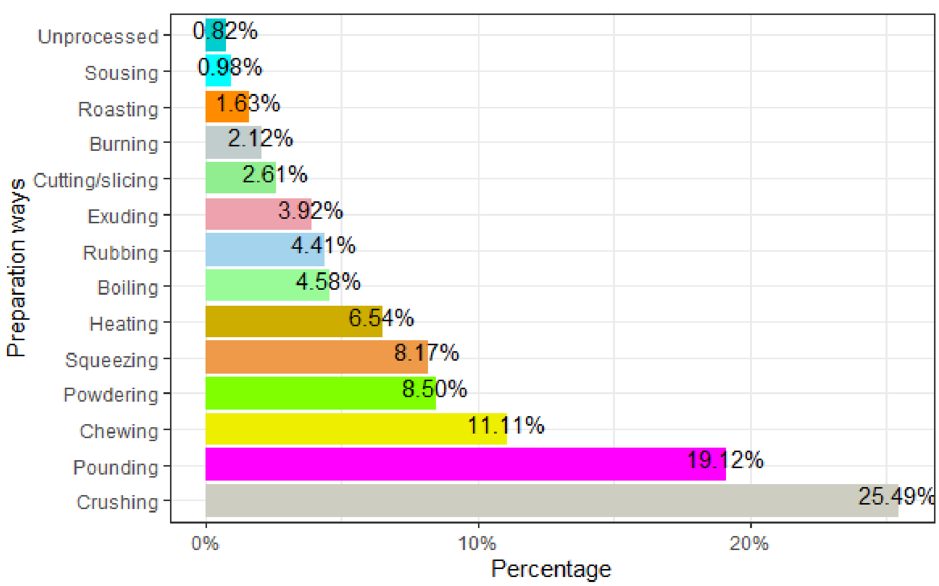

Figure 2.7. Preparation methods for medicinal plant parts in the Dibatie district.

2.3.8. Application routes of the medicinal plants

The informants in the present study area described that herbal medicines were mainly applied orally (52.20%), followed by dermal (17.62%), through fumigation (9.69%), and topical (9.69%). In addition, informants confirmed that there were multiple ways (4.41%) of application for a specific ailment through ocular (1.98%), nasal (1.76%), external (1.54%), and aural (1.10%) means of administration (Figure 2.8). The current results were consistent with several ethnobotanical findings in different regions of Ethiopia (Bekele et al., 2022; Bogale et al., 2023; Megersa et al., 2023; Megersa & Tamrat, 2022; Mekonnen et al., 2022; Tadesse & Teka, 2023; Tahir et al., 2023b; Yimam et al., 2022) and other countries (Aparicio et al., 2021; Hani et al., 2022; Huang et al., 2022; Karaköse, 2022; Nakibuuka & Mugabi, 2022). However, other studies (Giday et al., 2009; Tahir et al., 2021; Woldeamanuel et al., 2022) reported dermal remedy administration as the most frequently applied in some areas of Ethiopia. The present study also reported the practice of using more than one route of administration to treat a single disease type, which is in line with previous findings (Demie et al., 2018). This might be essential to attribute the synergistic effect of remedies via a variety of applications. The preference for oral remedy administration might be due to its simplicity (Yimam et al., 2022) or the fast reaction of the medicine to take part in healing (Bekele et al., 2022). The routes of administration may also be dependent on the type of illness and the location of affected body parts (Bogale et al., 2023). Accordingly, internal ailments need to be treated through oral modes of remedy application (Mekonnen et al., 2022; Tahir et al., 2023b), while cutaneous diseases require dermal routes of administration (Giday et al., 2009; Woldeamanuel et al., 2022).

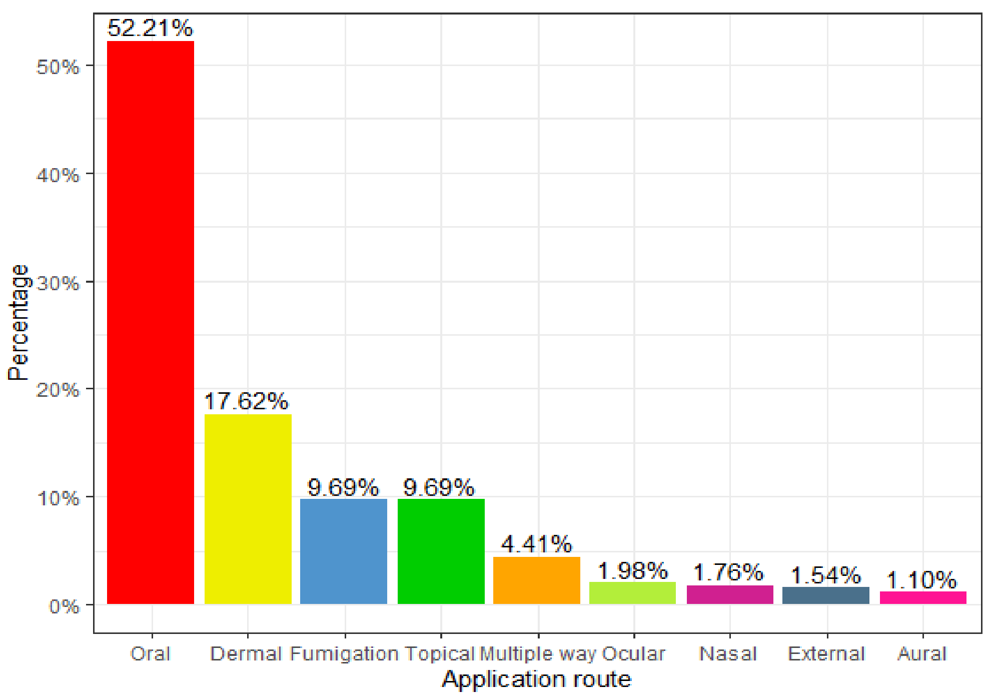

Figure 2.8. Application methods of traditional herbal medicine in the Dibatie district.

2.3.9. Additives of the medicinal plants

The medicinal plant remedies in the current study area were applied with or without additives. Indeed, 32.72% of medicinal plant remedies were administered without additives. Whereas, some herbal medicines were applied with additives such as water (29.70%), salt (9.23%), local alcoholic and non-alcoholic drinks ('Tella', 'Kenneto', or 'Areqe') (5.70%), honey (4.70%), porridge or syrup (4.53%), chicken stew (3.69%), butter (2.85%), sugar (2.35%), milk, yogurt, or cheese (1.34%), bread or 'Injera' (0.84%), spices (0.67%), hot drinks (tea or coffee) (0.67%), soot (0.34%), egg yolk (0.34%), and Hippo's skin ash (0.34%) (Table 2.2). A large proportion of traditional remedies in the present study were administered with no additives, similar to previous findings (Tahir et al., 2021; Yimam et al., 2022) in the country. On the other hand, the current findings are in line with other studies (Getaneh & Girma, 2014; Megersa et al., 2023; Mekonnen et al., 2022), which reported the use of additives like coffee, milk, honey, water, salt, tea, red 'teff' powder, sugar, butter, eggs, bread ('Injera'), and local alcoholic beverages ('Tella' and 'Areqe'). However, none of the previous studies in Ethiopia claimed the use of soot and Hippo's skin ash in traditional herbal medicine. This implies the diversity of indigenous knowledge among ethnic groups in Dibatie district with respect to the utilization of traditional medicines. The local people may use additives in traditional medicine in order to reduce the toxicity of medicine, soften the remedy, or improve the taste (Bekele et al., 2022; Chekole, 2017; Mekonnen et al., 2022). Informants in the present study stated that additives were also believed to be vital for increasing the healing efficacy of the remedies, consistent with the previous reports (Eshete & Molla, 2021; Wubu et al., 2023) in their respective study areas. This may need extra investigation to prove whether the healing potential is from additives, medicinal plants, or the synergistic effects of both ingredients. Water is the most frequently used vehicle in the preparation of herbal medicine in the present study as well as other ethnomedicinal studies (Mekonnen et al., 2022; Yimam et al., 2022) in Ethiopia. This might be due to the easy availability of water relative to other ingredients in the locality.

Table 2.2: Additives used by local people during the preparation of medicinal plants in the Dibatie district

Additives	**Frequency (N = 596)**	**Percent (%)**
No additive	195	32.72
Water	177	29.70
Bar salt or table salt	55	9.23
Local drinks	34	5.70
Honey	28	4.70
‘Teff’ porridge or syrup	27	4.53
Chicken stew	22	3.69
Butter	17	2.85
Sugar	14	2.35
Milk, yogurt, or cheese	8	1.34
Bread or ‘Injera’	5	0.84
Spices	4	0.67
Hot drinks (tea or coffee)	4	0.67
Soot	2	0.34
Egg yolk	2	0.34
Hippo's skin ash	2	0.34

2.3.10. Adverse effects and antidotes of the traditionally used medicinal plants

In the current study area, no adverse effects were reported for most (97 species, 57.06%) medicinal plants. Out of the documented medicinal plants, 35 species (20.59%) were reported to have adverse effects related to overdose, and 23 species (13.53%) were indicated to have negative effects due to misuse of prescription. Other medicinal plants were reported to cause diarrhea (20 species, 11.76%), vomiting (17 species, 10.00%), body irritation (16 species, 9.41%), gastric inflammation (9 species, 5.29%), effect on pregnancy (6 species, 3.53%), bad mouth feeling (5 species, 2.94%), effect on eyesight (5 species, 2.94%), skin damage (5 species, 2.94%), and tooth crushing (2 species, 1.18%). Local people described numerous antidotes (milk, butter, egg yolk, porridge, syrup, linseed, ‘Injera’, honey, sugar, coffee, and water) and prevention methods (e.g., avoiding eye, healthy skin, and tooth contact and keeping away from pregnant women) that could be employed to counteract adverse effects (Table 2.3).

In agreement with the present study, a study (Yimam et al., 2022) conducted in the Artuma Fursi district of northeast Ethiopia reported that most (81.25%) medicinal plants have no complaints of adverse side effects. On the other hand, the current study aligns with other studies that described some adverse effects such as overdose problems (Megersa & Tamrat, 2022), diarrhea, vomiting (Megersa & Tamrat, 2022; Nigussie et al., 2022; Shimels et al., 2017; Tadesse & Teka, 2023; Teshome et al., 2023), bad mouth taste (Teshome et al., 2023), gastric or stomach inflammation (Tadesse & Teka, 2023; Teshome et al., 2023), and skin irritation (Nigussie et al., 2022) in different parts of Ethiopia. Participants in the present study reported that the occurrence of diarrhea, vomiting, and internal inflammation was usually linked with an overdose of orally applied medicines. Reports from similar investigations (Kassa et al., 2020; Tahir et al., 2021) indicated the dosage effect associated with oral prescriptions. This might be correlated with the highly sensitive nature of the internal body parts compared to the external body.

Local communities in the present study area and across the country (Chekole, 2017; Eshete & Molla, 2021; Megersa & Tamrat, 2022; Tahir et al., 2021) were reported to use various antidotes like milk, butter, honey, coffee, linseed, and local drinks to reduce the risks related to the negative effects of traditional medicines. For instance, overdosage of *Euphorbia abyssinica* J.F.Gmel. exudate was reported to cause diarrhea and weaken the patient when taken orally to treat gonorrhea; hence, milk or porridge was given as an antidote by traditional practitioners. Informants also indicated that *E. abyssinica* exudate was formulated with butter and creamed dermally to treat Tinea versicolor as it wounds the skin alone. Local people in the present study area also indicated that doses of herbal medicines were adjusted based on the age and physical condition of the patients, which is found to be consistent with previous report (Chekole, 2017) in Gubalafto district, northern Ethiopia. Although some negative side effects were recorded, herbal medicines have recently been mentioned as safer than conventional drugs (Faye et al., 2021; Siraj et al., 2020). Therefore, medicinal plant remedies and associated knowledge need to be preserved as low-risk indigenous medicines.

Table 2.3: Reported adverse effects of traditional medicines used in the Dibatie district and antidotes or prevention methods employed

Adverse effects	**Number of species**	**Percent (%)**	**Antidote/prevention methods**
Over dosage	35	20.59	Milk, butter, egg yolk, porridge, syrup, 'Injera', and coffee
Prescription violence	23	13.53	Keeping the prescriptions
Diarrhea	20	11.76	Porridge, linseed, 'Injera', and coffee
Vomiting	17	10	Porridge, linseed, sugar, 'Injera', and coffee
Body irritation	16	9.41	Butter, milk, and water
Gastric inflammation	9	5.29	Porridge, butter, sugar, and syrup
Affecting pregnancy	6	3.53	Avoiding from pregnant women
Bad mouth feeling	5	2.94	Honey or sugar
Affecting eyesight	5	2.94	Butter, or keeping from eyes
Skin damage	5	2.94	Butter, or avoid from healthy skin
Tooth crushing	2	1.18	Avoid from uninfected tooth

2.3.11. Informant consensus factor (ICF)

The informant consensus factor (ICF) was calculated to assess the homogeneity of informants' traditional knowledge on the use of medicinal plants against the broadly classified human ailments in the study area. Accordingly, the ICF value ranges from 0.45 for pregnancy-related ailments (abortion, erythroblastosis fetalis, infertility, milk deficiency, and placenta retention) to 0.88 for psychosocial problems (enemy protection, nightmares, and human relationships), as shown in Table 2.4. The highest ICF value indicates a good degree of agreement among informants on the utility of the reported medicinal plants to cure a particular ailment category, and *vice versa* (Bogale et al., 2023; Tefera & Kim, 2019). As a result, the highest agreement was observed between the respondents with respect to the medicinal plants used to treat psychosocial problems, followed by that of general and unspecified ailments such as acute febrile illness, chest pain, evil eye, general malaise, internal swelling, leech infestation, malaria, rabies, splenomegaly, trauma, and typhoid fever (ICF = 0.72). Here, the ICF value was different for each disease type involved in a specific disease category. This is because the current result was computed for a combination of disease types in a certain disease category.

Table 2.4: Informant consensus factors on medicinal plants use to treat 15 human ailment categories

Ailment category	**Nt**	**Nur**	**ICF**
Anemia, lymphadenitis, and elephantiasis	14	39	0.66
Blood pressure and hemorrhoids	11	35	0.71
Abdominal pain, amoeba, ascaris, colic, constipation, diarrhea, choking, gastritis, gum bleeding, hepatitis, rectal prolapse, tape worm, stomachache, toothache, and vomiting	73	216	0.67
Ear ache and ear mite	5	12	0.64
Eye diseases	5	9	0.5
Acute febrile illness, chest pain, evil eye, general malaise, internal swelling, leech infestation, malaria, rabies, splenomegaly, trauma, and typhoid fever	43	150	0.72
Brest swelling, excessive menstrual flow, gonorrhea, impotency, and uterus prolapse	24	78	0.7
Goiter, hypoglycemia, and loss of appetite	6	12	0.55
Back bone and arthritis	7	15	0.57
Bell's palsy, child delay to walk, headache, and migraine headache	10	20	0.53
Abortion, erythroblastosis fetalis, infertile women, milk deficiency, and placenta retention	12	21	0.45
Asthma, common cold, cough, and tonsillitis	24	49	0.52
Boils, eczema, herpes, leishmaniasis, leprosy, ringworm, scabies, scorpion venom, snake venom, swelling, thorn infection, tinea favosa, tinea versicolor, and wound	69	217	0.69
Psycho-social problems (enemy protection, nightmare, and relationship)	2	9	0.88
Kidney disease, uncontrolled urine, and urinary retention	3	5	0.5

Nt Number of plant species; *Nur* Number of use citation; *ICF* Informant consensus factor

2.3.12. Preference ranking of plants used to cure hemorrhoids in humans

Results of the preference ranking performed by ten (10) key informants on 10 medicinal plants used to treat hemorrhoids showed that *Euphorbia abyssinica* was the most preferred (ranked 1st) to heal the disease, followed by *Calotropis procera* (Aiton) W.T.Aiton (2nd) (Table 2.5). Here, informants gave the highest score (number 7) for the medicinal plant that they thought was most effective and the lowest (number 1) for the least effective medicinal plant species. This indicates that local communities prefer one medicinal plant over the other, while multiple plant species were also suggested to cure a particular ailment.

Table 2.5: Preference ranking of medicinal plant species stated to treat hemorrhoids in humans

Medicinal plant species	Respondents coded R_1 to R_{10}										Total score	Rank
	R_1	R_2	R_3	R_4	R_5	R_6	R_7	R_8	R_9	R_{10}		
Brucea antidysenterica J. F. Mill.	6	5	5	7	5	4	5	3	5	6	51	4th
Calotropis procera (Aiton) W.T.Aiton	6	7	6	7	5	6	5	7	6	5	60	2nd
Clematis simensis Fresen.	5	4	7	5	6	5	7	6	5	6	56	3rd
Euphorbia abyssinica J.F.Gmel.	7	6	7	5	7	6	7	7	6	5	63	1st
Ricinus communis L.	2	3	1	2	1	3	3	1	1	1	18	8th
Salvia tiliifolia Vahl	2	1	1	1	3	2	1	2	3	1	17	9th
Solanum incanum L.	3	4	2	1	2	3	4	3	2	1	25	7th
Tapinanthus globifer (A. Rich.) Tiegh.	1	2	1	1	3	1	1	1	1	2	14	10th
Thunbergia alata Bojer ex Sims	6	5	4	5	6	3	5	4	3	6	47	5th
Xanthium strumarium L.	5	4	3	2	1	2	3	4	5	4	33	6th

The results of the preference ranking showed that *E. abyssinica* was the most preferred medicinal plant to treat hemorrhoids. In support of this finding, earlier ethnomedicinal studies (Mekonnen et al., 2022; Teshome et al., 2023) have reported its traditional utility to cure hemorrhoids in different parts of Ethiopia. In addition, *E. abyssinica* was reported to treat other human ailments, including gastritis (Bogale et al., 2023), gonorrhea (Megersa et al., 2023), hepatitis (Zemede et al., 2024), jaundice (Amsalu et al., 2018), leishmaniasis, malaria, stomachache (Mekonnen et al., 2022), rabies (Alemneh, 2021; Amsalu et al., 2018), and swelling (Giday et al., 2016) across the country. A second plant, *C. procera*, was also reported to treat different human ailments such as breast cancer (Tesfaye et al., 2020), hemorrhoids (Megersa & Tamrat, 2022; Yimam et al., 2022), wart (Osman et al., 2020), breast swelling, dyspepsia, herpes zoster, typhoid (Teklehaymanot, 2017), and wounds (Getaneh & Girma, 2014). This indicates their important role in the primary healthcare of different communities in Ethiopia.

2.3.13. Fidelity level index (FL)

Results showed that *Embelia schimperi* Vatke, *Glinus lotoides* L., *Haplosciadium abyssinicum* Hochst., *Mucuna melanocarpa* Hochst. ex A. Rich., and *Phragmanthera macrosolen* (Steud. ex A. Rich.) M.G.Gilbert had the highest fidelity level values (100%) against the corresponding ailments, followed by *Cassia arereh* Delile, *Justicia schimperiana* (Hochst. ex Nees) T. Anderson., *Phytolacca dodecandra* L'Hér., and *Acmella caulirhiza* Delile with the fidelity level values of 92%, 88%, 85%, and 80%, respectively (Table 2.6). This may indicate that these plants were effective against the corresponding ailments explained to be treated with them.

Table 2.6: The fidelity level of 25 medicinal plants against certain ailments in the Dibatie district

Medicinal plant species	**Ailments**	**Ip**	**Iu**	**FL**	**FL%**
Acmella caulirhiza Delile	Boils	4	5	0.80	80
Capparis tomentosa Lam.	Evil eye	7	12	0.58	58
Carissa spinarum L.	General malaise	7	17	0.41	41
Cassia arereh Delile	Snake venom	12	13	0.92	92
Cissus cornifolia (Baker) Planch.	Swelling	5	8	0.63	63
Clematis hirsuta Perr. & Guill.	Headache	6	14	0.43	43
Clematis simensis Fresen.	General malaise	3	9	0.33	33
Cordia africana Lam.	Diarrhea	9	17	0.53	53
Croton macrostachyus Hochst. ex Delile	Gonorrhea	6	29	0.21	21
Cynoglossum lanceolatum Forssk.	Diarrhea	5	15	0.33	33
Embelia schimperi Vatke	Tapeworm	5	5	1.00	100
Euphorbia abyssinica J.F.Gmel.	Rabies	8	13	0.62	62
Gardenia ternifolia Schumach. & Thonn.	Tonsillitis	3	10	0.30	30
Glinus lotoides L.	Tapeworm	11	11	1.00	100
Gnidia involucrata Steud. ex A.Rich.	Toothache	7	13	0.54	54
Haplosciadium abyssinicum Hochst.	Snake venom	18	18	1.00	100
Indigofera spicata Forssk.	Impotency	6	12	0.50	50
Justicia schimperiana (Hochst. ex Nees) T. Anderson.	Rabies	7	8	0.88	88
Momordica foetida Schumach.	General malaise	6	12	0.50	50
Mucuna melanocarpa Hochst. ex A. Rich.	Tick infestation	11	11	1.00	100
Phragmanthera macrosolen (Steud. ex A. Rich.) M.G.Gilbert	General malaise	7	7	1.00	100
Phytolacca dodecandra L'Hér.	Rabies	11	13	0.85	85
Rotheca myricoides (Hochst.) Steane & Mabb.	General malaise	4	13	0.31	31
Stereospermum kunthianum Cham.	Snake venom	7	13	0.54	54
Tapinanthus globifer (A. Rich.) Tiegh.	Lymphadenitis	12	28	0.43	43

It is realized that the plants mentioned for a single ailment by many respondents will have the greatest FL% values, while those reported for many ailments exhibit the least (Bogale et al., 2023). In the present study, for example, *Croton macrostachyus* Hochst. ex Delile exhibited the lowest (21%) fidelity level value against gonorrhea since it was reported for the healing of several (14) diseases compared to others. The medicinal plants with the highest FL% values were claimed to be helpful in getting a hint of their phytochemical constituents for further investigation of bioactive compounds (Tahir et al., 2023b).

2.3.14. Jaccard's coefficient of similarity (JCS)

The results of Jaccard's similarity coefficient revealed that the traditional utilization of medicinal plants in Oromo and Shinasha ethnic groups showed the highest (44%) resemblance, followed by Amhara and Shinasha ethnic groups accounting for 29% (Table 2.7). This may indicate the greatest share of indigenous knowledge between Oromo and Shinasha people relative to the other communities in the area.

Table 2.7: Jaccard's similarity coefficient among ethnic groups in Dibatie district on the use of medicinal plants

	Jaccard measure			
	Amhara ethnic group	Oromo ethnic group	Shinasha ethnic group	Agaw ethnic group
Amhara ethnic group	1.00	0.26	0.29	0.06
Oromo ethnic group	0.26	1.00	0.44	0.07
Shinasha ethnic group	0.29	0.44	1.00	0.07
Agaw ethnic group	0.06	0.07	0.07	1.00

2.3.15. Taboos related to medicinal plants in the study area

In the current study, some informants verified that they don't put medicinal plants, even in their containers, on the ground. They believe the remedy loses its efficacy if placed on the ground. Informants also indicated that a snake-bitten person should not be allowed to get into the old traditional house and should not be allowed to sleep until recovery. This is because local people thought a person could not wake up after sleeping, thinking he or she might die. Traditional healers usually cut the herbal medicines early in the morning before washing their hands and eating breakfast, hiding themselves from humans or animals. Some healers justified that morning hands were perceived to have the power to heal patients. Healers also verified that they hide themselves for the sake of efficacy, though it might be in order not to show their remedies to other people. About 10% of traditional healers indicated that they keep themselves away from sexual intercourse during the days of harvesting, preparing, and applying the herbal remedies. Healers also pointed out that patients restrict themselves from sexual intercourse while taking the remedies. In addition, informants confirmed that Monday, Wednesday, and Friday were the preferred days for remedy harvesting, preparation, and administration. They believed that a remedy would lose its effectiveness if the rules were violated.

2.3.16. Additional uses of medicinal plants in the study area

The medicinal plants in the study area were used by the local residents for a variety of several purposes beyond their medicinal uses. Even if all plants are ecologically important, almost all (168 species, 98.82%) medicinal plants in the present study were reported to have extra uses other than their use in herbal medicines. In this perspective, they were reported to be used as bee forage, fodder, food, fuel wood, fence, shade, household utensil, construction material, cleaning material, beehive tree, land demarcation, tooth brush, fumigating material, farm material, fishing implement, traditional soap, beehive raw material, charcoal, local beverage, soil fertilizer, timber, bread wrap, hot drink, handling stick, ornament, attractant, stimulating drug, lubricant, and plate softening (Appendix 1**)**. Similar studies elsewhere in the country (Asfaw et al., 2022; Bekele et al., 2022; Eshete & Molla, 2021; Megersa & Tamrat, 2022; Tefera & Kim, 2019; Wubu et al., 2023; Yimam et al., 2022) revealed additional uses of medicinal plants in addition to their therapeutic values.

The direct matrix ranking results of multipurpose medicinal plants showed that *Ficus sycomorus* L. was ranked first and *Cordia africana* Lam. was second for eight use types including beehive trees, charcoal, construction, fodder, food, fuel wood, medicine, and household utensils. The remaining multipurpose plants, *Ficus sur* Forssk., *Stereospermum kunthianum* Cham., *Croton macrostachyus*, *Grewia mollis* Juss., *Breonadia salicina* (Vahl) Hepper & J.R.I.Wood, and *Terminalia laxiflora* Engl. & Diels, were ranked 3rd, 4th, 5th, 6th, 7th, and 8th, respectively. Besides, the comparison of use categories revealed that the use of these plants for construction ranked 1st, followed by the uses for fuel wood, medicine, fodder, charcoal, household utensils, beehive trees, and food, which ranked 2nd to 8th, respectively (Table 2.8). This result indicates that multipurpose medicinal plants in the present study area have been highly used for construction purposes compared to other uses. This in turn may lead to the depletion of primarily used plant species unless proper awareness is created in the community for the wise use and sustainable management practices of the plants. For example, informants confirmed that *Breonadia salicina*, *Stereospermum kunthianum*, and *Terminalia laxiflora* were highly required for construction due to their high termite resistance, and *Cordia africana* was extensively needed for timber production. It is evidenced that those widely used multipurpose medicinal plants are often threatened owing to overexploitation for different purposes (Asfaw et al., 2022; Megersa & Tamrat, 2022; Tahir et al., 2021; Yimam et al., 2022). The loss of multipurpose medicinal plants leads to the loss of associated indigenous knowledge, increasing the incidence of human and livestock health problems (Agize et al., 2022). Therefore, these multipurpose medicinal plants need to be used wisely and given appropriate conservation considerations in the current study area and the country as a whole.

Table 2.8: A direct matrix ranking of selected multipurpose medicinal plants based on the average values of scores given by 7 informants for eight use criteria in the community

	Use categories								Total	Rank
Plant species	**Bt**	**Ch**	**Co**	**Fd**	**Fo**	**Fw**	**M**	**U**		
Breonadia salicina	5	1	5	0	0	5	3	1	20	7th
Cordia africana	2	3	5	5	5	4	5	5	34	2nd
Croton macrostachyus	4	5	5	0	0	3	5	1	23	5th
Ficus sur	1	5	4	4	5	4	2	5	30	3rd
Ficus sycomorus	5	5	4	5	5	4	2	5	35	1st
Grewia mollis	0	1	1	5	5	3	3	3	21	6th
Stereospermum kunthianum	1	3	5	5	0	3	5	2	24	4th
Terminalia laxiflora	3	1	5	2	0	5	2	1	19	8th
Total	21	24	34	26	20	31	27	23		
Rank	7th	5th	1st	4th	8th	2nd	3rd	6th		

Bt Beehive tree, *Ch* Charcoal, *Co* Construction, *Fd* Fodder, *Fo* Food, *Fw* Fuel wood, *M* Medicine, *U* Utensil

2.3.17. Use value (UV) index

The use value was calculated for each plant species to determine the relative importance of the recorded medicinal plants in the study area (Appendix 2). In this perspective, *Breonadia salicina*, *Ficus sycomorus*, and *Terminalia laxiflora* had the highest importance in the community, accounting for UV of 5.00 each, followed by *Cordia africana* with UV = 4.24, among others (Table 2.9). The use value is crucial in estimating the most locally useful plant species and assessing the possible usages of a particular plant (Zenderland et al., 2019). However, the technique of UV measures only some aspects of human and plant interaction since it is influenced by the number of uses and the consensus of informants (Albuquerque et al., 2006).

Table 2.9: The use value (UV) of the first 15 medicinal plant species in the Dibatie district

No.	Medicinal plant species	ΣUi	n	UV
1	*Breonadia salicina* (Vahl) Hepper & J.R.I.Wood	30	6	5.00
2	*Ficus sycomorus* L.	10	2	5.00
3	*Terminalia laxiflora* Engl. & Diels	10	2	5.00
4	*Cordia africana* Lam.	72	17	4.24
5	*Albizia schimperiana* Oliv.	8	2	4.00
6	*Phoenix reclinata* Jacq.	8	2	4.00
7	*Croton macrostachyus* Hochst. ex Delile	105	29	3.62
8	*Dichrostachys cinerea* (L.) Wight & Arn.	14	4	3.50
9	*Grewia mollis* Juss.	7	2	3.50
10	*Jatropha curcas* L.	7	2	3.50
11	*Afrocarpus falcatus* (Thunb.) C.N.Page	7	2	3.50
12	*Ficus sur* Forssk.	10	3	3.33
13	*Faurea rochetiana* (A.Rich.) Chiov. ex Pic.Serm.	16	5	3.20
14	*Gymnanthemum amygdalinum (Delile) Sch.Bip.*	19	6	3.17
15	*Stereospermum kunthianum* Cham.	41	13	3.15

In the current study area, *B. salicina* was among the medicinal plants with the highest use values within the communities. It is an evergreen, riverine tree reported to be essential for water conservation, refreshing air sources, and a shelter for wild life like birds, reptiles, and monkeys. In the present study, *F. sycomorus* was also one of the most important medicinal plants, with crucial environmental and cultural roles. In this sense, it was reported to serve as a shade for animals during sunny times, and local people usually conduct meetings under its shade. In line with the current study, a study conducted by (Dalle et al., 2005) reported that *F. sycomorus* was a culturally respected tree under which certain ritual ceremonies and meetings are held in the Oromia region of Ethiopia. In addition, *B. salicina* and *F. sycomorus* were among the indigenous trees traditionally used for beehive hanging and transferred from father to son along the generations. This implies that these plants are critical from environmental and cultural perspectives within the communities and need to be conserved for future generations.

2.3.18. Marketability of medicinal plants in the study area

The market survey and interview showed that most (133 species, 78.24%) medicinal plants in the study area were not marketable primarily for their medicinal use. Only few (2 species, 1.18%) medicinal plants were reported to be sold for medicinal purpose. Some medicinal plants were vended for other purposes, such as food or local drinks (24 species, 14.12%), stimulant drugs (2 species, 1.18%), and traditional plate softening (1 species, 0.59%) but were also used as traditional medicine. Others were marketable for the purposes of construction (3 species, 1.76%), making household utensils (3 species, 1.76%), milk containers' fumigation (1 species, 0.59%), and timber (1 species, 0.59%) (Table 2.10). Similar ethnomedicinal studies (Abebe, 2022; Giday et al., 2009; Tadesse & Teka, 2023; Tamene et al., 2023; Teshome et al., 2023) reported that the majority of traditional medicinal plants in Ethiopia were not marketable for medicinal purposes. Instead, they were reported to be sold usually for spice, food, firewood, construction, beverage, and as stimulants (Tadesse & Teka, 2023; Teshome et al., 2023), consistent with the reports of the present study. This indicates that medicinal plants are less marketable in the open market across the country. This might be due to the habits of the local residents, who search for medicinal plants only when required for medication (Tamene et al., 2023). As a result, it is important to promote the trading of medicinal plants to improve income generated from them at individual and national levels. In the present study area, however, traditional healers were reported to take payments at the moment of treatment, though the amount of payment varied from one healer to another. Similarly, an earlier study (Megersa et al., 2023) reported the trading of medicinal plants by healers at home instead of selling them on the open market. The reason is that most traditional practitioners prefer to hide their medicinal plants (Giday et al., 2009).

Table 2.10: Marketability of medicinal plants in Dibatie district

Marketability	Number of species	Percent (%)
Not marketable	133	78.24
Marketable	37	21.76
For food or drink	24	14.12
For household utensil	3	1.76
For construction	3	1.76
For stimulating drug	2	1.18
For medicine	2	1.18
For fumigating containers	1	0.59
For plate softening	1	0.59
For timber	1	0.59

2.3.19. Threats to and conservation practice of medicinal plants

The results of ethnobotanical survey revealed that medicinal plants in the study area were mainly threatened by deforestation accounting for 33.70% of the total threats reported. Over grazing or browsing was the second cited threatening factor accounting for 18.75%. The other threatening factors for medicinal plants in the area were drought, overexploitation, agricultural expansion, herbicides, wildfire, uprooting as a weed, destruction by animals, and insect or fungal pests (Table 2.11).

The local people in the present study area cut medicinal plants to fulfill their various livelihood needs, such as shelter construction for themselves or domestic animals, fuel wood, fodder, fences, household materials, charcoal, and so on. A number of researchers (Asfaw et al., 2022; Tadesse & Teka, 2023; Tahir et al., 2023b; Teshome et al., 2023; Wubu et al., 2023) reported the destruction of medicinal plants for different purposes elsewhere in Ethiopia. On the other hand, other similar studies (Bogale et al., 2023; Megersa et al., 2023; Mekonnen et al., 2022; Tadesse & Teka, 2023) described agricultural expansion as the most commonly threatening factor for medicinal plants in their respective study sites. In the present study, overgrazing was also mentioned as a common threat to medicinal plants. This might be linked with the mixed agricultural lifestyle of the residents, which involves the livestock husbandry parallel to crop production. In this respect, farmers cut some medicinal plants for their cattle during dry season beyond free grazing.

Informants also claimed that drying was the third most threatening factor to medicinal plants. Because the months from January to April were usually dry in the study area, annual herbs, including herbaceous medicinal plants, disappeared during these months. This is in line with the previous studies (Abebe, 2022; Tahir et al., 2021; Wubu et al., 2023), which identified drying and overgrazing as serious threats to medicinal plants in different parts of Ethiopia.

Overexploitation for multiple uses was reported to be a cause for the current depletion of medicinal plants, consistent with the earlier reports (Asfaw et al., 2022; Megersa & Tamrat, 2022; Tahir et al., 2021; Yimam et al., 2022) in the country. For instance, *Albizia gummifera* (J. F.Gmel.) C. A. Sm. was debarked by fishermen, and its bark was added to water to collect a fainted fish. This may lead to the death and reduction of plant species if the activity continues for years. In the present study, the use of herbicides and uprooting of medicinal plants as weeds were reported in the farming areas, similar to finding (Tahir et al., 2021) in Adwa district, northern Ethiopia. This might be because of the low awareness of the local community about the ecological, economic, and health benefits of medicinal plants. Besides, wildfire, destruction by animals, and insect or fungal attacks on medicinal plants were described in the study area. This calls for urgent conservation measures to ensure the continued availability of medicinal plants in the current study area and across the country.

Table 2.11: Threats to medicinal plants in the Dibatie district

Threats	**Frequency (N=736)**	**Percent (%)**
Cutting or deforestation	248	33.70
Grazing or browsing	138	18.75
Drying	92	12.50
Overexploitation	76	10.33
Agricultural expansion	65	8.83
Herbicide	50	6.79
Wildfire	26	3.53
Uprooting as a weed	25	3.40
Destruction by animals	11	1.49
Insect or fungal pests	5	0.68

Out of the reported medicinal plants, most (112 species, 65.88%) were not conserved in the study area. Some (28 species, 16.47%) medicinal plants were cultivated by the local communities as staple foods, spices, fruit plants, or cash crops. Some others (19 species, 11.18%) were conserved by traditional healers for medicine, and a few (11 species, 6.47%) were preserved by the local communities near home gardens or farmland for various purposes, such as construction, timber, live fences, shade, land demarcation, and beehive hanging trees.

In the current study area, the conservation practice of medicinal plant resources was very minimal. Similar studies (Jima & Megersa, 2018; Megersa & Tamrat, 2022; Tamene et al., 2023; Teklehaymanot, 2017) also reported the poor conservation practices of medicinal plants in different regions of Ethiopia. This might be due to the fact that the majority of medicinal plants in the country are from wild natural vegetation (Bogale et al., 2023; Mekonnen et al., 2022). However, a little bit of effort toward medicinal plant conservation was started by traditional healers and some local communities in the present study area. For example, some originally wild medicinal plants, such as *Acmella caulirhiza*, *Aloe benishangulana* Sebsebe & Tesfaye, *Brucea antidysenterica* J. F. Mill., *Calpurnia aurea* (Aiton) Benth., *Cissus quadrangularis* L., *Euphorbia abyssinica*, *Kalanchoe densiflora* Rolfe, *Ocimum gratissimum* L., *Rumex nepalensis* Spreng., *Rumex nervosus* Vahl, *Withania somnifera* (L.) Dunal, and *Verbena officinalis* L. were observed being protected in the gardens of traditional healers for medicinal purposes. This is in alignment with the reports of previous findings (Tahir et al., 2023b; Tamene et al., 2023; Teshome et al., 2023) in different regions of Ethiopia. Recently, administrative leaders and development agents have progressed legally to inhibit the cutting of trees, especially riverine trees like *Breonadia salicina* and *Syzygium guineense* (Wild.) DC. subsp. *guineense*, for the preservation of the plants as well as the rivers. In addition, local residents were reported to apply certain indigenous conservation measures by protecting some plants near homesteads, on farmlands, as live fences, and as beehive hanging trees. The beehive hanging trees like *B. salicina, C. macrostachyus,* and *F. sycomorus* have been transferred from a father to a son, just like permanent wealth in the area. Likewise, previous study (Teshome et al., 2023) conducted in the Ensaro district of northern Ethiopia reported the indigenous conservation methods of useful medicinal plant species. As a result, the conservation initiative habits of the local communities should be encouraged, and *in situ* and *ex situ* conservation strategies should be applied for sustainable use of medicinal plant resources with the associated indigenous knowledge in the country.

2.4. Conclusion

This study documented 170 traditional medicinal plant species used for the treatment of 79 human and 29 livestock ailments. The study area was rich in potential medicinal plant diversity and associated indigenous knowledge that can be used to alleviate various human and domestic animal health problems. For example, Bell's palsy, boils, diarrhea, general malaise, gonorrhea, hemorrhoids, hepatitis, herpes, impotency, leishmaniasis, lymphadenitis, rabies, rectal prolapse, tumors, tapeworm, and wounds were among the human diseases reported to be traditionally cured by medicinal plants in the Dibatie district. Blackleg, rabies, wound worm, diarrhea, placenta retention, breast swelling, eye disease, hemorrhoids, Newcastle disease, tick infestation, febrile disease, leech infestation, and lumpy skin were examples of livestock ailments treated by traditional practitioners. Nevertheless, the beneficial medicinal plant species in the study area were predominantly threatened by anthropogenic factors due to cutting or deforestation for the purposes of construction, fuel wood, fodder, timber, charcoal, fences, household utensils, farm materials, and so on. The conservation practices of medicinal plants in the study area were found to be very low, though some conservation habits were observed to be practiced by traditional healers and some community members. Therefore, immediate conservation practices, proper management, and careful utilization of medicinal plants should be applied to sustain the health benefits and transfer them to the next generation along with the associated indigenous knowledge. Moreover, appropriate registration and recognition should be given to the traditional healers in order to encourage them to preserve their indigenous knowledge. Furthermore, the recorded medicinal plants need to be validated through experimental studies to integrate traditional medicine with modern medication systems and improve healthcare services.

CHAPTER THREE

Paper II

3. Antibacterial Activity, Antioxidant Potential and Phytochemical Screening of Selected Medicinal Plants in Dibatie District, Metekel Zone, Western Ethiopia

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Abstract

Background: Medicinal plants play a major role in the delivery of healthcare, particularly among the rural population of Ethiopia. Plant extracts and their bioactive compounds have been utilized for the treatment of several diseases. This study was aimed at evaluating the antibacterial activity, antioxidant capacity, and phytochemical content of selected medicinal plants used in Dibatie district, western Ethiopia.

Methods: Samples of study plants were collected, shade dried, pulverized, extracted by maceration in 80% ethanol, and subjected to antibacterial, antioxidant, and phytochemical tests. Minimum inhibitory concentration (MIC) was determined using 96-well microplates and nutrient broth microdilution. Antioxidant activity was evaluated using the 2,2-diphenyl-1-picrylhydrazyl (DPPH) free radical scavenging assay. Phytochemical screening was conducted using standard test methods.

Results: The ethanolic extract of *Polystachya steudneri* Rchb.f. pseudobulbs was the most active against gram-negative *Proteus mirabilis*, *Salmonella typhimurium*, *Klebsiella pneumoniae*, *Escherichia coli*, and *Shigella flexneri*, with MIC values of 8 ± 0, 11 ± 5, 3 ± 1, 3 ± 1, and 2 ± 0 mg/mL, respectively. The ethanolic extract of *P. steudneri* was also the most effective against gram-positive *Staphylococcus aureus*, *Staphylococcus epidermidis*, *Streptococcus agalactiae*, and *Enterococcus faecalis*, with MIC values of 8 ± 0, 8 ± 0, 3 ± 1, and 16 ± 0 mg/mL, respectively. Ethanolic extracts of *Gnidia involucrata* Steud. ex A.Rich. stems and roots were effective antioxidants, with respective 50% DPPH free radical inhibitory concentrations (IC_{50}) of 168.68 and 181.79 µg/mL, followed by that of *P. steudneri* (IC_{50} = 203.11 µg/mL). The study plants contained alkaloids, anthocyanins, anthraquinones, cardiac glycosides, coumarins, flavonoids, phenols, saponins, steroids, tannins, and terpenoids.
Conclusions: This study confirmed the antibiotic, antioxidant activities, and different phytochemical constituents of the investigated plants suggesting further investigations that may lead to bioactive lead compounds.

Keywords: Antibacterial, Antioxidant, Phytochemical, Medicinal plants

3.1. Background

Infectious diseases are the most common causes of mortality and morbidity among human beings throughout the world (Teka et al., 2015). Recently, the rapid emergence and spread of multidrug-resistant pathogens have been considered a major challenge for the treatment of several infectious diseases (Acharjee et al., 2023; Singh et al., 2021). The multiple drug resistance mechanisms include drug uptake limitation, drug target modification, drug inactivation, and active drug efflux, and the resistance processes differ based on microbial types (Qadri et al., 2022). Besides, certain pathogenic bacteria form biofilms through quorum sensing and develop drug resistance (Prabu et al., 2020). Hence, there is a need for the discovery of new drugs against multidrug-resistant pathogenic microorganisms.

