Tadesse *et al.*
Journal of Ethnobiology and Ethnomedicine (2025) 21:7
https://doi.org/10.1186/s13002-025-00761-9

Journal of Ethnobiology and Ethnomedicine

RESEARCH

Open Access

Ethnobotanical study of wild edible plants in Metema and Quara districts, Northwestern Ethiopia

Daniel Tadesse[1,2*], Getinet Masresha[2], Ermias Lulekal[3] and Asmamaw Alemu[4]

Abstract

Background Wild edible plants (WEPs) are vital to enhance food security and generate income. Despite Ethiopia's vast area and cultural diversity, there remains a need for further investigation of WEPs. Therefore, this study aimed to document WEPs, and the indigenous knowledge associated with them in the Metema and Quara districts of northwestern Ethiopia.

Methods Data on WEPs were collected through semi-structured interviews with 396 informants, guided field walks, focus group discussions, and market surveys. The data were analyzed using preference ranking, priority ranking, direct matrix ranking, and Jaccard's index.

Results We documented 51 WEPs that were distributed among 26 families and 39 genera. Fabaceae was the most represented family with eight species. Trees accounted for 49% of WEPs and were primarily consumed by their fruits (57%). Local communities usually consume these plants raw as a supplementary food, although some require processing. Of the recorded WEPs, 94.1% had multipurpose uses, in addition to nutrition. The main threats to WEPs availability were agricultural land expansion, fuelwood harvest, and construction use.

Conclusions WEPs play a crucial role in enhancing food security, nutrition, and income generation for local communities. However, they are facing increasing threats from human activity. Therefore, sustainable utilization, conservation efforts, and collaboration among stakeholders are necessary for the future use of WEPs. Furthermore, a nutritional composition assessment is recommended for the most promising WEPs.

Keywords Edible plants, Ethnobotany, Indigenous knowledge, Metema, Quara, Wild edible plants

*Correspondence:
Daniel Tadesse
kaleabfather@gmail.com
[1] Department of Plant Sciences, College of Agriculture and Environmental Sciences, University of Gondar, Gondar, Ethiopia
[2] Department of Biology, College of Natural and Computational Sciences, University of Gondar, Gondar, Ethiopia
[3] Department of Plant Biology and Biodiversity Management, College of Natural and Computational Sciences, Addis Ababa University, Addis Ababa, Ethiopia
[4] Department of Forestry, College of Agriculture and Environmental Sciences, University of Gondar, Gondar, Ethiopia

Introduction

Throughout history, plants have played a crucial role in human existence, offering vital resources including sustenance, animal feed, energy sources, medicinal compounds, housing materials, and ornamental value [1, 2]. A considerable portion of the plants consumed by humans are wild edible plants (WEPs), which grow naturally without cultivation or management and can be gathered from their native environments for consumption [3]. WEPs serve as valuable complements to cultivated crops, providing essential nutrients that contribute to food security and improve dietary quality, especially in less developed nations [4–7]. Due to their high nutritional content and market potential, WEPs can help combat chronic malnutrition while also generating economic opportunities [6, 7]. Incorporating WEPs into diets can significantly aid in addressing one of the most critical challenges of our era: hunger [3]. WEPs often serve as crucial food sources, ranking third in importance after vegetables and fruits, and surpassing common grains in nutritional value [3].

Ethiopia has huge floristic species diversity resources due to its highly variable topography, climate, ecology, and other physical features such as soil [8]. WEPs are an integral part of this remarkable diversity, with rural households in Ethiopia relying on various uncultivated plant species. A review by [9] identified approximately 651 WEPs in Ethiopia. However, the country faces several human-induced pressures that have resulted in the loss of thousands of hectares of forest that once harbored valuable WEPs. This loss has limited the benefits that local communities can derive from these plants and has endangered the indigenous knowledge associated with them [7]. The risk of losing this ethnobotanical knowledge is further amplified by declining intergenerational knowledge transfer and dependence on traditional oral transmission, which are susceptible to distortion and loss [10].