Plant extracts and their bioactive compounds have been utilized for the treatment of several diseases since ancient times (Prabu et al., 2020). Medicinal plants were the major sources of bioactive compounds that could be used as potential alternatives to conventional antimicrobials (Rajput & Kumar, 2020). The antibacterial activity of the plants could be ensured either by inhibiting the growth of bacteria or by disturbing the cell-to-cell communication system between the bacteria through anti-quorum sensing (AQS) (Baloyi et al., 2019), in which the latter is currently preferable, especially against antimicrobial-resistant bacteria. Hence, plant-derived medicines have been considered convenient therapies due to their fewer side effects and greater pharmacological efficacy (Nazar et al., 2020). Medicinal plants contain natural phytochemicals such as alkaloids, flavonoids, saponins, tannins, terpenoids, steroids, resins, cardiac glycosides, coumarins, and phenolic compounds, among others, that could have a multitude of biological activities (Mapfumari et al., 2022).

Moreover, medicinal plants are potent antioxidants and play an important role in sequestering reactive oxygen species (ROS) in living cells owing to the presence of various phytochemicals (Jafri et al., 2023). Polyphenols from plants scavenge free radicals and inhibit enzymes that are responsible for the formation and accumulation of reactive oxygen species (ROS) (Atta et al., 2023). Antioxidant phenolic compounds reduce the level of free radicals in living cells, thereby preventing the oxidation of cellular components by donating hydrogen atoms to free radicals and forming stable, nontoxic compounds like phenoxyl radicals (Alu'datt et al., 2018). These compounds prevent or treat diseases related to oxidative stress, such as cancer, diabetes, cardiovascular diseases, inflammatory joint diseases, dementia, asthma, eye diseases, and atherosclerosis (Jafri et al., 2023). Additionally, plant-derived phenolic compounds capture and neutralize free radicals in human cells to protect them from aging (Iqbal et al., 2015).

Ethiopia is a center for plant diversity, diverse topography, and multiple ethnic groups, languages, cultures, and beliefs, which enhance the practice of using medicinal plants. Particularly, the Metekel zone in Benishangul Gumuz Regional State has various ethnic groups (e.g., Agaw, Amhara, Gumuz, Oromo, and Shinasha), multiple cultures, and a diversity of medicinal plants. For instance, *Asparagus flagellaris* (Kunth) Baker, *Brucea antidysenterica* J. F. Mill., *Celosia trigyna* L., *Crepis rueppellii* Sch. Bip., *Gnidia involucrata* Steud. ex A.Rich., *Polystachya steudneri* Rchb.f., and *Sauromatum venosum* (Aiton) Kunth are traditionally used to treat toothache, leishmaniasis, tapeworm, diarrhea, gonorrhea, wounds, and amoeba, respectively, in the Dibatie district of the Metekel zone, western Ethiopia. However, there are limited reports yet on the ethnomedicine, antimicrobial activity, antioxidant properties, and phytochemical profiles of these plants in Ethiopia as a whole and in the Dibatie district of the Metekel zone in particular. Therefore, the current study was aimed at evaluating the antibacterial activity, antioxidant potential, and phytochemical constituents of the above medicinal plants.

3.2. Methods

3.2.1. Study period, study design and area

This study involved a preliminary ethnomedicinal survey through a semi-structured interview (Martin, 1995), which was conducted from April 2021 to June 2022. Following the ethnomedicinal investigation, the medicinal plants were selected, and the laboratory samples were collected in November 2022. Then, the laboratory work was carried out from February to June 2023. The field ethnobotanical data and sample collection were conducted in the Dibatie district of the Metekel zone, Benishangul Gumuz Regional State, western Ethiopia. Residents from eleven kebeles (sub-districts), namely Berber, Dibatie-02, Donben, Galessa, Gipho, Jan, Lega-buna, Parzeyit, Qorqa, Sombo-sire, and Tuski-gambela, participated in the interview process. The plant material preparation, extraction, antibacterial test, antioxidant assay, and phytochemical screening were carried out at the laboratory of the Directorate of Modern and Traditional Medicine Research at the Ethiopian Public Health Institute, Addis Ababa, Ethiopia.

3.2.2. Plants selection

Medicinal plants were selected for laboratory work depending on the prior ethnobotanical survey of their traditional medicinal uses. The selection criteria were mainly based on the medicinal plants traditionally used to treat human ailments such as amoeba, diarrhea, gonorrhea, leishmaniasis, tapeworm, toothache, and wounds. Because these diseases were caused or aggravated due to the infestation by bacteria, protozoans, or helminthes. The selection of the study plants also emphasized the relative curing potential of each plant species (percentage of fidelity level) to heal the above ailments. The percentage of fidelity level helps to give a hint for further investigations on the medicinal efficacy of bioactive constituents. The percentage of fidelity level (FL%) was calculated using the formula: $FL\% = Ip/Iu \times 100$, where Ip is the number of respondents who indicated the use of a species for the same major ailments and Iu is the total number of respondents who mentioned the plant for any major ailments indicated (Tahir et al., 2023b). Accordingly, plants with a fidelity level greater than 45% were selected for the laboratory investigations (Table 3.1). In addition, the selected plants were prioritized since they were not studied using the same methods as the present study so far.

Table 3.1: Ethnomedical data on medicinal plants selected for laboratory based studies

Scientific name	Family	Local name (Language)	Geographic location	Ailments treated	Parts used	Ip	Iu	FL%	Voucher number
Asparagus flagellaris	Asparagaceae	Saritii (AO)	10˚34.745'N, 36˚11.095'E	Toothache	Root	4	7	57	BA-04
Brucea antidysenterica	Simaroubaceae	Qomonyoo (AO)	10˚15.582'N, 36˚05.918'E	Leishmaniasis	Fruit	5	10	50	BA-45
Celosia trigyna	Amarnthaceae	Babilinda (AO)	10˚26.480'N, 36˚08.175'E	Tapeworm	Inflorescence, seed	10	10	100	BA-77
Crepis rueppellii	Asteraceae	Yefyel wetet (Am)	10˚33.849'N, 36˚07.970'E	Diarrhea	Root	5	9	56	BA-62
Gnidia involucrata	Thymelaeaceae	Qamaxxee (AO)	10˚34.235'N, 36˚11.879'E	Gonorrhea	Root	6	13	46	BA-151
Polystachya steudneri	Orchidaceae	-	10˚29.878'N, 36˚10.399'E	Wounds	Pseudobulb	6	12	50	BA-08
Sauromatum venosum	Araceae	Muuna (Sh)	10˚36.015'N, 36˚10.102'E	Amoeba	Tuber	4	8	50	BA-42

AO: Afaan Oromoo; Am: Amharic; Sh: Shinashigna

3.2.3. Sample collection and preparation

Based on the above criteria, roots of *Asparagus flagellaris*, fruits of *Brucea antidysenterica*, inflorescence having seeds of *Celosia trigyna*, roots of *Crepis rueppellii*, roots and stems of *Gnidia involucrata*, pseudobulbs of *Polystachya steudneri*, and tubers of *Sauromatum venosum* were collected from Berber, Galessa, Jan, Lega-buna, Sombo-sire, and Tuski-gambela sub-districts. The collected plants were identified by Dr. Ermias Lulekal and Mr. Baressa Anbessa in the Department of Plant Biology and Biodiversity Management at Addis Ababa University. In addition, the scientific names were checked by referring to the website Plants of the World Online (POWO). Voucher specimens were deposited at the National Herbarium of Addis Ababa University (ETH).

Fruits, seeds, and inflorescences of the indicated plants (Table 3.1) were shade dried without washing since their dust content was negligible. Roots, stems, and pseudobulbs were washed with tap water, rinsed with distilled water to remove dust, and shade dried in a solar drier. Dried samples were pulverized using an electric grinder to a moderately fine powder and kept in the refrigerator at 4 ºC until extraction.

3.2.4. Extraction process

As the local community usually uses water as a solvent, aqueous 80% ethanol was used for effective extraction of bioactive compounds from medicinal plant materials. The reason is that aqueous-alcoholic (80% ethanol) extracts are better in phytochemical (e.g., phenolics, flavonoids, tannins, etc.) content and antioxidant activity (Gonfa et al., 2020; Sultana et al., 2009). The extraction was carried out by macerating 50 g of powdered plant parts in 500 mL of 80% ethanol and continuously shaking for 24 hours using a magnetic stirrer. The mixture was filtrated using Whatman number 1 filter paper. The residue was re-macerated for 24 hours and filtered. The filtrates were combined and concentrated *in vacuo* using a rotary evaporator (BUCHI R-300 Rotavapor, Switzerland). The concentrated extracts were dried in a water bath at 40 ºC and kept in desiccators with active silica gel until they dried well.

3.2.5. Antibacterial assay

The test microorganisms were from the American Type Culture Collection (ATCC). Ethanolic extracts of each sample were tested *in vitro* against the active pathogenic bacterial strains existing in the laboratory. These include the gram-negative (*Proteus mirabilis* ATCC-35659, *Salmonella typhimurium* ATCC-13311, *Klebsiella pneumoniae* ATCC-700603, *Escherichia coli* ATCC-

25922, and *Shigella flexneri* ATCC-12022) and the gram-positive (*Staphylococcus aureus* ATCC-25923, *Staphylococcus epidermidis* ATCC-12228, *Streptococcus agalactiae* ATCC-12386, and *Enterococcus faecalis* ATCC-1829212) bacterial strains.

Nutrient broth and Mueller-Hinton agar were used for microorganism sub-culturing and growing. For that purpose, 13 g of nutrient broth was dissolved in 1000 mL of distilled water, well mixed, and autoclaved at 121 °C and 15 pounds per square inch (psi) for 15 minutes. Mueller-Hinton agar (38 g) was also dissolved in 1000 mL of distilled water, well mixed, boiled on a hot plate, and autoclaved.

Mueller-Hinton agar for bacteria was used for the subculturing of microorganisms. In this regard, 3-5 well-isolated colonies of the same morphological type from the refreshed agar plate culture were selected. The bacterial colonies were inoculated on sterilized plates containing Mueller-Hinton agar, followed by incubation at 37 °C for 24 hours. Later, the bacterial colonies were transferred to the nutrient broth using the sterilized inoculating loop.

The minimum inhibitory concentration (MIC) was determined using 96-well microplates by the nutrient broth microdilution method. Tween 80 was used to dissolve the extracts since it is a low-toxicity surfactant that increases the solubility of bioactive phytochemicals (Iswandana et al., 2020). The ethanolic extract of each sample was dissolved in 5% Tween 80 to an end concentration of 32 mg/mL, which needs to be engaged in serial dilutions. An aliquot of 100 µL of each extract was subjected to serial dilutions in nutrient broth to concentrations of 16, 8, 4, 2, 1, 0.50, 0.25, and 0.13 mg/mL. A standard reference (ciprofloxacin) was taken as a positive control in concentrations of 10, 5, 2.50, 1.25, 0.63, 0.31, 0.16, and 0.08 µg/mL. Tween 80 (5%) was used as a negative control. The microorganism suspension was standardized to 1 x 10^8 CFU/mL (0.08 to 1.00 turbidity) using a UV-Vis spectrophotometer at 625 nm. An aliquot of 100 µL of standardized microorganisms was inoculated into each well containing serially diluted extracts and controls (positive, negative, and growth controls), except for sterility control. Then, plates were incubated at 37 °C for 18-24 hours. In order to read the microorganism growth, 40 µL of 2, 3, 5 tripenyl tetrazolium chloride (TTC) with a concentration of 0.40 mg/mL was added into each well and incubated at 37 °C for 30 minutes. The development of pink color in the microplate well indicated the presence of living cells (microorganisms), and the reverse result showed inhibition of microbial growth. The lowest concentration of each extract displaying no visible pink color was recorded as the MIC.

During the antibacterial test, we followed various safety practices to avoid any potential hazards. Bacterial cultures were treated as potential pathogens. All materials, media, tubes, plates, loops, needles, pipettes, and other items used were sterilized by autoclaving or using commercially sterilized products. Work spaces were thoroughly cleaned using 70% ethanol or 10% bleach both before and after usage. Mouth pipetting was avoided by staying away from food and drink in the laboratory and washing hands with disinfectant soap before and after working. Labeling everything clearly, autoclaving or disinfecting all waste material, and cleaning up spills with care were also the other safety precautions that we followed during the experiments. Additionally, all necessary personal protective equipment and biological safety cabinets (class II) were used to avoid contamination.

3.2.6. Antioxidant (2,2-diphenyl-1-picrylhydrazyl (DPPH)) assay

The free radical scavenging ability of ethanolic extracts was determined by using a 2,2-diphenyl-1-picrylhydrazyl (DPPH) assay (Kızıl et al., 2008). Briefly, a fresh 0.1 mM DPPH solution was prepared in 80% ethanol. Ethanolic extracts and ascorbic acid (a positive control) were kept in test tubes at different concentrations (15.63-500 µg/mL) through serial dilution in 80% ethanol. Then, 1 mL of DPPH solution was mixed with 1 mL of each extract and a positive reference in the test tube. The mixtures were shaken thoroughly and incubated in the dark for 30 minutes at room temperature. The mixture of 1 mL of 80% ethanol and 1 mL of DPPH solution was considered a blank. The absorbance of each mixture was measured at 517 nm against a blank using a UV-VIS spectrophotometer (UV-1800 SHIMADZU).

The percentage of inhibition was calculated using the formula: % Inhibition = [(Ab - As) / Ab] x 100, where Ab is the absorbance of the blank and As is the absorbance of the sample. Later, the 50% inhibition concentration (IC_{50}) was calculated for ascorbic acid and extracts of medicinal plants by using the slope equation: Y = mx + c (Jafri et al., 2023).

3.2.7. Phytochemical screening

The ethanolic extracts were employed for preliminary screening of phytochemicals such as alkaloids, anthocyanins, anthraquinones, cardiac glycosides, coumarins, flavonoids, phenols, saponins, steroids, tannins, and terpenoids following the standardized protocols (Bargale et al., 2019; Iqbal et al., 2015; Mechqoq et al., 2022; Prabu et al., 2020; Shaikh & Patil, 2020). The results were expressed as (+) for the presence and (-) for the absence of phytochemical compounds.

3.2.8. Statistical data analysis

The percentage of fidelity level was computed based on the ethnobotanical data to assess the healing potential of each plant species against the corresponding disease. The minimum inhibitory concentration (MIC) data were described as the means ± standard deviation of triplicate analyses. Depending on the MIC values, the principal component analysis (PCA) was computed to indicate variations in the antibiotic effect of medicinal samples and the susceptibility of bacterial strains using R-statistical packages (ggplot2 and grid). The DPPH free radical scavenging activity and the 50% inhibition concentration (IC_{50}) were expressed as means of triplicate determinations. Qualitative phytochemical profiles were expressed as the presence (+) and absence (-) of phytochemical constituents. Microsoft Excel version 2013 was also used for the data analysis.

3.3. Results

3.3.1. Antibacterial activities of medicinal plants

Minimum inhibitory concentration (MIC) values of selected medicinal plants were evaluated against gram-negative (*Proteus mirabilis*, *Salmonella typhimurium*, *Klebsiella pneumoniae*, *Escherichia coli*, and *Shigella flexneri*) and gram-positive (*Staphylococcus aureus*, *Staphylococcus epidermidis*, *Streptococcus agalactiae*, and *Enterococcus faecalis*) bacterial strains at concentrations less than or equal to 16 mg/mL.

3.3.1.1. MIC values of plant extracts against gram-negative bacteria

The ethanolic extract of *P. steudneri* pseudobulbs showed the highest antibacterial activity against gram-negative bacterial strains by inhibiting *P. mirabilis, S. typhimurium*, *K. pneumoniae*, *E. coli*, and *S. flexneri* with MIC values of 8 ± 0, 11 ± 5, 3 ± 1, 3 ± 1, and 2 ± 0 mg/mL, respectively. Whereas the ethanolic extract of *A. flagellaris* roots exhibited the lowest antibacterial activity as it inhibited both *S. typhimurium* and *E. coli* at MIC values of 16 ± 0 mg/mL, and *P. mirabilis*, *K. pneumoniae*, and *S. flexneri* at MIC values > 16 mg/mL each (Table 3.2).

Table 3.2: MIC values of 80% ethanolic extracts (mg/mL) of studied medicinal plants and ciprofloxacin (µg/mL) against gram-negative bacterial strains

Plant species and controls	**Bacterial strains**				
	P. mirabilis	*S. typhimurium*	*K. pneumoniae*	*E. coli*	*S. flexneri*
A. flagellaris (root)	> 16	16 ± 0	> 16	16 ± 0	> 16
B. antidysenterica (fruit)	> 16	16 ± 0	> 16	> 16	8 ± 0
C. trigyna (seed, inflorescence)	16 ± 0	8 ± 0	13 ± 5	7 ± 2	13 ± 5
C. rueppellii (root)	> 16	8 ± 0	16 ± 0	8 ± 0	16 ± 0
G. involucrata (root)	> 16	8 ± 0	16 ± 0	8 ± 0	8 ± 0
G. involucrata (stem)	> 16	8 ± 0	8 ± 0	8 ± 0	8 ± 0
P. steudneri (pseudobulb)	8 ± 0	11 ± 5	3 ± 1	3 ± 1	2 ± 0
S. venosum (tuber)	> 16	> 16	> 16	8 ± 0	> 16
Ciprofloxacin	< 0.08	0.31	0.31	< 0.08	1.25
Tween 80	–	–	–	–	–

Values are means ± standard deviation of triplicate examinations

3.3.1.2. MIC values of plant extracts against gram-positive bacteria

The ethanolic extracts of *P. steudneri* pseudobulbs and *G. involucrata* stems were the most active against gram-positive bacterial strains. The extract of *P. steudneri* inhibited *S. aureus*, *S. epidermidis*, *S. agalactiae*, and *E. faecalis* at MIC values of 8 ± 0, 8 ± 0, 3 ± 1, and 16 ± 0 mg/mL, and that of *G. involucrata* stems inhibited these bacteria at MIC values of 3 ± 1, 16 ± 0, 2 ± 0, and 16 ± 0 mg/mL, respectively. On the other hand, ethanolic extracts of *A. flagellaris* roots and *S. venosum* tubers were active only against *S. agalactiae*, with MIC values of 4 ± 0 and 2 ± 0 mg/mL, respectively (Table 3.3).

Table 3.3: MIC values of 80% ethanolic extracts (mg/mL) of studied medicinal plants and ciprofloxacin (µg/mL) against gram-positive bacterial strains

Plant species and controls	**Bacterial strains**			
	S. aureus	*S. epidermidis*	*S. agalactiae*	*E. faecalis*
A. flagellaris (root)	> 16	> 16	4 ± 0	> 16
B. antidysenterica (fruit)	4 ± 0	> 16	8 ± 0	16 ± 0
C. trigyna (seed, inflorescence)	16 ± 0	> 16	16 ± 0	8 ± 0
C. rueppellii (root)	4 ± 0	> 16	4 ± 0	> 16
G. involucrata (root)	3 ± 1	> 16	2 ± 0	> 16
G. involucrata (stem)	3 ± 1	16 ± 0	2 ± 0	16 ± 0
P. steudneri (pseudobulb)	8 ± 0	8 ± 0	3 ± 1	16 ± 0
S. venosum (tuber)	> 16	> 16	2 ± 0	> 16
Ciprofloxacin	0.63	0.63	0.63	1.25
Tween 80	–	–	–	–

Values are means ± standard deviation of triplicate examinations

3.3.1.3. Coordinates of study plants and bacterial strains based on MIC values

The results of principal component analysis (PCA) revealed that the ethanolic extract of *P. steudneri* pseudobulb was the most effective antibacterial, closest to the positive reference (ciprofloxacin). The extracts of *A. flagellaris* root and *S. venosum* tuber were the least effective antibacterials among the studied medicinal plant species. The results of PCA also showed that *S. agalactiae* was the most susceptible bacterial strain, illustrated with the longest arrow, while *P. mirabilis* was found to be the least susceptible (Figure 3.1).

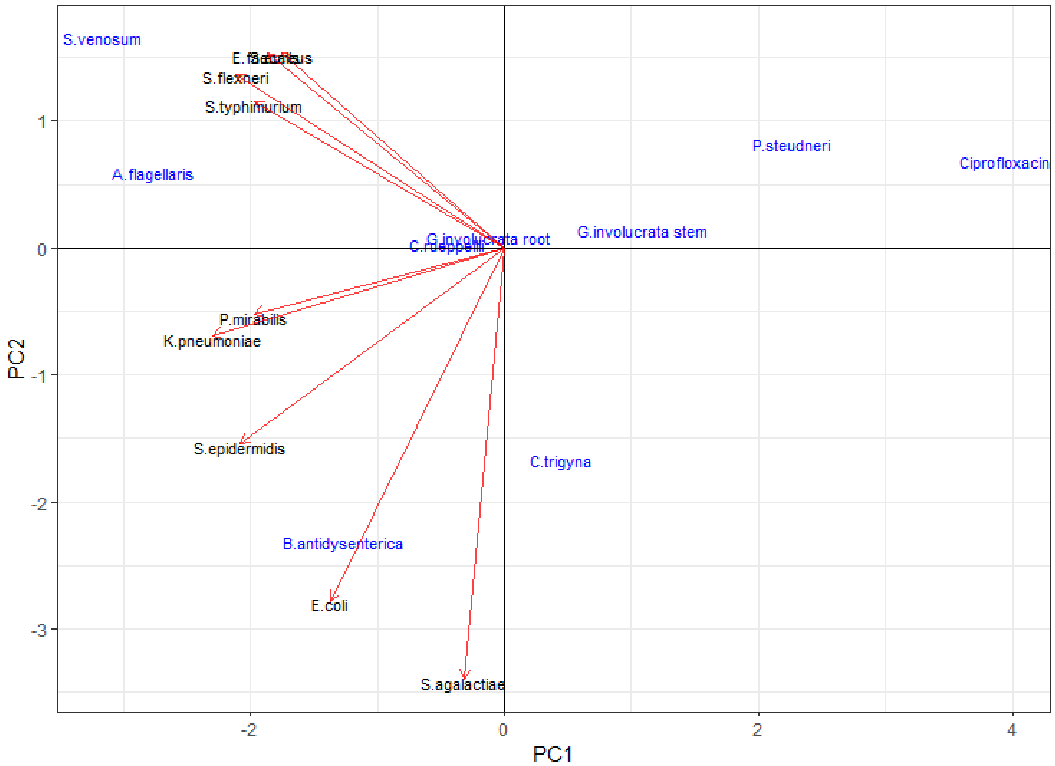

Figure 3.1. The PCA illustrating the positions of medicinal samples based on their MIC values against the tested bacterial strains.

3.3.2. Antioxidant activity of the study plants

3.3.2.1. DPPH free radical scavenging ability

The deep purple color of the DPPH solution changed to colorless when it was mixed with plant extracts having antioxidant properties and ascorbic acid (positive reference). In contrast, the purple color was retained when the DPPH solution was mixed with extracts of plants with less antioxidant activity and the negative control. In this perspective, following the ascorbic acid, ethanolic extracts of *G. involucrata* stems and roots exhibited the highest DPPH free radical scavenging activity, while extracts of *C. rueppellii* roots showed the lowest (Figure 3.2).

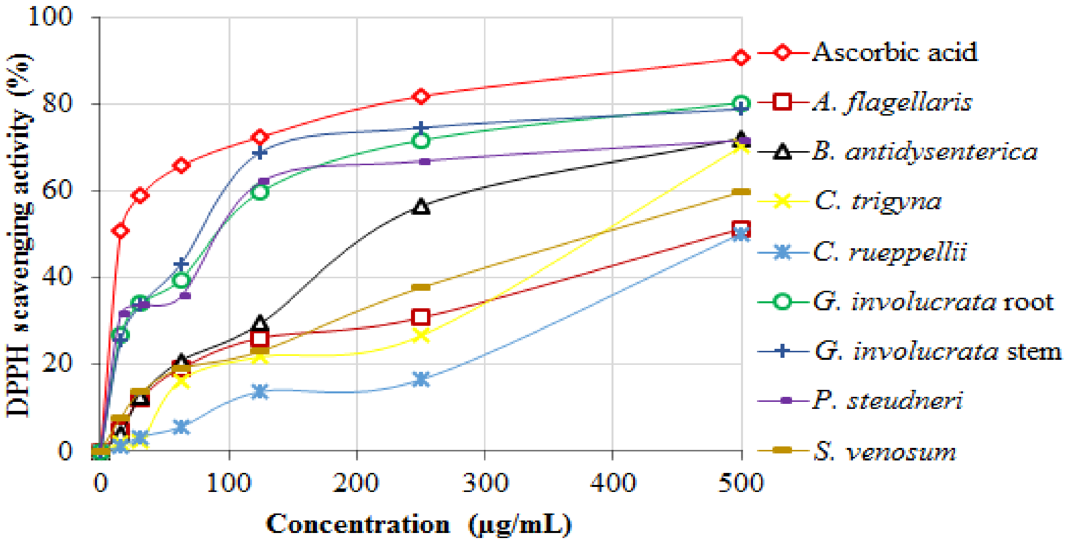

Figure 3.2. Percentage of DPPH free radical scavenging activity.

3.3.2.2. The 50% inhibitory concentration (IC_{50})

Relative to the positive reference (IC_{50} = 53.76 µg/mL), ethanolic extracts of *G. involucrata* stems showed IC_{50} value of 168.68 µg/mL, followed by extracts of *G. involucrata* roots (IC_{50} = 181.79 µg/mL). Ethanolic extracts of the remaining plants, such as *P. steudneri*, *B. antidysenterica*, *C. trigyna*, *S. venosum*, *A. flagellaris*, and *C. rueppellii*, exhibited IC_{50} values of 203.11, 293.56, 366.15, 387.82, 459.55, and 527.57 µg/mL, respectively (Figure 3.3).

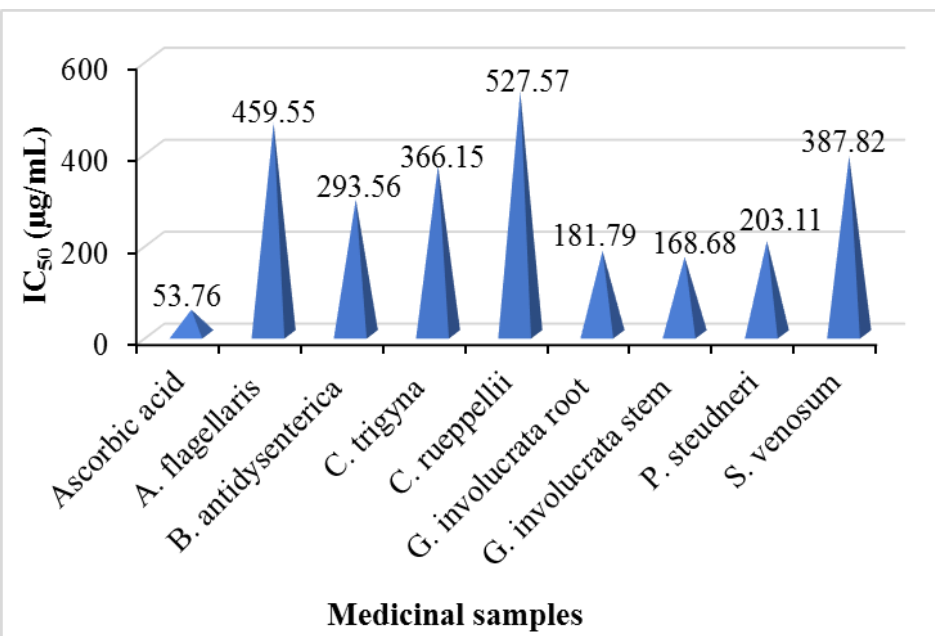

Figure 3.3. 50% inhibition concentration (IC_{50}) of the medicinal samples.

3.3.3. Phytochemical screening of medicinal plants

Qualitative phytochemical screening was carried out to determine the presence or absence of alkaloids, anthocyanins, anthraquinones, cardiac glycosides, coumarins, flavonoids, phenols, saponins, steroids, tannins, and terpenoids in the ethanolic extracts of the studied medicinal plants, and a summary of the findings is presented in Table 3.4. Accordingly, root extracts of *A. flagellaris* were confirmed to have all the tested compounds apart from anthraquinones and steroids. Extracts of *B. antidysenterica* fruits contained all tested phytoconstituents except anthocyanins, anthraquinones, cardiac glycosides, and saponins. Except for anthraquinones, all the tested phytochemicals were detected in extracts of *C. trigyna* inflorescence with seeds. The root extracts of *C. rueppellii* were observed to contain alkaloids, cardiac glycosides, coumarins, and terpenoids. Extracts of *G. involucrata* roots and stems contained almost similar phytochemicals (anthocyanins, anthraquinones, cardiac glycosides, flavonoids, phenols, tannins, and terpenoids) except for the presence of saponins in roots but not in stems, and the reverse was true for steroids. The tested phytochemicals were observed in the extracts of *P. steudneri* pseudobulbs, except for alkaloids, saponins, and terpenoids. Tubers of *S. venosum* contained the tested constituents except anthocyanins, anthraquinones, saponins, and terpenoids.

Table 3.4: Preliminary phytochemical screening of the selected medicinal plants

	Medicinal plant extracts							
Phytochemicals	*A. flagellaris* (root)	*B. antidysenterica* (fruit)	*C. trigyna* (seed, inflorescence)	*C. rueppellii* (root)	*G. involucrata* (root)	*G. involucrata* (stem)	*P. steudneri* (pseudobulb)	*S. venosum* (tuber)
Alkaloids	+	+	+	+	–	–	–	+
Anthocyanins	+	–	+	–	+	+	+	–
Anthraquinones	–	–	–	–	+	+	+	–
Cardiac glycosides	+	–	+	+	+	+	+	+
Coumarins	+	+	+	+	–	–	+	+
Flavonoids	+	+	+	–	+	+	+	+
Phenols	+	+	+	–	+	+	+	+
Saponins	+	–	+	–	+	–	–	–
Steroids	–	+	+	–	–	+	+	+
Tannins	+	+	+	–	+	+	+	+
Terpenoids	+	+	+	+	+	+	–	–

(+), present; (–), absent

3.4. Discussion

In the ethnomedicinal perspective, leaves and stems of *A. flagellaris* were reported to be used against gonorrhea and syphilis in Nigeria (Odeja et al., 2021), its fruits for eye diseases, and its roots for measles in Uganda (Masters, 2023). Leaves of *B. antidysenterica* were used to treat wounds in Zuway Dugda district (Megersa et al., 2023) and diarrhea surrounding the Gullele Botanic Garden in central Ethiopia (Woldeamanuel et al., 2022). Whole parts of *Celosia trigyna* were reported to heal arthritis, diarrhea, and dysentery in Kafa Zone (Gosa & Wana, 2022), and seeds were used to treat tapeworm in Libo Kemkem district, northwest Ethiopia (Chekole et al., 2015). Leaves and roots of *Crepis rueppellii* were used to cure dysentery by residents on the Dek Island of Lake Tana, northwest Ethiopia (Teklehaymanot, 2009). Roots of *Gnidia involucrata* were reported to treat gonorrhea and ascaris in the Bule Hora district of southern Ethiopia (Eshete et al., 2016). The tubers of *S. venosum* were traditionally used to treat ascaris (Teklehaymanot, 2009) and hemorrhoids (Giday et al., 2007) in northwest Ethiopia. Hence, the literature supports the ethnomedicinal data in the present study and the effectiveness of the study plants against several infectious diseases, except for *P. steudneri*, which has not been studied yet.

In the current study, it was observed that the minimum inhibitory concentrations (MIC) of the investigated medicinal plants were dependent on the types of bacterial strains. The investigated medicinal plants exhibited various MIC values against different gram-negative and gram-positive bacterial strains. Similar to the current findings, previous studies reported *P. mirabilis* as an antimicrobial-resistant bacterial strain (Liu et al., 2023; Tumbarello et al., 2012). In line with the present study, other previous studies also reported the antimicrobial resistance of *S. epidermidis* among gram-positive bacteria (Chabi & Momtaz, 2019; Eladli et al., 2019). This indicates the multiple antibiotic resistance of both *P. mirabilis* and *S. epidermidis*.

An earlier study conducted by Taye et al. (2011) reported that the methanolic extracts of *B. antidysenterica* root showed a MIC value of 15.63 mg/mL against *S. aureus*, while the ethanolic extracts of its fruits inhibited the same bacterial strain at a MIC value of 4.00 mg/mL in the present study. Here, variation in the antibacterial activity of *B. antidysenterica* might be due to differences in the extraction solvents used or the bioactivity of the tested plant parts. A similar study conducted by Kalbessa et al. (2019) reported the highest efficacy of the ethyl acetate extracts of *G. involucrata* root bark against *S. aureus* compared to the other bacterial strains. However, the current findings revealed the most sensitive bacteria, *S. agalactiae*, to the ethanolic extracts of *G. involucrata* roots than *S. aureus*. On the other hand, the study conducted by Zakerifar et al. (2023) showed that *S. agalactiae* was reported to be resistant to certain antibiotics like erythromycin, levofloxacin, ofloxacin, quinupristin, and tetracycline and susceptible to chloramphenicol, gentamicin, linezolid, penicillin, and vancomycin. In this respect, there are variations in the antibacterial efficacy of medicinal plants and differences in the degree of susceptibility of bacterial strains. Thus, MIC values varied among the extracts of different medicinal plants in the present study. This might be linked to the difference in the biologically active phytochemicals they contain (Guadie et al., 2020). Besides, MIC values differed among different bacterial strains owing to their variation in antibiotic resistance.

The study conducted by Odeja et al. (2021) showed that the leaf essential oil of *A. flagellaris* had high antioxidant activity, with 90.74% inhibition of DPPH free radicals at a concentration of 500 µg/mL. In the present findings, however, the ethanolic extracts of its root exhibited 51.28% inhibition at the same concentration. In this case, the variation in the antioxidant activity of *A. flagellaris* might be because of the extraction methods employed or the excess of phytoconstituents in leaves rather than roots. Other study conducted by Kalbessa et al. (2019) indicated that ethyl acetate extracts of *G. involucrata* root bark and its isolated compound exhibited 70.70 and 85.80% inhibition at concentrations of 100 µg/mL, respectively. This is slightly comparable with the current findings, in which the ethanolic extracts of *G. involucrata* stem showed 68.91% inhibition at 125 µg/mL. This confirms the antioxidant potential of different parts of *G. involucrata* to reduce risks related to free radicals.

The antibacterial and antioxidant activities of medicinal plants depend on their phytochemical constituents. This is due to the fact that the phytochemical constituents of the medicinal plants are associated with their antioxidant and antibacterial activities (El Hachlafi et al., 2023; Mapfumari et al., 2022). Medicinal plants contain mainly phenolic antioxidants like ß-carotene, flavonoids, phenolic acids, terpenes, tocopherols, vitamin C, and so on (Škrovánková et al., 2012). Antioxidant phenolic compounds scavenge free radicals and prevent oxidation of cellular components either by donating hydrogen atoms to free radicals to form stable, harmless compounds (Alu'datt et al., 2018) or by inhibiting enzymes responsible for the production of reactive oxygen species (Atta et al., 2023). Thus, they take part in the prevention or treatment of oxidative stress-related diseases, for example, atherosclerosis, biliary diseases, cancer, dementia, diabetes, hypertension, kidney disease, macular degeneration, neurodegenerative diseases, and obesity (Liguori et al., 2018).

The phytochemical screening of ethanolic extracts showed that the selected medicinal plants contain important phytochemicals, which could play crucial roles in their bioactivities. Phytochemical constituents, mainly bioactive secondary metabolites, play significant roles in the bioactivities of medicinal plants by eliciting a definite and specific action on the human body (Agidew, 2022). The current results showed the presence of steroids in the ethanolic extracts of *B. antidysenterica* fruits, *C. trigyna* inflorescence with seeds, *G. involucrata* stems, *P. steudneri* pseudobulbs, and *S. venosum* tubers. Steroids are used to treat rheumatism, asthma, allergies, skin infections, and inflammations (Mlozi, 2022) and to relieve inflammation and swelling in cancer patients (Agidew, 2022; Mlozi, 2022). Cardioactive steroids, for example, cardenolides, improve heart function, although they are highly toxic and received at a therapeutic dose of 60% of the lethal dose (Nagorny & Cichowicz, 2016). Results of phytochemical screening revealed the presence of alkaloids in the extracts of *A. flagellaris*, *B. antidysenterica*, *C. trigyna*, *C. rueppellii*, and *S. venosum*. Isoquinoline alkaloids are found in higher plants and are known to have antispasmodic, antiviral, antifungal, anticancer, antioxidant, and enzyme inhibitory activities (Dey et al., 2020). Besides, diterpenoid alkaloids are potent to treat various cancers as new drugs (Shen et al., 2020).

Flavonoids, tannins, and phenols were identified from the ethanolic extracts of all investigated medicinal plants except that of *C. rueppellii*. Flavonoids have antioxidant, anti-inflammatory, and antimicrobial activities; hence, they attribute to the medicinal properties of different medicinal plants (Mlozi, 2022). For instance, plants like *Zingiber*, *Curcuma*, and *Acorus* were reported as sources of antibacterial and antiseptic agents owing to their flavonoid content (Sharma et al., 2020). Tannins were described as healing agents for inflammation, hemorrhoids, and gonorrhea (Agidew, 2022) and were known to have anticancer (Sharma et al., 2020) and antidiabetic (Bouyahya et al., 2021) effects. Polyphenolic compounds have been beneficial as antioxidants, anti-inflammatory, and antibacterial agents and reduce blood pressure and heart disease (Sharma et al., 2020). Out of the examined plants, saponins were found in extracts of *A. flagellaris* roots, *C. trigyna* inflorescence with seeds, and *G. involucrata* roots. Saponins were stated to treat different human diseases, such as skin infections, liver diseases, trauma, chronic venous insufficiency, and kidney diseases (Bailly & Vergoten, 2020).

The tested medicinal plants were positive for cardiac glycosides, except for *B. antidysenterica*. In agreement with the current findings, the studies conducted by Liu et al. (2019) and Ravi et al. (2020) reported the existence of cardiac glycosides in many medicinal plants. Cardiac glycosides have beneficial effects for the heart (Sharma et al., 2020) in that they treat congestive heart failure and cardiac arrhythmia by inhibiting the Na^+/K^+ pump and increasing the level of calcium ions (Ca^+), which enhances the contraction of heart muscles and reduces swelling (Iqbal et al., 2015). Terpenoids were detected in ethanolic extracts of *A. flagellaris* roots, *B. antidysenterica* fruits, *C. trigyna* inflorescence with seeds, *C. rueppellii* roots, and *G. involucrata* roots and stems. Medicinally, they provide significant actions such as antiviral, antibacterial, antimalarial, anti-inflammatory, anticancer, and inhibition of cholesterol synthesis (Agidew, 2022). Coumarins are among the essential phytochemical compounds found in medicinal plants (Agidew, 2022). In this regard, results from the current study indicated the presence of coumarins in ethanolic extracts of the investigated medicinal plants, except in the roots and stems of *G. involucrata*. Medicinally, coumarins were appreciated to treat microbial infections, cancers, tuberculosis, inflammatory diseases, malaria, and AIDS-acquired immunodeficiency syndrome (Patil, 2022).

The qualitative phytochemical screening revealed that anthraquinones were identified from ethanolic extracts of *G. involucrata* roots and stems and *P. steudneri* pseudobulbs. The plant-derived natural anthraquinones were reported to have antiviral potential against different infectious viruses (Ntemafack et al., 2022). Results also showed that the examined medicinal plants, such as *A. flagellaris, C. trigyna, G. involucrata, and P. steudneri,* were positive for the anthocyanins test. Plant-based anthocyanins have antioxidant properties that play important roles in health and therapeutic effects (Netravati et al., 2022). Furthermore, the presence of phytochemicals such as alkaloids, flavonoids, glycosides, phenolic compounds, saponins, tannins, and triterpenoids promotes the anthelmintic properties of medicinal plants (Kancherla et al., 2019).

In the present study, a comparative investigation was carried out between the extracts of *G. involucrata* roots and stems, though local people traditionally use its roots. The extract of *G. involucrata* stems showed even higher antibacterial activity, antioxidant capacity, and phytochemical contents than the root extract. This might be due to the distribution of secondary metabolites from the areas of synthesis (leaves) to the areas of sink (roots and stems) *via* phloem tissue. Hence, results from the current study suggest the use of *G. involucrata* stems instead of its roots since root harvesting is usually destructive for the sustainable use of medicinal plants.

3.5. Conclusions

Ethanolic extracts of the investigated medicinal plants were active against different gram-negative and gram-positive bacterial strains at various concentrations. Additionally, the ethanolic extracts exhibited considerable antioxidant activity compared to ascorbic acid. The qualitative phytochemical screening revealed the presence of important bioactive compounds in the tested medicinal plants. Hence, the findings from this study support the traditional medicinal use of the investigated plants. The study was restricted to their 80% ethanolic extracts. Thus, further investigations using different solvents of various polarities will be required to extract lead compounds for the development of appropriate drugs. Besides, toxicity studies will be necessary to encourage their further use. Especially, *G. involucrata* and *P. steudneri* should be prioritized for further studies since they were substantial in antibacterial activity and antioxidant potential among the examined plants.

CHAPTER FOUR

Paper III

4. Ethnobotanical Study of Wild Edible Plants in Dibatie District, Metekel Zone, Benishangul Gumuz Regional State, Western Ethiopia

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Abstract

Background: Plants deliver livelihood and food for millions of people in the world. Indeed, wild edible plants support rural communities in developing countries to overcome seasonal unfavorable conditions. In rural areas of Ethiopia, wild edible plants play an indispensable role in fighting food insecurity as emergency or supplementary foods. Hence, this research was aimed at studying the ethnobotany of wild edible plants in Dibatie district, Metekel zone, western Ethiopia.
Methods: Ethnobotanical data was collected using a semi-structured interview, field observation, focus group discussions, a market survey, and the ranking of selected plants. Besides, voucher specimens were collected and stored at the National Herbarium of Ethiopia. Descriptive statistics, preference ranking, direct matrix ranking, and familiarity index were computed for data analysis.
Results: This study has documented 54 wild edible plant species belonging to 33 plant families and 46 genera. Of these, most (38.90%) had tree growth habits. Wild edible plants bear mostly fruits (72.20%) as edible parts. Local people usually consume these plants freshly raw as complementary foods, though some wild edibles require processing. They were mostly harvested in the January (31.48%) and May (27.78%) months, with the least collected in September (7.41%). Most wild edible plants (78.57%) were available in uncontrolled habitats, while others (21.43%)

grow in farmlands, home gardens, and as live fences. Out of the recorded plants, about 98% had additional uses besides their nutritional values.
Conclusion: Wild edible plants assist the livelihoods of the local people in food security, agriculture, energy sources, construction, medicines, ecological services, aesthetics, income generation, and household utensils. Nevertheless, wild edible plants are recently threatened due to various anthropogenic factors in the study area. Thus, they need wise use and *in-situ* and *ex-situ* conservation measures from all the concerned bodies for sustainable use in the future.

Keywords: Dibatie district, Ethnobotany, Food security, Indigenous knowledge, Wild edible plants

4.1. Background

Plants supply livelihood and food in the form of non-timber forest products (NTFPs) for about 300 million people worldwide (Bharucha & Pretty, 2010). These NTFPs are used as food and medicine, especially in tropical and low-income countries (Sardeshpande & Shackleton, 2019). For instance, in areas of poverty and malnutrition, forests serve as the source of edible wild mammals, birds, reptiles, insects, wild spinaches, wild mushrooms, and wild fruits that supplement domestic diets (McGarry & Shackleton, 2009). Predominantly wild edible plants are crucial for human diet, especially in poor rural communities during periods of food scarcity (Łuczaj & Szymański, 2007).

Wild edible plants contribute a lot to households in rural Africa by decreasing their sensitivity to environmental changes and coping with less favorable conditions (Shumsky et al., 2014). Because they mitigate malnutrition of micro- and macronutrients in addition to their role in enhancing food security (Getachew et al., 2013). Since some wild edible plants (WEPs) are rich in essential nutrients, they can be used to generate dietetic diversity and avoid overdependence on limited food resources (Duguma, 2020; Lulekal et al., 2011). Besides, they play an important role in income generation for certain local residents (Tahir et al., 2023a). Numerous wild edible plants are believed to have positive effects on human health owing to their medicinal functions (Durst & Bayasgalanbat, 2014). These plants are called ‘nutraceutical plants’ since they provide both nutritional and pharmaceutical benefits (Wondimu et al., 2006).

In Ethiopia, WEPs are very helpful to combat food insecurity during periods of hardship (e.g., war, drought, low crop production, etc.) as emergency or supplementary foods (Lulekal et al., 2011). Malnutrition and food insecurity are still among the major humanitarian crises in some parts of the country (Hassen, 2021). Some rural people rely on wild edible plant resources for dietary supplementation and income generation during famine periods (Tahir et al., 2023a). However, the diversity of WEPs is gradually decreasing with the associated indigenous knowledge due to various factors such as agricultural expansion, overgrazing, misuse, and less attention to the preservation of indigenous knowledge (Ashagre et al., 2016; Kidane & Kejela, 2021; Tebkew et al., 2018). Besides, WEPs are underestimated among different indigenous people, as they are considered foods of the poor in some communities of the country (Duguma, 2020; Gebru et al., 2019; Getachew et al., 2013; Guzo et al., 2023), and the associated knowledge is transmitted by oral means (Tahir et al., 2023a). They are much more marginalized to document and conserve due to the changes in food habits and lifestyles (Feyssa, 2012) and the emphasis many researchers placed on cultivated cereal, oil, and industrial crops in the current Ethiopia (Dandena, 2010). As a result, WEPs need safeguarding attention from researchers, governmental and non-governmental administrators, policymakers, local communities, community leaders, religious leaders, and other stakeholders, along with the associated indigenous knowledge.

Although some studies (Abera & Belay, 2022; Alemneh, 2020; Dejene et al., 2020; Giday & Teklehaymanot, 2023; Guzo et al., 2023; Hankiso et al., 2023; Hassen, 2021; Kidane & Kejela, 2021; Masresha et al., 2023; Tahir et al., 2023a; Yiblet & Adamu, 2023) have attempted to document WEPs in different regions of Ethiopia, there is still a need for documentation and investigation of new research concerning WEPs due to their nutritional, medicinal, economic, ecological, and other uses, as well as the incidence of threats currently facing them. The study area, Dibatie district in Metekel zone, is rich in ethnic and plants diversity (Awas et al., 2010). Different ethnic groups in the area consume WEPs as dietary supplements, famine resilience, and confectionery foods in addition to their other uses. However, the literature indicates that these crucial wild food plants in the present study area are not documented along with the associated indigenous knowledge up-to-date. Therefore, this study was aimed at investigating the ethnobotany of wild edible plants in Dibatie district, Metekel zone, Benishangul Gumuz Regional State, western Ethiopia.

4.2. Materials and methods

4.2.1. Study area

The study was conducted in Dibatie district, Metekel zone, Benishangul Gumuz Regional State in western Ethiopia (Figure 4.1). Dibatie district is among the seven administrative districts in Metekel zone. It is located about 550 km north-west of Addis Ababa, which is the capital city of the country. The district contains a total of 30 kebeles (the smallest administrative units in Ethiopia), of which 25 are rural kebeles and 5 are town. The current study was carried out in 11 kebeles, which are Dibatie_02, Parzeyit, Lega-buna, Berber, Jan, Donben, Gipho, Tuski-gambela, Galessa, Qorqa, and Sombo-sire kebeles (Figure 4.1). The district is inhabited by Agaw, Amhara, Gumuz, Oromo, and Shinasha ethnic groups. Out of these, however, Gumuz ethnic groups have not participated in this study due to a long-lasting ethnic conflict that erupts in the area during data collection.

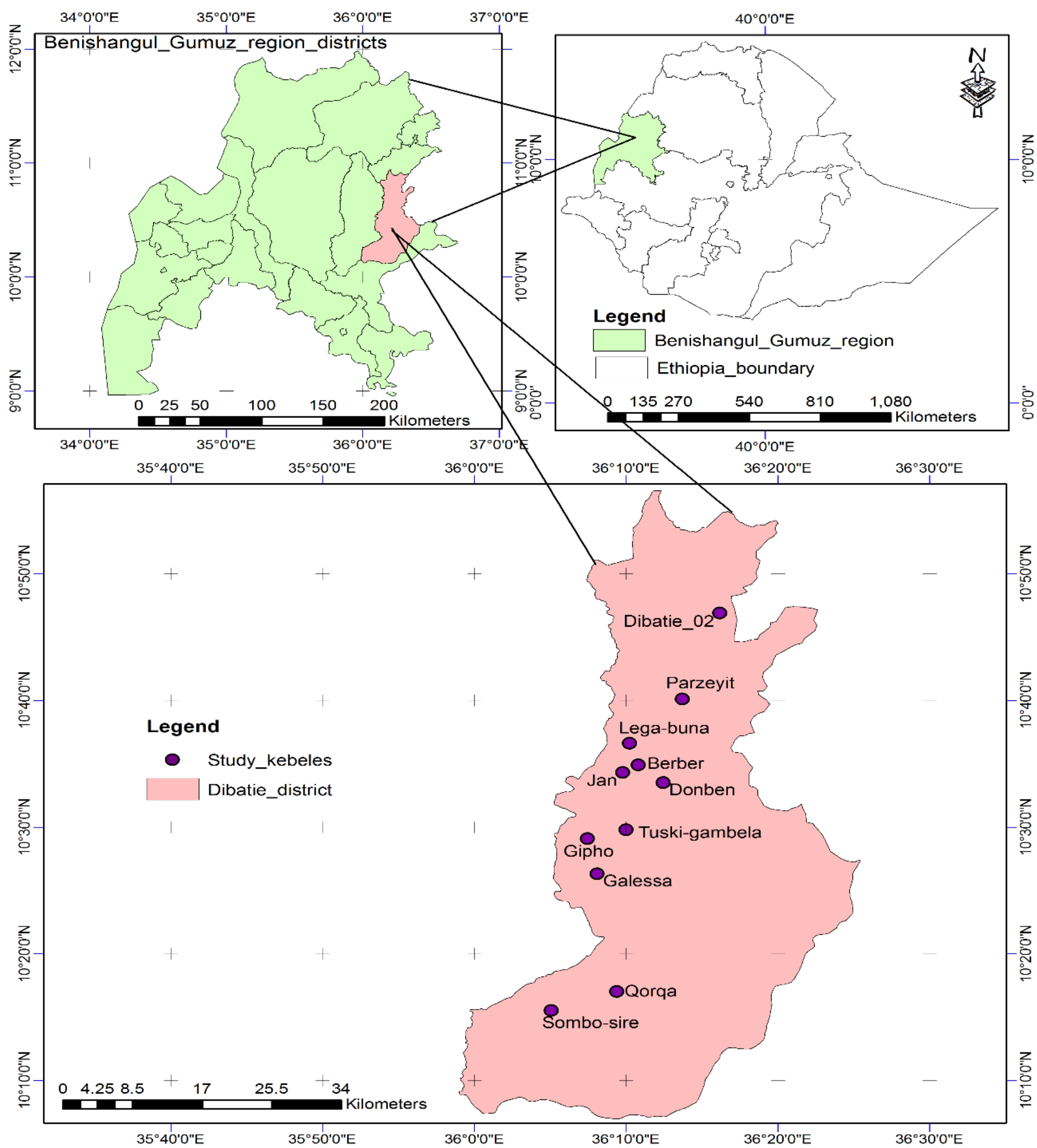

Figure 4.1. Map of Ethiopia showing Benishangul Gumuz Regional State and the study district (details of the study sites are also presented in Table 4.1).

The study area is found in the elevation range of 1475-2370 meters above sea level. It has a mono-modal rainfall pattern, which occurs usually from May to October, with maximum rainfall appearing in July and August. The average annual rainfall in the area is 1211 mm, and the mean annual minimum temperature is 9.3 °C in the highlands, while the mean maximum temperature is found to be 29.3 °C in the lowland areas (Figure 4.2). Agro-ecologically, the study area includes lowland (Qola), mid-highland (Weyina-Dega), and highland (Dega) agro-climatic zones.

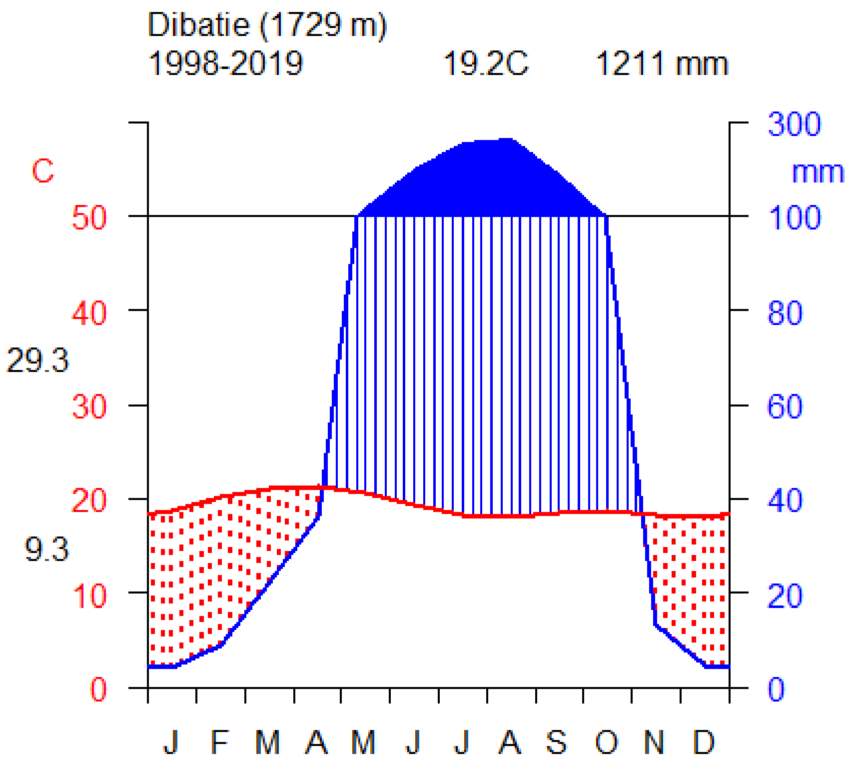

Figure 4.2. Climadiagram showing mean annual temperature and rainfall from 1998-2019.

Data source: National Meteorological Services Agency, 2022

The livelihood of the local community is mainly dependent on rain-fed cereal-based mixed agricultural systems (Nigussie et al., 2018). Hence, the local people practice traditional lifestyles, including the cultivation of staple food crops (e.g., maize, finger millet, sorghum, teff, lablab, vegetables, cherry pepper, pumpkin, and beans), fruits (e.g., mango, papaya, and banana), oil crops (e.g., groundnut, linseed, niger seed, sesame, castor, and sunflower), and the husbandry of livestock such as cattle, donkeys, sheep, and goats (Awas et al., 2010; Giday et al., 2007). Additionally, some (especially Gumuz people) practice ancient activities, i.e., hunter-gatherer and inactive agricultural lifestyles (Awas et al., 2010).

4.2.2. Sampling methods and socio-demographic characteristics of informants

The study sites (kebeles) were selected purposefully based on the geographic variations, native ethnic group composition, security of the area, and road access to the study site. Accordingly, 11 kebeles with 9879 total households were selected as representative study sites. Out of these householders, a total of 374 informants were selected as representative respondents using the formula developed by Cochran's (1977) at a 95% confidence level (Cochran, 1977). The representative informants include 220 randomly selected general householders and 154 purposively selected key informants, such as community elders, administrative leaders, and religious leaders. Accordingly, 34 informants were interviewed from each kebele.

In perspective of their socio-demographic feature, 274 male and 100 female informants participated in the interview. Out of the total of 374 informants, Agaw, Amhara, Oromo, and Shinasha ethnic groups were represented by 10, 64, 158, and 142 respondents, respectively. These ethnic groups were found differently within the study sites (kebeles) and participated in the data collection accordingly. The informants speak Amharic, Agawgna, Afaan oromoo, and Shinashigna languages, in which a particular individual can speak more than one language. Regarding their religion, informants follow Islam (45, 12.03%), Orthodox (163, 43.58%), and Protestant (166, 44.39%) religion types. Informants in the age group greater than 18 years old participated in the interview. Accordingly, respondents of age categories 18-40 years (109, 29.14%), 41-60 years (167, 44.65%), 61-80 years (87, 23.26%), and above 80 years (11, 2.94%) were interviewed. Most (319, 85.29%) informants were farmers, some (28, 7.49%) were civil servants, some others (23, 6.15%) were merchants, and a few (4, 1.07%) were laborers. The details of the socio-demographic profiles of interviewees are presented in Table 4.1.

Table 4.1: Sampled administrative kebeles with their position, elevation, number of householders, and socio-demographic profiles of interviewed informants

Kebele (Sub district)	Latitude	Longitude	Altitude (m asl)	NH	Socio-demographic characteristics of informants: General informants M	General informants F	Key informants M	Key informants F	Eth (Ag, Am, Or, Sh)	Lan (Ac, Agn, Ao, Shi)	Rel (Is, Ort, Pr)	Age (18-40, 41-60, 61-80, >80 years)	Occ (Cs, Fa, La, Me)
Berber	$10^0$34'54"N	$36^0$10'48"E	1599	1261	13	7	11	3	Am, Or, Sh	Ac, Ao, Shi	Is, Ort, Pr	10 (18-40) , 16 (41-60), 8 (61-80)	Cs, Fa, Me
Dibatie_02	$10^0$46' 53"N	$36^0$16'10"E	1503	937	14	6	9	5	Ag, Am, Or, Sh	Ac, Agn, Ao, Shi	Is, Ort, Pr	9 (18-40) , 18 (41-60), 7 (61-80)	Cs, Fa, La, Me
Donben	$10^0$33'30"N	$36^0$12'27"E	1597	1091	14	6	10	4	Ag, Am, Or, Sh	Ac, Agn, Ao, Shi	Is, Ort, Pr	11 (18-40) , 15 (41-60), 7 (61-80), 1 (>80)	Cs, Fa
Galessa	$10^0$26'18"N	$36^0$08'05"E	1627	1687	13	7	9	5	Am, Or	Ac, Ao, Shi	Is, Ort, Pr	11 (18-40) , 19 (41-60), 4 (61-80)	Cs, Fa, Me
Gipho	$10^0$29'05"N	$36^0$07'27"E	1678	864	15	5	11	3	Am, Or, Sh	Ac, Ao, Shi	Ort, Pr	8 (18-40) , 19 (41-60), 4 (61-80), 3 (>80)	Cs, Fa, Me
Jan	$10^0$34'18"N	$36^0$09'47"E	1601	485	14	6	11	3	Am, Sh	Ac, Ao, Shi	Is, Ort, Pr	12 (18-40) , 12 (41-60), 8(61-80), 2 (>80)	Fa, Me
Lega-buna	$10^0$36'36"N	$36^0$10'14"E	1535	489	16	4	12	2	Am, Sh	Ac, Ao, Shi	Is, Ort, Pr	9 (18-40) , 15 (41-60), 9(61-80), 1 (>80)	Cs, Fa
Parzeyit	$10^0$40'06"N	$36^0$13'42"E	1567	809	15	5	12	2	Am, Sh	Ac, Ao, Shi	Is, Ort	11 (18-40) , 14 (41-60), 7 (61-80), 2 (>80)	Cs, Fa, Me
Qorqa	$10^0$17'01"N	$36^0$09'23"E	1704	1154	11	9	10	4	Or, Sh	Ac, Ao, Shi	Ort, Pr	11 (18-40) , 12 (41-60), 11 (61-80)	Cs, Fa, Me
Sombo-sire	$10^0$15'31"N	$36^0$05'04"E	2079	483	14	6	11	3	Or, Sh	Ac, Ao, Shi	Ort, Pr	10 (18-40) , 13 (41-60), 11 (61-80)	Cs, Fa
Tuski-gambela	$10^0$29'47"N	$36^0$10'00"E	1560	619	17	3	12	2	Or, Sh	Ac, Ao, Shi	Ort, Pr	7 (18-40) , 14 (41-60), 11 (61-80), 2 (>80)	Cs, Fa
Total				9879	156	64	118	36					

NH Number of householder; *M* Male; *F* Female; Ethnicity (Eth), *Ag* Agaw, *Am* Amhara, *Or* Oromo, *Sh* Shinasha; Language (Lan), *Ac* Amharic, *Agn* Agawgna, *Ao* Afaan oromoo, *Shi* Shinashigna; Religion (Rel), *Is* Islam, *Ort* Orthodox, *Pr* Protestant; Occupation (Occ), *Cs* Civil servant, *Fa* Farmer, *La* Laborer, *Me* Merchant

4.2.3. Data collection

The ethnobotanical information was collected by using a semi-structured interview, field observation, market survey, and ranking of selected plants based on their roles to fight famine and multiple uses (Martin, 1995). In addition, a focus group discussion was conducted in each kebele with the community elders, cattle herders, and school boys, as described in Addis et al. (2013).

The interview was carried out in Afaan oromoo, Agawgna, Amharic, and Shinashigna languages, with the help of translators, while the researchers were not able to understand the native languages of participants. The interviews focused on the edible parts, harvesting time, occasions and modes of consumption, adverse effects, and additional uses of wild edible plants (Appendix 5). Additionally, it included the local name of plants, marketability, threats to, and management methods of wild edible plants in the study area. The field survey was conducted through guided field observation, focus group discussions, and the collection of voucher specimens for identification. One group discussion, with five to ten participants, was conducted in each kebele with the key informants. The discussion emphasized the traditional uses, preferences, and conservation practices of common WEPs in their locality. Later, the identification of voucher specimens was carried out at the National Herbarium of Addis Ababa University (ETH). The identified botanical names were confirmed by taxonomic experts at ETH and then cross-checked for taxonomic updates by referring to the website Plants of the World Online (POWO).

4.2.4. Data Analysis

The collected ethnobotanical data were analyzed through descriptive statistics (percentage and frequency distribution). Preference ranking and direct matrix ranking were applied to assess the degree of preference of selected wild edible plants (Martin, 1995). The familiarity index (Fi) was calculated to indicate the relative popularity of wild edible plants within the community (Tabuti et al., 2004) using the formula: $\mathrm{Fi} = \frac{\text{Number of times a given species was mentioned as food}}{\text{Total number of respondents}} \times 100$. Microsoft Excel version 2013 and R-statistical packages (climatol, ggplot2, scales, and dplyr) were used for data analysis.

4.3. Results and discussion

4.3.1. Taxonomic diversity of wild edible plants

The study has documented 54 wild edible plant species belonging to 33 plant families and 46 genera. The family Rubiaceae was represented by 5 plant species (9.26%), followed by the Malvaceae, Moraceae, Myrtaceae, and Solanaceae families, each containing 3 edible plant species (5.56%). All the other families were denoted by two or less wild edible plant species. The genus *Ficus* had relatively the highest number (3 wild edible plant species), followed by *Dioscorea*, *Grewia, Rumex*, *Searsia*, *Solanum*, and *Syzygium*, each of which contains 2 species, while each of the remaining genera was represented by a single species (Table 4.2).

In this study, the family Rubiaceae was represented by the highest number of wild edible plant species, unlike that reported by other studies conducted in Ethiopia (Abera & Belay, 2022; Ashagre et al., 2016; Dejene et al., 2020; Tahir et al., 2023a). Moreover, the number of WEPs recorded in the study area was higher compared to the number of wild edible plant species documented by other studies (Abera & Belay, 2022; Ashagre et al., 2016; Tahir et al., 2023a; Tebkew et al., 2018) in various parts of Ethiopia. The higher number of WEPs in the study area indicates the diversity of wild edible plant resources and the dependence of the local people for consumption (Guzo et al., 2023). The relatively higher diversity of WEPs in the specific area also implies a strong interaction between the plants and the local communities (Kebebew & Leta, 2016). In addition, the number of preserved WEPs depends on the proximity of the area to city and the lifestyles of the residents (Sina & Degu, 2015).

Compared to the previous ethnobotanical studies in Ethiopia, the studies conducted in Midakegn district, central Ethiopia (Guzo et al., 2023), Soro district, southern Ethiopia (Hankiso et al., 2023), and Bullen district, northwest Ethiopia (Berihun & Molla, 2017) reported the most overlaps of WEPs (18 species each) recorded in the present study. In addition, the study conducted by Dejene et al. (2020) in lowland areas of Ethiopia reported high (16 species) overlaps of WEPs with the current study, followed by Hassen (2021) in North Wollo, northeastern Ethiopia (12 species), Abera & Belay (2022) in Sedie Muja district, northwest Ethiopia (12 species), Asfaw et al. (2023) in Ensaro district, central Ethiopia (12 species), Tebkew et al. (2018) in Quara district, northwest Ethiopia (11 species), Kidane & Kejela (2021) in Berek district, central Ethiopia (11 species), and Alemneh (2020) in Yilmana Densa and Quarit districts, northwest Ethiopia (11 species). Whereas, other ethnobotanical studies showed less than 11 overlapping wild edible plant species (Table 4.2). The similarity in the distribution of WEPs along with their traditional use might be due to the geographical similarity and the cultural sharing between local communities inhabiting different areas (Tahir et al., 2023a). However, some WEPs could be used differently in various parts of the country. For instance, the seed powder of *Amaranthus caudatus* L. was eaten being prepared into porridge in the present study area and in Burji district, southern Ethiopia (Ashagre et al., 2016), and reported to be consumed as a leafy vegetable in Soro district (Hankiso et al., 2023) and in Derashe and Kucha districts of southern Ethiopia (Balemie & Kebebew, 2006).

Out of the 54 recorded WEPs in the study area, 4 species, such as *Keetia zanzibarica* (Klotzsch) Bridson, *Lippia abyssinica* (Otto & A.Dietr.) Cufod., *Physalis lagascae* Roem. & Schult., and *Psychotria orophila* E.M.A.Petit were not reported in previous studies conducted in different parts of Ethiopia, as well as in the list of 413 WEPs reviewed by Lulekal et al. (2011). On the other hand, some WEPs, such as *Carissa spinarum* L., *Cordia africana* Lam., *Ficus sur* Forssk., and *Ximenia americana* L., were highly reported by previous studies and widely consumed in many areas of the country.

Table 4.2: List of WEPs including their local names, families, growth habits, edible parts, modes of consumption, additional uses and habitats

Scientific name	Local name (La)	Family	GH	EP	MoC	AU	Ha	Citation in Ethiopia	VN
Amaranthus caudatus L.	Ambartifo (AO)	Amaranthaceae	H	S	Po	Bf	Fl,Ho	(Ashagre et al., 2016; Balemie & Kebebew, 2006; Hankiso et al., 2023)	BA-194
Ampelocissus schimperiana (Hochst. ex A. Rich.) Planch.	Laalu (AO)	Vitaceae	C	F,Ys	Fr	Fo	Rv	(Lulekal et al., 2011)	BA-164
Annona senegalensis Pers.	Bamburxaa (AO)	Annonaceae	T	F	Fr	Fw,Bf	Ow,Gl	(Kidane et al., 2014; Lulekal et al., 2011)	BA-132
Borassus aethiopum Mart.	Guchii (AO)	Arecaceae	T	F,Ys	Fr,Ck	Fo,O	Ho,Sa	(Assefa & Abebe, 2011; Berihun & Molla, 2017; Dejene et al., 2020; Teklehaymanot & Giday, 2010)	BA-47
Bridelia scleroneura Müll.Arg.	Bacancuwa (AO)	Phyllanthaceae	T	F	Fr	Fw	Ow,Rv	(Addis et al., 2013; Ashagre et al., 2016; Berihun & Molla, 2017)	BA-186
Canarina abyssinica Engl.*	Xuuxo-rooba (AO)	Campanulaceae	C	N	Fr	M	Rv	(Regassa et al., 2015)	BA-203
Capparis tomentosa Lam.*	Gimero (Am)	Capparidaceae	Sh	F	Fr	M	Rv	(Bahru et al., 2013; Tebkew et al., 2018)	BA-9
Carissa spinarum L.*	Agamssa (AO)	Apocynaceae	Sh	F	Fr	Fe,Bf,M,Fw	Ow,Rv,Gl	(Abera & Belay, 2022; Asfaw et al., 2023; Giday & Teklehaymanot, 2023; Guzo et al., 2023; Hankiso et al., 2023; Hassen, 2021; Kidane & Kejela, 2021; Masresha et al., 2023; Tahir et al., 2023a; Teklehaymanot, 2017; Yiblet & Adamu, 2023)	BA-28
Corchorus olitorius L.	-	Malvaceae	H	L,Ys	Ck	Bf,Fo	Fl,Sa	(Addis et al., 2013; Balemie & Kebebew, 2006; Berihun & Molla, 2017; Dandena, 2010; Kidane et al., 2015; Masresha et al., 2023; Tebkew et al., 2014, 2018; Teklehaymanot & Giday, 2010)	BA-198
Cordia africana Lam.*	Wanza (Am)	Boraginaceae	T	F	Fr,Dr	Ti,Fo,Fw,Bf,M,U	Fl,Ho	(Abera & Belay, 2022; Alemneh, 2020; Asfaw et al., 2023; Dejene et al., 2020; Giday & Teklehaymanot, 2023; Guzo et al., 2023; Hankiso	BA-142

								et al., 2023; Hassen, 2021; Kidane & Kejela, 2021; Masresha et al., 2023; Tahir et al., 2023a)	
Dioscorea praehensilis Benth.*	Eecaa (AO)	Dioscoreaceae	C	Tu	Bo,R	M	Ow,Rv	(Balemie & Kebebew, 2006; Mosissa, 2018; Teklu & Abduljabar, 2019; Yimer et al., 2023a)	BA-3
Dioscorea schimperiana Hochst. ex Kunth	Barodaa (AO)	Dioscoreaceae	C	Tu	Bo,R	-	Rv	(Ayele & Negasa, 2017; Hankiso et al., 2023; Lulekal et al., 2011)	BA-75
Diospyros abyssinica (Hiern) F. White	Ciinciroo (AO)	Ebenaceae	T	F	Fr	Fw,Fo	Rv,Fm	(Kebebew & Leta, 2016; Masresha et al., 2023; Tebkew et al., 2014, 2018)	BA-103
Embelia schimperi Vatke*	Hanquu (AO)	Primulaceae	Sh	F	Fr	M,Bm	Rv	(Abera & Belay, 2022; Alemayehu et al., 2015b; Alemneh, 2020; Asfaw et al., 2023; Guzo et al., 2023; Hankiso et al., 2023; Regassa et al., 2015; Tahir et al., 2023a; Teklu & Abduljabar, 2019; Yimer et al., 2021)	BA-118
Ensete ventricosum (Welw.) Cheesman	Baala-warqee (AO)	Musaceae	H	F	Fr	U	Ho,Sa	(Alemneh, 2020; Berihun & Molla, 2017; Fentahun & Hager, 2009; Kidane & Kejela, 2021)	BA-79
Eugenia bukobensis Engl.	Dhala-badda (AO)	Myrtaceae	T	F	Fr	Fe	Rv	(Yimer et al., 2021)	BA-88
Ficus sur Forssk.*	Fuka (Shi)	Moraceae	T	F	Fr,Dr	Fo,U,M,Sf,Ch,Co	Rv,Gl	(Abera & Belay, 2022; Alemneh, 2020; Asfaw et al., 2023; Dejene et al., 2020; Gebru et al., 2019; Giday & Teklehaymanot, 2023; Guzo et al., 2023; Hankiso et al., 2023; Hassen, 2021; Kidane et al., 2018b; Kidane & Kejela, 2021; Masresha et al., 2023; Tebkew et al., 2018; Yiblet & Adamu, 2023)	BA-155
Ficus sycomorus L.*	Odaa (AO)	Moraceae	T	F	Fr,Dr	Fo,U,M,Sd,Bt,Ch,Sf	Ow,Fl,Gl	(Abera & Belay, 2022; Asfaw et al., 2023; Dejene et al., 2020; Gebru et al., 2019; Guzo et al., 2023; Hankiso et al., 2023; Hassen, 2021; Kidane & Kejela, 2021; Tebkew et al., 2018; Yiblet & Adamu, 2023)	BA-33
Ficus vasta Forssk.	Qilxuu (AO)	Moraceae	T	F	Fr,Dr	Sd,U	Rv,Fm,Sa	(Abera & Belay, 2022; Alemneh, 2020; Asfaw et al., 2023; Berihun & Molla, 2017; Dejene et al., 2020; Gebru et al., 2019; Giday &	BA-144

								Teklehaymanot, 2023; Guzo et al., 2023; Hankiso et al., 2023; Yiblet & Adamu, 2023)	
Flacourtia indica (Burm.f.) Merr.	Akukku (AO)	Salicaceae	Sh	F	Dr	U	Ow	(Assefa & Abebe, 2011; Emire et al., 2022; Guzo et al., 2023; Hankiso et al., 2023; Kidane et al., 2014; Tahir et al., 2023a)	BA-173
Flueggea virosa (Roxb. ex Willd.) Royle*	Baskaya (Shi)	Phyllanthaceae	Sh	F	Fr	M,Fo	Ow,Gl	(Ashagre et al., 2016; Dejene et al., 2020; Fentahun & Hager, 2009; Kebebew & Leta, 2016; Masresha et al., 2023; Tebkew et al., 2014; Teklehaymanot & Giday, 2010)	BA-13
Gardenia ternifolia Schumach. & Thonn.*	Gambelloo (AO)	Rubiaceae	T	F	Fr	Fo,Fw,U,M	Ow,Gl	(Addis et al., 2013; Berihun & Molla, 2017; Dejene et al., 2020; Emire et al., 2022; Guzo et al., 2023; Tebkew et al., 2018)	BA-31
Grewia ferruginea Hochst. ex A. Rich.	Dhoqunu gurracha (AO)	Malvaceae	Sh	F	Fr	U	Rv,Fm	(Abera & Belay, 2022; Dejene et al., 2020; Guzo et al., 2023; Hassen, 2021; Kidane & Kejela, 2021; Masresha et al., 2023; Tahir et al., 2023a)	BA-102
Grewia mollis Juss.*	Qoriya (Shi)	Malvaceae	T	B,F	Fr,Ck	Bf,M,U,Lu,Ts	Ow,Rv	(Addis et al., 2013; Berihun & Molla, 2017; Giday & Teklehaymanot, 2023; Kebebew & Leta, 2016; Tebkew et al., 2018; Wondimu et al., 2006)	BA-35
Justicia schimperiana (Hochst. ex Nees) T. Anderson.*	Simiza (Am)	Acanthaceae	Sh	N	Fr	M,Fe,Bf	Lf,Sa	(Berihun & Molla, 2017; Lulekal et al., 2011; Regassa et al., 2015)	BA-159
Keetia zanzibarica (Klotzsch) Bridson	Shumbura boyye (AO)	Rubiaceae	Sh	F	Fr	Fw	RV,Fm	Not reported	BA-109
Lantana camara L.	Kusayee (Ao)	Verbenaceae	Sh	F	Fr	Fe,O	Lf,Sa	(Bahru et al., 2013; Fentahun & Hager, 2009; Hassen, 2021; Kebebew & Leta, 2016)	BA-162
Lippia abyssinica (Otto & A.Dietr.) Cufod.	Kusayee durbaa (AO)	Verbenaceae	Sh	F	Fr	Bf	Fm	Not reported	BA-171
Mimusops kummel Bruce ex A.DC.	Qolaxii (AO)	Sapotaceae	T	F	Fr	Fw,Bf,U,Fo	Rv	(Abera & Belay, 2022; Alemneh, 2020; Asfaw et al., 2023; Dejene et al., 2020; Emire et al., 2022; Girmay et al., 2022; Guzo et al., 2023; Hankiso et al., 2023; Hassen, 2021; Tahir et al., 2023a; Yiblet & Adamu, 2023)	BA-89

Momordica foetida Schumach.*	Qorii-arragessa (AO)	Cucurbitaceae	C	F,L,Ys	Fr,R	M,Fo	Lf,Sa	(Asfaw et al., 2023; Berihun & Molla, 2017; Emire et al., 2022; Hankiso et al., 2023; Regassa et al., 2015; Tebkew et al., 2018; Yimer et al., 2021)	BA-72
Mussaenda arcuata Poir.	Futfutii (AO)	Rubiaceae	C	F	Fr	Fw	Rv	(Kidane et al., 2014; Lulekal et al., 2011; Yimer et al., 2021)	BA-131
Nauclea latifolia Sm.*	Kurumba (Shi)	Rubiaceae	T	F	Fr	M	Ow,Gl	(Dejene et al., 2020)	BA-119
Oxytenanthera abyssinica (A.Rich.) Munro	Shimel (Am)	Poaceae	Cu	Ys	Ck	Co,Fe,Fo,U,Bm	Ho,Rv	(Berihun & Molla, 2017; Guyu & Muluneh, 2015; Lulekal et al., 2011)	BA-154
Phoenix reclinata Jacq.*	Mexxi (AO)	Arecaceae	T	F,Th	Fr,Ck	U,Fo,M,Tb	Rv	(Abera & Belay, 2022; Dejene et al., 2020; Guzo et al., 2023; Hankiso et al., 2023; Kidane & Kejela, 2021; Tebkew et al., 2018; Yiblet & Adamu, 2023)	BA-26
Physalis lagascae Roem. & Schult.	Awut (Am)	Solanaceae	H	F	Fr	Bf	Fl,Ho	Not reported	BA-16
Piliostigma thonningii (Schumach.) Milne-Redh.	Lillu (AO)	Fabaceae	T	F	Dr	Bf,Fo,Fw	Ow,Fl,Gl	(Addis et al., 2013; Assefa & Abebe, 2011; Berihun & Molla, 2017; Fentahun & Hager, 2009; Hailemariam et al., 2021; Hankiso et al., 2023; Tebkew et al., 2018)	BA-32
Psychotria orophila E.M.A.Petit	Bururii (AO)	Rubiaceae	Sh	F	Fr	Fe	Rv,Fm	Not reported	BA-86
Rubus apetalus Poir.	Goraa (AO)	Rosaceae	Sh	F	Fr	Fe	Rv,Fm	(Alemneh, 2020; Guzo et al., 2023; Hankiso et al., 2023; Kidane et al., 2014; Kidane & Kejela, 2021; Regassa et al., 2015)	BA-97
Rumex abyssinicus Jacq.*	Dhangaggo (AO)	Polygonaceae	H	Tu	Sp	M	Sa	(Abera & Belay, 2022; Alemneh, 2020; Asfaw et al., 2023; Giday & Teklehaymanot, 2023; Hankiso et al., 2023; Hassen, 2021; Yiblet & Adamu, 2023; Yimer et al., 2021)	BA-135
Rumex nervosus Vahl*	Embacho (Am)	Polygonaceae	Sh	Ys	Fr	M	Ho,Sa	(Abera & Belay, 2022; Adamu et al., 2022; Alemneh, 2020; Giday & Teklehaymanot, 2023; Guzo et al., 2023; Hankiso et al., 2023; Hassen, 2021; Kidane & Kejela, 2021)	BA-24
Saba comorensis (Bojer ex A.DC.) Pichon	Wenno (AO)	Apocynaceae	C	F	Fr	Bm,U,Co,Bf	Rv	(Berihun & Molla, 2017; Dejene et al., 2020; Kidane et al., 2014; Masresha et al., 2023;	BA-17

								Tebkew et al., 2018; Teklehaymanot & Giday, 2010)	
Searsia glutinosa (Hochst. ex A.Rich.) Moffett	Xaaxessaa (AO)	Anacardiaceae	Sh	F	Fr,Dr	Fe,Fw	Rv	(Alemneh, 2020; Giday & Teklehaymanot, 2023; Guzo et al., 2023; Kebebew & Leta, 2016; Kidane & Kejela, 2021; Tebkew et al., 2014)	BA-188
Searsia ruspolii (Engl.) Moffett	Xaaxessaa (AO)	Anacardiaceae	Sh	F	Fr,Dr	Fo,Fw,Fe	Ow,Gl	(Addis et al., 2013; Berihun & Molla, 2017; Kidane et al., 2014)	BA-48
Senna petersiana (Bolle) Lock*	Sarar-qamale (AO)	Fabaceae	Sh	F	Fr,Dr	M	Ow,Fm	(Yimer et al., 2021)	BA-80
Solanum lycopersicum L.	Qumadoro xiqqo (AO)	Solanaceae	H	F	Fr,Ck	Bf	Ho,Sa	(Ocho et al., 2012)	BA-176
Solanum villosum Mill.*	Huncha (Shi)	Solanaceae	H	F,L,Ys	Fr,R	M	Fl,Ho	(Asfaw et al., 2023; Ashagre et al., 2016; Hankiso et al., 2023)	BA-153
Strychnos innocua Delile	Amburqaa (AO)	Loganiaceae	T	F	Fr	Fw,Fo	Ow,Rv	(Asfaw et al., 2023; Berihun & Molla, 2017; Dejene et al., 2020; Fentahun & Hager, 2009; Kidane et al., 2014)	BA-157
Syzygium guineense (Wild.) DC. subsp. *guineense*	Baddessaa (AO)	Myrtaceae	T	F	Fr	Fw,Co,Bf,Sd,Cm,Ch	Rv	(Addis et al., 2013; Ashagre et al., 2016; Berihun & Molla, 2017; Guzo et al., 2023)	BA-66
Syzygium guineense (Wild.) DC. subsp. *macrocarpum* (Engl.) F.White	Goosu (AO)	Myrtaceae	T	F	Fr	Ch,Fw,Bf	Ow,Fl,Gl	(Berihun & Molla, 2017; Guzo et al., 2023)	BA-7
Uvaria angolensis Welw. ex Oliv.	Geergisoo (AO)	Annonaceae	Sh	F	Fr	Bm	Rv,Fm	(Lulekal et al., 2011)	BA-110
Vepris nobilis (Delile) Mziray	Hadheessa (AO)	Rutaceae	T	F	Fr	Fe,Fw	Rv	(Guzo et al., 2023; Regassa et al., 2015)	BA-106
Vitex doniana Sweet	Ququraa (AO)	Lamiaceae	T	F	Fr,Dr	Ch,Sd,Co,Fo,Bf,Bt	Ow,Fl,Gl	(Berihun & Molla, 2017; Dejene et al., 2020; Hassen, 2021; Kidane et al., 2014; Yimer et al., 2021)	BA-29
Ximenia americana L.*	Hudhaa (AO)	Olacaceae	Sh	F	Fr	Fw,M,Cm	Ow,Rv	(Abera & Belay, 2022; Alemneh, 2020; Asfaw et al., 2023; Dejene et al., 2020; Giday & Teklehaymanot, 2023; Girmay et al., 2022; Guzo et al., 2023; Hankiso et al., 2023; Hassen, 2021; Kidane & Kejela, 2021; Yimer et al., 2021)	BA-49

Ziziphus abyssinica Hochst. ex A. Rich.*	Unguga (Shi)	Rhamnaceae	T	F	Dr	M,Fo,U	Ow,Gl	(Addis et al., 2013; Berihun & Molla, 2017; Dejene et al., 2020; Hassen, 2021; Kebebew & Leta, 2016; Tahir et al., 2023a; Tebkew et al., 2014)	BA-12

Language (La), *AO* Afaan Oromoo, *Am* Amharic, *Shi* Shinashigna; Growth habit (GH), *C* Climber, *Cu* Culm, *H* Herb, *Sh* Shrub, *T* Tree; Edible parts (EP), *B* Bark, *F* Fruit, *N* Nectar, *S* Seed, *Th* Trunk heart, *Tu* Tuber, *L* leaf, *Ys* Young *shoot*; Mode of consumption (MoC), *Bo* Boiled, *Ck* Cooked, *Dr* Dry raw, *Fr* Fresh raw, *Po* Porridge, *R* Roasted, *Sp* Spice; Additional uses (AU), *Bf* Bee forrage, *Bt* Beehive tree, *Bm* Beehive materials, *Ch* Charcoal, *Cm* Cleaning materials, *Co* Construction, *Fe* Fence, *Fo* Fodder, *Fw* Fuel wood, *Lu* Lubricant, *M* Medicine, *O* Ornamental, *Sd* Shade, *Sf* Soil fertilizer, *Ti* Timber, *Ts* Traditional soap, *Tb* tooth brush, *U* Utensils; Habitats (Ha), *Fl* Farmland, *Fm* Forest margin, *Gl* Grazing land, *Ho* Home garden, *Lf* live fences, *Ow* Open woodland, *Rv* Riparian vegetation, *Sa* Settlement areas; Nutraceutical plants (*); Voucher number (VN); BA-XY/XYZ [2–3 digital number; BA, Baressa Anbessa; XY, two digital number; XYZ, three digital number]

4.3.2. Growth forms of wild edible plants

Wild edible plants in the study area exhibit different growth forms. Out of the reported WEPs, 38.90% were trees, followed by shrubs (33.30%), climbers (13.00%), herbs (13.00%), and culms (1.90%) (Figure 4.3). In the current study, wild edible trees were dominant, in line with the studies conducted by Kidane & Kejela (2021) in Berek district, central Ethiopia, (Masresha et al., 2023), in Metema district, northwestern Ethiopia, and (Hankiso et al., 2023), in Soro district, southern Ethiopia. However, studies conducted in Mieso district, eastern Ethiopia (Tahir et al., 2023a), Burji district, southern Ethiopia (Ashagre et al., 2016) and Sedie Muja district, northwestern Ethiopia (Abera & Belay, 2022) reported the dominance of shrubs, and the study by Alemneh (2020) in Yilmana Densa and Quarit districts, northwest Ethiopia, stated the dominance of herbs. The similarity or variation in growth habits of WEPs might be owing to their distribution in similar or different climatic conditions, topographies, and altitudes (Abera & Belay, 2022; Tahir et al., 2023a).