To date, ethnobotanical studies on WEPs in Ethiopia has been limited, encompassing merely 8.4% of the country's districts [9]. This limited scope underscores the substantial regional and ethnic gaps in WEP documentation and comprehension. Many areas remain unexplored, leading to the potential loss of invaluable traditional knowledge and resources. Additionally, the majority of WEP inventories have been conducted in regions where major language such as Amharic [11], Oromiffa [12], and Tigrinyae [13] are spoken. Ethiopia has experienced various resettlement initiatives, government-led and self-initiated, with Quara and Metema serving as prominent examples. As individuals from highland and midland regions interact with local populations, it becomes essential to examine their environmental engagement and WEP knowledge. Consequently, there exists a considerable gap in the comprehensive documentation of indigenous knowledge and practices related to WEPs in Northwestern Ethiopia's lowlands, an area characterized by diverse ethnic backgrounds and settlement histories.

The lowlands of northwestern Ethiopia, specifically Metema and Quara districts, are home to a diverse array of woody plant species. This biodiversity is supported by the Altash National Park, Mahibere Selassie community conservation area, and various communal woodlands [14]. However, these areas have faced deforestation and degradation owing to several factors. These include land-demanding initiatives, such as agricultural investments and re-settlement programs, coupled with weak regulatory frameworks, forest fires, cropland expansion, overgrazing, and exploitation of forest resources for multiple purposes [15–17]. To date, studies on WEPs in northwestern Ethiopian lowland areas have been limited, with only two studies conducted (16, 18). These investigations were limited in scope and focused on a small number of kebeles as sampled areas. Moreover, they failed to adequately account for variations resulting from diverse ethnic backgrounds, settlement patterns, and agroecological environments.

Although WEPs play a crucial role as food sources and for various other purposes in Metema and Quara districts, their ethnobotanical aspects have not been comprehensively investigated. This is particularly significant given the region's diverse ethnic composition, varied settlement patterns, and unique ecological settings coupled with the pressing need to document and safeguard WEP knowledge. This study aimed to: (1) document WEPs and associated indigenous knowledge used by the people of Metema and Quara districts, (2) identify the most preferred and marketed WEP species in the study areas, which may serve as a basis for conservation and nutritional analysis, and (3) compare the WEPs of the study areas with previously published studies in Ethiopia, for possible new data on WEPs consumed or variations in the edible parts.

Material and methods

Description of the study area

This study was conducted in the Metema and Quara districts of the West Gondar Zone, Amhara Regional State, Northwestern Ethiopia (Fig. 1). These districts are neighboring each other.

Metema District is located approximately 925 km northwest of Addis Ababa, the capital city. It comprises 31 kebeles (the smallest administrative unit in Ethiopia), with Genda Wuha serving as its administrative center. The district is home to the Agew, Amhara, Gumuz, and Kimant ethnic groups, with a total population of 110,231 [17]. The elevation ranges from 550 to 1608 m above sea level, covering an area of about 440,000 ha [14]. The Metema district is characterized by lowland agroecology, with a mean annual rainfall of 1008 mm and a mono-modal rainfall pattern occurring from June to September [18]. The mean annual temperature is 26.2 °C, ranging from 15.7 to 41.0 °C [18]. Major crops include sesame, cotton, and sorghum, whereas goats and cattle are the primary livestock [18].

Quara District is situated approximately 1,045 km northwest of Addis Ababa. It consists of 28 kebeles, with Gelegu as its administrative center. The district