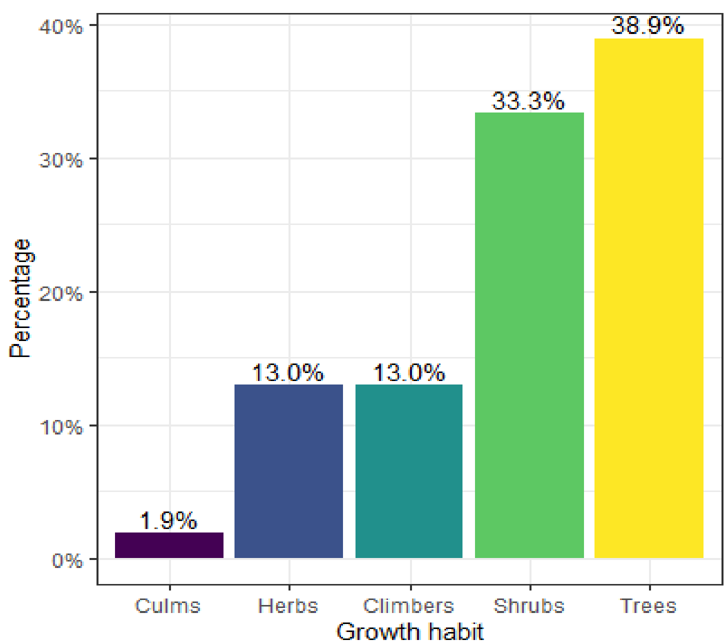

Figure 4.3. Growth habits of wild edible plants in the Dibatie district.

4.3.3. Edible parts of wild edible plants in the area

Wild edible plants in the study area have various edible parts, mostly fruits (72.20%), followed by multiple edible parts (13.00%), tubers (5.60%), nectar (3.70%), young shoots (3.70%), and seeds (1.90%) (Figure 4.4). Multiple edible parts are those in which two or more parts of a single species are eaten. For instance, the bark and fruits of *Grewia mollis*, the trunk heart and fruits of *Phoenix reclinata*, and the leaves, young shoots, and fruits of *Solanum villosum* Mill. were consumed by different ethnic groups at the same or different times in the area (Table 4.2).

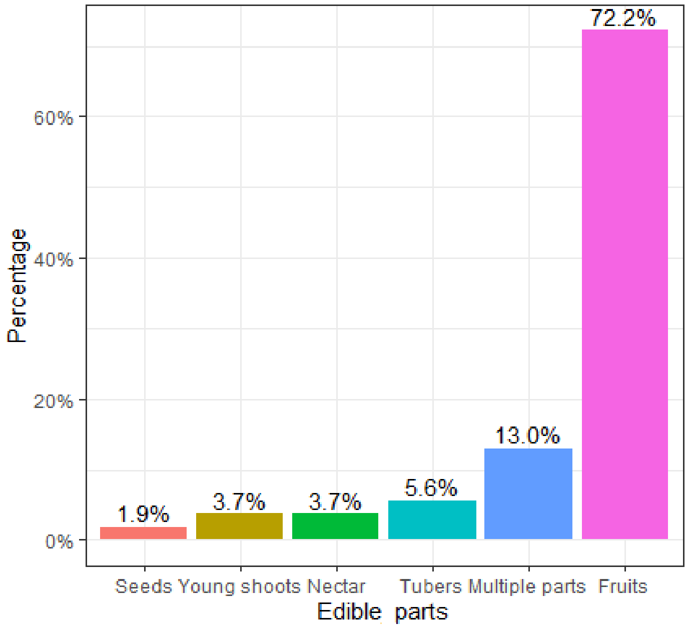

Figure 4.4. Edible parts of wild edible plants in the Dibatie district.

Fruits were the predominantly eaten wild edible plant parts (72.20%) in the study area, similar to the dominance of fruit edibility mentioned in the reports of other studies (Ashagre et al., 2016; Tahir et al., 2023a; Tebkew et al., 2018; Yiblet & Adamu, 2023) across the country. This might be due to the ease of consuming fruits raw, without processing, by livestock herders, travelers, and schoolchildren. Moreover, the consumption of multiple edible parts of a single plant (13.00%) was reported in the current study, consistent with the previous findings reported by (Lulekal et al., 2011). Such plants have a potent effect on food security in that they provide alternative edible parts at different periods of the year for society (Masresha et al., 2023). In the study area, for example, young leaves and shoots of *Momordica foetida* Schumach. were eaten roasted, usually by Gumuz ethnic groups and sometimes by Oromo and Shinasha communities, and its ripe fruits were eaten uniformly by all ethnic groups in the area. Previous studies (Asfaw et al., 2023; Emire et al., 2022; Hankiso et al., 2023; Regassa et al., 2015; Tebkew et al., 2018) conducted in other parts of the country also confirmed the consumption of *M. foetida* fruits in different communities. However, its boiled tuber is consumed as a root vegetable by the Meinit community living in Bench-Maji zone, southwest Ethiopia (Yimer et al., 2021). This indicates the potency of *M. foetida,* which needs to be promoted and developed as a leafy and root vegetable as well as a fruit-bearing plant at the national level throughout the country. On the other hand, the current study and other studies (Alemneh, 2020; Berihun & Molla, 2017; Fentahun & Hager, 2009) conducted in northwest Ethiopia reported *Ensete ventricosum* (Welw.) Cheesman as a wild edible plant in which its ripe fruits were edible rather than its stem. Besides, other studies conducted in north-central (Kidane & Kejela, 2021) and west-central (Regassa et al., 2015) Ethiopia have reported *E. ventricosum* as an underutilized wild edible plant with edible fruit and stem. In the southern parts of Ethiopia, however, it is cultivated and taken as a staple or co-staple food crop, and its processed stem is regularly consumed by about 25 million people throughout the year (Dilebo et al., 2023). It is also reported that *E. ventricosum* is rich in dietary starch and fiber content and less susceptible to short-term climate changes (Borrell et al., 2019). Therefore, the habits of its management and utilization practices in the southern parts of Ethiopia needs to be expanded to other parts of the country in order to enhance its role in food security.

In the present study, the bark mucilage of *G. mollis* was prepared into the edible souse with spices such as *Allium sativum, Capsicum annuum, Foeniculum vulgare, Zingiber officinale,* and salt and eaten with porridge or local bread (Injera), mainly by Gumuz and Shinasha ethnic groups and rarely by others. Small-scale farmers consume the souse of its bark mucilage as a substitute for homemade stew during normal times and during short-term food scarcity. The bark mucilage consumption of *G. mollis* was previously reported only by the studies conducted in Bullen district, northwest Ethiopia (Berihun & Molla, 2017) and in the Amaro Special District of southern Ethiopia (Kebebew & Leta, 2016), while the fruit edibility was highly reported by other studies (Addis et al., 2013; Giday & Teklehaymanot, 2023; Tebkew et al., 2018; Wondimu et al., 2006) in the country. In other African countries, a ripe fruit is edible in Uganda (Masters, 2021), a bark mucilage is used as an additives in local cake preparation, and a bark powder is used to improve the texture of foods in Nigeria (Sambo et al., 2015). This shows the vital attributes of *G. mollis* in traditional food preparations and fighting against food insecurity in Ethiopia as well as in Africa.

4.3.4. Harvesting periods of wild edible plants

Harvesting periods indicate the seasonal availability of wild edible plants in the area. The majority of WEPs in the area were harvested in January (31.48%), May (27.78%), February (25.93%), December (25.93%), April (24.07%), March (20.37%), June (20.37%), July (20.37%), August

(20.37%), and November (20.37%), and rarely collected in October (9.26%) and September (7.41%). Certain wild edible plants (11.11%) are still eaten throughout the year (Figure 4.5). For example, tubers of *Dioscorea* spp. (*D. praehensilis* Benth. and *D. schimperiana* Hochst. ex Kunth), the trunk heart of *P. reclinata*, the bark of *G. mollis*, and the young shoots of *Borassus aethiopum* Mart. were consumed year-round.

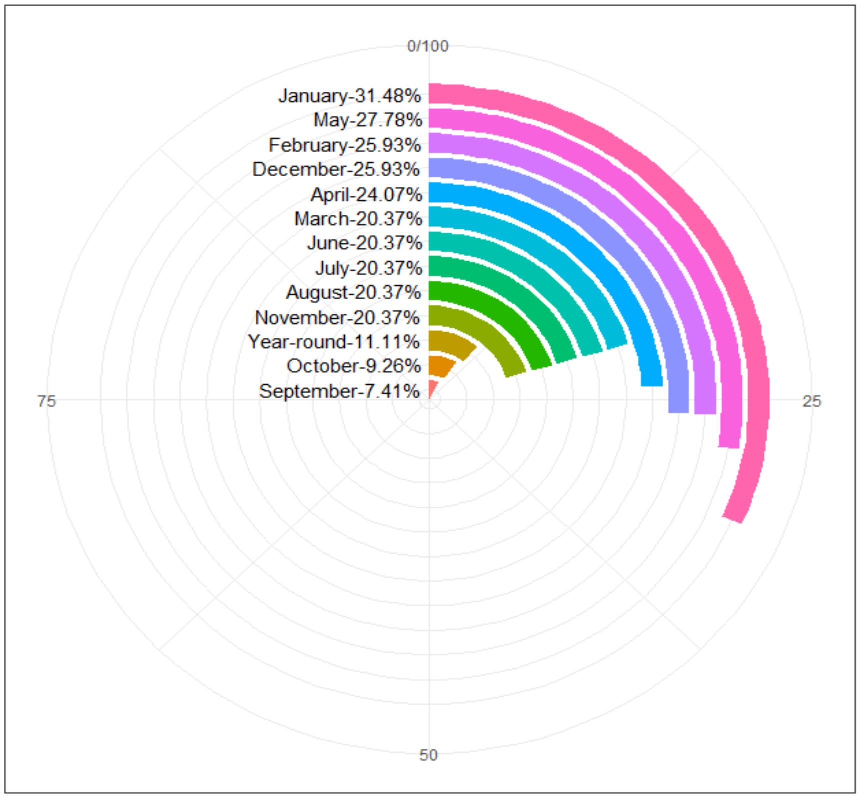

Figure 4.5. Harvesting periods of wild edible plants in the Dibatie district.

This finding revealed that WEPs were mainly collected in the months of January, May, February, and December and relatively rare in September and October. Contrary to the current study, the study conducted by Giday & Teklehaymanot (2023) in Raya-Azebo district, northern Ethiopia, described September and October as the main harvesting months for wild edible plants. In another study (Tahir et al., 2023a), March, April, and May months were reported as the major harvesting periods in Mieso district, eastern Ethiopia. February and March were also reported by Gebru et al. (2019) as the major collecting months for wild edible plants. Thus, the seasonal availability of WEPs might vary slightly from region to region in Ethiopia, and this could be due to variations in the agro-ecological and climatic conditions (Balemie & Kebebew, 2006; Dejene et al., 2020; Hassen, 2021; Sina & Degu, 2015) and dissimilarity in plant species (Fentahun & Hager, 2009).

Herbaceous edible vegetables are usually available during the rainy season and sometimes in irrigated areas during the dry season (Balemie & Kebebew, 2006). Whereas shrubby and tree edible fruit species are harvested mainly during the dry season (Kidane et al., 2014).

Similar to the present finding, the study conducted by Tahir et al. (2023a) has stated some WEPs that were collected throughout the year. These year-round harvested plants may have a huge contribution to reduce food insecurity due to their availability during all seasons of the year (Feyssa et al., 2011b; Tebkew et al., 2018). Indeed, the above-described examples of year-round WEPs in the present study area were reported to be consumed mainly during seasonal food shortages and to relieve hunger during normal times. Therefore, they have the ability to combat famine and food insecurity in the current study area and throughout the country.

4.3.5. Mode of consumption

The local communities in the study area are endowed with indigenous knowledge of how to use wild edible plants. Usually, they consumed wild edible fruits and vegetables freshly raw without any processing (31 species, 57.41%). Local people sometimes ate wild edible plants in a fresh, raw, or dry state (8 species, 14.81%). Besides, some wild plants were eaten fresh raw or cooked (4 species, 7.41%), dry raw (3 species, 5.56%), boiled or roasted (2 species, 3.70%), cooked (2 species, 3.70%), fresh raw or roasted (2 species, 3.70%), and in porridge (1 species, 1.85%) and spice (1 species, 1.85%) forms (Table 4.3).

Table 4.3: Mode of consuming wild edible plants in the area

Mode of consumption	No. of wild edible plants	Percent (%)
Fresh raw	31	57.41
Fresh/dry raw	8	14.81
Fresh raw/cooked	4	7.41
Dry raw	3	5.56
Boiled/roasted	2	3.70
Cooked	2	3.70
Fresh raw/roasted	2	3.70
Porridge	1	1.85
Spice	1	1.85

Wild edible plants were usually consumed freshly or dry as emergency or supplementary foods by livestock herders, travelers, schoolchildren, and fuel wood collectors. Likewise, outdoor consumption of unprocessed WEPs was reported in different parts of the country in agricultural fields, during cattle herding, travelling, and firewood collection (Addis et al., 2013; Ashagre et al., 2016; Guzo et al., 2023). However, some plants require different preparation techniques to be consumed at home or at work. Especially green leafy vegetables and tubers need to be boiled, roasted, or cooked before consumption. It is perceived that cooking is essential to reduce the level of anti-nutritional factors such as phytates, tannins, and oxalates in green vegetables and tubers (Aragaw et al., 2021). Besides, seeds of *Amaranthus caudatus* were reported to be powdered with cultivated cereals (e.g., *Eleusine coracana* (L.) Gaertn., *Eragrostis tef* (Zucc.), etc.) and eaten as porridge during the shortage of staple food. This result is consistent with the study conducted by Ashagre et al. (2016) in Burji district, southern Ethiopia, indicating the similarity in indigenous knowledge of the local people living about thousand kilometers away from each other. On the other hand, tubers of *Rumex abyssinicus* Jacq. were processed as spice with other plants like *Allium sativum*, *Coriandrum sativum*, *Foeniculum vulgare,* and *Zingiber officinale* even during normal periods. Informants confirmed that it gives a yellowish color to the spice used in food stew. Similarly, the study conducted by Asfaw et al. (2023) in Ensaro district, north-central Ethiopia, reported the use of powdered tuber as a spice in cooking food. Other studies conducted in North Wollo (Hassen, 2021) and Raya-Azebo district (Giday & Teklehaymanot, 2023), northern Ethiopia, reported the use of *R. abyssinicus* tuber as tea spice, and other studies conducted in Yilmana Densa and Quarit districts, northwest Ethiopia (Alemneh, 2020), and in Chelia district, west-central Ethiopia (Regassa et al., 2015), revealed the use of its tuber for butter refining and as an ingredient for local tea preparation. In addition, several researchers (Abera & Belay, 2022; Hankiso et al., 2023; Regassa et al., 2015; Yiblet & Adamu, 2023; Yimer et al., 2021) verified that the young shoots of *R. abyssinicus* are consumed raw in different regions of the country. This implies the diverse nutritional roles of WEPs and the rich associated indigenous knowledge of the local communities living in different areas.

4.3.6. Occasions of consuming wild edible plants

Results showed that WEPs in the study area were eaten as complementary foods (70%), both as complementary and famine foods (19%), and as famine foods (11%) (Figure 4.6). Here, local communities consume the majority (38 species, 70%) of WEPs mainly as additional foods due to their pleasant tastes, though staple foods are plentiful. However, some WEPs (16 species, 30%) in the study area were consumed to relieve hunger while spending time at schools, farming places, and livestock herding, and during the scarcity of staple food staff in the area. Thus, local communities depend on WEPs as alternative foods and as famine foods to fill the food gaps during the scarcity of popular crops. In agreement with the present study, the study conducted by Tebkew et al. (2018) reported the consumption of nearly 70% of WEPs as supplementary foods and a few (about 35%) WEPs as famine or drought foods. However, contrary to the current finding, other studies (Tahir et al., 2023a; Teklehaymanot & Giday, 2010) conducted in different areas of Ethiopia have reported that most WEPs are consumed as famine foods. This implies that consumption of WEPs might be more dependent on the productivity and/or access to popular crops in different parts of the country (Fentahun & Hager, 2009; Ocho et al., 2012). Moreover, the collection and consumption of WEPs depend on the wealth status of households (Hailemariam et al., 2021). This indicates that the lower the wealth category of the households, the more they are dependent on WEPs, and vice versa. Such habits of the local people underestimate the nutritional values of WEPs and their contribution to food security.

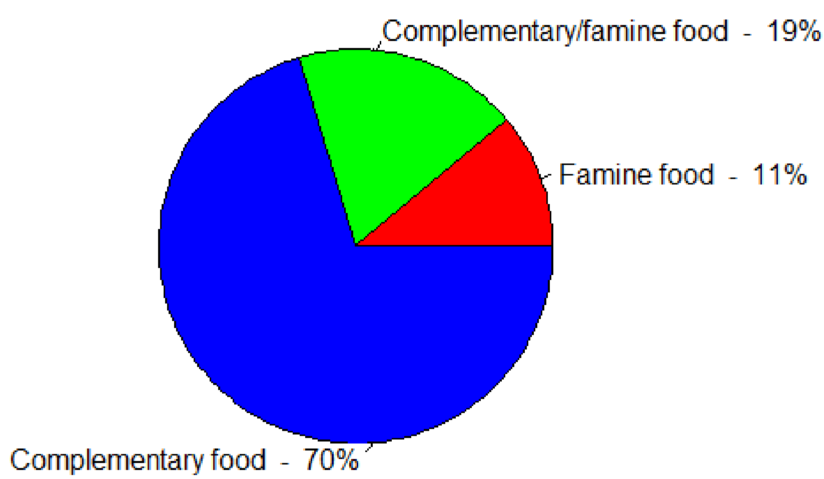

Figure 4.6. Consuming occasions of wild edible plants in the Dibatie district.

As the study area consists of three types of agro-ecological zones (lowland, mid-highland, and highland areas) with sufficient monomodal rainfall, the frequency of drought-induced famine is lower compared to other lowland and semi-arid areas of the country, like the Afar, Somali, and southern Oromia. As a result, most (70%) WEPs in the area are reported to be consumed as supplementary foods. On the other hand, informants verified that some WEPs, such as *Amaranthus* *caudatus*, *Corchorus olitorius* L., *Dioscorea schimperiana*, and *Oxytenanthera abyssinica* (A.Rich.) Munro, were eaten only during the seasonal food shortage but not during the normal periods. Especially, *A. caudatus* and *C. olitorius* were considered weeds of cultivated crops during normal times. In other parts of the country, however, these plants are commonly eaten and prepared in the form of various products. For example, in southern Ethiopia, the seed powder of *A. caudatus* is reported to be consumed in the forms of pan cake, porridge, and local beverages (Ashagre et al., 2016), and its leaves and seeds are also eaten cooked (Hankiso et al., 2023). In the Afar region of eastern Ethiopia, young shoots and leaves of *C. olitorius* are consumed cooked as vegetables, and its dried leaves were reported to be sold in supermarkets and exported to neighboring country (Djibouti) (Dandena, 2010). It is also reported as a preferable leafy vegetable in the southern (Balemie & Kebebew, 2006; Teklehaymanot & Giday, 2010) and the northwestern (Masresha et al., 2023; Tebkew et al., 2014, 2018) parts of Ethiopia. This indicates the food source potential of *A. caudatus* and *C. olitorius*, which needs to be incorporated in the agriculture and food policies of the country. Because these plants are short-season annual plants, they can be harvested more than once per year.

In the present study, boiled or roasted tubers of *Dioscorea praehensilis* and *Dioscorea schimperiana* were stated to be consumed during seasonal food gaps. *D. praehensilis* was also reported as a favorite supplementary food for rural communities. These tuberous WEPs consist of stored food reserves (carbohydrates) that help with their growth and are rich in essential nutrients (Mosissa, 2018). For example, *D. praehensilis* is described as a cheap source of macro- and micronutrients, combating malnutrition in some rural communities in Ethiopia (Aragaw et al., 2021; Yimer et al., 2023a). Moreover, root and tuber crops like sweet potato (*Ipomoea batatas* L.) and *Dioscorea* spp. are drought-resistant and productive even on marginalized lands with low soil nutrients compared to cereal crops such as maize, wheat, triticale, and so on (Matsumoto et al., 2021; Motsa et al., 2015). Thus, it is better to domesticate and propagate such multiple stress-resistant and nutrient-full tuberous WEPs to reduce hunger, malnourishment, and poverty, and to use them consistently in the future. That is because it is essential for developing countries like Ethiopia to look for alternative food sources in order to ensure sustainable food and nutrition security (Dandena, 2010).

A preference ranking was carried out by seven key informants to rank seven commonly used WEPs based on their contribution to combating famine, their taste, and their safety to eat. Key informants were requested to give values (1 to 7) according to their point of view on the selected plants, where number 7 represents the most likely preferred plant and number 1 denotes the least likely plant. Accordingly, *Syzygium guineense* (Wild.) DC. subsp. *macrocarpum* (Engl.) F.White was ranked 1st, followed by *Syzygium guineense* (Wild.) DC. subsp. *guineense*, *Ximenia americana*, *Vitex doniana* Sweet, *Carissa spinarum*, *Dioscorea praehensilis*, and *Ficus sycomorus* L., with their corresponding ranks of 2nd, 3rd, 4th, 5th, 6th, and 7th, respectively (Table 4.4). The scores depend on the views of key informants who participated, since the habit of using WEPs varies from person to person.

Table 4.4: Preference ranking of the seven selected wild edible plants according to the views of respondents

	Respondents (R_1-R_7)							Total	
Wild edible plants	**R_1**	**R_2**	**R_3**	**R_4**	**R_5**	**R_6**	**R_7**	**score**	**Ranking**
C. spinarum	4	5	4	6	4	4	6	33	5th
D. praehensilis	2	3	3	3	1	2	2	16	6th
F. sycomorus	1	2	2	2	2	3	1	13	7th
S. guineense subsp. *guineense*	6	7	6	5	7	5	6	42	2nd
S. guineense subsp. *macrocarpum*	7	6	7	7	6	7	7	47	1st
V. doniana	6	4	5	4	5	6	4	34	4th
X. americana	5	5	6	5	6	4	5	36	3rd

4.3.7. Additional uses of wild edible plants in the study area

Out of the reported wild edible plants, about 98% had additional uses beyond their food values across the community (Table 4.2). These additional uses include utilization as bee forages, beehive hanging trees, beehive materials, charcoal, cleaning materials, construction materials, fences, soil fertilizers, fodders, fuel woods, lubricants, traditional medicines, as ornamentals, tooth brushes, shade, timber, traditional soaps, and household utensils. For example, both *S. guineense* subsp. *guineense* and *S. guineense* subsp. *macrocarpum* were important sources of bee forage and charcoal. In addition, *Cordia africana* was reported as an important source of timber, *Phoenix reclinata* was identified as a good raw material for the preparation of traditional mats, and

Oxytenanthera abyssinica was reported as a nice raw material for the construction of traditional houses and the preparation of household utensils, and figs of *Ficus* spp. (*F. sycomorus*, *F. sur*, and *F. vasta* Forssk.) were used as fodder for livestock and soil fertilizer, among others. Different studies (Ashagre et al., 2016; Dejene et al., 2020; Hassen, 2021; Tahir et al., 2023a; Tebkew et al., 2018) in various parts of Ethiopia have also reported additional uses of WEPs besides their food values.

4.3.8. Direct matrix ranking

Results of direct matrix ranking revealed that out of the selected seven multipurpose wild edible plants, *C. africana, S. guineense* subsp. *guineense,* and *O. abyssinica* were ranked 1st, 2nd, and 3rd, respectively, based on ten use categories. Whereas *F. sycomorus, F. sur, G. mollis,* and *P. reclinata* were ranked 4th, 5th, 6th, and 7th, respectively (Table 4.5). The use categories were bee forage, charcoal, construction, fence, fodder, food, fuel wood, household utensils, medicine, and shade. Like the current result, studies undertaken by Ashagre et al. (2016) in Burji district, southern Ethiopia, and Kidane & Kejela (2021) in Oromia special zone, central Ethiopia, have ranked *C. africana* as the most commonly used plant in the societies. This indicates the extreme demand for *C. africana* for several values within the country. However, widely used plants are usually threatened due to overexploitation for various purposes. Studies (Ashagre et al., 2016; Dejene et al., 2020; Giday & Teklehaymanot, 2023) revealed that WEPs are usually exploited for purposes other than nutritional value. According to the present study, for example, *C. africana* was usually utilized for its timber production and fodder, whereas *S. guineense* subsp. *guineense* and *O. abyssinica* were highly required for construction purposes within the community. As a result, *C. africana* and *O. abyssinica* were highly declining from the natural forests and started to be propagated in the gardens.

On the other hand, out of the listed use categories, utilization of WEPs for food, household utensils, and construction were ranked 1st, 2nd, and 3rd, respectively, while the rest of the use categories were respectively fuel wood (4th), fodder (5th), medicine (6th), shade (7th), bee forage (8th), charcoal (9th), and fence (10th) (Table 4.5). Thus, extensive use of WEPs as household utensils, construction materials, fuel wood, fodder, medicine, charcoal, and fence might be considered the major threatening factors of multipurpose plants.

Table 4.5: Direct matrix ranking of 7 multipurpose WEPs based on average values given for 10 use categories (7, most likely used; 1, least likely used; 0, not used)

Use categories	Wild edible plants							Total score	Rank
	Cordia africana	*Ficus sur*	*Ficus sycomorus*	*Grewia mollis*	*Oxytenanthera abyssinica*	*Phoenix reclinata*	*S. guineense* subsp. *guineense*		
Bee forage	7	1	1	6	0	4	7	26	8th
Charcoal	3	5	5	2	1	0	7	23	9th
Construction	6	4	4	3	7	6	7	37	3rd
Fence	2	2	3	2	7	1	3	20	10th
Fodder	7	5	5	4	6	5	1	33	5th
Food	7	6	6	7	6	5	7	44	1st
Fuel wood	5	5	6	5	6	1	7	35	4th
Household utensil	7	6	6	6	7	7	2	41	2nd
Medicinal	7	5	3	5	3	7	2	32	6th
Shade	7	3	7	1	4	3	5	30	7th
Total score	58	42	46	41	47	39	48		
Rank	1st	5th	4th	6th	3rd	7th	2nd		

4.3.9. Familiarity index (Fi) of wild edible plants in the study area

A familiarity index (Fi) was computed to indicate the relative popularity of the major and minor wild edible plants. Indeed, the top ten WEPs were revealed based on their popularity as wild foods. Accordingly, *S. guineense* subsp. *macrocarpum* was the most popular (Fi = 31.36) wild edible plant, followed by *V. doniana* (Fi = 25.91) in the area (Table 4.6). These commonly edible wild plants play an important role in combating food insecurity, in addition to the cultivated plants in the area. Especially, *S. guineense* subsp. *macrocarpum* provides a high yield and is consumed well for the entire two months (April and May) in the study area. Hence, local people usually talk about how children may grow by eating this wild fruit, even when staple foods are scarce.

Table 4.6: Familiarity index (Fi) of top ten popular wild edible plants

Wild edible plants	Number of times a species was mentioned	Fi
Syzygium guineense subsp. *macrocarpum*	69	31.36
Vitex doniana	57	25.91
Carissa spinarum	54	24.55
Cordia africana	48	21.82
Ximenia americana	48	21.82
Syzygium guineense subsp. *guineense*	42	19.09
Saba comorensis	30	13.64
Dioscorea praehensilis	28	12.73
Ficus sycomorus	27	12.27
Ficus sur	24	10.91

4.3.10. Nutraceutical wild edible plants

The current finding showed that 21 plant species (38.89%) were reported to have both medicinal and nutritional roles (Table 4.2 and appendix 1). These plants are known as nutraceuticals because their various parts provide dietary and therapeutic values. Out of the reported nutraceuticals, for example, unripe, roasted fruits of *C. spinarum* and fruits of *C. africana* with seeds were swallowed to expel ascaris, trunk hearts of *P. reclinata* were consumed to relieve malaria, and tubers of *D. praehensilis* were eaten to treat impotency in men. Because nutraceutical plants have phytocomplexes, which play important roles in therapeutic properties owing to the natural active principles they contain (Santini & Novellino, 2017). Indeed, WEPs are rich in micronutrients and bioactive secondary metabolites; some also have antioxidant and antimicrobial properties (Bacchetta et al., 2016). For instance, *Amaranthus hybridus* L., *Haplocarpha rueppellii* (Sch.Bip.) Beauverd, *Haplocarpha schimperi* Beauverd, and *Rumex nervosus* Vahl (Adamu et al., 2022), as well as *Cleome gynandra* L. and *Solanum nigrum* L. (Yimer et al., 2023b), are potential WEPs with good sources of phenolics, flavonoids, and antioxidant agents, treating oxidative stress-related diseases.

In addition to the above examples, informants in the present study confirmed that the decoction of *Embelia schimperi* fruit with seed was commonly used traditionally to treat tapeworm, beyond the nutritional role of a ripe fleshy fruit berry. Similarly, previous studies (Alemayehu et al., 2015b; Alemneh, 2020; Asfaw et al., 2023; Regassa et al., 2015; Yimer et al., 2021) reported the nutritional and medicinal contributions of this plant from different areas of the country. This indicates the nutraceutical potential of *E. schimperi* that can be improved in the development of various drugs and food products.

4.3.11. Marketability of wild edible plants

Results showed that some WEPs were reported to serve as sources of income. Out of the reported WEPs in the area, about 13% were marketable as food or spice in the local market, towns, and schools. For instance, tubers of *R. abyssinicus* were prepared as spice with other spice plants and sold in the local markets. Besides, *X. americana, S. comorensis, G. mollis, V. doniana, B. aethiopum,* and *Mimusops kummel* Bruce ex A.DC. were other marketable WEPs mainly vended in towns and schools for consumption. Wild edible plants were mostly collected and sold by youths, schoolchildren, and sometimes women. This is in agreement with reports of previous studies conducted in different parts of Ethiopia (Addis et al., 2013; Bahru et al., 2013; Balemie & Kebebew, 2006). This implies that community members living in different parts of the country have similar traditions of consuming and selling wild edible plants.

However, 87% of WEPs were not marketable as foods, although some of them were sold within the community for other purposes or products such as timber, charcoal, mats, construction materials, and so on. Similarly, an earlier study conducted by Alemneh (2020) reported that the majority of WEPs were not marketable owing to their limited access and low habits of consumption compared to domesticated plants. Furthermore, other studies (Balemie & Kebebew, 2006; Kebebew & Leta, 2016) have described the marketability of some WEPs for other products or uses (e.g., timber, agricultural tools, construction, and firewood) rather than nutritional purposes. This indicates an insignificant level of market value chain in the trade of WEPs, though they are highly valuable foods within or outside the country. On the other hand, studies conducted in Quara district (Tebkew et al., 2018) and Metema district (Masresha et al., 2023), northwest Ethiopia, reported the export of WEPs, such as *Adansonia digitata* L., *Balanites aegyptiaca* (L.) Delile, and *Tamarindus indica* L., to neighboring country (Sudan). A report by Dandena (2010) also revealed the high marketability of dried and packed leaves of *C. olitorius* in the Afar region of eastern Ethiopia to be exported to Djibouti.

4.3.12. Adverse side effects of consuming wild edible plants

The present study showed that the majority (about 78%) of WEPs in the study area did not have adverse effects. Certainly, few plants (22%) were reported to exhibit slightly negative effects on human beings and domestic animals either during or after consumption. The adverse effects were mainly associated with the consumption of unripe fruits, eating with seeds, and excessive consumption. For instance, *Ficus* species were described as causing abdominal pain when excessively consumed with seeds. Besides, unripe fruits of *C. spinarum* and *Rubus apetalus* Poir. resulted in temporary mouth burning, and excessive consumption of *S. guineense* subsp. *macrocarpum*, *C. africana*, *R. apetalus,* and *Senna petersiana* (Bolle) Lock fruits was reported to cause stomach discomforts. Similarly, adverse effects were reported by Fentahun & Hager (2009) when WEPs were eaten unripe, in excess, and with an empty stomach. In the current finding, the seeds of *M. kummel* were reported to be lethal when consumed by goats. Likewise, earlier studies by Balemie & Kebebew (2006) and Fentahun & Hager (2009) have reported that the seeds of *Lepisanthes senegalensis* (Poir) Leenh. were lethal to goats and camels. Therefore, few WEPs require proper handling mechanisms to avoid or reduce the risks of adverse side effects.

4.3.13. Habitats of wild edible plants

The current study showed that 28.57% of the WEPs were found in riparian vegetation, followed by open woodlands (18.37%). The rest of the WEPs inhabit grazing land (12.24%), settlement areas (10.20%), forest margins (9.18%), farmland (9.18%), home gardens (9.18%), and serve as live fences (3.06%) (Table 4.7). A particular wild edible plant can inhabit one or more types of habitats. In agreement with the present finding, other studies (Ashagre et al., 2016; Kidane & Kejela, 2021) have reported various habitats of WEPs, such as riverine areas, woodlands, farmlands, natural forests, grazing lands, live fences, and home gardens. The current finding also described settlement areas as habitats for WEPs, in line with the previous study reported by Tahir et al. (2023a). Similar to other studies (Abera & Belay, 2022; Ashagre et al., 2016; Hassen, 2021; Tahir et al., 2023a; Yiblet & Adamu, 2023) conducted in Ethiopia, most WEPs were collected from natural habitats and thus exposed to habitat destruction. However, the availability of some WEPs in farmlands, live fences, home gardens, and settlement areas indicates the promising attempts of local communities toward their conservation.

Table 4.7: Habitats of wild edible plants in the study area

Habitat type	Number of species	Percentage (%)
Riverine	28	28.57
Open woodland	18	18.37
Grazing land	12	12.24
Settlement area	10	10.20
Forest margin	9	9.18
Farmland	9	9.18
Home garden	9	9.18
Live fence	3	3.06

4.3.14. Threats to and conservation status of wild edible plants

Informants described that the major threats to WEPs in the study area were cutting (60.62%), overexploitation (8.50%), agricultural expansion (7.93%), root utilization (5.95%), herbicide (5.10%), overgrazing (5.10%), wildfire (3.68%), and weeding (3.12%) (Figure 4.7). Local communities cut or deforest WEPs for various purposes such as food, medicine, fencing, timber, fuel wood, charcoal, construction, fodder, household utensils, and farm materials, among others. Thus, widely used multipurpose WEPs were highly threatened due to their extensive uses for different purposes. This shows that human activities pose the main threats to WEPs in the study area compared to natural disasters. Hence, these plants require wise use and special attention from all the concerned bodies in order to sustain them with associated indigenous knowledge for the next generation. In agreement with the present finding, other studies (Alemneh, 2020; Ashagre et al., 2016; Hassen, 2021; Kidane & Kejela, 2021; Tahir et al., 2023a) conducted in Ethiopia have revealed human activities as the major threats to WEPs. On the other hand, the study conducted by Fentahun & Hager (2009) in Adiarkay, Debark, and Dejen districts of the Amhara region of northern Ethiopia has reported catastrophic factors as the major threats to wild edible plants.

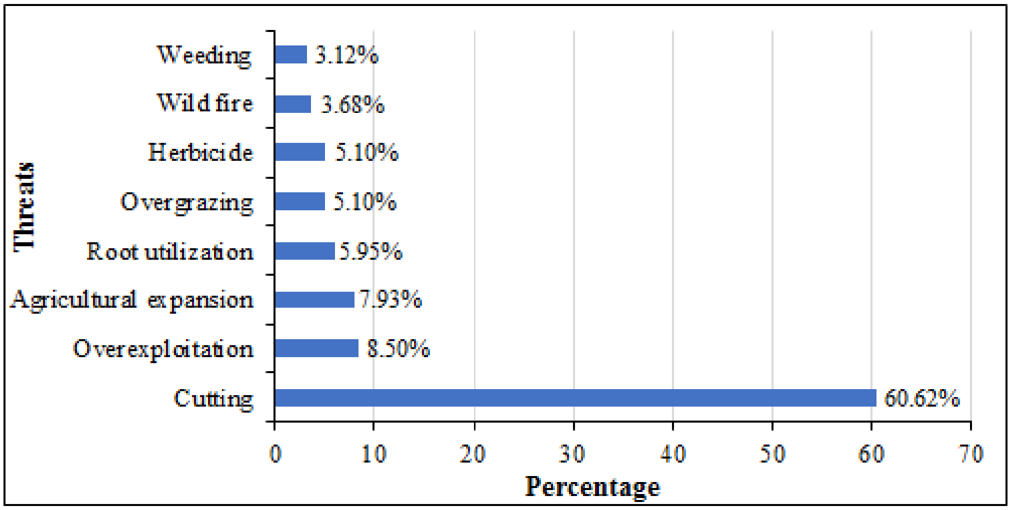

Figure 4.7. Threats to wild edible plants in the Dibatie district.

This finding showed that local communities did not conserve about 76% of the WEPs in the area. Likewise, the previous study conducted by Hassen (2021) reported that a large number (58.5%) of WEPs were not conserved in Wollo, northern Ethiopia. In the present study area, however, some WEPs (approximately 24%) were slightly conserved due to their extra uses apart from nutrition. For instance, some people keep *C. africana* in gardens or farmland for its timber; a few people cultivate *O. abyssinica* for house construction, fences, preparation of household utensils, and sources of income; and some others conserve *F. sycomorus* for its shade and its use as a beehive hanging tree. In line with the current study, elsewhere in Ethiopia, researchers (Ashagre et al., 2016; Dejene et al., 2020; Kidane & Kejela, 2021; Tahir et al., 2023a) have reported that some important WEPs were deliberately retained in farmland or propagated in gardens by the local communities. According to the current results, local people believed that some plants, including wild edibles, were contributing to water conservation. For example, *S. guineense* subsp. *guineense* and *F. sur* were considered water-preserving plants since they inhabit riverine or wet environments. Thus, community elders and administrative leaders were inhibiting the destruction of such plants near rivers. Similarly, study conducted by Kidane & Kejela (2021) in Berek district, Oromia special zone, central Ethiopia, stated the roles of social norms and beliefs of the local communities in conserving WEPs onsite. Although the progress is promising, the conservation practices are still very stunted elsewhere in the country (Balemie & Kebebew, 2006; Hassen, 2021; Tebkew et al., 2018; Teklehaymanot & Giday, 2010). As a result, WEPs are declining from the natural forests from time to time (Giday & Teklehaymanot, 2023).

4.4. Conclusions

The present finding has documented 54 wild edible plant species consumed by the local community living in Dibatie district, western Ethiopia. The majority (70%) of the recorded wild edibles were eaten as alternative foods in the presence of staple foods. However, few (11%) WEPs were consumed only during the scarcity of staple food crops in the area. Thus, the intensity of consuming WEPs depends on access to the cultivated crops. Beside their nutritional supplements, WEPs support livelihoods through beekeeping, energy sources, cleaning materials, construction raw materials, fences, soil fertilizers, livestock fodders, traditional medicines, aesthetics, shade, furniture, farm materials, and household utensils. Moreover, wild Aves and some wild animals were highly dependent on the consumption of wild edible plant resources in the area. Nevertheless, the perception of local people was low toward the conservation, wise use, and management of wild edible plants. Because WEPs are recently threatened by anthropogenic factors (like deforestation, overexploitation, agricultural expansion, root utilization, herbicides, weeding, overgrazing, and human-induced wildfire), they have drastically declined over the last 30 to 40 years. Therefore, this study calls for an urgent *in-situ* and *ex-situ* conservation strategy in order to conserve and pass wild edible plant resources and associated indigenous knowledge of the local communities on to the next generation.

In general, local people in the study area have a strong relationship with WEPs since they use them for nutrition, income generation, traditional medicine, construction, and the preparation of household materials. Hence, wild edible plants require wise use and special conservation attention from all the stakeholders (e.g., local communities, governmental and non-governmental bodies) for sustainable use in the future. Moreover, the national green legacy initiatives should include the plantation of indigenous wild edible plants in all regions of the country. Furthermore, the recorded wild edible plants should be validated by conducting further investigations on their nutritional analysis, phytochemical composition, antioxidant activity, and toxicity examination.

CHAPTER FIVE

Paper IV

5. Nutritional Values, Functional Properties, Antioxidant Activity and Phytochemicals of Three Commonly Consumed Wild Plants by Dibatie People, Western Ethiopia

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Abstract

This study was aimed to evaluate the nutritional, techno-functional, anti-nutritional, and antioxidant properties and phytochemical constituents of *Saba comorensis* (Bojer ex A.DC.) Pichon fruits, *Syzygium guineense* (Wild.) DC. subsp. *macrocarpum* (Engl.) F.White fruits, and *Dioscorea praehensilis* Benth. tubers consumed by inhabitants of Dibatie district, western Ethiopia. Juices of edible plants were used to determine pH, acidity, and total soluble solids (TSS). Lyophilized powders were analyzed to determine vitamin C, proximate composition, minerals, techno-functional properties, anti-nutritional factors, antioxidant capacity, and phytoconstituents. The *Saba comorensis* fruits had the highest ($p < 0.05$) acidity, vitamin C, and TSS. The studied plants contained nutrients such as fiber (2.50–15.50%), fat (0.75–4.00%), protein (4.38–10.50%), carbohydrate (59.63–68.83%), and energy (267.75–324.08 kcal/100g). The studied plants were rich sources of calcium (522.27–995.04 mg/100g), iron (19.80–111.94 mg/100g), magnesium (923.25–1592.18 mg/100g), manganese (0.50–5.72 mg/100g), potassium (591.69–1357.71 mg/100g), sodium (0.60–17.17 mg/100g), and zinc (1.00–1.74 mg/100g). In terms of functional properties, *D. praehensilis* tubers had the highest bulk density, water absorption, water holding, foaming, and foam stability. The fruits of *S. comorensis* and *S. guineense* subsp. *macrocarpum* had the highest water solubility and oil absorption index, respectively. The studied plants had phytates (65.11–70.67 mg/100g), oxalates (170.00–790.00 mg/100g), and tannins (196.51–11147.55 mg CE/100g). *Saba comorensis* fruits showed substantial DPPH free radical scavenging activity with an IC_{50} value of 0.07 mg/mL compared to ascorbic acid (IC_{50} = 0.04 mg/mL). This is because they were rich in phenolics, flavonoids, and alkaloids. The investigated plants were good sources of valuable nutrients, minerals, and phytochemicals, along with considerable functional, anti-nutritional, and antioxidant properties. Thus, they require special conservation measures for sustainable usage in the form of various food products.

Keywords: *Saba comorensis*; *Syzygium guineense* subsp. *macrocarpum*; *Dioscorea praehensilis*; physico-chemical properties; anti-nutritional factors; antioxidant; phytochemicals

5.1. Background

The consumption of wild edible plants (WEPs) is a fundamental culture in different rural communities of Ethiopia (Teklehaymanot & Giday, 2010). They serve as additional, seasonal, and emergency aids for household food supplies (Tebkew et al., 2018). The issue of food insecurity is resolved by a wider usage of WEPs in certain drought-prone parts of the country (Ashagre et al., 2016). They can be used as chief sources of food both during an abundance of regular food and during food scarcity (Addis et al., 2013). However, some WEPs are consumed only when preferred alternatives do not exist or during a serious food shortage (Balemie & Kebebew, 2006). Because their consumption is usually considered an implication of poverty in the majority of Ethiopian communities (Getachew et al., 2013), there is a lack of awareness of their nutritional values and health effects, which are comparable to cultivated plants (Aragaw et al., 2021).

However, indigenous WEPs are good sources of nutrients such as protein, crude fiber, carbohydrate, moisture, vitamins A and C, and essential minerals like calcium, iron, magnesium, manganese, zinc, and phosphorous (Aragaw et al., 2021; Dandena, 2010; Getachew et al., 2013). For example, WEPs such as *Celosia argentea* L., *Coccinia grandis* (L.) Voigt, *Cynanchum insipidum* (E.Mey.) Liede & Khanum, and *Justicia flava* (Forssk.) Vahl are reported to be rich in protein content (Getachew et al., 2013). They also play an important role in improving human health because of their therapeutic properties (Durst & Bayasgalanbat, 2014). In this regard, they are considered 'nutraceutical plants' because of their both medicinal and nutritional advantages (Feyssa et al., 2011c). For instance, wild edible indigenous plants are potential sources of novel natural products (Albuquerque et al., 2016), which help with weight management and minimize health problems like cardiovascular diseases (Sibiya et al., 2021) since they constitute various phytochemicals, including phenolic compounds and flavonoids, among others (Amel et al., 2013).

Moreover, some WEPs (e.g., *Saba comorensis* (Bojer ex A.DC.) Pichon and *Vitex doniana* Sweet) were reported to have even more antioxidant activities than certain cultivated plants such as *Ananas comosus* (L.) Merr., *Citrus* × *aurantium* f. *aurantium*, *Citrus* × *limon* (L.) Osbeck, and *Musa acuminata* Colla (Charles & Mgina, 2021). For agro-food industries and gastronomy, consumers currently need more natural additives than synthetic ones (Romojaro et al., 2013). Plant-derived natural bioactive compounds are essential sources of lead compounds in the pharmaceutical industry for drug development (Nirmala et al., 2022). Consequently, since a large number of wild edible plant extracts are safe, they may be used as antioxidant supplements and additions to treat oxidative stress-related illnesses (Seal et al., 2022).

Nevertheless, edible wild or semi-wild plants may constitute natural anti-nutritional substances that prevent the absorption of essential nutrients, similar to some cultivated green vegetables (Getachew et al., 2013). Anti-nutritional substances like phytate and oxalate limit the absorption of essential minerals by binding with metal ions like calcium, iron, magnesium, and zinc (Amalraj & Pius, 2015; Samtiya et al., 2020). Besides, the interaction of factors such as protease inhibitors, amylase inhibitors, phytates, oxalates, lectins, goitrogens, hydrogen cyanide, total free phenolics, and tannins influences protein digestion (Mohan & Kalidass, 2010). As a result, appropriate measures (processing technologies) are required to reduce their levels in wild edible fruits and vegetables (Getachew et al., 2013). For example, the quantity of anti-nutritional components in edible plants can be minimized by using food preparation techniques like fermentation, heating, soaking, and puffing (Samtiya et al., 2020).

Saba comorensis (Bojer ex A.DC.) Pichon (locally called '*Wenno*'), *Syzygium guineense* (Wild.) DC. subsp. *macrocarpum* (Engl.) F.White (locally named '*Goosu*'), and *Dioscorea praehensilis* Benth. (locally called '*Eeca*') are wild plants eaten by local residents of Dibatie district, western Ethiopia (Anbessa et al., 2024). The fruits of *S. comorensis* are harvested from late May to late June by youth, students, and cattle herders. The fruits of *S. guineense* subsp. *macrocarpum* are eaten by people of any age group, predominantly in April and May. In addition, tubers of *D. praehensilis* are consumed, roasted, or boiled as supplementary food by people of any age group almost throughout the year. These plants are consumed mainly as a supplementary food or to fill the seasonal food gap without considering their nutritional values, phytochemical contents, or health effects. Very limited or no previous research has documented their nutritional composition, techno-functional profiles, anti-nutritional factors, antioxidant activity, and phytochemical contents up-to-date. Therefore, the current study was aimed to evaluate the nutritional values, techno-functional, anti-nutritional, antioxidant, and phytochemical constituents of the above-mentioned WEPs, which are commonly consumed by the indigenous people of Dibatie district, Metekel zone, western Ethiopia.

5.2. Materials and methods

5.2.1. Sample collection and preparation

The ripe fruits of *Saba comorensis* and *Syzygium guineense* subsp. *macrocarpum,* and the tubers of *Dioscorea praehensilis* (Figure 5.1), were collected in May and June 2022. The sample collection was carried out in Lega-buna (10º36.166′N and 36º09.509′E), Jan (10º33.603′N and 36º07.959′E), and Gipho (10º28.340′N and 36º06.110′E) sub-districts (kebeles) of the Dibatie district, western Ethiopia. The collected samples were brought to the Center for Food Science and Nutrition Laboratory of Addis Ababa University. The edible, fleshy mesocarp of *S. comorensis* fruits was separated manually from the seeds and exocarp and kept in a clean polythene bag at -20 °C. The edible, fleshy exocarp of *S. guineense* subsp. *macrocarpum* fruits was peeled off manually and preserved in a clean polythene bag at -20 °C, while the inner stony seeds were discarded. Tubers of *D. praehensilis* were peeled, sliced with a stainless steel knife, and stored in a polythene bag at -20 °C. The fresh and/or dissolved juices of edible parts were applied for the determination of pH value, titratable acidity, and TSS. The edible parts were lyophilized, pulverized into a fine powder, and preserved in deep freeze until analysis of vitamin C, proximate composition, mineral content, phytochemical constituents, and techno-functional, anti-nutritional, and antioxidant properties.

Figure 5.1. The study plants; *Saba comorensis* fruits (A), *Syzygium guineense* subsp. *macrocarpum* fruits (B), and *Dioscorea praehensilis* tubers (C) consumed in Dibatie district, Metekel zone, western Ethiopia.

5.2.2. Extraction of plant materials

The plant materials were extracted and stored following the procedures stated by Muddathir et al. (2017). Briefly, the lyophilized powder (5 g) was macerated in 50 mL of absolute methanol (99.8%) with continuous shaking for 24 hours. Then the mixture was filtered using Whatman No. 1 filter paper, and the residue was macerated in the same solvent again, followed by filtration. After combining the filtrates, the solvent was removed *in vacuo* using a rotary evaporator set at 40 °C. Until being utilized for analysis, every dried extract was kept at 4 °C.

5.2.3. Determination of pH and titratable acidity

The pH value was determined following the procedures stated by Korese et al. (2022), with a few minor adjustments. That is, a frozen 20 g of each sample was dissolved in 20 mL of distilled water and well homogenized. Then, a digital pH meter was used to determine the pH value of homogenized samples. The pH meter was maintained at 20.60 °C and calibrated using standard buffer solutions with pH values of 4.0 and 7.0. Later, the electrode was cleaned with distilled water and wiped dry with tissue paper before the pH determination for each sample.

The titratable acidity of the edible samples was determined following the approaches used by Sharma & Saini (2021) and Tiencheu et al. (2021). In short, 5 g of each sample was dissolved in 20 mL of distilled water, followed by filtration using Whatman No. 1 filter paper. To attain a pH of 8.1, a known volume (10 mL) of the filtrate was titrated against 0.1 N NaOH by recording the consumed volume of sodium hydroxide. The total titratable acidity was calculated by using the formula:

$$\%\ \text{Acid} = \frac{(\text{Volume of base titrant}) \times (\text{Normality of base}) \times (\text{Eq. wt. of acid})}{(\text{Volume of sample}) \times 10}$$

Where Eq. wt. of acid is equivalent weight of citric acid (64.04) (Nielsen, 2017).

5.2.4. Determination of total soluble solids and vitamin C

The total soluble solids of the fresh fruit juice were measured using digital refractometers and expressed as “degrees of Brix” (ºBrix). Vitamin C was determined spectrophotometrically by using potassium permanganate, following Bayang et al. (2021). The lyophilized sample powder (0.2 g) was combined with 5 mL of 0.5% oxalic acid, agitated in the dark for 24 hours, and filtered using Whatman No. 1 filter paper. Then, 0.5 mL of sample was thoroughly combined with 1.5 mL of 0.1% $KMnO_4$, which was previously dissolved in 0.1 M H_2SO_4. The absorbance was measured at

525 nm with a UV-Vis spectrophotometer. Vitamin C was determined using the standard L-ascorbic acid (0–80 μg/mL) calibration curve. Results were quantified as milligrams of L-ascorbic acid equivalent per 100 g of sample.

5.2.5. Proximate composition analysis

The composition of the study plants in terms of moisture, total ash, crude fiber, crude protein, and crude fat was measured using the Association of Official Analytical Chemists (AOAC, 2016). The moisture content was ascertained by oven (OV/125/SS/F/DIG/A, Genlab Limited, UK) drying at 105 °C until a constant weight was obtained. Ash content was determined using a heated muffle furnace (Furnace type CSF 12/13, Carbolite, England) at 550 °C. Crude fiber content was ascertained following the AOAC Official Method 920.86. Protein (N × 6.25) quantification was carried out by the Kjeldahl (BUCHI Distillation Unit K-350, Switzerland) method, depending on the levels of nitrogen. Fat was quantified using the full automated Soxhlet (BSXT-06 Soxhlet Extractor, Wuhan, China) extraction using petroleum ether. The total carbohydrate content was calculated from the difference using the following equation:

$$\text{Carbohydrate } (\%) = 100 - (\text{moisture} + \text{ash} + \text{crude fiber} + \text{crude protein} + \text{crude fat})\%$$

The gross calorific value of the edible samples was calculated using the following equation:

$$\text{Gross energy } (\text{kcal}/100\text{g}) = 4 \times \text{protein } (\%) + 4 \times \text{carbohydrate } (\%) + 9 \times \text{fat } (\%)$$

5.2.6. Determination of minerals

The mineral composition was quantified following the method described in Hegazy et al. (2019). The concentration of mineral ions such as calcium, copper, magnesium, manganese, iron, and zinc was quantified using atomic absorption spectrophotometry (AA 800, PerkinElmer, Canada) after wet digestion. A microwave plasma atomic emission spectrometer (4210 MP-AES, Agilent, USA) was used to measure the sodium and potassium contents. Phosphorus was determined colorimetrically by a UV-Vis spectrophotometer (Lambda 950, PerkinElmer, Waltham, USA) using the potassium dihydrogen phosphate standard.

5.2.7. Analysis of techno-functional properties

The bulk density of the lyophilized sample powder was analyzed following the method used by Kesselly et al. (2023). Briefly, 10 g of each sample powder was added to a measuring cylinder in triplicate. Each cylinder was tapped carefully on a table until a constant volume was obtained. A weight per volume ratio was used to express the end result.

Water absorption and water solubility were analyzed following the method used in Mokhtar et al. (2018). Briefly, 1 g of sample powder was added to 10 mL of distilled water in a dried centrifugation tube that had been previously weighed. After two minutes of stirring, the tube was centrifuged for fifteen minutes at 1790 g. The supernatant was transferred carefully to a pre-weighed plate. The weight of the residue was obtained from the tarred tube. Then, the water absorption index was computed using the formula:

$$\text{Water absorption index} = \frac{\text{wet residue weight in g}}{\text{sample weight in g}}$$

Then, a plate with the supernatant was oven dried at 105 °C, and the weight of the dry solids from the supernatant was obtained from the tarred plate. The solubility index was calculated as follows:

$$\text{Solubility index} = \frac{\text{weight of dry solids obtained from supernatant in g}}{\text{sample weight in g}}$$

The water holding capacity of the lyophilized powder was determined following the procedure used in Delgado-Ospina et al. (2021). In short, each sample powder (0.3 g) was added to 10 mL of distilled water, homogenized with an electronic vortex for 1 minute, and left overnight. Then, centrifugation was performed to avoid unabsorbed water for 20 minutes at 1790 g. The water holding capacity was calculated as follows:

$$\text{Water holding capacity} = \frac{\text{weight (g) of the water retained}}{\text{weight (g) of the sample}}$$

The oil absorption index was analyzed following the procedure used in Mokhtar et al. (2018). In brief, the sample powder (0.5 g) was combined with 6 mL of purified sunflower oil in a centrifugation tube. After one minute of stirring, the tube was left for thirty minutes, followed by centrifugation for twenty minutes at 1790 g. The amount (mL) of remaining oil was measured to find out how much oil was absorbed. The index of oil absorption was quantified as follows:

$$\text{Index of oil absorption} = \frac{\text{absorbed oil volume in mL}}{\text{sample weight in g}}$$

Foaming capacity and stability were analyzed following the methods used in Mokhtar et al. (2018) and Delgado-Ospina et al. (2021). For this purpose, the sample powder (2 g) was added to 70 mL of distilled water and homogenized using a dispersing apparatus (IKA T25 digital ULTRA TURRAX, Vietnam) at 25000 rpm for 1 minute. The total volume was recorded after foam formation, and the volume of foam formed was obtained through the difference between the initial volume of a mixture and the total volume. The percentage of foaming capacity was calculated as follows:

$$\text{Percentage of foaming capacity} = \frac{\text{volume (mL) of foam formed}}{\text{volume (mL) of initial mixture}} \times 100$$

After an hour, the volume of foam was measured to determine the stability of the foam. The foam stability was articulated as a percentage of foam volume (mL) after an hour per initial foam volume (mL).

5.2.8. Determination of anti-nutritional factors

Phytic acid determination was performed using Wade's reagent colorimetric technique used in Achaglinkame et al. (2019). Triplicate sample powder (0.2 g) was extracted in 10 mL of 0.2 M HCl for 1 hour, followed by centrifugation for 30 minutes at 1790 g. The supernatant (3 mL) was transferred into a clear test tube along with Wade's reagent (2 mL) (i.e., sulfosalicylic acid and $FeCl_3.6H_2O$ solution in a 1:1 ratio) and 0.2 M hydrochloric acid (2 mL). A UV-Vis spectrophotometer was used to measure the absorbance of the mixture at 500 nm. The phytic acid standard curve was employed to calculate the phytate content.

The determination of oxalic acid was carried out by colorimetric titration using potassium permanganate, as stated in Djikeng et al. (2022). Briefly, each sample powder (1 g) was mixed with 75 mL of 3 M H_2SO_4, agitated carefully using a magnetic stirrer for an hour, followed by filteration with Whatman No. 1 filter paper. The filtrate (25 mL) was collected and titrated until a faint pink color that lasted for 30 seconds was achieved against a heated (80–90 °C) 0.1 M KMnO4 solution. The level of oxalic acid in each sample was calculated from the equation: 1 mL of 0.1 M $KMnO_4$ consumption = 0.00450 g of oxalic acid in the sample. The experiment was done in triplicates for each sample.

The tannic acid was quantified using the vanillin-HCl assay technique employed in Wu et al. (2018). Each sample powder (1 g) was measured in a test tube and combined with 1% of hydrochloric acid (10 mL) in methanol. The mixture was shaken mechanically for twenty-four hours, followed by centrifugation for 5 minutes at 1790 g. In a separate test tube, 1 mL of the supernatant was combined with 5 mL of the vanillin-HCl reagent. After letting the solution stand for 20 minutes, the absorbance was measured using UV-Vis spectrophotometry at 500 nm. Catechin standard reference was used, and the final value was expressed as milligrams of catechin equivalents (mg CE) per gram sample. The experiment was done in triplicates for each sample.

5.2.9. Determination of antioxidant activity

The 2,2-diphenyl-1-picrylhydrazyl (DPPH) free radical scavenging assay was assessed spectrophotometrically, as previously stated in Amari et al. (2014). For each sample, a 50 mg/mL stock solution of crude extract was made in methanol. A solution of DPPH was mixed with extracts in methanol at different concentrations (0.02, 0.04, 0.08, 0.12, 0.16, and 0.2 mg/mL). After gently vortexing the mixture, it was allowed to keep in the dark for half an hour. Using a UV-Vis spectrophotometer, the absorbance of a mixture was read against a blank at 517 nm. The greater scavenging of DPPH free radicals was shown by a decreased absorbance of the solution. Ascorbic acid was taken as a standard reference, and the percentage of inhibition was computed as follows:

$$\text{Inhibition (\%)} = \frac{(\text{AB} - \text{AS})}{\text{AB}} \text{ x } 100$$

Where AB is the absorption of a blank and AS is the absorption of a test sample. The experiment was conducted in triplicates for each sample.

To calculate the 50% inhibitory concentration (IC_{50}) of each sample and ascorbic acid, the slope equation was utilized as follows:

$$\text{Y} = \text{mx} + \text{c}$$

Where m is slope, x is concentration, and c is intercept (Jafri et al., 2023).

The technique followed by Amari et al. (2014) was employed to determine the ferric-reducing antioxidant power (FRAP) of each sample. Stock solutions contained 300 mM acetate buffer (3.1 g $C_2H_3NaO_2 \cdot 3H_2O$ and 16 mL $C_2H_4O_2$), pH 3.6, 10 mM 2, 4, 6-tripyridyl-s-triazine (TPTZ) solution in 40 mM HCl, and 20 mM $FeCl_3 \cdot 6H_2O$. A new working solution was made by combining acetate buffer (25 mL), TPTZ solution (2.5 mL), and $FeCl_3 \cdot 6H_2O$ solution (2.5 mL). It was allowed to warm for about 37–40 °C before use. Then, 0.3 mL of each sample extract at a concentration of 0.15 mg/mL was reacted with FRAP solution (3 mL) and distilled water (0.3 mL) in the dark for 30 minutes. Using a UV-Vis spectrophotometer, the absorbance of the reaction mixture was measured at 593 nm. The greater reducing power was shown by the higher absorbance of the mixture. The ascorbic acid equivalent was utilized to express the results, taking ascorbic acid as a positive reference. The experiment was conducted in triplicates for each sample.

5.2.10. Analysis of phytochemical constituents

The Folin-Ciocalteu technique was used to determine the total phenolic content of each sample, as stated in Agourram et al. (2013) and Prakash et al. (2016). Briefly, each extract (150 µL) was mixed with Folin-Ciocalteu reagent (1 mL) and 1 mL sodium carbonate (75 g/L) in clean test tubes. For the purpose of developing color, the test tubes were vortexed and left in the dark for half an hour. A UV-Vis spectrophotometer was used to measure the solution's absorbance at 765 nm. Gallic acid was dissolved in absolute methanol at a concentration of 1.25 mg/mL to create a gallic acid standard solution. The milligrams of gallic acid equivalents (mg GAE) per gram of dry extract were used to express the total phenolic content. The experiment was conducted in triplicates for each sample.

The determination of the total flavonoid content was carried out following the methods previously used in Amari et al. (2014). In short, 1 mL of the methanolic extracts (0.125 to 0.15 mg/mL) was combined with 1 mL of 2% AlCl3 (w/v in distilled water). After 10 minutes of room-temperature treatment, the mixture's absorbance was measured in relation to a blank at 415 nm. Quercetin standard (0 to 0.125 mg/mL) was used, and milligrams of quercetin equivalents (mg QE) per dry extract were employed to express the total flavonoid content in each sample. The experiment was done in triplicates for each sample.

The previous procedures used in Kumar et al. (2022) were employed to determine the alkaloid content of each sample. In brief, a 10% acetic acid (v/v in ethanol) solution (50 mL) was used to dissolve 2 g of each sample powder. The solution was allowed to stand for 4 hours after being shaken with a magnetic stirrer. Then, filtration was made using Whatman No. 1 filter paper, and the filtrate was evaporated on a hot plate to 1/4 of its original volume. To precipitate the alkaloids, a concentrated ammonium hydroxide solution was added drop-wise to the resultant solution. The precipitate was washed with a 1% ammonium hydroxide solution after filtering it with a previously weighed Whatman No. 1 filter paper. After two hours of drying at 60 °C in a hot air oven, the filter paper containing alkaloid precipitates was cooled, followed by weight recording. The alkaloid content was ascertained gravimetrically from the weight difference using a triplicate analysis, and it was then quantified as a percentage of the sample examined.

5.2.11. Statistical data analysis

The results were reported using the mean and standard deviation. Tukey's honestly significant difference (Tukey's HSD) test was used to assess the mean differences at $P < 0.05$ using one-way analysis of variance (ANOVA). A paired sample t-test was also computed to compare the means at $P < 0.05$. Microsoft Excel (version 2013) and Statistical Package for the Social Sciences (SPSS) version 21.0 were used for the data analysis.

5.3. Results and discussion

5.3.1. pH, titratable acidity, vitamin C and TSS

The investigated plants were significantly ($P < 0.05$) different in pH values and titratable acidity (Table 5.1). The fruits of *S. comorensis* and *S. guineense* subsp. *macrocarpum* had pH values of 3.52 ± 0.00 and 5.20 ± 0.01, respectively, and *D. praehensilis* tubers had pH values of 5.40 ± 0.02. The fruits of *S. comorensis* were most acidic (1.91 ± 0.02 % citric acid/100g), followed by the fruits of *S. guineense* subsp. *macrocarpum* (0.23 ± 0.01 % citric acid/100g), and the tubers of *D. praehensilis* were less acidic (0.06 ± 0.01 % citric acid/100g). The titratable acidity of fruits and vegetables extends their shelf-life by retaining their surface color and preventing microbial growth (Ali et al., 2020; Ghimire et al., 2021). However, titratable organic acids gradually decline through respiration during the storage of edible vegetables and fruits (Madanipour et al., 2019).

Table 5.1: pH value, titratable acidity, vitamin C, and TSS of *S. comorensis* fruits, *S. guineense* subsp. *macrocarpum* fruits, and *D. praehensilis* tubers consumed in Dibatie district, Metekel zone, western Ethiopia.

Parameters	**Plant species**		
	S. comorensis	*S. guineense* subsp. *macrocarpum*	*D. praehensilis*
pH value	3.52 ± 0.00^c	5.20 ± 0.01^b	5.40 ± 0.02^a
% acidity (% citric acid/100g)	1.91 ± 0.02^a	0.23 ± 0.01^b	0.06 ± 0.01^c
Vitamin C (mg AAE/100g)	44.18 ± 0.50	BDL	ND
Total soluble solids (°Brix)	$15.50 \pm 0.56^*$	7.10 ± 0.36	ND

Values are the mean ± standard deviations (SD) of triplicate analyses. Values with different superscripts within a row are different ($P < 0.05$) using one-way analysis of variance (ANOVA), Turkey's test. *indicates significant difference ($P < 0.05$) between mean values using paired t-test. ND: not determined; BDL: below detection limit; AAE: ascorbic acid equivalent.

In *S. comorensis* fruits, the vitamin C concentration was 44.18 ± 0.50 mg AAE/100g, but it was below the detection limit in *S. guineense* subsp. *macrocarpum* fruits. The fruit juices of *S. comorensis* and *S. guineense* subsp. *macrocarpum* had total soluble solids of 15.50 ± 0.56 and 7.10 ± 0.36 °Brix, respectively (Table 5.1). Vitamin C is an essential water-soluble antioxidant that reduces the effect of oxidative stress (Alpsoy & Yalvac, 2011) and promotes iron absorption in the human body (Mithril et al., 2013). Groups of compounds that dissolve in water, such as soluble sugars and other soluble substances, are included in total soluble solids (Li et al., 2016). In this respect, *S. comorensis* fruits had comparable TSS to most mango-based products, fulfilling the required ranges of TSS (14 to 28 °Brix) and pH (3.5 to 4.0) (Kaushik et al., 2015). This indicates the potential of *S. comorensis* fruits to be used, like mango fruits, in the form of various food products.

5.3.2. Proximate composition

The study plants contained various levels of moisture, total ash, crude fiber, crude fat, crude protein, carbohydrate, and energy contents, as presented in Table 5.2. The total ash content ranged from 1.17 ± 0.29 g/100g in *D. praehensilis* tubers to 2.25 ± 0.35 g/100g in *S. comorensis* fruits. Crude fiber content was maximum in the fruits of *S. guineense* subsp. *macrocarpum* (15.50 ± 0.71

g/100g) and *S. comorensis* (14.00 ± 1.41 g/100g), and low in the *D. praehensilis* tubers (2.50 ± 0.71 g/100g). The crude fat content in the fruit of *S. comorensis* was 4.00 ± 0.71 g/100g, and it was found to be 0.75 ± 0.35 g/100g in both *S. guineense* subsp. *macrocarpum* fruits and *D. praehensilis* tubers. The crude protein content ranged from 4.38 ± 0.17 g/100g in *S. comorensis* fruits to 10.50 ± 0.18 g/100g in *D. praehensilis* tubers. The utilizable carbohydrate content ranged from 59.63 ± 3.00 g/100g in *S. comorensis* fruits to 68.83 ± 2.82 g/100g in *D. praehensilis* tubers. The studied plants contained calorific values ranging from 267.75 ± 5.56 kcal/100g in *S. guineense* subsp. *macrocarpum* fruits to 324.08 ± 9.27 kcal/100g in *D. praehensilis* tubers.

Table 5.2: Proximate composition of *S. comorensis* fruits, *S. guineense* subsp. *macrocarpum* fruits, and *D. praehensilis* tubers consumed in Dibatie district, Metekel zone, western Ethiopia.

Nutrients	**Plant species**		
	S. comorensis	*S. guineense* subsp. *macrocarpum*	*D. praehensilis*
Moisture fresh weight (g/100g)	77.42 ± 0.76^{b}	82.24 ± 1.66^{a}	71.15 ± 2.02^{c}
Moisture dry weight (g/100g)	15.75 ± 0.35^{a}	16.50 ± 0.00^{a}	16.25 ± 1.77^{a}
Total ash (g/100g)	2.25 ± 0.35^{a}	2.00 ± 0.50^{ab}	1.17 ± 0.29^{b}
Crude fiber (g/100g)	14.00 ± 1.41^{a}	15.50 ± 0.71^{a}	2.50 ± 0.71^{b}
Crude fat (g/100g)	4.00 ± 0.71^{a}	0.75 ± 0.25^{b}	0.75 ± 0.25^{b}
Crude protein (g/100g)	4.38 ± 0.17^{c}	5.60 ± 0.18^{b}	10.50 ± 0.18^{a}
Carbohydrate (g/100g)	59.63 ± 3.00^{b}	59.65 ± 1.28^{b}	68.83 ± 2.82^{a}
Energy (kcal/100g)	292.00 ± 4.95^{b}	267.75 ± 5.56^{c}	324.08 ± 9.27^{a}

Values are the mean ± SD of triplicate analyses. Values with different superscripts within a row are different ($p < 0.05$) using one-way ANOVA, Tukey's test.

In the current study, lyophilized plant parts were almost similar ($p > 0.05$) in moisture content. The decrease in moisture content usually inhibits microbial development and enzymatic activity, keeping fruits and vegetables fresher for long periods of time (Liu et al., 2023). Ash content is often considered the amount of inorganic, macro, and essential minerals in fruits and vegetables (Alzahrani et al., 2017). Soluble fibers were reported to drop serum cholesterol levels, and insoluble fibers have laxative advantages for human health (Slavin & Lloyd, 2012). The lower crude protein content in fruits might be linked with the existence of non-protein nitrogen in senescent tissues and overripe fruits (Vincente et al., 2014). Carbohydrates are the most prevalent macronutrient in edible fruits and vegetables, ranging from 50 to 80% (Vincente et al., 2014). This confirms the abundance of carbohydrates in the studied plants. Consistent with the present findings, Yimer et al. (2023a) reported maximum gross energy (354.1 ± 5.4 kcal/100g) from the tubers of *D. praehensilis*. Besides, the sweet fruits of *Syzygium guineense* (Wild.) DC. subsp. *guineense* and *Carissa spinarum* L. were reported to have high energy values (Aragaw et al., 2021), similar to the wild edible fruits in the current finding. This indicates the essential role of wild fruits and vegetables as rich sources of energy for local communities.

5.3.3. Mineral composition

The present study analyzed the calcium, copper, iron, magnesium, manganese, phosphorus, potassium, sodium, and zinc contents of the studied WEPs (Table 5.3). Calcium content ranged from 522.27 ± 12.23 mg/100g in *S. comorensis* fruits to 995.04 ± 9.45 mg/100g in *D. praehensilis* tubers. Both *S. comorensis* fruits and *D. praehensilis* tubers had 0.50 ± 0.04 mg/100g copper content, while it was found to be below the detection limit in *S. guineense* subsp. *macrocarpum* fruits. The studied plants exhibited iron content ranging from 19.80 ± 1.31 mg/100g in *S. comorensis* fruits to 111.94 ± 5.11 mg/100g in *D. praehensilis* tubers. The magnesium content ranged from 923.25 ± 7.21 mg/100g in *S. comorensis* fruits to 1592.18 ± 13.17 mg/100g in *S. guineense* subsp. *macrocarpum* fruits. The manganese content ranged from 0.50 ± 0.06 mg/100g in *S. guineense* subsp. *macrocarpum* fruits to 5.72 ± 0.21 mg/100g in *D. praehensilis* tubers. The phosphorus content was significantly ($p < 0.05$) varied among the studied plants, ranging from 0.49 ± 0.01 mg/100g in *D. praehensilis* tubers to 0.92 ± 0.01 mg/100g in *S. comorensis* fruits. Potassium content ranged from 591.69 ± 7.99 mg/100g in *D. praehensilis* tubers to 1357.71 ± 3.20 mg/100g in *S. comorensis* fruits. Sodium content ranged from 0.60 ± 0.20 mg/100g in *S. comorensis* fruits to 17.17 ± 0.40 mg/100g in *S. guineense* subsp. *macrocarpum* fruits. The studied plants had zinc content ranging from 1.00 ± 0.03 mg/100g in *D. praehensilis* tubers to 1.74 ± 0.10 mg/100g in *S. guineense* subsp. *macrocarpum* fruits.

Table 5.3: Mineral composition of *S. comorensis* fruits, *S. guineense* subsp. *macrocarpum* fruits, and *D. praehensilis* tubers consumed in Dibatie district, Metekel zone, western Ethiopia.

Minerals	**Plant species**		
	S. comorensis	*S. guineense* subsp. *macrocarpum*	*D. praehensilis*
Calcium (mg/100g)	522.27 ± 12.23^{c}	919.09 ± 11.12^{b}	995.04 ± 9.45^{a}
Copper (mg/100g)	0.50 ± 0.04^{a}	BDL	0.50 ± 0.04^{a}
Iron (mg/100g)	19.80 ± 1.31^{b}	22.36 ± 2.06^{b}	111.94 ± 5.11^{a}
Magnesium (mg/100g)	923.25 ± 7.21^{c}	1592.18 ± 13.17^{a}	1044.79 ± 8.14^{b}
Manganese (mg/100g)	1.73 ± 0.11^{b}	0.50 ± 0.06^{c}	5.72 ± 0.21^{a}
Phosphorus (mg/100g)	0.92 ± 0.01^{a}	0.54 ± 0.00^{b}	0.49 ± 0.01^{c}
Potassium (mg/100g)	1357.71 ± 3.20^{a}	1094.83 ± 3.39^{b}	591.69 ± 7.99^{c}
Sodium (mg/100g)	0.60 ± 0.20^{b}	17.17 ± 0.40^{a}	16.98 ± 0.20^{a}
Zinc (mg/100g)	1.73 ± 0.10^{a}	1.74 ± 0.10^{a}	1.00 ± 0.03^{b}

Values are the mean ± SD of triplicate analyses. Values with different superscripts within a row are different ($p < 0.05$) using one-way ANOVA, Tukey's test. BDL: below detection limit.

Root and tuberous vegetables were reported to contain a substantial level of calcium (Campos et al., 2018; Mithril et al., 2013), which is consistent with the current results. Calcium takes part in bone growth, tooth repair, and muscle contraction (Tharmabalan, 2023). Similarly, root and tuberous vegetables were reported to have substantial levels of iron (Campos et al., 2018; Mithril et al., 2013). Iron plays vital roles in erythropoiesis, hemoglobin oxygenation, oxidation-reduction reactions, immune function, cell division and development, DNA synthesis, protein metabolism, thyroid hormone regulation, and neurotransmitter formation (Mohammadifard et al., 2019). The amounts of magnesium in the studied plants are higher than the values (68.20–588.10 mg/100g) reported by a previous study in southwest Ethiopia (Yimer et al., 2023a). Dietary consumption of magnesium-rich plants reduces the frequency of obesity, type 2 diabetes, and metabolic disorders (Piuri et al., 2021). Manganese was reported to play essential roles in the protection of impaired glucose metabolism and cardiometabolic health (Lo et al., 2021). In the studied three WEPs, potassium was in higher concentration than sodium. Hence, the sodium-to-potassium ratio was less than one in the investigated plants. This is similar to the reports disseminated by Yimer et al.

(2023a) in WEPs from southwest Ethiopia. Zinc is essential for the growth, differentiation, and apoptosis of cells, in addition to its role in the immune system, energy production, hemostasis, thrombosis, repair, reproduction, vision, taste, neurogenesis, and wound healing (Maret & Sandstead, 2006; Mohammadifard et al., 2019).

5.3.4. Functional properties

The lyophilized powders of the studied WEPs were analyzed for techno-functional properties as presented in Table 5.4. The *D. praehensilis* tubers had the highest (0.60 ± 0.01 g/mL) bulk density, and *S. guineense* subsp. *macrocarpum* fruits exhibited the lowest (0.37 ± 0.01 g/mL). The *D. praehensilis* tubers were significant ($p < 0.05$) in water absorption index (3.57 ± 0.12 g/g). Fruits of *S. comorensis* had the highest (37.50 ± 0.50%) water solubility index, while tubers of *D. praehensilis* had the lowest (6.50 ± 0.50%). Out of the studied WEPs, *D. praehensilis* tubers had the highest water holding capacity (4.20 ± 0.17 g/g). On the other hand, *S. guineense* subsp. *macrocarpum* fruits had the highest oil absorption index (2.00 ± 0.00 mL/g). The *D. praehensilis* tubers had the highest foaming capacity (45.24 ± 2.18%) and foam stability (45.24 ± 2.18%) compared to the other studied plants.

Table 5.4: Techno-functional properties of *S. comorensis* fruits, *S. guineense* subsp. *macrocarpum* fruits, and *D. praehensilis* tubers consumed in Dibatie district, Metekel zone, western Ethiopia.

Functional properties	**Plant species**		
	S. comorensis	*S. guineense* subsp. *macrocarpum*	*D. praehensilis*
Bulk density (g/mL)	0.39 ± 0.01^{b}	0.37 ± 0.01^{c}	0.60 ± 0.01^{a}
Water absorption index (g/g)	3.05 ± 0.01^{b}	3.20 ± 0.14^{b}	3.57 ± 0.12^{a}
Water solubility index (%)	37.50 ± 0.50^{a}	33.50 ± 0.50^{b}	6.50 ± 0.50^{c}
Water holding capacity (g/g)	3.57 ± 0.23^{b}	3.48 ± 0.05^{b}	4.20 ± 0.17^{a}
Oil absorption index (mL/g)	1.20 ± 0.20^{b}	2.00 ± 0.00^{a}	1.50 ± 0.10^{b}
Foaming capacity (%)	2.33 ± 0.33^{b}	2.33 ± 0.33^{b}	45.24 ± 2.18^{a}
Foam stability (%)	0.00 ± 0.00^{b}	0.00 ± 0.00^{b}	45.24 ± 2.18^{a}

Values are the mean ± SD of triplicate analyses. Values with different superscripts within a row are different ($p < 0.05$) using one-way ANOVA, Tukey's test.

Bulk density affects the extent of food flows, packaging design, and volume of packaging materials (Afoakwah, 2022). In support of the current study, the water absorption index is greater in starch-rich foods owing to the gelatinization of more starch granules to absorb water (Webb et al., 2020). The extent of particle dissolution and damage to molecular components in water is indicated by the water solubility index (Haritha et al., 2014; Jyothi et al., 2009). Water solubility is usually affected by temperature (Afoakwah, 2022), chemical components, and the physical nature of the food powder (Haritha et al., 2014). Hence, in this study, the edible fruits were more soluble than the tubers. This might be due to the easily soluble fructose sugars found in the ripening fruits. The water holding capacity of *D. praehensilis* tubers in the current study was comparable with that of *Helianthus tuberosus* L. tubers (4.78 ± 0.31 g/g) reported by Afoakwah (2022). This implies a similarity in the functional properties of certain tuberous edible plants. Water holding capacity determines the swelling, emulsification, viscosity, and gelation of food components (Lobo et al., 2021). Oil absorption index is crucial in the food processing industry as it enhances the aroma and taste of food products (Adebo & Kesa, 2023; Kesselly et al., 2023). As foaming agents, the food proteins migrate to the air-water boundary and form a cohesive layer surrounding the air bubbles when shaken (Romano et al., 2021). In this context, the foaming capability observed in the *D. praehensilis* tubers in the current findings confirmed its protein composition compared to the other investigated WEPs.

5.3.5. Anti-nutritional factors

The current results showed that the level of phytic acid ranged from 65.11 ± 1.44 mg/100g in *S. comorensis* fruits to 70.67 ± 1.68 mg/100g in *S. guineense* subsp. *macrocarpum* fruits. The amount of oxalic acid ranged from 170.00 ± 20.00 mg/100g in *S. guineense* subsp. *macrocarpum* fruits to 790.00 ± 110.00 mg/100g in *S. comorensis* fruits. The tannin content ranged from 196.51 ± 4.93 mg CE/100g in *D. praehensilis* tubers to 11147.55 ± 139.26 mg CE/100g in *S. comorensis* fruits (Table 5.5).

Table 5.5: Anti-nutritional constituents of *S. comorensis* fruits, *S. guineense* subsp. *macrocarpum* fruits, and *D. praehensilis* tubers consumed in Dibatie district, Metekel zone, western Ethiopia.

Anti-nutritional compounds	**Plant species**		
	S. comorensis	*S. guineense* subsp. *macrocarpum*	*D. praehensilis*
Phytic acid (mg/100g)	65.11 ± 1.44^{b}	70.67 ± 1.68^{a}	69.88 ± 0.03^{a}
Oxalic acid (mg/100g)	790.00 ± 110.00^{a}	170.00 ± 20.00^{b}	190.00 ± 20.00^{b}
Tannins (mg CE/100g)	11147.55 ± 139.26^{a}	6094.11 ± 189.77^{b}	196.51 ± 4.93^{c}

Values are the mean ± SD of triplicate analyses. Values with different superscripts within a row are different ($p < 0.05$) using one-way ANOVA, Tukey's test. CE: catechin equivalent.

The amount of phytic acid in the studied plants was higher than the previous reports, 0.02–0.17 mg/100g (Adamu et al., 2022) and 0.33–1.52 mg/100g (Yiblet, 2024), on the phytate content of WEPs. On the other hand, our results were lower than the levels of phytic acid (175.60–307.30 mg/100g) in the leaves of *Cleome gynandra* L., *Solanum nigrum* L., and *Vigna membranacea* A. Rich. (Yimer et al., 2023a). The study plants were also higher in oxalate content relative to the reports, 3.37–11.73 mg/100g (Adamu et al., 2022) and 0.52–0.92 mg/100g (Yiblet, 2024) in the earlier studies. However, similar findings by Yimer et al. (2023a) revealed oxalate content in the leaves of *C. gynandra* (205.00 mg/100g), *S. nigrum* (443.90 mg/100g), and *V. membranacea* (307.30 mg/100g), which were higher than in the current plants except for *S. comorensis* fruits. The sweetly sour taste of *S. comorensis* fruits might be due to the high oxalic acid concentration, which induces a sharp acidic taste (Bello et al., 2019). It was indicated that diets high in phytic acid and oxalates resulted in low bioavailability of calcium, causing calcium deficiency diseases like rickets and osteomalacia (Pettifor, 2014).

The amount of tannins in the studied plants was much greater than that in the previous reports by Adamu et al. (2022) (1.38–5.49 mg/100g) and Yiblet (2024) (0.23–0.53 mg/100g). However, the level of tannins (6314 mg/100g) in *Ximenia caffra* Sond. revealed by Getachew et al. (2013) is higher than the present reports, except for *S. comorensis* fruits. Consistent with the current findings, it was reported that higher levels of tannins are found in edible fruit parts than in tubers (Getachew et al., 2013). The highest tannin content might be very crucial in medicinal perspectives owing to the antioxidant role of tannic acid (Gülçin et al., 2010), although it affects the absorption of nutrients in the human body (Kiewlicz & Rybicka, 2020; Samtiya et al., 2020). The phytic acid, oxalic acid, and tannins in *D. praehensilis* tubers were higher in the current findings relative to a similar study conducted on the same plant (Yimer et al., 2023a). The variation in the anti-nutritional levels might be because of the differences in the edaphic (soil) factors where the plant samples were collected. Since anti-nutritional factors pose adverse effects on nutrient bioavailability, certain food preparation approaches like fermentation, cooking, puffing, and soaking can be employed to reduce their amount in edible plants (Samtiya et al., 2020).

5.3.6. Antioxidant activity

5.3.6.1. DPPH free radical scavenging activity

The DPPH free radical scavenging capacity of the three studied WEPs is shown in Figure 5.2. Accordingly, as the concentration of extracts increased, so did their capacity to scavenge free radicals. With the corresponding concentrations (0.00, 0.02, 0.04, 0.08, 0.12, 0.16, and 0.20 mg/mL), the methanolic extracts of *S. comorensis* fruits had the highest (% inhibition = 0.00, 30.60, 56.88, 69.96, 81.79, 83.36, and 84.71) DPPH free radical scavenging ability, followed by the extracts of *S. guineense* subsp. *macrocarpum* fruits (% inhibition = 0.00, 13.98, 31.15, 50.20, 74.32, 83.27, and 87.39). Whereas, extracts of *D. praehensilis* tubers exhibited the lowest DPPH free radical scavenging activity (% inhibition = 0.00, 4.13, 10.93, 22.07, 27.85, 36.26, and 41.24).

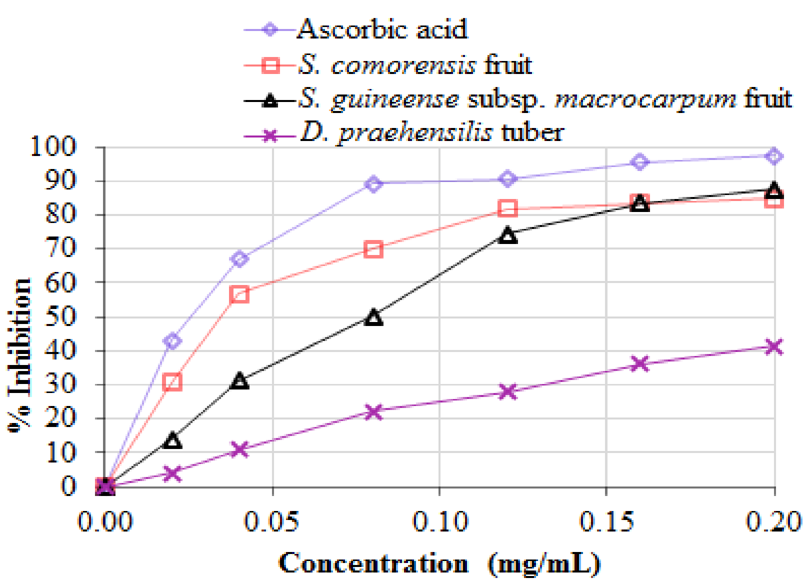

Figure 5.2. DPPH free radical scavenging activity of *S. comorensis* fruits, *S. guineense* subsp. *macrocarpum* fruits, and *D. praehensilis* tubers consumed in Dibatie district, Metekel zone, western Ethiopia.