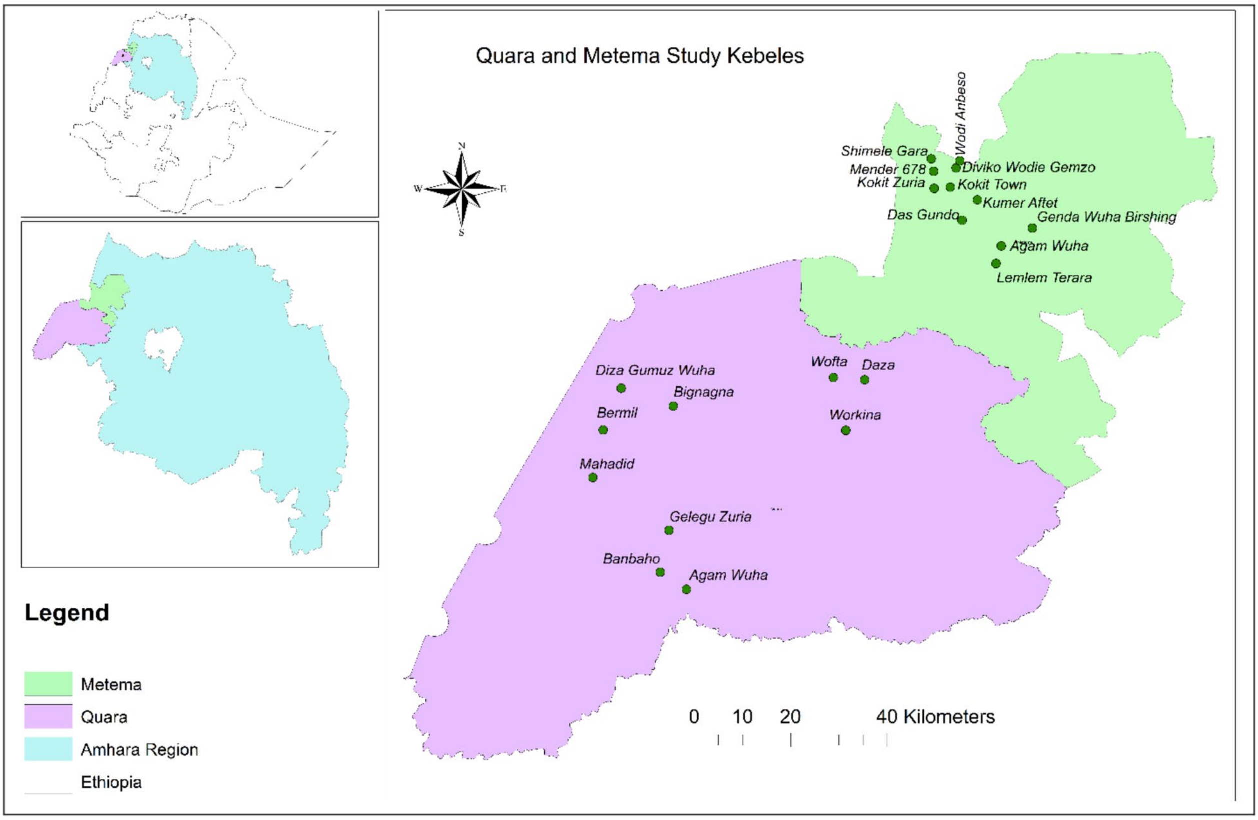

Fig. 1 Map of Ethiopia showing the Amhara region and study sites

is inhabited by the Agew, Amhara, and Gumuz ethnic groups with an estimated population of 93,629 [17]. The elevation in Quara ranges from 530 to 1900 m above sea level, encompassing a total area of approximately 858,588 ha [19]. The mean annual temperature ranges from 26 to 42 °C, with annual rainfall varying from 600 to 1200 mm and an average of 800 mm. The rainy season typically begins in early May and ends in early October following a monomodal pattern. The district features both midland and lowland agroecology, with agricultural production (sesame, sorghum, and cotton) and livestock rearing (cattle, goats, and equines) serving as the main income sources [16].

According to the broad classification of Ethiopia's forests, the lowland dry forests of the Quara and Metema districts are categorized as *Combretum-Terminalia* woodlands. The dominant vegetation type is mixed dry deciduous woodlands, with abundant *Combretum* and *Terminalia* tree species [20], alongside *Sterculea setigera*, *Boswellia papyrifera*, *Terminalia leiocarrpa*, *Lannea fruticosa*, *Stereospermum kunthianum*, *Dichrostachys cinerea*, and *Pterocarpus lucens* [14, 21].

Research design

Reconnaissance survey and site selection

This study was conducted in two districts with diverse ethnic backgrounds, agroecology, and settlement histories to obtain a more comprehensive understanding of indigenous knowledge related to WEPs. The reconnaissance survey aimed to identify the sample kebeles for the actual study. It was conducted in two phases: July 2–9, 2022, in the Metema district, and July 15–22, 2022, in the Quara district. A multistage sampling strategy was employed to select study kebeles and participants (Table 1). Initially, 21 kebeles were selected using stratified sampling, ensuring proportional representation across lowland and midland areas, ethnic diversity, and varying settlement history. These 21 kebeles accounted for 35.59% of all kebeles within the two districts, reflecting a comprehensive sampling approach that enhances the validity of the study.