It was realized that antioxidants decrease DPPH free radicals by providing electrons and creating stable compounds, for example, 2,2-diphenyl-1-hydrazine (Mahadkar et al., 2013). Free radicals like reactive oxygen species damage biomolecules, leading to oxidative stress at higher concentrations (Phaniendra et al., 2015). Antioxidant phenolic compounds have the ability to scavenge free radicals and prevent the oxidation of cellular components (Alu'datt et al., 2018). Hence, they reduce the incidence of chronic illnesses like diabetes, cardiovascular and gastrointestinal disorders, and some types of cancer (Phaniendra et al., 2015). Antioxidant molecules from plants include phytochemicals such as phenolics, flavonoids, flavonols, tannins, saponins, proanthocyanidins, and α-glucosidase, among others (Alu'datt et al., 2018).

The lowest concentration of plant extracts required to prevent 50% of free radicals in DPPH is presented in Figure 5.3. Accordingly, extracts of *S. comorensis* and *S. guineense* subsp. *macrocarpum* fruits exhibited substantial antioxidant capacity, with respective IC_{50} values of 0.07 and 0.09 mg/mL, compared to ascorbic acid (IC_{50} = 0.04 mg/mL). Whereas, the lowest antioxidant ability was observed in extracts of *D. praehensilis* tubers (IC_{50} = 0.23 mg/mL). Similar to the current findings, Yimer et al. (2023b) revealed that *D. praehensilis* tubers had the least antioxidant capacity among the studied WEPs in southwest Ethiopia. This implies that *D. praehensilis* tubers are insignificant in terms of antioxidant activity relative to certain WEPs.

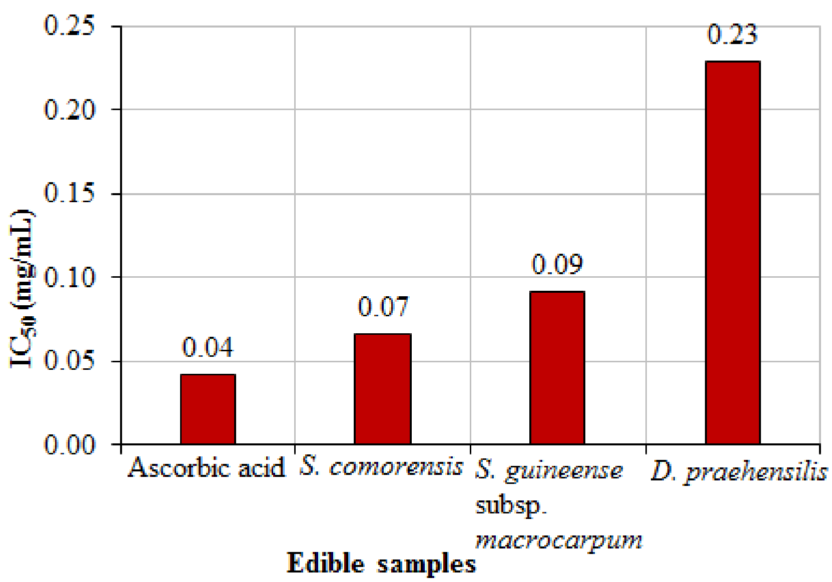

Figure 5.3. IC_{50} values in scavenging DPPH free radicals by *S. comorensis* fruits, *S. guineense* subsp. *macrocarpum* fruits, and *D. praehensilis* tubers consumed in Dibatie district, Metekel zone, western Ethiopia.

5.3.6.2. Ferric-reducing antioxidant power (FRAP)

The antioxidant activity of the three WEPs was also measured using the ferric-reducing power of the methanolic extracts (Table 5.6). The highest ferric reducing power was obtained in the extracts of *S. guineense* subsp. *macrocarpum* fruits (133.00 ± 4.15 mg AAE/100g extract) ($p < 0.05$) compared to the extracts of *S. comorensis* fruits (90.10 ± 5.03 mg AAE/100g extract) and *D. praehensilis* tubers (85.31 ± 0.73 mg AAE/100g extract), with a concentration of 0.15 mg/mL.

Table 5.6: Ferric reducing capacity of *S. comorensis* fruits, *S. guineense* subsp. *macrocarpum* fruits, and *D. praehensilis* tubers consumed in Dibatie district, Metekel zone, western Ethiopia.

Wild edible plant species	**FRAP at 0.15 mg/mL**
	mg AAE/100g extract
S. comorensis	90.10 ± 5.03^{b}
S. guineense subsp. *macrocarpum*	133.00 ± 4.15^{a}
D. praehensilis	85.31 ± 0.73^{b}

Values are the mean ± SD of triplicate analyses. Values with different superscripts within a column are different ($p < 0.05$) using one-way ANOVA, Tukey's test. AAE: ascorbic acid equivalent.

5.3.7. Phytochemical constituents

Phytochemicals such as phenolics, flavonoids, and alkaloids were significantly ($p < 0.05$) different among the edible parts of the studied plants (Table 5.7). Total phenolics content was the highest in extracts of *S. comorensis* fruits (285.01 ± 5.77 mg GAE/100g), and it was found to be the lowest in extracts of *D. praehensilis* tubers (73.81 ± 1.10 mg GAE/100g). The extracts of *S. comorensis* fruits had also the highest total flavonoids (241.87 ± 4.37 mg QE/100g), while extracts of *D. praehensilis* tubers exhibited the lowest (124.97 ± 5.35 mg QE/100g). The alkaloids content ranged from 2000.00 ± 710.00 mg/100g in *D. praehensilis* tubers to 6500.00 ± 710.00 mg/100g in *S. comorensis* fruits.

Table 5.7: Phytochemical constituents of *S. comorensis* fruits, *S. guineense* subsp. *macrocarpum* fruits, and *D. praehensilis* tubers consumed in Dibatie district, Metekel zone, western Ethiopia.

Phytochemical compounds	**Plant species**		
	S. comorensis	*S. guineense* subsp. *macrocarpum*	*D. praehensilis*
Total phenolics (mg GAE/100g dry extract)	285.01 ± 5.77[a]	174.66 ± 7.22[b]	73.81 ± 1.10[c]
Total flavonoids (mg QE/100g dry extract)	241.87 ± 4.37[a]	168.65 ± 4.26[b]	124.97 ± 5.35[c]
Total alkaloids (mg/100g dry sample)	6500.00 ± 710.00[a]	4750.00 ± 350.00[b]	2000.00 ± 710.00[c]

Values are the mean ± SD of triplicate analyses. Values with different superscripts within a row are different ($p < 0.05$) using one-way ANOVA, Tukey's test. GAE: gallic acid equivalent; QE: quercetin equivalent.

The total phenolics in the studied plants were higher compared to the values (0.79–17.02 mg GAE/100g) reported by Adamu et al. (2022) in WEPs collected from northeastern Ethiopia. However, the total phenolics in the studied plants were lower than the values (2297.00–3573.00 mg GAE/100g) reported for the leaves of *Cleome gynandra*, *Solanum nigrum*, *Trilepisium madagascariense* DC., and *Vigna membranacea* collected from southwest Ethiopia (Yimer et al., 2023b). It has been suggested that plant-based phenolics have antioxidant benefits and prevent a number of chronic illnesses (Adamu et al., 2022; Asami et al., 2003). The total flavonoids in the studied plants were much greater than the values (2.27–7.12 mg QE/100g) in WEPs reported by Adamu et al. (2022). Flavonoids modulate intracellular signaling cascades, which are essential to cellular functions, in addition to their antioxidant properties (Williams et al., 2004). The plant-derived alkaloids are reported to have a healing ability for myotonic dystrophy type I (Herrendorff et al., 2016). Due to the fact that different plant species may produce various levels of secondary metabolites, the phytochemical constituents vary among different wild edible plant species. Therefore, the investigated WEPs will have various antioxidant and therapeutic potentials in addition to their nutritional importance.

5.4. Conclusions

In this study, *S. comorensis* fruits were significant in titratable acidity, TSS, and vitamin C. The fruits of both *S. comorensis* and *S. guineense* subsp. *macrocarpum* were rich in crude fiber content. Overall, the three wild edible plants were appreciated for their carbohydrate content and calorific values. The studied plants were also chief sources of minerals like calcium, magnesium, iron, sodium, and potassium. The amount of phytic acid was optimal in the three investigated plants, while the levels of oxalic acid and tannins were found to be high in *S. comorensis* fruits. The fruits of *S. comorensis* and *S. guineense* subsp. *macrocarpum* were observed to have substantial levels of phytochemicals, which are essential to their antioxidant activities. Thus, they showed significant ($p < 0.05$) DPPH free radical scavenging ability and ferric reducing power, respectively. Since they are nutritionally and pharmaceutically essential, the studied plants need to be conserved and widely used in the form of various food products by the local community as well as other societies in the country.

CHAPTER SIX

6. General Discussion, Conclusions and Recommendations

6.1. Discussion

This study involved four parts, as follows: in **Paper I**, we assessed the traditional use of medicinal plants in the Dibatie district of the Metekal zone, western Ethiopia. **Paper II** evaluated the antibacterial activity, antioxidant capacity, and phytochemical content of medicinal plants including *Asparagus flagellaris*, *Brucea antidysenterica*, *Celosia trigyna*, *Crepis rueppellii*, *Gnidia involucrata*, *Polystachya steudneri*, and *Sauromatum venosum*. In **Paper III**, we also assessed the traditional usage of wild edible plants by local residents of Dibatie district, Metekal zone, western Ethiopia. **Paper IV** analyzed the nutritional composition, techno-functional profile, anti-nutritional content, antioxidant ability, and phytochemical constituents of commonly edible wild plants, including *Saba comorensis*, *Syzygium guineense* subsp. *macrocarpum*, and *Dioscorea praehensilis*.

The ethnomedicinal study, in **Paper I**, documented 170 medicinal plant species utilized to treat various human and livestock ailments. It was confirmed that 35.88% of the medicinal plants in the study area were herbaceous (Figure 2.2), and 79.41% of them were collected from wild sources (Figure 2.3). Nevertheless, wild medicinal plants are highly exposed to habitat destruction, which may lead to the decline of plant resources and associated indigenous knowledge as indicated by Teklehaymanot (2017). It was reported that local people prepare most (41.17%) of the herbal remedies from multiple parts of the medicinal plants (Figure 2.5). In the study area, local practitioners prescribe most (60.13%) of the medicinal plants in fresh states (Figure 2.6). The traditional medicines were often administered through oral (52.21%) routes of application (Figure 2.8). This may increase the healing potential of the herbal remedies due to the fast reaction rate (Bekele et al., 2022). Traditional healers prepare and/or prescribe medicinal plants with different additives to minimize the risk of toxicity and adverse effects, improve the taste, and increase the healing efficacy (Chekole, 2017; Eshete & Molla, 2021).

Out of the recorded medicinal plants, *Embelia schimperi*, *Glinus lotoides*, *Haplosciadium abyssinicum*, *Mucuna melanocarpa*, and *Phragmanthera macrosolen* showed the highest (100%) fidelity level values against corresponding ailments (Table 2.6). This indicates that these plants are effective in treating specific diseases in the study area. Local people in the study area use medicinal plants for several purposes besides their medicinal roles (Appendix 1). For instance, *Breonadia salicina, Ficus sycomorus,* and *Terminalia laxiflora* were the most widely utilized medicinal plants with the highest use value (Table 2.9). However, multiple uses of medicinal plants can lead to overexploitation, threatening the survival of the plants (Eshete & Molla, 2021; Megersa & Tamrat, 2022; Tahir et al., 2021; Yimam et al., 2022). As a result, multipurpose medicinal plants require appropriate conservation measures to ensure their sustainable usage in the future.

Paper II places emphasis on the antibacterial activity, antioxidant potential, and phytochemical profiles of selected medicinal plants including *Asparagus flagellaris*, *Brucea antidysenterica*, *Celosia trigyna*, *Crepis rueppellii*, *Gnidia involucrata*, *Polystachya steudneri*, and *Sauromatum venosum*. The medicinal plants were traditionally reported to treat human ailments such as toothache, leishmaniasis, tapeworm, diarrhea, gonorrhea, wounds, and amoeba, respectively (Table 3.1). These diseases are caused by the infections of parasitic helminthes, protozoa, or bacteria. Hence, we evaluated the antibacterial activity of the above-mentioned medicinal plants to validate their traditional uses. Accordingly, the ethanolic extract of *P. steudneri* pseudobulb was the most effective antibacterial against gram-negative bacterial strains (*P. mirabilis*, *S. typhimurium*, *K. pneumoniae*, *E. coli,* and *S. flexneri*) (Table 3.2). The ethanolic extracts of *P. steudneri* pseudobulb and *G. involucrata* stem were the most active against gram-positive bacteria (*S. aureus, S. epidermidis*, *S. agalactiae,* and *E. faecalis*) (Table 3.3). It is understood that the antibacterial activity of medicinal plants depends on the availability and type of bioactive phytocontituents, the extraction ability of the solvents, the susceptibility of the bacterial strain, and the mutual effect of the three aforementioned situations (Guadie et al., 2020). In this regard, *P. steudneri* was the most effective antibiotic plant, and *S. agalactiae* was found to be the most sensitive bacterial strain (Figure 3.1).

Next to ascorbic acid, ethanolic extracts of *G. involucrata* stem and root exhibited the highest DPPH free radical scavenging activity, with IC_{50} values of 168.68 and 181.79 µg/mL, respectively (Figures 3.2 and 3.3). Medicinal plants have elevated amounts of antioxidants that can prevent or postpone the oxidation of lipids and other cellular components. Consequently, they are well recognized for their several health advantages, which include lowering blood pressure, preventing cardiovascular illnesses, and decreasing the risk of cancer (Škrovánková et al., 2012).

Additionally, it was reported that medicinal plants with rich phenolic compounds were found to be good antioxidants (Afrokh et al., 2023). The qualitative phytochemical screening in this study showed that the selected medicinal plants were positive (+) for the majority of examined phytocompounds, such as alkaloids, anthocyanins, anthraquinones, cardiac glycosides, coumarins, flavonoids, phenols, saponins, steroids, tannins, and terpenoids (Table 3.4).

Paper III focuses on the ethnobotanical investigation of wild edible plants in Dibatie district, Metekel zone, western Ethiopia. This section of our study documented 54 wild edible plants that were consumed by local communities as supplementary or famine foods. The WEPs in the study area were dominated by trees (38.90%), followed by shrub (33.30%) growth forms (Figure 4.3). The majority (72.20%) of them were recorded to have edible fruit parts (Figure 4.4). This might be due to the fact that fruits are easily consumable outdoors (during farming, travel, and livestock herding) without extra processing (Guzo et al., 2023). Moreover, WEPs in the study area were usually harvested during the dry months, i.e., December to May (Figure 4.5). This is because edible fruits of trees and shrubs were mostly reported to be ripened during the dry seasons compared to the rainy periods (Kidane et al., 2014).

Furthermore, it was reported that most (31 species, 57.41%) WEPs in the study area were consumed freshly raw without processing (Table 4.3). The local people consume the majority (70%) of these plants as alternative food during normal times and eat some (30%) of them to recover the scarcity of food (Figure 4.6). As a result, local residents in the study area mainly rely on WEPs as secondary sources of food. The current study area is quite productive for cultivated crops and receives a sufficient amount of annual rainfall. Hence, the frequency of visiting WEPs depends on the productivity of staple crops in the area (Fentahun & Hager, 2009; Ocho et al., 2012). In addition to their nutritional value, the locals use WEPs for a variety of purposes. These include beehive hanging trees, beehive raw materials, charcoal, cleaning supplies, building materials, fences, fodder, fuel wood, lubricant, household utensils, medicine, decorations, tooth brushes, shade, timber, and traditional soap. However, the conservation of these multipurpose plant resources was very limited, as they were threatened by various anthropogenic factors in their natural habitats.

The 4th paper (**Paper IV**) deals with the evaluation of nutritional composition, techno-functional property, antioxidant capacity, and phytochemicals of commonly edible wild plant species, such as *Saba comorensis, Syzygium guineense* subsp. *macrocarpum,* and *Dioscorea praehensilis* in Dibatie district, Metekel zone, western Ethiopia. Out of the studied plants, the fruits of *S. comorensis* were the most acidic and rich in vitamin C, with pH values of 3.52 compared to others (Table 5.1). Additionally, the fruits of *S. comorensis* contained total soluble solids (15.50 ± 0.56 °Brix) that were comparable to several mango-based products (Kaushik et al., 2015). It is suggested that the acidity of fruits and vegetables could increase their shelf-life, prevent microorganisms, and raise their nutritional quality (Ali et al., 2020; Ghimire et al., 2021).

The fruits of *S. comorensis* (14.00 ± 1.41 g/100g) and *S. guineense* subsp. *macrocarpum* (15.50 ± 0.71 g/100g) had a significant amount of crude fiber content. The studied plants contained carbohydrates ranging from 59.63 ± 3.00 g/100g in *S. comorensis* fruits to 68.83 ± 2.82 g/100g in *D. praehensilis* tubers. They contained energy ranging from 267.75 ± 5.56 kcal/100g in *S. guineense* subsp. *macrocarpum* fruits to 324.08 ± 9.27 kcal/100g in *D. praehensilis* tubers (Table 5.2). Here, the carbohydrates and energy content might be rich in *D. praehensilis* due to the accumulation of more starch in edible tubers than in fruits. The studied plants were rich in minerals like calcium (522.27 ± 12.23-995.04 ± 9.45 mg/100g), iron (19.80 ± 1.31-111.94 ± 5.11 mg/100g), magnesium (923.25 ± 7.21-1592.18 ± 13.17 mg/100g), and potassium (591.69 ± 7.99-1357.71 ± 3.20 mg/100g), among others (Table 5.3). It is known that the mineral content of edible plants is associated with health issues and indicates their nutritional quality (Wu et al., 2018). For example, disparities in electrolytes such as calcium, magnesium, sodium, and potassium may cause cardiovascular diseases like hypertension and heart-related diseases (Mohammadifard et al., 2019).

The analysis of techno-functional properties among the examined plants revealed that *D. praehensilis* tubers had significantly ($p < 0.05$) the highest bulk density, water absorption index, water holding capacity, foaming capacity, and foam stability (Table 5.4). However, the fruits of *S. comorensis* and *S. guineense* subsp. *macrocarpum* had the highest water solubility index and oil absorption index, respectively. It has been realized that the functional properties of plant-based foods depend on their physicochemical characteristics, post-harvest processing procedures, and degree of grinding or particle size (Saha et al., 2023). Hence, the functional properties of edible plants could influence their processing, quality, and usage as food and in food preparations (Sahan et al., 2015). Regarding the anti-nutritional factors, *S. guineense* subsp. *macrocarpum* fruits and *D. praehensilis* tubers were significantly ($p < 0.05$) greater in phytate content (Table 5.5).

However, the levels of oxalic acid (790.00 ± 110.00 mg/100g) and tannins (11147.55 ± 139.26 mg CE/100g) were significantly ($p < 0.05$) the highest in *S. comorensis* fruits. In this sense, high consumption of WEPs containing elevated amounts of anti-nutritional factors like phytates, oxalates, and tannins may lead to a deficiency of macro- and micronutrients due to the impairment of their bioavailability (Getachew et al., 2013).

Out of the investigated WEPs, *S. comorensis* fruits exhibited the highest DPPH free radical scavenging capacity, and *S. guineense* subsp. *macrocarpum* fruits showed substantial ferric reducing power, while *D. praehensilis* tubers were found to have the least antioxidant power (Figure 5.2 and Table 5.6). Besidies, *S. comorensis* fruits were found significantly ($p < 0.05$) to have the highest amount of total phenolics, total flavonoids, and total alkaloids, followed by fruits of *S. guineense* subsp. *macrocarpum* (Table 5.7). This confirms that the antioxidant activity of the plants is linked to their phytoconstituents, such as flavonoids and phenolic compounds (Chigayo et al., 2016).

6.2. Conclusions

In this study, the ethnobotanical investigation of medicinal plants has documented 170 plant species, which were traditionally used to treat about 79 human and 29 livestock ailments in Dibatie district of the Metekal zone, western Ethiopia. The local people were endowed with huge indigenous knowledge of how to use a variety of plant resources in their area. Local residents indicated that they prefer traditional healers rather than conventional health centers to treat certain ailments like Bell's palsy, boils, general malaise, hemorrhoids, hepatitis, herpes, impotency, leishmaniasis, lymphadenitis, rabies, rectal prolapse, scorpion venom, and snake venom, among others. It has been reported that traditional medicine is sometimes preferable to modern healthcare systems to treat some diseases in Ethiopia (Tahir et al., 2023b; Teshome et al., 2023). Consequently, the inhabitants of Dibatie district rely highly on herbal medicines for the treatment of several human and domestic animal diseases.

Out of the ethnobotanically recorded medicinal plants, *Asparagus flagellaris*, *Brucea antidysenterica*, *Celosia trigyna*, *Crepis rueppellii*, *Gnidia involucrata*, *Polystachya steudneri*, and *Sauromatum venosum* were examined for their antibacterial activity, antioxidant potential, and phytochemical profiles. The studied plants were active against gram-negative (*Proteus mirabilis*, *Salmonella typhimurium*, *Klebsiella pneumoniae*, *Escherichia coli*, and *Shigella flexneri*) and gram-positive (*Staphylococcus aureus, Staphylococcus epidermidis*, *Streptococcus agalactiae*, and *Enterococcus faecalis*) bacterial strains at different concentration levels. Additionally, they were observed to be good antioxidants relative to the positive control. Furthermore, the examined plants were found to contain the majority of the tested phytochemicals, namely alkaloids, anthocyanins, anthraquinones, cardiac glycosides, coumarins, flavonoids, phenols, saponins, steroids, tannins, and terpenoids. As a result, our findings supported the local use of the examined plants in herbal medicine.

The ethnobotanical study also documented 54 wild edible plant species, which were traditionally consumed by the native people in the Dibatie district of the Metekal zone, western Ethiopia. The recorded plants were often consumed as supplementary foods and rarely eaten as famine foods during the shortage of cultivated crops. This is because the tendency to consume WEPs was highly associated with the access to and productivity of staple crops. Hence, WEPs were usually eaten as a supplement to staple foods and to fill the gaps of seasonal food scarcity (Yiblet & Adamu, 2023). Wild edible plants in the study area were also appreciated in that they provide nutritional support for both domestic and wild animals. Therefore, they play an important role in food security, ecological service, and food chain balance.

The edible parts of *Saba comorensis, Syzygium guineense* subsp. *macrocarpum*, and *Dioscorea praehensilis* were subjected to nutritional, techno-functional, anti-nutritional, antioxidant, and phytochemical analyses among the identified wild edible plants in the study area. In this respect, *S. comorensis* fruits had substantial levels of titratable acidity, TSS, and vitamin C. The studied plants were rich in carbohydrates, energy, and essential minerals like calcium, magnesium, iron, sodium, and potassium. The tubers of *D. praehensilis* exhibited the highest bulk density, water absorption index, water holding ability, foaming capacity, and foam stability. The investigated plants were optimum in phytate content, though *S. comorensis* fruits were found to be high in oxalates and condensed tannins. The fruits of *S. comorensis* showed significant ($p < 0.05$) DPPH free radical scavenging activity. However, the fruits of *S. guineense* subsp. *macrocarpum* exhibited the highest ($p < 0.05$) ferric reducing power. As a result, the fruits of *S. comorensis* and *S. guineense* subsp. *macrocarpum* were good antioxidants and contained substantial amounts of phytochemicals compared to the tubers of *D. praehensilis*.

Beyond their medicinal and nutritional utility, the medicinal and wild edible plants in the study area were used for different purposes, such as apiculture, fuel wood, cleaning goods, building raw materials, fences, soil fertilizer, animal feed, ornament, shade, farming tools, and domestic furnishings. However, these multipurpose plants were gradually degraded due to various threatening factors like deforestation, agricultural expansion, overgrazing, overexploitation, root harvesting, wildfire, herbicides, and insect or fungal pests. There are limited practices of the local people toward the conservation of plant resources and associated indigenous knowledge in the study area as well as across Ethiopia as a whole (Hankiso et al., 2023; Tamene et al., 2023; Teklehaymanot, 2017). Therefore, appropriate conservation measures are needed to be applied in order to ensure the continuity of the plants along with the related indigenous knowledge throughout the country.

6.3. Recommendations

Based on the overall results, the following Key recommendations are forwarded:

- Immediate conservation practices, proper management, and careful utilization of multipurpose plants like *Breonadia salicina*, *Cordia africana*, *Croton macrostachyus*, *Ficus sur*, *Ficus sycomorus*, *Grewia mollis*, *Oxytenanthera abyssinica*, *Stereospermum kunthianum*, *Syzygium guineense* subsp. *guineense*, *Syzygium guineense* subsp. *macrocarpum*, *Terminalia laxiflora*, and so on need to be applied by the local people, the office of natural resource management in the Dibatie district, and the Ethiopian Biodiversity Institute to sustain the health and nutritional benefits and transfer them, with the associated indigenous and local knowledge, to the next generation.

- The national green legacy initiative coordinating office should include the plantation of indigenous medicinal and wild edible plants in all regions of the country.

- Appropriate registration and recognition need to be given to the traditional healers in the study area by the Dibatie district's health office, Ethiopian Food and Drug Authority, Ethiopian Public Health Institute, and the Traditional and Modern Medicine Research and Development Directorate, Armauer Hansen Research Institute, to encourage them and preserve their indigenous and local knowledge.

- The recorded medicinal plants need to be confirmed through experimental investigations by researchers, and research institutes such as the Ethiopian Public Health Institute, the Armauer Hansen Research Institute, and universities to integrate local knowledge with conventional medicine system and improve healthcare services.
- The recorded wild edible plants need to be verified through research institutes like the Ethiopian Public Health Institute and universities in collaboration with food and agricultural research centers in the Metekel zone based on additional findings on their nutritional analysis, phytochemical profile, antioxidant activity, and toxicity examination.
- Medicinal plants, such as *Asparagus flagellaris*, *Brucea antidysenterica*, *Celosia trigyna*, *Crepis rueppellii*, *Gnidia involucrata*, *Polystachya steudneri*, and *Sauromatum venosum*, showed substantial fidelity levels to treat various infectious diseases, and their 80% ethanolic extracts exhibited considerable antibacterial activities. Thus, they need to be extracted using different solvents of various polarities to extract lead compounds further for the development of appropriate drugs. Additionally, toxicity studies should be conducted to encourage further utility of these herbal medicines.
- This study confirmed that wild edible plants such as *Saba comorensis*, *Syzygium guineense* subsp. *macrocarpum*, and *Dioscorea praehensilis* were essential from nutritional and pharmaceutical perspectives. Hence, they need to be conserved in natural forests, near home gardens and farmlands, and sustainably utilized in the form of various food products by the local community in the study area as well as other people in the country.

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APPENDICES

Appendix 1: List of medicinal plants, their plant family, local name, growth habit, human or livestock ailments treated, remedy part, use condition, preparation and application, additional use, and voucher specimen number

Scientific name	Family	Local name (La)	Ha	Ailments treated	RP	Use form	Preparation and additives and application	Used for	AU	VN
Acalypha petiolaris Hochst.	Euphorbiaceae	Qemco (AO)	SSh	Stomachache	R	Fr/D	Pounded, water dissolved, filtered, and taken orally	Hu	Bf,Fd	BA-91
Acanthus polystachius Delile	Acanthaceae	Kosorruu (AO)	Sh	Impotency	R	D	Powdered with roots of *Tragia doryodes*, *Indigofera spicata*, *Momordica foetida*, root bark of *Carissa spinarum*, and tuber of *Gloriosa superba*, and taken with local drinks, chicken stew, or porridge	Hu	Bf,Fd,Fw	BA-130
				Wound worm	R	Fr	Cut into pieces and tied to the tail or horn of ill cattle	L		
Achyranthes aspera L.	Amaranthaceae	Telenj (Am)	H	Tonsillitis	R	Fr/D	Chewed with tubers of *Zingiber officinale* and spat into the mouth	Hu	Bf	BA-136
				Eye diseases	L	Fr	Rubbed, squeezed, and dropped into the infected eye	L		
				Impotency	R	D	Powdered with roots of *I. spicata*, *A. flagellaris*, *T. doryodes*, *Solanum anguivi*, tubers of *Rumex abyssinicus* and *Canarina abyssinica*, whole parts of *Polystachya steudneri*, root bark of *C. spinarum*, *Steganotaenia araliacea*, and *Pterolobium stellatum*, and taken with foods or drinks	Hu		
				Choking	R	Fr	Chewed and spat into the left nose	Hu		
				Boils	L	Fr	Rubbed, mixed with unwashed butter, and tied to being a slightly-cut infected part with a blade	Hu		
Acmella caulirhiza Delile	Asteraceae	Simmo (AO)	H	Boils	L,Ys,R	Fr/D	Crushed or powdered with fruits of *Cynoglossum lanceolatum*, leaves of *Sida rhombifolia*, and roots or flowers of *Rumex nepalensis*, mixed with honey and Hippo's skin ash, and tied on the ill site	Hu	Bf,Fd	BA-52
				Tonsillitis	R	Fr	Chewed and its filtrate swallowed	Hu		
				Thorn injury	R	Fr	Rubbed with fruits of *C. lanceolatum*, leaves of *S. rhombifolia*, and root or flowers of *R. nepalensis*, mixed with honey or salt, and tied on the infected part	Hu		
Afrocarpus falcatus (Thunb.) C.N.Page	Podocarpaceae	Birbirssa (AO)	T	Wound	B	Fr/D	Crushed or powdered and dispersed on the infected wound	Hu	Bt,Co,Fw, Sd	BA-126
				Evil eye	R,B	Fr/D	Crushed or powdered with *L. sativum* seeds, *R. chalepensis* leaves, and *A. sativum* garlics, and sniffed	Hu		
Ageratum conyzoides L.	Asteraceae	Abba korbu (AO)	H	Wound	Wp	Fr/D	Squeezed and dropped, or powdered and added to the wound	HuL	Bf,Fd	BA-70
				Wound worm	Wp	Fr/D	Crushed with leaves of *C. lanceolatum*, squeezed and dropped, or powdered and added to the wound	L		
				Boils	L	Fr/D	Crushed, mixed with honey, and tied to the infected part	Hu		

Albizia gummifera (J. F.Gmel.) C. A. Sm.	Fabaceae	Jibiya (Shi)	T	Scorpion venom	B	Fr/D	Crushed or powdered and pasted on the bitten site	Hu	Bf,Bt,Fi, Fw	BA-124
				Toothache	B	Fr/D	Crushed or powdered and inserted under the infected tooth	Hu		
				Evil eye	B	Fr	Pounded, water dissolved, filtered, and taken orally	Hu		
Albizia schimperiana Oliv.	Fabaceae	Muka booke (AO)	T	Toothache	B	Fr	Crushed and bitten on the infected tooth	Hu	Co,Fd,Fw, Ti	BA-36
Alectra sessiliflora (Vahl) Kuntze	Orobanchaceae	Sararaxe (AO)	H	Scabies	Wp	Fr/D	Crushed or powdered, mixed with water, and creamed on the infected part	Hu	Bf	BA-114
Allium sativum L.	Amaryllidaceae	Nech shinkurt (Am)	H	Evil eye	B	Fr	Crushed with the *Podocarpus falcatus* bark, *Lepidium sativum* seeds, leaves of *Capparis tomentosa* and *Ruta chalepensis* and sniffed, or water dissolved, filtered, and drunk	Hu	Fo	–
Aloe benishangulana Sebsebe & Tesfaye	Aloaceae	Irgifa (AO)	Sh	Wound	E	Fr	Exudate collected and creamed on the wound	HuL	Bf	BA-78
Annona senegalensis Pers.	Annonaceae	Bamburxaa (AO)	T	Abdominal pain	B	Fr	Crushed, water dissolved, filtered, and taken orally	Hu	Bf,Fo,Fw	BA-132
Asparagus africanus Lam.	Asparagaceae	Sariiti (AO)	C	Placenta retention	R	Fr	Pounded with the roots of *Dracaena afromontana* and *T. doryodes*, water dissolved, filtered, and given for livestock with salt and cereal syrup	L	Bf, Fd,Tb	BA-94
Asparagus flagellaris (Kunth) Baker	Asparagaceae	Saritii (AO)	SSh	Impotency	R	D	Powdered with roots of *I. spicata*, *T. doryodes*, *S. anguivi*, tubers of *R. abyssinicus*, *C. abyssinica*, whole parts of *P. steudneri*, root barks of *C. spinarum*, *S. araliacea*, and *P. stellatum*, and taken with local drinks, chicken stew, or porridge	Hu	Bf,Cm,Fd, Tb	BA-04
				Placenta retention	R	Fr	Crushed, water dissolved, filtered, and given to a delivered woman or livestock	HuL		
				Snake venom	R	Fr	Crushed, water dissolved, filtered, and drunk	Hu		
				Herpes	L	Fr	Chewed with salt and spat on the infected body	Hu		
				Toothache	R,St	Fr/D	Chewed and used as a brush or bitten on the infected tooth	Hu		
Azadirachta indica A. Juss.	Meliaceae	Mimi (AO)	T	Newcastle disease	L	Fr	Crushed, mixed with water, and given to hens	L	Fe,O,Sd	BA-137
				Hepatitis	L	Fr	Pounded with roots or leaves of *Justicia schimperiana*, roots of *Gnidia involucrata*, bark of *Stereospermum kunthianum*, root bark of *Cordia africana*, and little exudate of *Euphorbia abyssinica*, boiled in water, filtered, and drunk with 'Tella' or 'Kenneto'	Hu		
Bidens pilosa L.	Asteraceae	Maxanne (AO)	H	Wound	L	Fr/D	Crushed with the leaves or bark of *Brucea antidysenterica* and pasted on the wound	Hu	Bf	BA-168
Breonadia salicina (Vahl) Hepper & J.R.I.Wood	Rubiaceae	Dabessa (AO)	T	Toothache	Rb,B	Fr/D	Chewed and bitten on the infected tooth	Hu	Bt,Cf,Co, Fw,Sd	BA-37
Brucea antidysenterica J. F. Mill.	Simaroubaceae	Qomonyoo (AO)	Sh	Lymphadenitis	F	D	Ground, slightly cut the infected part, and inserted in it	Hu	Bf,Fe,Fw	BA-45
				Tinea favosa	F	Fr/D	Crushed and pasted on the infected part	Hu		
				Leishmaniasis	F	Fr/D	Crushed and added to the infected part with butter or alone	Hu		
				Hemorrhoids	L,F,R	Fr/D	Crushed and added to the infected part with butter or alone	Hu		

				Wound	L,B	Fr/D	Crushed with the leaves of *B. pilosa* and added to the wound	Hu		
				Swelling	Rb,B,L	Fr	Crushed, water dissolved, filtered, and given orally to humans or cattle	HuL		
				Toothache	Rb	Fr	Crushed and bitten on the infected tooth	Hu		
Calotropis procera (Aiton) W.T.Aiton	Apocynaceae	Qilinxoo (AO)	Sh	Hemorrhoids	E,L	Fr/D	Exudate collected, or dry leaves are powdered and added to the infected part after being slightly cut with a blade	Hu	Bf	BA-65
				Wound	E	Fr	Exudate is collected and creamed on the wound	Hu		
Calpurnia aurea (Aiton) Benth.	Fabaceae	Digita (Am)	Sh	Diarrhea	L,R	Fr/D	Squeezed or crushed and water dissolved, filtered, and drunk	Hu	Cm,Hs,Tb	BA-23/47
				Vomiting	L	Fr	Rubbed with a little water, squeezed, and taken orally	Hu		
				Wound scar	L	D	Powdered, mixed with butter, and creamed on the infected part	Hu		
				Erythroblastosis fetalis	S	D	Powdered, mixed with honey, and eaten by a 5th month pregnant woman	Hu		
				Eye disease	L	D	Powdered, water dissolved, filtered, and dropped in the infected eye	Hu		
Canarina abyssinica Engl.	Campanulaceae	Xuxxo rooba (AO)	C	Impotency	Tu	D	Powdered with roots of *A. flagellaris, I. spicata*, *T. doryodes, S. anguivi*, and *A. polystachius*, tubers of *R.abyssinicus*, whole part of *P. steudneri*, root bark of *C. spinarum, S. araliacea*, and *P. stellatum*, and taken with 'Tella', 'Kenneto', chicken stew and porridge	Hu	Fo	BA-203
Capparis tomentosa Lam.	Capparaceae	Gimero (Am)	Sh	Ear mite	L	Fr	Rubbed, squeezed, and dropped into the infected ear	Hu	Fo	BA-09
				Evil eye	R	Fr/D	Crushed with the roots of *C. spinarum* and *Croton macrostachyus* and fumigated, or mixed with bulbs of *Allium sativum* and leaves of *R. chalepensis*, water dissolved, filtered, and taken orally	Hu		
				Herpes	L	Fr	Chewed and spat on the infected body parts	Hu		
				Impotency	Rb	D	Powdered with roots of *I. spicata and S. anguivi*, tubers of *R. abyssinicus*, whole part of *P. steudneri*, root bark of *R. myricoides* and *C. spinarum*, and consumed with foods and drinks	Hu		
				Toothache	Rb	Fr/D	Crushed and bitten on the infected tooth for 20-30 minutes	Hu		
				General malaise	Rb	Fr	Crushed, added to water, and steamed using pre-heated stones covered in cloth	Hu		
Capsicum frutescens L.	Solanaceae	Barbare (Am)	H	Tick	F	Fr/D	Crushed with a tuber of *Mucuna melanocarpa*, water dissolved, and sprayed on the infected part	L	Bf,Fo	–
				Diarrhea	F	Fr/D	Crushed with the bark of *S. kunthianum*, water dissolved, filtered, mixed with bar salt, and given orally to livestock	L		
				Blackleg	F	Fr/D	Crushed with the root of *Clematis simensis*, water dissolved, filtered, and given orally to livestock	L		
				Constipation	F	Fr/D	Pounded, water dissolved, mixed with mucillage of *Grewia mollis*, and given orally to cattle	L		

Carica papaya L.	Caricaceae	Papaya (Am)	T	Malaria	L	Fr	Squeezed and its filtrate drunk	Hu	Fo	–
Carissa spinarum L.	Apocynaceae	Agamssa (AO)	Sh	General malaise	R	Fr/D	Crushed with leaves of *M. foetida* and *Cucumis maderaspatanus*, roots of *P. stellatum*, *C. macrostachyus*, and *Securidaca longepedunculata*, added in water and steamed with pre-heated stones, or fire fumigated	Hu	Bf,Fe,Fo, Fw	BA-28
				Impotency	Rb	D	Powdered with roots of *I. spicata*, *T. doryodes*, *A. flagellaris*, *S. anguivi*, and *A. polystachius*, tubers of *R. abyssinicus* and *C. abyssinica*, the whole part of *P. steudneri*, root bark of *S. araliacea*, *P. stellatum*, *R. myricoides*, and *C. tomentosa*, and taken with 'Tella', 'Kenneto', chicken stew, and porridge	Hu		
				Ascaris	F	Fr	Unripe fruits are boiled or roasted and eaten into the empty stomach	Hu		
				Evil eye	R	Fr/D	Crushed with the root bark of *C. tomentosa* and *C. macrostachus* and steamed or fire-fumigated	Hu		
				"Qorxomat"	R	Fr/D	Pounded with the roots of *Monosis theophrastifolia* and *T. doryodes* and the root bark of *Gardenia ternifolia*, water dissolved, filtered and drunk	Hu		
				Rectal prolapse	R	Fr	Pounded with bar salt, barks of *S. kunthianum*, *Cassia arereh*, *G. ternifolia*, *Erythrina abyssinica*, and *Vachellia abyssinica*, roots of *C. lanceolatum*, and leaves of *Tacazzea conferta*, filtered and taken orally	Hu		
Cassia arereh Delile	Fabaceae	Coosa (Shi)	T	Snake venom	Rb,B	Fr/D	Chewed and its filtrate swallowed, or pounded with the *I. spicata* root, the barks of *Terminalia macroptera*, *C. Africana*, and *S. kunthianum*, *Haplosciadium abyssinicum* tuber, water dissolved, filtered, and drunk	HuL	Co,Fw	BA-06
				Placenta retention	B	Fr	Crushed, water dissolved, filtered, and given orally to a newly delivered woman or cow	HuL		
				Hepatitis	R,B	Fr	Pounded with *Flueggea virosa* root bark, *C. africana* bark, and *E. abyssinica* J.F.Gmel. exudate, boiled in water, filtered, and drunk	Hu		
				Rectal prolapse	B	Fr	Pounded with bar salt, barks of *G. ternifolia* and *E. abyssinica* Lam., roots of *C. spinarum* and *C. lanceolatum*, and leaves of *T. conferta*, filtered and taken orally	Hu		
				Stomachache	B	Fr	Pounded, water dissolved, filtered, and drunk with sugar	Hu		
				Newcastle disease	B	Fr/D	Pounded, water dissolved, filtered, and given to the chicken orally	L		
				Diarrhea	B	Fr/D	Pounded, water dissolved, filtered, and taken orally	Hu		
				Hypoglycemia	B	Fr/D	Chewed and its filtrate swallowed, or pounded, water dissolved, filtered, and drunk	Hu		
Catha edulis (Vahl) Endl.	Celastraceae	Chat (Am)	Sh	Kidney disease	L	Fr	Boiled, filtered, mixed with sugar, and drunk into the empty stomach	Hu	Td	–
Celosia trigyna L.	Amaranthaceae	Babilinda (AO)	H	Tapeworm	Fl,S,L	Fr	Pounded, rounded, and swallowed into the empty stomach	Hu	Bf,Fd	BA-77
Cicer arietinum L.	Fabaceae	Shimbira (Am)	H	Colic	S	Fr/D	Soaked in water and eaten, followed by a drink of its water	Hu	Fo	–

Cissus cornifolia (Baker) Planch.	Vitaceae	-	SSh	Swelling	Tu	Fr	Sliced and eaten with ginger and bar salt, and tied to the swell	Hu	Bf,Tb	BA-01
				Breast swelling	Tu	Fr	Crushed, added to water, filtered, and drunk, or given to cattle with salt	HuL		
				Placenta retention	Tu	Fr	Crushed, water dissolved, filtered, and given to delivered women with local drinks and to livestock with bar salt	HuL		
				General malaise	St,L,Tu	Fr/D	Crushed and steamed using pre-heated stones and a metal, or fire-fumigated	Hu		
				Wound	Tu	D	Powdered and added to the wound	Hu		
Cissus quadrangularis L.	Vitaceae	Engucha (Shi)	C	Diarrhea	St	Fr	Crushed, mixed with bar salt and water, and given to livestock orally	L	Fd	BA-40
				Mouth wound	St	Fr	Pounded, mixed with water and bar salt, and creamed on the infected part	L		
Citrus x aurantiifolia (Christm.) Swingle	Rutaceae	Lomi (Am)	Sh	Asthma	F	Fr	Squeezed, mixed with the egg yolk, and taken orally	Hu	Fo	BA-196
				Gum bleeding	F	Fr	Sliced and rubbed on the gum every morning	Hu		
				Tinea versicolor	F	Fr	Its juice was squeezed and creamed on the infected skin	Hu		
Clausena anisata (Willd.) Benth.	Rutaceae	Ulumaa'i (AO)	Sh	Bell's palsy	R	Fr/D	Burned in fire and smoke fumigated	Hu	Tb	BA-120
Clematis hirsuta Perr. & Guill.	Ranunculaceae	Hidda fiixi (AO)	C	Headache	R,Fl	Fr/D	Roots burned, its smoke was inhaled, and the ash is sniffed, or flowers rubbed and sniffed	Hu	Bf,Bm,Fd	BA-128
				Elephantiasis	L	Fr	Crushed, tied to the infected body, and removed after a few minutes	Hu		
				Goiter	L	Fr	Crushed, tied to the infected body, and removed after a few minutes	Hu		
				Leishmaniasis	L	Fr/D	Fresh leaves squeezed and dropped on the infected body, or dried, powdered, mixed with butter, and creamed on the infected part	Hu		
				Asthma	Fl	Fr	Rubbed on the palm and sniffed	Hu		
				Wound worm	L,R	Fr	Crushed and tied to the infected part and smeared with the cattle dung	L		
Clematis simensis Fresen.	Ranunculaceae	Hidda fiixi (AO)	C	Hemorrhoids	L	Fr	Crushed and tied to the infected part	Hu	Bf,Bm,Fd	BA-63
				Boils	L,R	Fr/D	Crushed, mixed with honey, and tied to the infected part	Hu		
				Blackleg	R	Fr	Crushed with pepper, water dissolved, filtered, and given orally	L		
				General malaise	Ap	Fr	Crushed, added to water, and steamed using pre-heated stones and a metal	Hu		
				Swelling	Ap	Fr	Crushed, added to water, and steamed using pre-heated stones and a metal	Hu		
				Arthritis	R	Fr/D	Crushed with the *T. doryodes* root, mixed with water or 'Tella', filtered, and drunk	Hu		
				Leishmaniasis	L	Fr	Squeezed and dropped on the infected part and tied its residue to it	Hu		
Clinopodium abyssinicum (Benth.) Kuntze	Lamiaceae	Mut ansa (Am)	H	Bell's palsy	Wp	Fr/D	Crushed, added to water, and steamed using four pre-heated stones	Hu	Bf	BA-113

Coccinia abyssinica (Lam.) Cogn.	Cucurbitaceae	Ancotee (AO)	C	Back bone pain	Tu	Fr	Boiled, soused with butter, salt, *A. sativum*, and pepper, and eaten with 'Injera'	Hu	Bf,Fo	BA-74
Coffea arabica L.	Rubiaceae	Buna (Am)	Sh	Wound	S	D	Roasted, powdered, and dispersed on the wound	Hu	Bf,Hd	BA-193
				Cough	L	Fr	Boiled in water, mixed with sugar, and drunk	Hu		
Colocasia esculenta (L.) Scpre-heatedt	Araceae	Goodarre (AO)	H	Placenta retention	Tu	Fr	Crushed, water dissolved, filtered, and given to delivered woman or livestock	HuL	Fo	BA-83/85
				Chest pain	Tu,L	Fr	Boiled, mixed with salt, butter, and spice, and eaten	Hu		
Convolvulus arvensis L.	Convolvulaceae	-	H	Hypoglycemia	Wp,R	Fr/D	Pounded, water dissolved, filtered, and drunk with honey, or chewed and its filtrate swallowed	Hu	Bf,Fd	BA-51
Convolvulus kilimandschari Engl.	Convolvulaceae	Ananno (AO)	C	Boils	L	Fr	Rubbed and tied on the infected part using thin plastic	Hu	Bf,Fd	BA-156
Cordia africana Lam.	Boraginaceae	Wanza (Am)	T	Abdominal pain	B	Fr	Pounded, added in a little water, squeezed, and drunk	Hu	Bf,Fd,Fo, Fw,Ti,U	BA-142
				Diarrhea	Rb,B	Fr	Chewed and its filtrate swallowed, or pounded with salt, *S. kunthianum* root bark, *Laggera crispata* leaves, *Crepis rueppellii* root, water dissolved, filtered, and drunk, or given to livestock	HuL		
				Ascaris	F, S	Fr	Ripe fruits eaten, including seeds, into the empty stomach	Hu		
				Snake venom	Rb	Fr	Chewed and its filtrate swallowed, or pounded with *Echinops giganteus* root, *T. macroptera*, *C. arereh*, and *S. kunthianum* barks, and *H. abyssinicum* tuber, water dissolved, filtered, and drunk	Hu		
				Hepatitis	Rb,B	Fr	Pounded with root bark of *C. arereh*, *F. virosa*, and *S. kunthianum*, *J. schimperiana* root or leaves, *A. indica* leaves, and *G. involucrata* root, and *E. abyssinica* exudate, boiled in water, filtered, and taken with 'Tella' or 'Kenneto'	Hu		
				Placenta retention	Rb	Fr	Pounded with *L. crispata* leaves, *S. kunthianum* root bark, and *C. rueppellii* root, water dissolved, filtered, and drunk	Hu		
				Tonsillitis	L	Fr	Chewed and its filtrate spat into the mouths of kids by mothers	Hu		
Coriandrum sativum L.	Apiaceae	Orombiro (AO)	H	Ascaris	F,S	D	Powdered, mixed with fresh cheese, and drunk into an empty stomach	Hu	Bf,Fo	–
Costus spectabilis (Fenzl) K.Schum.	Costaceae	-	H	Boils	Tu	Fr/D	Crushed with salt and bulbs of *A. sativum* and tied to infected parts	Hu	Bf	BA-158
				Stomachache	L	Fr	Chewed and its filtrate swallowed	Hu		
Crepis rueppellii Sch. Bip.	Asteraceae	Yefyel Wetet (Ah)	H	Diarrhea	R	Fr	Chewed with salt, swallowing its filtrate, or pounded, water dissolved, filtered, and drunk	Hu	Bf,Fd	BA-62
				Wound	Wp	D	Pounded, water dissolved, filtered, and washed with its filtrate	Hu		
				Abdominal pain	Wp	Fr/D	Chewed and its filtrate swallowed or crushed, water dissolved, filtered, and drunk	Hu		
				Bell's palsy	Wp	Fr	Crushed with whole parts of *C. maderaspatanus* and *C. lanceolatum*, added to water, and steamed using pre-heated stones covered in cloth	Hu		

				Placenta retention	R	Fr	Pounded with *L. crispata* leaves, *S. kunthianum* and *C. africana* root barks, dissolved in water, filtered, and taken orally	Hu		
				Leishmaniasis	E	Fr	Exudate is collected and creamed on the infected part	Hu		
Croton macrostachyus Hochst. ex Delile	Euphorbiaceae	Makkanisa (AO)	T	Gonorrhea	Rb	Fr	Pounded, added to water, filtered, and drunk into the empty stomach	Hu	Bf,Bt,Ch, Co,Fw	BA-170
				Wound worm	B	Fr	Crushed with soot and salt, then placed on the infected wound	L		
				Ringworm	Ys,E	Fr	Crushed young shoots, or exudate, were creamed on infected parts	Hu		
				Leishmaniasis	E	Fr	Exudate is collected , and dropped into or on infected parts	Hu		
				General malaise	R,Ys	Fr/D	Crushed with aerial parts of *M. foetida* and *C. maderaspatanus*, roots of *C. spinarum*, *P. stellatum*, and *S. longepedunculata,* roots or leaves of *R. myricoides* and *Ocimum gratissimum*, added to water, and washed with the solution, or steamed with pre-heated stones, or fire-fumigated	Hu		
				Eczema	S	D	Roasted, ground, and tied to the infected skin after washing	Hu		
				Splenomegaly	Rb	Fr	Crushed with *G. ternifolia* root bark, water dissolved, filtered, and drunk	Hu		
				Evil eye	R	Fr/D	Crushed with the root barks of *C. tomentosa* and *C. spinarum* and steamed in water or fire-fumigated	Hu		
				Wound	E	Fr	Exudate is collected and dropped on the infected part	Hu		
				Constipation	Rb	Fr	Crushed, water dissolved, filtered, and drunk	Hu		
				Blackleg	L	Fr	Fire-fumigated with leaves of *Ximenia americana* and *Nauclea latifolia* and aerial parts of *M. foetida* and *Cyphostemma cyphopetalum*	L		
				Abdominal pain	Rb,Ys	Fr	Pounded, water dissolved, filtered, and drunk into the empty stomach	Hu		
				Malaria	Rb	Fr	Pounded, dissolved in water or 'Tella', filtered, and drunk	Hu		
				Rabies	Rb	Fr	Crushed with the roots of *G. involucrate*, *Phytolacca dodecandra*, *Stephanotis abyssinica,* and *S. anguivi*, dissolved in water, filtered, and given to sick people or livestock	HuL		
				Boils	Ys	Fr	Pounded, mixed with honey, and tied to the infected part	Hu		
Cucumis ficifolius A. Rich.	Cucurbitaceae	Hiddi yaatu (AO)	C	Rabies	L	Fr/D	Crushed, water dissolved, filtered, and drunk into the empty stomach	Hu	Fd	BA-184
Cucumis maderaspatanus L.	Cucurbitaceae	Sokokke (AO)	C	General malaise	Wp	Fr/D	Crushed with aerial parts of *M. foetida,* roots of *C. spinarum*, *P. stellatum*, and *S. longepedunculata*, roots or leaves of *C. macrostachus*, *R. myricoides*, and *O. gratissimum*, water dissolved, and washed with the solution, or steamed with pre-heated stones, or fire fumigated	Hu	Bf,Cm,Fd	BA-201
				Bell's palsy	Wp	Fr	Crushed with whole parts of *C. rueppellii* and *C. lanceolatum*, added to water, and steamed with pre-heated stones covered in cloth	Hu		

				Breast swelling	Wp	Fr	Wrapped in *C. macrostachyus* leaves, warmed in fire, and the tumor heated	L		
Cucurbita pepo L.	Cucurbitaceae	Dabaaqqula (AO)	C	Ascaris	S	D	Roasted and eaten into an empty stomach	Hu	Bf,Fo	BA-190
Cynoglossum lanceolatum Forssk.	Boraginaceae	Yebaltet fiqir (Am)	H	Tonsillitis	R	Fr/D	Chewed with seeds of *Nigella sativa*, root or young shoot of *Dichrostachys cinerea*, young shoots of *G. ternifolia* and *Ficus thonningii*, and spat in mouth, or crushed, squeezed, and given orally	Hu	Fd	BA-53
				Eye disease	L	Fr	Rubbed on the palm, squeezed, and dropped into the infected eye	Hu		
				Diarrhea	R	Fr	Crushed with *Solanum incanum* root and *S. kunthianum* bark, mixed with water and salt, filtered, and drunk	Hu		
				Vomiting	R	Fr	Crushed with *Solanum incanum* root and *S. kunthianum* bark, mixed with water and salt, filtered, and drunk	Hu		
				Wound worm	L	D	Powdered with *A. conyzoides* leaves and added to the infected site	L		
				Bell's palsy	Wp	Fr	Crushed with whole parts of *C. maderaspatanus* and *C. rueppellii*, added to water, and steamed using pre-heated stones covered in cloth	Hu		
				Rectal prolapse	R	Fr	Pounded with bar salt, barks of *G. ternifolia*, *C. arereh*, *S. kunthianum*, and *E. abyssinica* Lam., roots of *C. spinarum* and *V. abyssinica*, and leaves of *T. conferta*, filtered, and taken orally	Hu		
				Ear ache	L,R	Fr	Rubbed and squeezed with leaves of *Gymnema sylvestre* and dropped into the infected ear with butter	Hu		
				Boils	F,Fl	Fr	Pounded with leaves or fruits of *S. rhombifolia*, *A. caulirhiza* root, and root or flowers of *R. nepalensis*, and tied to the infected site	Hu		
				Thorn injury	F,Fl	Fr	Pounded with leaves or fruits of *S. rhombifolia*, *A. caulirhiza* root, and root or flowers of *R. nepalensis*, and tied to the infected site	Hu		
Cyphostemma adenocaule (Steud. ex A. Rich.) Desc. ex Wild & R.B. Drumm.	Vitaceae	-	C	Rectal prolapse	R	Fr	Crushed, water dissolved, filtered, mixed with honey, and drunk	Hu	Bf	BA-58/59
				Uterovaginal prolapse	R	Fr	Crushed, water dissolved, filtered, mixed with honey, and drunk	Hu		
				Excessive menstrual flow	R	Fr	Crushed, water dissolved, filtered, mixed with honey, and drunk	Hu		
				Anemia	R	Fr	Pounded, water dissolved, filtered, and drunk with milk or local drinks	Hu		
Cyphostemma cyphopetalum (Fresen.) Desc. ex Wild & R.B.Drumm.	Vitaceae	Hidda reeffa (AO)	C	Erythroblastosis fetalis	R	D	Powdered, mixed with *Eragrostis tef* (Zucc.) powder and honey, made as bread, and eaten at 6 months of pregnancy	Hu	Bf	BA-46
				Blackleg	R,L	Fr	Crushed roots, water dissolved, filtered, and given orally, and leaves fumigated in fire	L		
Cyphostemma pannosum Vollesen	Vitaceae	-	H	Wound worm	R	Fr	Peeled, crushed, and tied to the infected part	L	Bf	BA-57
Datura stramonium L.	Solanaceae	Elefilo (Shi)	H	Toothache	S	D	Boiled with butter and sucked into the infected tooth through tubes	Hu	Bf	BA-161

				Rabies	R,S	Fr/D	Pounded, given to dogs with milk, to cattle with water, and to humans with honey or tea	HuL		
Dichrostachys cinerea (L.) Wight & Arn.	Fabaceae	Warsamessa (AO)	Sh	Tonsillitis	Ys,R	Fr	Chewed with seeds of *N. sativa*, roots of *C. lanceolatum* and *Sporobolus africanus*, and young shoots of *G. ternifolia and F. thonningii*, then spat into the mouth or squeezed and taken orally	Hu	Bf,Fd,Fe, Fw,Hs	BA-34
				Choking	R	Fr	Chewed with *S. africanus* root and *G. ternifolia* young shoots and spat into the left nose side, or squeezed and dropped in it	Hu		
				Lymphadenitis	R	Fr/D	Cut into small pieces with *R. myricoides* root and tied to the neck	Hu		
				Eczema	F	Fr/D	Roasted, ground, and creamed on the infected skin with unwashed butter	Hu		
Dioscorea praehensilis Benth.	Dioscoreaceae	Eecaa (AO)	C	Impotency	Tu	Fr/D	Eaten raw or roasted, or dried, powdered, and eaten with flaxseeds, chicken stew, or bar salt	Hu	Fo	BA-03
Dracaena afromontana Mildbr.	Dracaenaceae	Baala warku (AO)	T	Placenta retention	L,R	Fr	Pounded with *A. africana* and *T. doryodes* roots, dissolved in water, filtered, mixed with salt and cereal powder, and given orally	L	O	BA-96
				Milk deficiency	R	Fr	Pounded, water dissolved, filtered, mixed with salt and cereal powder, and given to cows	L		
Drimiopsis barteri Baker	Asparagaceae	Qulubi jaldesa (AO)	H	Snake venom	B	Fr	Crushed and rubbed on the bitten body part	Hu	Bf	BA-71
Echinops amplexicaulis Oliv.	Asteraceae	Mataa jaarti (AO)	H	Chest pain	R	Fr/D	Pounded, water dissolved, filtered, and drunk	Hu	Bf	BA-92
Echinops giganteus A. Rich.	Asteraceae	Tokobukuni (Shi)	H	Swelling	R	Fr/D	Pounded, water dissolved, filtered, and drunk	Hu	Bf,Fi	BA-121
				General malaise	R	D	Added to the fire and smoke fumigated, covered in cloth	Hu		
				Snake venom	R	Fr	Crushed with *C. africana* and *S. kunthianum* barks, dissolved in water, filtered, and drunk	Hu		
Echinops kebericho Mesfin	Asteraceae	Kebericho (Am)	H	Expelling mosquitoes	R	D	Added to the fire and smoke fumigated at mosquitoes' living areas	Hu	Bf	BA-189
				Abdominal pain	R	Fr	Chewed and its filtrate swallowed, or crushed, water dissolved, filtered, and drunk	Hu		
				Acute febrile illness	R	Fr/D	Added to the fire and smoke fumigated in the house	Hu		
				Febrile disease	R	Fr/D	Added to the fire and smoke fumigated in the closed house	L		
Ekebergia capensis Sparrm.	Meliaceae	Somboo (AO)	T	Tonsillitis	Rb,B	Fr/D	Pounded, water dissolved, filtered, and dropped in the mouth	Hu	Bt,Cf,Fw	BA-105
Eleusine coracana (L.) Gaertn.	Poaceae	Dagusa (Am)	H	Wound	S	D	Roasted with seeds of *E. tef* to the black ash and added to the wound	Hu	Fo,Lb	–
Embelia schimperi Vatke	Primulaceae	Hanquu (AO)	Sh	Tapeworm	F	Fr/D	Crushed or ground, water dissolved, filtered, and drunk alone or with local drinks into the empty stomach	Hu	Bm,Fo	BA-118
				Hemorrhoids	B	Fr/D	Crushed or powdered, mixed with *E. abyssinica* exudate, and creamed to the infected part	L		
				Typhoid fever	F	Fr/D	Crushed or ground, water dissolved, filtered, and drunk alone or with local drinks	Hu		

Entada abyssinica Steud. ex A. Rich.	Fabaceae	Dingera (Sh)	T	Wound worm	St	Fr	Cut with a horn-handled knife and put it near the fire or in the sun, believing that the wound will dry while a plant dries	L	Bf,Fw	BA-11
Eragrostis tef (Zucc.)	Poaceae	Teff (Am)	H	Wound	S	D	Roasted with seeds of *E. coracana* to the black ash and added to the wound	Hu	Fo	–
Erythrina abyssinica Lam.	Fabaceae	Wallensuu (AO)	T	Wound worm	B	Fr	Crushed with salt and soot, put on the infected part, and creamed with cattle dung	L	Fe,Fw,Ld, Sd	BA-146
				Eye diseases	B	Fr	Crushed, its fluid squeezed, and dropped into the infected eye	L		
				Toothache	B	Fr	Crushed and bitten on the infected tooth, replacing a remedy until relief	Hu		
				Snake venom	B	Fr	Crushed with *S. kunthianum* and *Pterocarpus lucens* barks, dissolved in water, filtered, and taken orally	Hu		
				Diarrhea	B	Fr	Pounded, water dissolved, filtered, and taken orally	Hu		
				Rectal prolapse	B	Fr	Pounded with bar salt, *G. ternifolia*, *C. arereh*, and *S. kunthianum* barks, C. spinarum, *V. abyssinica*, and *C. lanceolatum* roots, and *T. conferta* leaves, filtered, and taken orally	Hu		
				Blackleg	B	Fr	Crushed, water dissolved, filtered, and given orally	L		
Eucalyptus camaldulensis Dehnh.	Myrtaceae	Bahr-zaf (Am)	T	Cough	L	Fr	Boiled with *C. arabica* leaves and fumigated every night, followed by a normal bath in the morning until relief	Hu	Co,Fw	BA-197
Euphorbia abyssinica J.F.Gmel.	Euphorbiaceae	Adamii (AO)	T	Rabies	E	Fr	Exuded, mixed with milk, prepared as a bread with bakery powder, and given orally to humans or livestock	HuL	O	BA-25
				Hemorrhoids	E	Fr	Exuded and creamed, or added in cotton and put on the ill part, or creamed on the infected parts with crushed *E. schimperi* bark	HuL		
				Gonorrhea	E	Fr	Exuded, mixed with *E. tef* powder, and taken orally	Hu		
				Wound	E	Fr	Exuded and creamed on the wound	Hu		
				Tinea versicolor	E	Fr	Exuded, mixed with butter, and creamed on the infected parts	Hu		
				Hepatitis	E	Fr	Exuded and made into bread with *E. tef* powder and eaten into an empty stomach, or mixed with pounded *J. schimperiana* root or leaves, *A. indica* leaves, *S. kunthianum* and *C. africana* barks, and *G. involucrata* root, boiled in water, filtered, and drunk with 'Tella' or 'Kenneto'	Hu		
				Tapeworm	E	Fr	Exuded and taken into the empty stomach with porridge	Hu		
				Mice expel	St	Fr/D	Cut into small pieces and fire-smoked where the mice exist	Hu		
				Cockroach killer	St	Fr	Cut into small pieces and put around cockroaches appearance	Hu		
Euphorbia hirta L.	Euphorbiaceae	Ananno (AO)	H	Wound	E	Fr	The exudate is collected and creamed on the wound	Hu	Bf	BA-199
Euphorbia schimperiana Scheele	Euphorbiaceae	Abidamo (Am)	H	Leishmaniasis	E	Fr	The exudate is collected and creamed on the infected parts	Hu	Fd	BA-95
Faurea rochetiana (A.Rich.) Chiov. ex Pic.Serm.	Proteaceae	Gaarri (AO)	T	Swelling	Rb,B	Fr/D	Pounded, boiled in a pot, cooled, filtered, and drunk with local drinks by humans, or given with salt to cattle	HuL	Bf,Co,Fw	BA-64

				Brest swelling	Rb	Fr	Pounded, water dissolved, filtered, and given orally to cows	L		
				Excessive menstrual flow	B	Fr	Pounded, water dissolved, filtered, mixed with chicken stew, and drunk	Hu		
Ficus sur Forssk.	Moraceae	Shola (Am)	T	Abortion	Rb,B	Fr	Pounded with *L. fruticosa* bark, dissolved in water, filtered, and drunk	Hu	Ch,Fd,Fo, Fw,Sf,U	BA-155
				Infertility (women)	Rb,B	Fr	Pounded, water dissolved, filtered, mixed with egg yolk and drunk by a requiring women	Hu		
				Cough	B,Ys	Fr	Chewed with *T. macroptera* young shoots and its filtrate swallowed	Hu		
Ficus sycomorus L.	Moraceae	Odaa (AO)	T	Cough	Rb	Fr	Pounded, water dissolved, filtered, and taken orally	Hu	Bt,Ch,Fd, Fo,Sd,Sf,U	BA-33
				Common cold	B	Fr	Chewed and its filtrate swallowed	Hu		
Ficus thonningii Blume	Moraceae	Dambii (AO)	T	Tonsillitis	Ys,B	Fr	Chewed with *N. sativa* seeds, *C. lanceolatum* root, *G. ternifolia* and *D. cinerea* young shoots, *Z. officinale* tubers, filtrate spat into mouth, and its bark tied on neck	Hu	Fw,Ld,Sd	BA-147
Flueggea virosa (Roxb. ex Willd.) Royle	Phyllanthaceae	Baskaya (Shi)	Sh	Hepatitis	L,Rb	Fr	Leaves crushed with *X. americana* leaves, boiled in water, and steamed, or root bark pounded with *C. arereh* and *C. africana* barks and mixed with *E. abyssinica* exudate, boiled in water, filtered, and drunk	Hu	Fd,Fo,Fw	BA-13
Foeniculum vulgare Mill.	Apiaceae	Ensilal (Am)	H	Colic	L,Fl	Fr/D	Crushed or powdered, water dissolved, filtered, and drunk, or given to livestock	HuL	Bf,Fo	BA-183
Gardenia ternifolia Schumach. & Thonn.	Rubiaceae	Gambelloo (AO)	T	Lymphadenitis	St	Fr/D	Warmed in fire and put on the infected part	Hu	Fd,Fo,Fw, U	BA-31
				Hypoglycemia	L	Fr	Pounded and squeezed with a little water, and drunk	Hu		
				Urinary retention	L	Fr	Leaves are tied at the bladder side using a belt	Hu		
				Tonsillitis	Ys,L	Fr	Chewed with *N. sativa* seeds, *C. lanceolatum* root, root or young shoots of *D. cinerea*, and *F. thonningii* yong shoots, filtrate spat into mouth, or crushed, squeezed, and taken orally	Hu		
				Splenomegaly	Rb	Fr	Crushed with *C. macrostachyus* root bark, water dissolved, filtered, and drunk	Hu		
				Choking	Ys,L	Fr	Chewed with *S. africanus* and *D. cinerea* roots and spat into the left nose, or crushed, squeezed, and dropped into the left nose	Hu		
				Arthritis	Rb,B	Fr/D	Pounded with *M. theophrastifolia*, *T. doryodes*, and *C. spinarum* roots, dissolved in water, filtered, and drunk	Hu		
				Rectal prolapse	B	Fr	Pounded with bar salt, *S. kunthianum*, *C. arereh*, and *E. abyssinica* Lam. barks, *C. spinarum*, *Vachellia abyssinica*, and *C. lanceolatum* roots, and *T. conferta* leaves, filtered, and taken orally	Hu		
				Snake venom	Rb,B	Fr	Chewed and its exudate swallowed	Hu		
Glinus lotoides L.	Molluginaceae	Emberesho (AO)	H	Tapeworm	Ap	Fr/D	Soused with aerial parts of *P. quadrifida* or mixed with *E. tef* porridge and swallowed into an empty stomach	Hu	Bf,Fd	BA-111
Gloriosa superba L.	Colchicaceae	Yemariam Tsiwa (Am)	H	Leishmaniasis	Tu	Fr	Pounded, squeezed, and dropped into or on the infected parts	Hu	Bf,Fd	BA-60

				Impotency	Tu	Fr/D	Crushed or powdered with *T. doryodes*, *A. flagellaris*, *I. spicata*, *A. polystachius*, and *M. foetida* roots, *C. spinarum* root bark, and taken with local drinks, chicken stew, and porridge	Hu		
Gnidia involucrata Steud. ex A.Rich.	Thymelaeaceae	Qamaxxee (AO)	SSh	Toothache	R	Fr/D	Crushed and bitten on the infected tooth	Hu	Bf,Fd,U	BA-151
				Rabies	R	Fr	Crushed with *S. abyssinica* root and *C. macrostachyus* root bark, dissolved in water, filtered, and given to humans or livestock	HuL		
				Constipation	R	Fr/D	Crushed, water dissolved, filtered, and drunk	Hu		
				Colic	R	Fr/D	Pounded, water dissolved, filtered, mixed with sugar or honey, and drunk into an empty stomach	Hu		
				Anemia ("Asiliki")	R	Fr/D	Pounded, water dissolved, filtered, mixed with sugar or honey, and drunk to an empty stomach	Hu		
				Gonorrhea	R	Fr/D	Pounded, water dissolved, filtered, drunk with the syrup of *E. tef* into the empty stomach	Hu		
				Hepatitis	R	Fr	Pounded with *J. schimperiana* root or leaves, *A. indica* leaves, *S. kunthianum* bark, *C. africana* root bark, and a little exudate *E. abyssinica* J.F.Gmel., boiled in water, filtered, and taken orally	Hu		
				Ascaris	R	Fr/D	Pounded, water dissolved, filtered, and given orally to cattle	L		
Grewia mollis Juss.	Malvaceae	Dhoqonuu diima (AO)	T	Respiratory disorder	B	Fr	Pounded with *Z. officinale* tubers, squeezed, mixed with bar salt, and given orally to cattle	L	Bf,Fo,Fm, Lu,Ts	BA-35
				Constipation	B	Fr	Pounded, dissolved in water, filtered, mixed with *C. annuum* fruits, and given orally to cattle	L		
Guizotia scabra (Vis.) Chiov.	Asteraceae	Cuqii dhaltuu (AO)	H	Wound	Ys,L	Fr	Crushed, squeezed, dropped on the wound, and covered with cotton	Hu	Bf,Fd	BA-192
Gymnanthemum amygdalinum (Delile) Sch.Bip.	Asteraceae	Eebicha (AO)	Sh	Malaria	Ys,L	Fr	Crushed, water dissolved, filtered, and taken orally	Hu	Bf,Fd,Fe, Fw,Sd	BA-145
				Diarrhea	L,R	Fr	Crushed with bar salt, water dissolved, filtered, and taken orally	Hu		
				Ear mite	L	Fr	Squeezed and dropped into the infected ear, directing upward	Hu		
				Tonsillitis	L	Fr	Chewed and spat into kids mouths by mothers	Hu		
Gymnema sylvestre (Retz.) R. Br. ex Schult.	Asclepiadaceae	Xirooftu (AO)	C	Ear ache	F,L	Fr	Squeezed with *C. lanceolatum* root and added to infected ears with butter	Hu		BA-104
Gymnosporia senegalensis (Lam.) Loes.	Celastraceae	Kombolcha (AO)	T	Toothache	B	Fr/D	Crushed and bitten on the infected tooth	Hu	Fe,Fd,Fw	BA-21
Haplosciadium abyssinicum Hochst.	Apiaceae	Abba Ingidu (AO)	H	Snake venom	Tu	Fr/D	Eaten raw, or crushed, water dissolved, filtered, and drunk or given to livestock mixed with salt and pepper	HuL	Bf,Fd	BA-148
				Blackleg	Tu	Fr/D	Pounded, water dissolved, filtered, and given orally	L		
				Chest pain	Tu	Fr	Pounded, water dissolved, filtered, and taken orally	Hu		

Hypericum quartinianum A. Rich.	Hypericaceae	Tamsas (AO)	Sh	Blackleg	L	Fr	Crushed with *Premna schimperi, R. myricoides,* and *H. quartinianum* leaves, *Zehneria scabra, M. foetida*, and *Phragmanthera macrosolen* aerial parts, and fumigated on fire	L	Fe,Fw	BA-100
				General malaise	L	Fr	Crushed with *P. schimperi*, *R. myricoides,* and *H. quartinianum* leaves, *Z. scabra*, *M. foetida*, and *P. macrosolen* aerial parts, and fire-fumigated	Hu		
Hypoxis schimperi Baker	Hypoxidaceae	-	H	Toothache	Tu	Fr	Peeled, heated on fire, and bitten on the infected tooth	Hu	Bf,Fd	BA-55
Indigofera emarginella Steud. ex A. Rich. var. *emarginella*	Fabaceae	Maqori (Shi)	SSh	Diarrhea	R	Fr/D	Chewed and filtrate swallowed, or pounded, water dissolved, filtered, and drunk	Hu	Fd	BA-99
				Snake venom	R	Fr	Pounded, water dissolved, filtered, and taken orally	Hu		
Indigofera spicata Forssk.	Fabaceae	Tsepha (Shi)	H	Boils	Wp	Fr	Crushed, mixed with honey or butter, and tied to the infected part	Hu	Bf,Fd	BA-02
				Impotency	R	Fr/D	Chewed alone, or powdered with *T. doryodes, A. flagellaris, M. foetida, S. anguivi,* and *A. polystachius* roots, *R. abyssinicus*, *C. abyssinica,* and *G. superba* tubers, *P. steudneri* whole parts, *C. spinarum*, *S. araliacea*, *P. stellatum*, *R. myricoides*, and *C. tomentosa* root barks, and taken with local drinks, chicken stew, and porridge	Hu		
				Gastritis	R	Fr	Chewed and its filtrate swallowed into an empty stomach	Hu		
				Scorpion venom	R	Fr/D	Chewed and filtrate swallowed, or crushed, water disolved, filtered, and drunk	Hu		
				Snake venom	R	Fr/D	Chewed and filtrate swallowed, or pounded with *C. arereh* bark, dissolved in water, filtered, and drunk	Hu		
				Hypoglycemia	R	Fr/D	Chewed and its filtrate swallowed	Hu		
				Child delay to walk	R	Fr	Pounded, water dissolved, filtered, and given orally to children	Hu		
				Swelling	R	Fr/D	Chewed and its filtrate swallowed	Hu		
Jatropha curcas L.	Euphorbiaceae	Chaqma (Am)	Sh	Abdominal pain	S	D	Crushed, mixed with local drinks, and drunk into the empty stomach	Hu	Fe,Ld,Sd	BA-169
Justicia schimperiana (Hochst. ex Nees) T. Anderson.	Acanthaceae	Simiza (Am)	Sh	Rabies	R,L,Fl	Fr/D	Crushed with *P. dodecandra* root and *S. abyssinica* leaves, filtered and drunk alone or with sugar, given with milk to dogs, and with salt or 'Tella' residue to cattle	HuL	Bf,Fe,Fo, Ld,Fw	BA-159
				Anemia	R	Fr	Crushed with *P. dodecandra* root, water dissolved, filtered, and drunk	Hu		
				Hepatitis	R,L	Fr	Pounded with *A. indica* leaves, *G. involucrata* root, *S. kunthianum bark, C. africana* root bark, and a little *E. abyssinica* exudate, boiled in water, filtered, and drunk	Hu		
Kalanchoe densiflora Rolfe	Crassulaceae	Endawula (Am)	H	Swelling	L	Fr	Warmed in fire and heated the tumor site, or tied on the tumor site	Hu	Bf	BA-87
				Breast swelling	St	Fr	Piece of stem, inserted into the dissected brisket, and tied with thread	L		
				Eye diseases	L	Fr	Warmed in fire, squeezed, and dropped into the infected eye	Hu		
Kleinia abyssinica (A. Rich.) A. Berger	Asteraceae	Qoricha bofaa (OA)	H	Snake venom	Tu	Fr	Chewed and filtrate swallowed, or pounded, water dissolved, filtered, and drunk	Hu	Bf	BA-115

Lablab purpureus (L.) Sweet	Fabaceae	Ephoo (AO)	C	Urinary retention	L	Fr	Leaves are tied at the bladder part using a belt	Hu	Bf,Fo	BA-05
Lagenaria siceraria (Molina) Standl.	Cucurbitaceae	Tsola (Shi)	C	Snake venom	F	Fr/D	Sliced into pieces, water dissolved, filtered, and taken orally	Hu	Fd,U	BA-174
				Lymphadenitis	S	D	Seeds pored, a thread inserted into holes, and tied on the neck	Hu		
Laggera alata (D.Don) Sch.Bip. ex Oliv.	Asteraceae	Foofo (AO)	H	Choking	L	Fr	Rubbed, squeezed, and dropped into a mouth, holding a nose	Hu	Bf	BA-93
Laggera crispata (Vahl) Hepper & J.R.I.Wood	Asteraceae	Foofo (AO)	H	Diarrhea	L	Fr	Pounded with *C. rueppellii* root, *S. kunthianum* and *C. africana* barks, water dissolved, filtered, mixed with salt, and taken orally	Hu	Bf	BA-90
				Placenta retention	L	Fr	Pounded with *C. rueppellii* root, *S. kunthianum* and *C. africana* barks, dissolved in water, filtered, and given to the delivered woman	Hu		
Lannea fruticosa (Hochst. ex A. Rich.) Engl.	Anacardiaceae	Bilga (Shi)	T	Abortion	B	Fr	Pounded with *F. sur* bark, water dissolved, squeezed, and taken orally	Hu	Bf,Ld,Sd	BA-185
Lepidium sativum L.	Brassicaceae	Feeto (Am)	H	Evil eye	S	D	Powdered with root bark or bark *P. falcatus*, *R. chalepensis* leaves, and *A. sativum* garlics, and sniffed	Hu	Fo	–
Maesa lanceolata Forssk.	Primulaceae	Abbayii (AO)	T	Leishmaniasis	L	Fr	Rubbed, squeezed, and dropped into or on the infected parts	Hu	Bw,Fw	BA-202
Mentha pulegium L.	Lamiaceae	Doqqinno (AO)	H	Acute febrile illness	L	Fr	Rubbed and put on ears while moving to the house of infected people	Hu	Cm	BA-191
Microglossa pyrifolia (Lam.) Kuntze	Asteraceae	Karrakoraa (AO)	Sh	Eye disease	L	Fr	Squeezed and dropped in the infected eye	Hu	Bf,Fd	BA-61
Momordica foetida Schumach.	Cucurbitaceae	Qorii arragessa (AO)	C	Wound	L	Fr	Squeezed, filtered with cotton, and dropped on wound	Hu	Bf,Fd,Fo	BA-72
				Ascaris	R	Fr	Crushed, water dissolved, filtered, and drunk into an empty stomach	Hu		
				General malaise	Wp	Fr/D	Crushed with *C. spinarum* roots, *M. theophrastifolia*, *H. quartinianum*, and *R. myricoides* leaves, *C. maderaspatanus*, *Z. scabra*, and *P. macrosolen* aerial parts, added in water, steamed with pre-heated stones, or fumigated in fire covered in cloth	Hu		
				Boils	R	Fr/D	Crushed or powdered, mixed with honey, and tied to the infected part	Hu		
				Blackleg	Wp	Fr/D	Burned in fire with *X. americana*, *N. latifolia*, *C. macrostachyus*, *R. myricoides*, and *H. quartinianum* leaves, and aerial parts of *C. cyphopetalum*, *Z. scabra*, and *P. macrosolen*, and fumigated	L		
				Impotency	R	D	Powdered with *T. doryodes*, *A. flagellaris*, *I. spicata*, and *A. polystachius* roots, root barks of *C. spinarum* and *G. superba*, and taken orally with 'Tella' or 'Kenneto', chicken stew, and porridge	Hu		
				Herpes	L	Fr	Rubbed, creamed with unwashed butter on the infected part, stayed on the sun for 15-30 minutes	Hu		
Monosis theophrastifolia (Schweinf. ex Oliv. & Hiern) C.Jeffrey	Asteraceae	Egadima (Shi)	Sh	Placenta retention	L,R	Fr	Crushed, dissolved in water, mixed with salt and butter, and drunk	Hu	Bf,Fw	BA-44
				Uncontrolled urine	R	Fr	Pounded, water dissolved, filtered, and taken orally	Hu		

				Internal swelling	R	Fr	Pounded, boiled in water, filtered, added to chicken stew, and eaten with 'Injera'	Hu		
				General malaise	L	Fr	Crushed with *M. foetida* root, added in water, and steamed with pre-heated stones, or fumigated on fire covered in cloth	Hu		
				Gastritis	R	Fr/D	Chewed and filtrate swallowed, or crushed, water dissolved, filtered, and drunk with sugar or alone	Hu		
				Arthritis	R	Fr/D	Pounded with *G. ternifolia and C. spinarum* root barks, *T. doryodes* root, water dissolved, filtered, and drunk	Hu		
Moringa stenopetala (Baker f.) Cufod.	Moringaceae	Shiferaw (Am)	T	Blood pressure	L	Fr/D	Freshly rubbed or dry powdered, boiled with water and sugar, and drunk	Hu	Sd	BA-38
				Gastritis	L	Fr	Eaten with sugar, or chewed alone and filtrate swallowed	Hu		
				Newcastle disease	L	Fr	Pounded, water dissolved, filtered, and given orally	L		
Mucuna melanocarpa Hochst. ex A. Rich.	Fabaceae	Abba tomma (AO)	C	Tick	Tu	Fr	Crushed with *C. annuum* fruits, water dissolved, filtered, and sprayed on infected parts, smeared with dung	L	Fi,Sf	BA-122
Nauclea latifolia Sm.	Rubiaceae	Kurumba (Shi)	T	Blackleg	L,St	Fr/D	Burned in fire with *X. americana* and *C. macrostachyus* leaves, *C. cyphopetalum* and *M. foetida* aerial parts, and fumigated, or crushed, water dissolved, filtered, and given orally	L	Fo	BA-119
				Chicken lice	L	Fr/D	Burned in fire and fumigated	L		
Nicotiana tabacum L.	Solanaceae	Timbo (AO)	H	Boils	L	Fr/D	Crushed or powdered, mixed with honey, and tied to the infected part	Hu	Td	BA-123
				Leech infestation	L,Fl,S	Fr/D	Crushed or powdered, water dissolved, and given orally to humans and nasally to livestock, followed by providing water	HuL		
Nigella sativa L.	Ranunculaceae	Tikur Azmud (Am)	H	Tonsillitis	S	D	Chewed with *C. lanceolatum* roots, *G. ternifolia*, *F. thonningii*, and *D. cinerea* young shoots, *Z. officinale* tubers, and spat its filtrate into kids mouths by their mother	Hu	Fo	–
				Breast swelling	S	D	Pounded with bar salt and *C. cornifolia* tubers, dissolved in water, filtered, and given orally	L		
Ocimum gratissimum L.	Lamiaceae	Ancabbii (AO)	SSh	General malaise	L,R	Fr/D	Crushed with *C. macrostachus* and *R. myricoides* roots, aerial parts of *C. maderaspatanus*, and *steamed* with pre-heated stones covered in cloth, and bath taken with its water, or crushed, boiled with coffee or sugar, and drunk	Hu	Bf,Fw	BA-54/180
				Evil eye	L,R	Fr	Crushed with *Solanum villosum* roots, squeezed, and creamed on face	Hu		
Osyris lanceolata Hochst. & Steud.	Santalaceae	Waato (AO)	Sh	Excretion difficulty	L	Fr	Pounded, water dissolved, filtered, and drunk with honey by humans, and given with pepper to livestock	HuL	Cf	BA-127
Parthenium hysterophorus L.	Asteraceae	Asedid (Am)	H	Wound	L	Fr/D	Rubbed, squeezed, filtrate dropped on the wound, and covered with residues, or powdered and dispersed on the wound	Hu	Bf	BA-179
				Tinea versicolor	L	Fr/D	Pounded or powdered, water dissolved, filtered, mixed with lemon juice, and creamed on the infected parts using cotton	Hu		
Paspalum scrobiculatum L.	Poaceae	Marga Uummo (AO)	H	Snake protection	Wp	Fr/D	Cut and put around the existence of the snake	HuL	Fd	BA-116