Sample size determination and informant selection

In the Metema district, the selected 11 kebeles had a total of 11,466 households, while the 10 kebeles in Quara had 29,792 households, resulting in a combined total of 41,258 households across the 21 kebeles. This was used to

Table 1 Description of study kebeles of data collection, highlighting key geographical and demographical attribute

District	Study kebele	GPS coordinates		Altitude (m)	Ecology	TNH	NI	Age			Gender		Informant type		Ethnicity (A, Ag, G)	Language (A, Ag, D, G)	Occupation (Cs, Fa, Me)	Religion (Is, Ort)
		Latitude	Longitude					20–39	40–59	≥60	M	F	GI	KI				
Quara	Bambaho	12° 05′ 03″ N	35° 56′ 12″ E	735	Lowland	4670	45	20	11	14	30	15	43	2	A, G, Ag	A, G, Ag	Cs, Fa, Me	Is, Ort
	Gelegu Zuria	12° 08′ 28″ N	35° 55′ 45″ E	761	Lowland	4150	40	22	8	10	28	12	39	1	A, G, Ag	A, G, Ag	Cs, Fa	Ort
	Mehadid	12° 17′ 52″ N	35° 45′ 49″ E	585	Lowland	1721	16	5	4	7	10	6	11	5	G	A, D	Fa, Me	Is
	Bermil	12° 23′ 32″ N	35° 44′ 13″ E	575	Lowland	2235	21	10	7	4	14	7	18	3	A	A	Cs, Fa	Ort
	Diza Gumuz Wuha	12° 24′ 45″ N	35° 45′ 34″ E	556	Lowland	3107	30	20	8	2	27	3	28	2	A	A	Cs, Fa	Ort
	Bignagna	12° 23′ 42″ N	35° 50′ 27″ E	586	Lowland	1948	19	7	7	5	14	5	14	5	G	G	Cs, Fa	Is
	Agam Wuha	12° 04′ 44″ N	36° 00′ 35″ E	787	Lowland	1608	15	5	4	6	9	6	9	6	Ag	A, Ag	Cs, Fa, Me	Ort
	Wofta	12° 17′ 54″ N	36° 13′ 19″ E	1733	Midland	3287	32	7	13	12	24	8	26	6	A	A	Fa	Ort
	Workina	12° 16′ 10″ N	36° 11′ 48″ E	1517	Midland	2034	20	7	10	3	13	7	18	2	A	A	Cs, Fa	Ort
	Daza	12° 16′ 30″ N	36° 13′ 30″ E	1764	Midland	5032	48	21	16	11	26	22	44	4	A	A	Cs, Fa, Me	Is, Ort
	Sub-total					29,792	286	124	88	74	195	91	250	36				

Table 1 (continued)

District	Study kebele	GPS coordinates		Altitude (m)	Ecology	TNH	NI	Age			Gender		Informant type		Ethnicity (A, Ag, G)	Language (A, Ag, D, G)	Occupation (Cs, Fa, Me)	Religion (Is, Ort)
		Latitude	Longitude					20–39	40–59	≥60	M	F	GI	KI				
Metema	Mender 678	12° 57′ 33″ N	36° 14′ 58″ E	705	Lowland	657	6	3	2	1	4	2	5	1	Ag	A, Ag	Cs, Fa	Ort
	Kokit Zuria	12° 51′ 53″ N	36° 14′ 42″ E	794	Lowland	1133	11	6	3	2	7	4	10	1	A	A	Cs, Fa	Ort
	Kokit town	12° 52′ 09″ N	36° 16′ 00″ E	726	Lowland	1500	14	6	4	4	9	5	12	2	A	A	Cs, Fa, Me	Is, Ort
	Das Gundo	12° 44′ 19″ N	36° 11′ 48″ E	838	Lowland	1372	13	4	5	4	8	5	12	1	A	A	Fa, Me	Is, Ort
	Kumer Aftet	12° 48′ 14″ N	36° 21′ 32″ E	742	Lowland	760	7	3	1	3	6	1	3	4	G	A, G	Cs, Fa, Me	Is
	Agam Wuha	12° 43′ 16″ N	36° 19′ 15″ E	848	Lowland	884	8	2	2	4	5	3	7	1	A	A	Cs, Fa	Is, Ort
	Lemlem Terara	12° 40′ 09″ N	36° 17′ 40″ E	889	Lowland	440	4	2	1	1	4	0	3	1	A	A	Cs, Fa	Is, Ort
	Diviko Wedie Gemzo	12° 57′ 48″ N	36° 19′ 17″ E	764	Lowland	2983	29	13	11	5	17	12	26	3	A	A	Cs, Fa	Ort
	Shimele Gara Tagur	13° 01′ 12″ N	36° 17′ 00″ E	740	Lowland	994	10	5	3	2	7	3	7	3	A	A	Cs, Fa	Ort
	Genda Wuha Birshign	12° 44′ 46″ N	36° 26′ 38″ E	764	Lowland	344	4	0	3	1	2	2	3	1	A	A	Cs, Fa	Ort
	Wedi Anbesso	12° 58′ 29″ N	36° 24′ 40″ E	849	Lowland	399	4	2	0	2	3	1	3	1	A	A	Cs, Fa	Ort
	Sub-total					11,466	110	46	35	29	72	38	91	19				
Total						41,258	396	170	123	103	267	129	341	55				