Pavonia kilimandscharica Gürke	Malvaceae	Inchini Boyye (AO)	Sh	Lymphadenitis	R	Fr/D	Cut into pieces and tied to the neck	Hu	Fd	BA-143
Philenoptera laxiflora (Guill. & Perr.) Roberty	Fabaceae	Urgaa (Shi)	T	Placenta retention	B	Fr	Crushed, water dissolved, filtered, and taken orally	Hu	Fw	BA-15
Phoenix reclinata Jacq.	Arecaceae	Meexxi (AO)	T	Eye diseases	L	Fr	Chewed and filtrate dropped into the infected eye	L	Fd,Fo,Tb, U	BA-26
				Malaria	St	Fr	Roasted or boiled and eaten before it cools	Hu		
Phragmanthera macrosolen (Steud. ex A. Rich.) M.G.Gilbert	Loranthaceae	Eerto dhandhansa adii (AO)	Sh	General malaise	L,St	Fr/D	Crushed with *Z. scabra* and *M. foetida* aerial parts, *H. quartinianum* and *R. myricoides* leaves, added in water, steamed with pre-heated stones, or fumigated in fire	Hu		BA-50
				Lymphadenitis	St	D	Warmed in fire, and heated the ill part, and fumigated in fire	Hu		
				Blackleg	L,St	Fr	Warmed in fire and heated the ill part	L		
Phytolacca dodecandra L'Hér.	Phytolaccaceae	Endod (Am)	Sh	Rabies	R	Fr/D	Crushed with *J. schimperiana* and *S. abyssinica* leaves, *S. anguivi* root and *C. macrostachyus* root bark, water dissolved, filtered, and given with sugar or honey to humans, with milk to dogs, and with bar salt to cattle	HuL	Bf,Ts	BA-82
				Leprosy	R	Fr/D	Crushed, water dissolved, filtered, and taken orally	Hu		
				Anemia	R	Fr/D	Crushed with *J. schimperiana* root, dissolved in water, filtered, and drunk	Hu		
				Diarrhea	R	Fr	Pounded, water dissolved, filtered, mixed with bar salt, and given orally	L		
				As abortifacient	Wp	Fr	Pounded, water dissolved, filtered, and taken orally	Hu		
				Gonorrhea	R	Fr	Pounded, water dissolved, filtered, and taken orally	Hu		
Piper capense L. f.	Piperaceae	Turffo (AO)	SSh	Trauma	L	Fr/D	Boiled and eaten with butter, yogurt, cheese, and porridge of red "teff"	Hu	Fd	BA-84
				Cattle thinness	L	Fr/D	Boiled and given to thin cattle with bar salt and bread	L		
Polygala persicariifolia DC.	Polygalaceae	Sottee simbiraa (AO)	H	Wound	L	Fr	Squeezed and dropped on the wound	Hu	Bf,Fd	BA-149
Polystachya steudneri Rchb.f.	Orchidaceae	-	H	Impotency	Wp	D	Powdered with *A. flagellaris*, *I. spicata*, *T. doryodes*, *M. foetida*, *S. anguivi* and *A. polystachius* roots, *R.abyssinicus* and *C. abyssinica* tubers, *C. spinarum*, *S. araliacea*, *P. stellatum*, *R. myricoides* and *C. tomentosa* root bark, and taken with local drinks, chicken stew, or porridge	Hu	Bf	BA-08
				Gastritis	Ps	Fr	Chewed and its filtrate swallowed	Hu		
				Scorpion venom	Ps	Fr	Chewed and filtrate swallowed, or pounded, water dissolved, filtered, and drunk	Hu		
				Diarrhea	Ps	Fr	Chewed and filtrate swallowed, or pounded, water dissolved, filtered, and drunk	Hu		
				Snake venom	Ps	Fr	Chewed and filtrate swallowed, or pounded, water dissolved, filtered, and drunk	Hu		
				Wound	Ps	Fr	Crushed and creamed on the wound	Hu		
Portulaca quadrifida L.	Portulacaceae	Kama (Shi)	H	Gastirits	Ap	Fr	Soused with salt, water, and spices and eaten with porridge, or 'Injera'	Hu	Bf,Fo	BA-76

				Loss of appetite	Ap	Fr	Soused with salt, water, and spices and eaten with porridge, or 'Injera'	Hu		
Premna schimperi Engl.	Lamiaceae	Urgeessaa (AO)	Sh	Toothache	Ys,L	Fr	Crushed and inserted under the infected tooth	Hu	Fe,Fw	BA-107
				Blackleg	L	Fr	Crushed with *R. myricoides* and *H. quartinianum* leaves, *Z. scabra, M. foetida,* and *P. macrosolen* aerial parts, and fumigated in fire	L		
				General malaise	L	Fr	Crushed with *R. myricoides* and *H. quartinianum* leaves, *Z. scabra, M. foetida,* and *P. macrosolen* aerial parts, and fire-fumigated cloth covered	Hu		
Psidium guajava L.	Myrtaceae	Zeyitona (Am)	Sh	Amoeba	F	Fr	Ripe fruit eaten into an empty stomach	Hu	Fo	BA-195
Pterocarpus lucens Lepr. ex Guill. & Perr.	Fabaceae	Daamboo (AO)	T	Snake venom	B	Fr	Chewed and filtrate swallowed, or crushed with *S. kunthianum* and *E. abyssinica* barks, water dissolved, filtered, and drunk	Hu	Fw,Sd	BA-166
				Migraine headache	B	Fr	Crushed, water dissolved, filtered, and taken orally	Hu		
Pterolobium stellatum (Forssk.) Brenan	Fabaceae	Arangamaa Gurracha (AO)	Sh	Impotency	Rb	D	Powdered with *I. spicata, T. doryodes, A. flagellaris, M. foetida, S. anguivi* and *A. polystachius* roots, *R. abyssinicus,* and *C. abyssinica* tubers, whole *P. steudneri* parts, *S. araliacea,* and *C. spinarum* root barks, and taken with local drinks, chicken stew, or porridge	Hu	Bf,Fe,Fw	BA-22
				General malaise	R	Fr/D	Crushed, with *C. spinarum, C. macrostachyus, and S. longepedunculata* roots, added to water, steamed with pre-heated stones, or fire-fumigated, and normal bath taken	Hu		
				Evil eye	R	Fr/D	Burned in fire and fumigated	Hu		
Rhamnus prinoides L'Hér.	Rhamnaceae	Geeshe (AO)	Sh	Tonsillitis	L	Fr	Chewed and spat into the kids mouths by their mothers	Hu	Lb	BA-123
Ricinus communis L.	Euphorbiaceae	Gulo (Am)	Sh	Snake venom	R	Fr	Crushed, water dissolved, filtered, and taken orally	Hu	Ps	BA-140
				Ascaris	R	Fr	Crushed, water dissolved, filtered, and drunk into an empty stomach	Hu		
				Toothache	R	Fr	Chewed and bitten on the infected tooth	Hu		
				Hemorrhoids	L,S	Fr/D	Pounded, wrapped in cloth, heated in fire, and put on the infected part	Hu		
Rotheca myricoides (Hochst.) Steane & Mabb.	Lamiaceae	Ulee harre (AO)	Sh	Lymphadenitis	R	Fr/D	Warmed in fire and put on the infected part, or cut into pieces with *D. cinerea* roots and tied to the neck	Hu	Bf,Fe,Fw	BA-138
				General malaise	L	Fr/D	Crushed with *P. schimperi* and *H. quartinianum* leaves, root or leaves of *O. gratissimum, Z. scabra, M. foetida,* and *P. macrosolen* aerial parts, added to water, steamed with pre-heated stones, or fire-fumigated in cloth covered	Hu		
				Eye diseases	L	Fr	Squeezed and dropped, or chewed and spat into the infected eye	L		
				Choking	Rb	Fr	Chewed, spat into mouth, and air pipped in nose, or pounded, dissolved in water, filtered, and dropped through left nose	HuL		
				Impotency	Rb	D	Powdered with *I. spicata* and *S. anguivi* roots, *R. abyssinicus* tubers, *P. steudneri* whole parts, the root bark of *S. araliacea,*	Hu		

							C. spinarum, and *C. tomentosa,* and taken with local drinks, chicken stew, or porridge			
				Urinary retention	R	Fr	Pounded, water dissolved, filtered, and given orally	L		
				Gonorrhea	Rb	Fr	Pounded, water dissolved, filtered, and taken orally	Hu		
				Blackleg	L	Fr	Crushed with *P. schimperi* and *H. quartinianum* leaves, *Z. scabra*, *M. foetida*, and *P. macrosolen* aerial parts, and fire-fumigated	L		
Rumex abyssinicus Jacq.	Polygonaceae	Dhangaggo (AO)	H	Impotency	Tu	D	Powdered with *I. spicata*, *T. doryodes*, *A. flagellaris*, *M. foetida*, *S. anguivi*, and *A. polystachius* roots, *C. abyssinica* tubers, *P. steudneri* whole parts, root bark of *C. spinarum*, *S. araliacea*, *P. stellatum*, *R. myricoides*, and *C. tomentosa*, and taken with local drinks, chicken stew, or porridge	Hu	Fo	BA-135
				Ascaris	Tu	D	Powdered, made into porridge with “teff” powder, and eaten into an empty stomach	Hu		
Rumex nepalensis Spreng.	Polygonaceae	Qunni (AO)	H	Abdominal pain	R	Fr	Root cleaned and eaten with honey into an empty stomach	Hu	Cm	BA-98
				Boils	R,Fl	Fr	Crushed with *C. lanceolatum* fruits, *S. rhombifolia* leaves, and *A. caulirhiza* leaves, roots, or young shoots, mixed with honey and Hippo's skin ash, and tied to the infected part	Hu		
				Thorn injury	R,Fl	Fr	Rubbed with *C. lanceolatum* fruits, *S. rhombifolia* leaves, and *A. caulirhiza* roots, mixed with honey or salt, and tied to the infected part	Hu		
				Eczema	R	Fr	Heated in fire, pounded, and creamed on the infected parts	Hu		
Rumex nervosus Vahl	Polygonaceae	Embacho (Am)	Sh	Constipation	L	Fr/D	Crushed or powdered, water dissolved, filtered, and drunk	Hu	Fo	BA-24
Ruta chalepensis L.	Rutaceae	Tena-adam (Am)	H	Evil eye	L	Fr	Crushed with root bark or bark *P. falcatus*, *L. sativum* seeds, and *A. sativum* garlics, and sniffed, or water dissolved with pounded *C. tomentosa* root bark and *A. sativum* garlics, filtered, and drunk	Hu	Fo	–
				Tonsillitis	L	Fr	Chewed and spat into the kids mouths by mothers, or crushed, water dissolved, and dropped in mouth	Hu		
Salvia tiliifolia Vahl	Lamiaceae	-	H	Hemorrhoids	L	Fr/D	Pounded or powdered, dissolved in a little water, added to cotton or tissue paper, and creamed to the infected part	Hu	Bf	BA-182
Sauromatum venosum (Dand. ex Aiton) Kunth	Araceae	Muuna (Shi)	H	Amoeba	Tu	Fr	Crushed, water dissolved, filtered, mixed with honey, sugar, bar salt, local drinks, or syrups, and drunk	Hu	Fd,At	BA-39/42
				Milk deficiency	Tu	Fr	Crushed, water dissolved, filtered, and given orally with sugar or local drinks to women and with bar salt to livestock	HuL		
				Back bone pain	Tu	Fr/D	Crushed or powdered, mixed chicken stew, and drunk	Hu		
				Cow refused milking	Tu	Fr	Rubbed on the palm and creamed on a cow, a calf, and a milking human	L		
				Snake venom	Tu	Fr	Crushed, water dissolved, filtered, and taken orally	Hu		
Sclerocarpus africanus Jacq.	Asteraceae	-	H	Toothache	R	Fr	Washed root chewed and bitten on the infected tooth	Hu	Bf	BA-181

Securidaca longepedunculata Fresen.	Polygalaceae	Temeniya (Am)	T	General malaise	R	Fr/D	Crushed with *C. spinarum*, *C. macrostachyus*, and *Pterolobium stellatum* roots, added in water, steamed with pre-heated stones, or fire-fumigated followed, by a normal bath	Hu	Bf,Fd,Ts	BA-112
				Common cold	Rb,L	Fr/D	Burned and fire-fumigated, or freshly squeezed and sniffed	Hu		
				Pests expel	Rb	Fr/D	Burned in the fire and fumigated in the house	HuL		
Senna obtusifolia (L.) Irwin & Barneby	Fabaceae	Gogoho Dhinya (Gz)	H	Scorpion venom	R	Fr	Warmed in fire and put on bitten part, and chewed and filtrate swallowed	Hu	Bf	BA-141
Senna petersiana (Bolle) Lock	Fabaceae	Sarar qamale (AO)	Sh	Tick	L	Fr	Squeezed and sprayed on the tick-infected body part	L	Fo	BA-80
Sida rhombifolia L.	Malvaceae	Mucaraa (AO)	H	Boils	L	Fr	Rubbed with *C. lanceolatum* fruits, *A. caulirhiza* roots, and *R. nepalensis* flowers and tied to the infected part with honey or salt	Hu	Bf,Cm,Fd, U	BA-175
				Thorn injury	L,F	Fr	Rubbed with *C. lanceolatum* fruits, *A. caulirhiza* roots, and *R. nepalensis* flowers and tied to the infected part with honey or salt	Hu		
Sida urens L.	Malvaceae	-	H	Child delay walking	L	Fr	Rubbed on a child's knee for 2-3 days in the morning	Hu	Bf,Fd	BA-172
Solanum anguivi Lam.	Solanaceae	Hiddi saree (AO)	SSh	Impotency	R	D	Powdered with *I. spicata*, *T. doryodes*, *A. flagellaris*, and *A. polystachius* roots, *R. abyssinicus* and *C. abyssinica* tubers, *P. steudneri* whole parts, root barks of *S. araliacea*, *C. spinarum*, *R. myricoides*, *P. stellatum*, and *C. tomentosa*, and taken with local drinks, chicken stew, or porridge	Hu	Bf	BA-108/133
				Rabies	R	Fr	Pounded with the root bark of *C. macrostachyus* and *P. dodecandra* root, dissolved in water, filtered, and given orally to humans and livestock	HuL		
Solanum dasyphyllum Schumach. & Thonn.	Solanaceae	Inpapa (Shi)	Sh	Sneezing	F	Fr	Squeezed mesocarp is mixed with the milk and given nasally or orally	L	Bf	BA-134
				Hemorrhoids	F	Fr	Squeezed and smeared on the infected body parts	L		
Solanum incanum L.	Solanaceae	Hiddi (AO)	SSh	Ear ache	F	Fr	Squeezed and dropped into the infected ear	Hu	Bf	BA-139
				Diarrhea	R	Fr	Crushed with *C. lanceolatum* root, water dissolved, filtered, and drunk	Hu		
				Vomiting	R	Fr	Crushed with *C. lanceolatum* root, water dissolved, filtered, and drunk	Hu		
				Lumpy skin	F	Fr	Heated in fire, squeezed, and creamed on the infected skin	L		
				Hemorrhoids	F	Fr	Heated in fire, squeezed, and creamed on the infected parts	HuL		
Solanum villosum Mill.	Solanaceae	Huncha (Shi)	H	Evil eye	R	Fr/D	Crushed with *O. gratissimum* root or leaf, squeezed, and creamed to face	Hu	Fo	BA-153
				Wound	L	Fr/D	Squeezed and smeared on the wound, or powdered and dispersed on it	Hu		
				Diarrhea	L	Fr	Squeezed and taken orally	Hu		
Sporobolus africanus (Poir.) Robyns & Tournay	Poaceae	Murii (AO)	H	Tonsillitis	R	Fr	Chewed with young shoots of *G. ternifolia and D. cinerea* and spat in the mouth, or crushed, squeezed, and taken orally	Hu	Cm,Fd	BA-117

				Choking	R	Fr	Chewed with young shoots of *G. ternifolia* and *D. cinerea* and spat in the left nose, or crushed together, squeezed, and dropped in the left nose	Hu		
Steganotaenia araliacea Hochst.	Apiaceae	Bosoqqee (AO)	T	Impotency	Rb	D	Powdered with *A. flagellaris*, *I. spicata*, *T. doryodes*, *S. anguivi*, and *A. polystachius* roots, *R. abyssinicus* and *C. abyssinica* tubers, *P. steudneri* whole parts, root barks of *C. spinarum* and *P. stellatum*, and taken with local drinks, chicken stew, or porridge	Hu	Bf,Fd,U	BA-127
				Snake venom	Rb,B	Fr	Chewed and filtrate swallowed, or pounded, water dissolved, filtered, and taken orally or nasally	Hu		
Stephania abyssinica (Dillon & A. Rich.) Walp. var. abyssinica	Menispermaceae	Hidda Kalaalaa (AO)	C	Rabies	L	Fr/D	Pounded or powdered with *P. dodecandra* roots and *J. schimperiana* leaves, dissolved in water, filtered, and given to humans or livestock	HuL	U	BA-81
Stephanotis abyssinica (Hochst.) S.Reuss, Liede & Meve	Apocynaceae	Andode gammoji (AO)	Sh	Rabies	R	Fr	Crushed with *G. involucrata* root and *C. macrostachyus* bark, water dissolved, filtered, and drunk, or given as a vaccine to dog pups by milk	HuL	Bf	BA-167
Stephanotis schimperi (Decne.) S.Reuss, Liede & Meve	Apocynaceae	-	Sh	Ringworm	L	Fr	Rubbed, squeezed, and creamed on the infected part	Hu	Bf	BA-178
Stereospermum kunthianum Cham.	Bignoniaceae	Botoroo (AO)	T	Diarrhea	Rb,B	Fr	Pounded with bar salt, *C. annuum* fruits, root bark or bark of *C. africana*, *L. crispata* leaves, and *C. rueppellii* roots, water dissolved, filtered, and drunk, or given to livestock	HuL	Bf,Co,Fd, Fm,Fw	BA-27
				Snake venom	Rb	Fr	Chewed and filtrate swallowed, or pounded with *I. emarginella* var. *emarginella* and *E. giganteus* roots, *E. abyssinica*, *P. lucens*, *T. macroptera*, *C. arereh*, and *C. africana* barks, *H. abyssinicum* tuber, water dissolved, filtered, and drunk	Hu		
				Toothache	B	Fr	Crushed and bitten on the infected tooth	Hu		
				Gastirits	Rb,B	Fr	Chewed and filtrate swallowed, or pounded, water dissolved, filtered, and drunk into an empty stomach	Hu		
				Rectal prolapse	B	Fr	Pounded with bar salt, *G. ternifolia*, *C. arereh*, and *E. abyssinica* Lam. barks, *C. spinarum*, *V. abyssinica*, and *C. lanceolatum* roots, and *T. conferta* leaves, filtered, and drunk	Hu		
				Placenta retention	B	Fr	Pounded with *L. crispata* leaves, root bark of *C. africana*, and *C. rueppellii* root, dissolved in water, filtered, and drunk	Hu		
				Hepatitis	B	Fr	Pounded with *C. africana*, *C. arereh*, and *F. virosa* root barks, *J. schimperiana* root or leaves, *A. indica* leaves, *G. involucrata* root, and *E. abyssinica* exudate, boiled in water, filtered, and drunk with 'Tella' or 'Kenneto'	Hu		
Tacazzea conferta N.E.Br.	Apocynaceae	Domesimaro (Shi)	Sh	Rectal prolapse	L	Fr	Pounded with bar salt, *G. ternifolia*, *C. arereh*, and *E. abyssinica* Lam. barks, and *C. spinarum* and *C. lanceolatum* root barks, filtered, and drunk	Hu	Bf,Fd	BA-165
Tapinanthus globifer (A. Rich.) Tiegh.	Loranthaceae	Eerto Makkanisaa	Sh	Lymphadenitis	St	Fr/D	Creamed by unwashed butter, fire heated, and held ill site, then cut into pieces and tied to neck by thread	Hu	Bf,Fd	BA-68
				Snake expel	St	Fr/D	Cut, saying "expel a snake," and fire-fumigated at its living areas	HuL		

				Snake venom	St	Fr/D	Chewed and filtrate swallowed, or fire-warmed and held on the bitten part	Hu		
				Nightmare	St	Fr/D	Cut, rotated over a patient head, and thrown toward the sun set	Hu		
				Enemy protection	St	Fr/D	Broken by a washed hand and put on a dry tree at a protecting boundary	Hu		
				General malaise	L,St	Fr/D	Crushed with *C. cornifolia* stem, added to water, steamed with pre-heated stones, or fumigated in fire	Hu		
				Diarrhea	St	Fr	Chewed and filtrate swallowed, or pounded with *V. adoensis* root, water dissolved, filtered, and drunk, or given orally to cattle with salt	HuL		
				Hemorrhoids	L,St	Fr/D	Crushed, water dissolved, filtered, and drunk, or steam or fire fumigated	Hu		
				Cow refused milking	St	Fr/D	Chewed with salt, spat on the palm, and creamed on a cow, a calf, and a milking human	L		
				Swelling	St	Fr	Heated in fire and put on the tumor part	Hu		
Terminalia laxiflora Engl. & Diels	Combretaceae	Warakka (AO)	T	Snake venom	B	Fr	Chewed and its filtrate swallowed	Hu	Bf,Bw,Cf, Co,Fw,Sd	BA-150
				Diarrhea	B	Fr	Pounded, water dissolved, filtered, and drunk with sugar	Hu		
Terminalia macroptera Guill. & Perr.	Combretaceae	Dabaqqa (AO)	T	Cough	B,Ys	Fr/D	Chewed with *F. sur* bark and filtrate swallowed, or pounded, water dissolved, filtered, and drunk	Hu	Bf,Co,Fm, Fw	BA-187
				Snake venom	B	Fr/D	Pounded with *C. arereh, S. kunthianum,* and *C. africana* barks, *H. abyssinicum* tuber, water dissolved, filtered, and taken orally	Hu		
Thunbergia alata Bojer ex Sims	Acanthaceae	Martee (AO)	C	Hemorrhoids	F,R	Fr/D	Crushed, mixed with honey, and creamed on the infected part	Hu	Bf	BA-163
Tragia doryodes M.G.Gilbert	Euphorbiaceae	Gurgubbe (AO)	C	Scorpion venom	R	Fr/D	Chewed with salt, filtrate swallowed, and residue tied to the bitten part	Hu	Fd	BA-67
				Impotency	R	D	Powdered with *I. spicata, A. flagellaris, M. foetida, S. anguivi,* and *A. polystachius* roots, *R. abyssinicus, C. abyssinica,* and *G. superba* tubers, whole parts of *P. steudneri*, root barks of *C. spinarum*, *S. araliacea,* and *P. stellatum,* and taken with local drinks, chicken stew, or porridge	Hu		
				Lymphadenitis	R	Fr	Heated in fire and placed on the sick part	Hu		
				Diarrhea	R	Fr	Chewed and its filtrate swallowed	Hu		
				Arthritis	R	Fr/D	Pounded or ground with *M. theophrastifolia* and *C. simensis* roots, root barks of *C. spinarum* and *G. ternifolia*, added to water or 'Tella', filtered, and drunk	Hu		
				Placenta retention	R	Fr	Pounded with *A. africana* and *D. afromontana* roots, mixed with bar salt, cereal powder, and water, filtered, and given to a delivered cow	L		
				Toothache	R	Fr	Chewed and bitten on the infected tooth, and filtrate swallowed	Hu		
Trigonella foenum-graecum L.	Fabaceae	Abesh (Am)	H	Eye disease	S	D	Roasted, powdered, and added to the infected eye	L	Fo,Lb	–

*Vachellia abyssinica (*Hochst. ex Benth.) Kyal. & Boatwr.	Fabaceae	Sipa (Shi)	T	Mosquitoes prevention	Rb	Fr/D	Burned in a fire and fumigated in the house	Hu	Fd,Fe,Fw	BA-20
				Rectal prolapse	Rb	Fr	Pounded with bar salt, *G. ternifolia*, *C. arereh*, and *E. abyssinica* barks, root barks of *C. spinarum* and *C. lanceolatum,* and *T. conferta* leaves, filtered, and drunk	Hu		
Vachellia seyal (Delile) P.J.H.Hurter	Fabaceae	Egaha (Sh)	T	Boils	Ys,L	Fr	Rubbed, mixed with honey, and tied to the infected part	Hu	Fd,Fe,Fm	BA-18
Verbena officinalis L.	Verbenaceae	Atuch (Am)	H	Evil eye	Wp	Fr/D	Pounded, boiled in water, filtered, and drunk into an empty stomach	Hu	Bf	BA-160
Vernonia adoensis (Sch. Bip. ex Walp.) H.Rob.	Asteraceae	Gurguca (Shi)	SSh	Diarrhea	R	Fr	Chewed and filtrate swallowed, or pounded with *L. fruticosa* stem, water dissolved, filtered, and drunk	Hu	Bf,Ta	BA-200
				Abdominal pain	R	Fr/D	Chewed and filtrate swallowed, or pounded, water dissolved, filtered, and drunk	Hu		
Withania somnifera (L.) Dunal	Solanaceae	Gizawa (Am)	Sh	Diarrhea	L,R	Fr	Crushed root or rubbed leaves are added to water, filtered, and drunk	Hu	Bf	BA-177
				Vomiting	L,R	Fr	Crushed root or rubbed leaves are added to water, filtered, and drunk	Hu		
Xanthium strumarium L.	Asteraceae	Marishoquni (Shi)	H	Tinea versicolor	L	Fr	Crushed and creamed on the infected skin and sat in the sun for minutes	Hu	Fd	BA-73
				Hemorrhoids	L	Fr	Pounded, squeezed with a little water, and creamed on the infected part	Hu		
Ximenia americana L.	Olacaceae	Hudhaa (AO)	Sh	Hepatitis	L,Rb	Fr/D	Leaves are pounded with *F. virosa* leaves, boiled in water, and steamed, and dried root bark is powdered, water dissolved, filtered, and drunk	Hu	Cm,Fo,Fw	BA-49
				Blackleg	L	Fr	Fumigated in fire with *N. latifolia* and *C. macrostachyus* leaves, and aerial parts of *C. cyphopetalum* and *M. foetida*	L		
				Breast swelling	Rb	Fr	Pounded with bar salt, water dissolved, filtered, and given orally	L		
				Tonsillitis	L	Fr	Chewed and spat into kids mouths by their mothers	Hu		
Zehneria scabra (L.f.) Sond.	Cucurbitaceae	Hareg resa (Am)	C	Blackleg	Ap	Fr	Crushed with *P. schimperi, R. myricoides,* and *H. quartinianum* leaves, aerial parts of *M. foetida* and *P. macrosolen*, and fire-fumigated	L	Bf,Cm	BA-101
				General malaise	Ap	Fr	Crushed with *P. schimperi, R. myricoides,* and *H. quartinianum* leaves, aerial parts of *M. foetida* and *P. macrosolen*, and fire-fumigated, covered in cloth	Hu		
				Cough	L	Fr/D	Boiled in water, steaming at evening, and took a bath next morning	Hu		
Zingiber officinale Roscoe	Zingiberaceae	Zinjible (Am)	H	Common cold	Tu	Fr/D	Pounded, boiled with water and sugar, and drunk as a hot drink	Hu	Fo,Hd	–
				Abdominal pain	Tu	Fr/D	Pounded with salt and *N. sativa* seeds, boiled in water, filtered, and drunk	Hu		
				Tonsillitis	Tu	Fr/D	Chewed with *A. aspera* root, *N. sativa* seeds, and young shoots of *F.thonningii*, and spat a filtrate into kids mouths by mothers	Hu		
				Swelling	Tu	Fr	Sliced into pieces with *C. cornifolia* tubers and eaten with bar salt	Hu		
Ziziphus abyssinica Hochst. ex A. Rich.	Rhamnaceae	Unguga (Shi)	T	Diarrhea	Rb	Fr/D	Crushed, water dissolved, filtered, and given orally with honey or sugar to humans and with bar salt to cattle	HuL	Fd,Fo,U	BA-12

Snake venom	Rb	Fr	Pounded, water dissolved, filtered, and taken orally	Hu
Toothache	Rb	Fr	Crushed and inserted in or bitten on the infected tooth	Hu

Local language (La): *Am* Amharic, *AO* Afaan Oromoo, *Gz* Gumuz, *Shi* Shinasha; **Habit (Ha):** *C* Climber, *H* Herb, *Sh* Shrub, *SSh* Subshrub, *T* Tree; **Remedy parts (RP):** *Ap* Aerial parts, *B* Stem bark, *L* Leaf, *E* Exudate, *F* Fruit, *Fl* Flower, *Ps* Pseudobulbs, *R* Root, *Rb* Root bark, *S* Seed, *St* Stem, *Tu* Tuber, *Wp* Whole plant, *Ys* Young shoot; **Used for:** *Hu* Human, *L* Livestock, *HuL* Human and Livestock; **Additional uses (AU),** *At* Attractant, *Bf* Bee forage, *Bt* Beehive tree, *Bm* Beehive making, *Bw* Bread wrapping, *Ch* Charcoal, *Cm* Cleaning material, *Cf* Container fumigation, *Co* Construction, *Fd* Fodder, *Fe* Fence, *Fo* Food, *Fi* Fishing implement, *Fm* Farm material, *Fw* Fuel wood, *Hd* Hot drink, *Hs* Handling stick, *Ld* Land demarcation, *Lb* Local beverage, *Lu* Lubricant, *O* Ornamental, *Ps* Plate softening, *Sd* Shade, *Sf* Soil fertilizer, *Td* Traditional drug, *Ti* Timber, *Ts* Traditional soap, *Tb* Tooth brush, *U* Utensil; Voucher number (VN)

Appendix 2: Use value index for each medicinal plant species collected from Dibatie district, Metekel zone, western Ethiopia

No.	Medicinal plant species	ΣUi	n	UV
1	*Breonadia salicina* (Vahl) Hepper & J.R.I.Wood	30	6	5.00
2	*Ficus sycomorus* L.	10	2	5.00
3	*Terminalia laxiflora* Engl. & Diels	10	2	5.00
4	*Cordia africana* Lam.	72	17	4.24
5	*Albizia schimperiana* Oliv.	8	2	4.00
6	*Phoenix reclinata* Jacq.	8	2	4.00
7	*Croton macrostachyus* Hochst. ex Delile	105	29	3.62
8	*Dichrostachys cinerea* (L.) Wight & Arn.	14	4	3.50
9	*Grewia mollis* Juss.	7	2	3.50
10	*Jatropha curcas* L.	7	2	3.50
11	*Afrocarpus falcatus* (Thunb.) C.N.Page	7	2	3.50
12	*Ficus sur* Forssk.	10	3	3.33
13	*Faurea rochetiana* (A.Rich.) Chiov. ex Pic.Serm.	16	5	3.20
14	*Gymnanthemum amygdalinum (Delile) Sch.Bip.*	19	6	3.17
15	*Stereospermum kunthianum* Cham.	41	13	3.15
16	*Albizia gummifera* (J. F.Gmel.) C. A. Sm.	9	3	3.00
17	*Annona senegalensis* Pers.	3	1	3.00
18	*Azadirachta indica* A. Juss.	12	4	3.00
19	*Capsicum frutescens* L.	15	5	3.00
20	*Carica papaya* L.	6	2	3.00
21	*Catha edulis* (Vahl) Endl.	3	1	3.00
22	*Cucurbita pepo* L.	6	2	3.00
23	*Erythrina abyssinica* Lam.	21	7	3.00
24	*Flueggea virosa* (Roxb. ex Willd.) Royle	6	2	3.00
25	*Lablab purpureus* (L.) Sweet	3	1	3.00
26	*Lannea fruticosa* (Hochst. ex A. Rich.) Engl.	6	2	3.00
27	*Pterocarpus lucens* Lepr. ex Guill. & Perr.	6	2	3.00
28	*Rhamnus prinoides* L'Hér.	6	2	3.00
29	*Senna petersiana* (Bolle) Lock	6	2	3.00
30	*Sida rhombifolia* L.	12	4	3.00
31	*Sporobolus africanus* (Poir.) Robyns & Tournay	3	1	3.00
32	*Terminalia macroptera* Guill. & Perr.	6	2	3.00
33	*Trigonella foenum-graecum* L.	6	2	3.00
34	*Vachellia abyssinica (*Hochst. ex Benth.) Kyal. & Boatwr.	6	2	3.00
35	*Vachellia seyal* (Delile) P.J.H.Hurter	3	1	3.00
36	*Ziziphus abyssinica* Hochst. ex A. Rich.	12	4	3.00
37	*Gardenia ternifolia* Schumach. & Thonn.	27	10	2.70

38	*Acanthus polystachius* Delile	8	3	2.67
39	*Securidaca longepedunculata* Fresen.	8	3	2.67
40	*Justicia schimperiana* (Hochst. ex Nees) T. Anderson.	21	8	2.63
41	*Clematis simensis* Fresen.	23	9	2.56
42	*Rotheca myricoides* (Hochst.) Steane & Mabb.	33	13	2.54
43	*Carissa spinarum* L.	43	17	2.53
44	*Calpurnia aurea* (Aiton) Benth.	5	2	2.50
45	*Hypoxis schimperi* Baker	5	2	2.50
46	*Lagenaria siceraria* (Molina) Standl.	5	2	2.50
47	*Ricinus communis* L.	5	2	2.50
48	*Stephania abyssinica* (Dillon & A. Rich.) Walp. var. abyssinica	5	2	2.50
49	*Gnidia involucrata* Steud. ex A.Rich.	32	13	2.46
50	*Acmella caulirhiza* Delile	12	5	2.40
51	*Cucumis maderaspatanus* L.	12	5	2.40
52	*Ficus thonningii* Blume	7	3	2.33
53	*Nauclea latifolia* Sm.	14	6	2.33
54	*Ximenia americana* L.	11	5	2.20
55	*Clematis hirsuta* Perr. & Guill.	24	11	2.18
56	*Indigofera spicata Forssk.*	26	12	2.17
57	*Acalypha petiolaris* Hochst.	2	1	2.00
58	*Ageratum conyzoides* L.	6	3	2.00
59	Alectra sessiliflora (Vahl) Kuntze	2	1	2.00
60	*Allium sativum* L.	4	2	2.00
61	*Asparagus africanus* Lam.	2	1	2.00
62	*Calotropis procera* (Aiton) W.T.Aiton	2	1	2.00
63	*Canarina abyssinica* Engl.	6	3	2.00
64	*Cicer arietinum* L.	2	1	2.00
65	*Cissus quadrangularis* L.	2	1	2.00
66	*Citrus x aurantiifolia* (Christm.) Swingle	4	2	2.00
67	*Clausena anisata* (Willd.) Benth.	2	1	2.00
68	*Coccinia abyssinica* (Lam.) Cogn.	8	4	2.00
69	*Coffea arabica* L.	4	2	2.00
70	*Colocasia esculenta* (L.) Schott	6	3	2.00
71	*Convolvulus kilimandschari* Engl.	2	1	2.00
72	Coriandrum sativum L.	6	3	2.00
73	*Costus spectabilis* (Fenzl) K.Schum.	2	1	2.00
74	*Cucumis ficifolius* A. Rich.	2	1	2.00
75	*Dioscorea praehensilis* Benth.	6	3	2.00
76	*Echinops amplexicaulis* Oliv.	2	1	2.00
77	*Echinops giganteus* A. Rich.	6	3	2.00

78	*Ekebergia capensis* Sparrm.	2	1	2.00
79	*Eleusine coracana* (L.) Gaertn.	2	1	2.00
80	*Embelia schimperi* Vatke	10	5	2.00
81	*Entada abyssinica* Steud. ex A. Rich.	2	1	2.00
82	*Eragrostis tef* (Zucc.)	2	1	2.00
83	*Eucalyptus camaldulensis Dehnh.*	2	1	2.00
84	*Euphorbia hirta* L.	2	1	2.00
85	*Foeniculum vulgare* Mill.	4	2	2.00
86	*Guizotia scabra* (Vis.) Chiov.	2	1	2.00
87	*Gymnosporia senegalensis* (Lam.) Loes.	2	1	2.00
88	*Hypericum quartinianum* A. Rich.	2	1	2.00
89	*Indigofera emarginella* Steud. ex A. Rich. var. *emarginella*	4	2	2.00
90	*Kleinia abyssinica* (A. Rich.) A. Berger	2	1	2.00
91	*Laggera alata* (D.Don) Sch.Bip. ex Oliv.	2	1	2.00
92	*Laggera crispata* (Vahl) Hepper & J.R.I.Wood	2	1	2.00
93	*Lepidium sativum* L.	2	1	2.00
94	*Maesa lanceolata* Forssk.	2	1	2.00
95	*Mentha pulegium* L.	2	1	2.00
96	*Microglossa pyrifolia* (Lam.) Kuntze	2	1	2.00
97	*Monosis theophrastifolia* (Schweinf. ex Oliv. & Hiern) C.Jeffrey	10	5	2.00
98	*Nicotiana tabacum* L.	4	2	2.00
99	*Nigella sativa* L.	8	4	2.00
100	*Ocimum gratissimum* L.	10	5	2.00
101	*Osyris lanceolata* Hochst. & Steud.	2	1	2.00
102	*Paspalum scrobiculatum* L.	2	1	2.00
103	*Pavonia kilimandscharica* Gürke	2	1	2.00
104	*Philenoptera laxiflora* (Guill. & Perr.) Roberty	2	1	2.00
105	*Phytolacca dodecandra* L'Her.	26	13	2.00
106	*Piper capense* L. f.	4	2	2.00
107	*Portulaca quadrifida* L.	8	4	2.00
108	*Premna schimperi* Engl.	4	2	2.00
109	*Psidium guajava* L.	2	1	2.00
110	*Rumex abyssinicus* Jacq.	6	3	2.00
111	*Rumex nervosus* Vahl	2	1	2.00
112	*Ruta chalepensis* L.	10	5	2.00
113	*Salvia tiliifolia* Vahl	2	1	2.00
114	Sclerocarpus africanus Jacq.	2	1	2.00
115	*Sida urens* L.	2	1	2.00
116	*Solanum villosum* Mill.	4	2	2.00
117	*Steganotaenia araliacea* Hochst.	10	5	2.00

118	*Tacazzea conferta* N.E.Br.	4	2	2.00
119	*Verbena officinalis* L.	2	1	2.00
120	*Vernonia adoensis* (Sch. Bip. ex Walp.) H.Rob.	4	2	2.00
121	*Withania somnifera* (L.) Dunal	2	1	2.00
122	*Zingiber officinale* Roscoe	8	4	2.00
123	*Capparis tomentosa* Lam.	23	12	1.92
124	*Crepis rueppellii* Sch. Bip.	17	9	1.89
125	*Tapinanthus globifer* (A. Rich.) Tiegh.	52	28	1.86
126	*Gloriosa superba* L.	7	4	1.75
127	*Momordica foetida* Schumach.	21	12	1.75
128	*Moringa stenopetala* (Baker f.) Cufod.	7	4	1.75
129	*Xanthium strumarium* L.	7	4	1.75
130	*Echinops kebericho* Mesfin	5	3	1.67
131	*Glinus lotoides* L.	17	11	1.55
132	*Achyranthes aspera* L.	9	6	1.50
133	*Cissus cornifolia* (Baker) Planch.	12	8	1.50
134	*Cyphostemma adenocaule* (Steud. ex A. Rich.) Desc. ex Wild & R.B. Drumm.	3	2	1.50
135	*Cyphostemma pannosum* Vollesen	3	2	1.50
136	*Dracaena afromontana* Mildbr.	3	2	1.50
137	*Euphorbia schimperiana* Scheele	3	2	1.50
138	*Parthenium hysterophorus* L.	3	2	1.50
139	*Polygala persicariifolia* DC.	3	2	1.50
140	*Pterolobium stellatum* (Forssk.) Brenan	6	4	1.50
141	*Rumex nepalensis* Spreng.	3	2	1.50
142	*Solanum incanum* L.	6	4	1.50
143	*Stephanotis abyssinica* (Hochst.) S.Reuss, Liede & Meve	3	2	1.50
144	*Zehneria scabra* (L.f.) Sond.	3	2	1.50
145	*Euphorbia abyssinica* J.F.Gmel.	19	13	1.46
146	*Asparagus flagellaris* (Kunth) Baker	10	7	1.43
147	*Celosia trigyna* L.	14	10	1.40
148	*Tragia doryodes* M.G.Gilbert	11	8	1.38
149	*Aloe benishangulana* Sebsebe & Tesfaye	4	3	1.33
150	*Convolvulus arvensis* L.	4	3	1.33
151	*Cyphostemma cyphopetalum* (Fresen.) Desc. ex Wild & R.B.Drumm.	4	3	1.33
152	*Datura stramonium* L.	4	3	1.33
153	*Cassia arereh* Delile	17	13	1.31
154	*Brucea antidysenterica* J. F. Mill.	13	10	1.30
155	Haplosciadium abyssinicum Hochst.	23	18	1.28
156	*Mucuna melanocarpa* Hochst. ex A. Rich.	14	11	1.27

157	*Sauromatum venosum* (Dryand. ex Aiton) Kunth	7	6	1.17
158	*Cynoglossum lanceolatum* Forssk.	16	15	1.07
159	*Bidens pilosa* L.	1	1	1.00
160	*Clinopodium abyssinicum (Benth.) Kuntze*	1	1	1.00
161	*Drimiopsis barteri* Baker	2	2	1.00
162	*Gymnema sylvestre* (Retz.) R. Br. ex Schult.	2	2	1.00
163	*Kalanchoe densiflora* Rolfe	2	2	1.00
164	*Phragmanthera macrosolen* (Steud. ex A. Rich.) M.G.Gilbert	7	7	1.00
165	*Polystachya steudneri* Rchb.f.	12	12	1.00
166	*Senna obtusifolia* (L.) Irwin & Barneby	1	1	1.00
167	*Solanum anguivi* Lam.	4	4	1.00
168	*Solanum dasyphyllum* Schumach. & Thonn.	2	2	1.00
169	*Stephanotis schimperi* (Decne.) S.Reuss, Liede & Meve	1	1	1.00
170	*Thunbergia alata* Bojer ex Sims	1	1	1.00

Ui Number of uses mentioned by each informant for a specific species, *n* Total number of informants, *UV* Use value

Appendix 3: Pictures of medicinal and wild edible plants selected for laboratory-based investigatin and some other plants


Asparagus flagellaris


Brucea antidysenterica


Celosia trigyna


Crepis rueppellii


Gnidia involucrata


Epiphytic *Polystachya steudneri*


Sauromatum venosum

Saba comorensis

S. guineense subsp. *macrocarpum*

Dioscorea praehensilis shoot and tuber

Aloe benishangulana

Portulaca quadrifida in market

Osyris lanceolata marketable for fumigation

Appendix 4: Interview questions regarding the ethnobotany of medicinal plants

Name: ________________________________ Marital status: ___________________

Age: __________ Gender: ________________ Religion: _______________________

Occupation: ____________________________ Ethnicity: _______________________

Educational level: _______________________ Kebele: _________________________

No.	**Local name of Medicinal plants** (language)	**Ailments treated** (H/L/B)	**Remedy parts**	**Use condition** (F/D/FD)	**Preparation ways** (chew, boil, grind, crush, etc.)	**Additive agents** (honey, milk, etc.)	**Routes** (Oral, Dermal, Va, etc.)	**Dosage**	**Side-effect** (if yes specify & antidotes)	**Cultural taboos** (if yes specify)	**Additional uses**	**Threats to**	**Conservation status**	**Coll. No.**

Appendix 5: Interview questions regarding the ethnobotany of wild edible plants

Name: ______________________________ Marital status: __________________

Age: _________ Gender: _______________ Religion: ______________________

Occupation: __________________________ Ethnicity: ______________________

Educational level: _____________________ Kebele: ________________________

No.	**Local name of WEPs** (language)	**Edible parts**	**Harvesting time** (months)	**Dev'tal stage** (young, mature)	**Consumption reason** (war, famine, snack, alternative)	**Mode of use** (fresh, dried, cooked, etc.)	**Side-effect** (if yes specify and **antidotes**)	**Cultural taboos** (if yes specify)	**Additional uses** (fence, medicine, timber, etc.)	**Marketable or not** (local, national, int. level)	**Threats to**	**Conservation status**	**Coll. No.**