TNH Total number of householders, *NI* Number of interviewees, Gender (*M* Male, *F* Female), Informant type (*GI* General Informant, *KI* Key Informant), Ethnicity (*A* Amhara, *Ag* Agew, *G* Gumuz), Language (*A* Amharic, *Ag* Agew, *D* Detsan, *G* Gumuz), Occupation (*Cs* Civil servant, *Fa* Farmer, *Me* Merchant), Religion (*Is* Islam, *Ort* Orthodox) determine the sample size. From these households, 396 informants were selected as representative respondents, calculated using Cochran's formula at a 95% confidence level [22].

The study participants were comprised of 341 general informants and 55 key informants. General informants were selected through simple random sampling from village lists using the random lottery method, while key informants were chosen using purposive sampling in consultation with local authorities and elders as well as through snowball sampling [23]. The ages of all interviewees ranged from 20 to 81 years, with 267 males and 129 females. The sociodemographic characteristics of the participants are presented in Table 1. Experts in the study areas were selected as key informants because of the extensive local knowledge gained from long-term residences. These individuals provide researchers with access to a rich source of indigenous expertise. Additionally, they offered supplementary insights that complemented the information gathered through the semi-structured interviews.

Data collection

Ethnobotanical data were collected using a variety of methods, including semi-structured interviews, focus group discussions, guided tours, market surveys, and collection of voucher specimens for subsequent identification [23]. Field trips were conducted from August 2022 to October 2023, accompanied by local informants in the Metema and Quara districts, to identify and collect species of WEPs. Each interview lasted an average of two hours, extending up to four hours for the key informants. The head of the household was typically interviewed; if unavailable, a family member aged 20 years or above was selected to ensure fair representation of both genders and age groups.

For focus group discussions (FGDs), we included elderly and knowledgeable individuals who had lived in the area for many years and were well acquainted with local plants. FGDs were conducted for each of the three ethnic groups, considering their settlement histories (locals and settlers) and agroecological zones (midland and highland). A guided tour involves field visits with knowledgeable informants to verify the names of the plants cited during the interviews. During these tours, we identified WEPs recognized by community members and collected specimens of the WEPs mentioned in the interviews. Each kebele had one guided tour conducted with 2–3 knowledgeable informants. A market survey was conducted in Kebeles with open markets as well as in the main towns of the districts. These surveys were carried out twice a year at each market to capture seasonal variations. During the market surveys, we recorded the WEPs available for sale, including their units of measurement, prices per unit, and information about sellers (age and sex). Additionally, we inquired with sellers about other potential markets for WEPs beyond the district.

Interviews were primarily conducted in Amharic, with translators available for informants who did not speak Amharic. The interviews focused on gathering information regarding the local names of the plants, edible parts, growth habits, harvesting seasons, modes of consumption, marketability, threats, management methods, and additional uses of WEPs. Interviews were conducted with eight focus group discussions, four in each district, involving knowledgeable individuals. Each discussion included five to seven participants and focused on the traditional uses, preparation methods, threats, and conservation practices of WEPs in local communities. These discussions also helped identify multipurpose WEPs, their common uses, the most preferred species, and common threats to WEPs. The insights gained from the focus group discussions contributed to the direct matrix ranking (DMR), preference ranking, and prioritization of threats to WEPs exercises.

Specimen identification

The collected voucher specimens were authenticated using taxonomic literature (https://powo.science.kew.org/; http://alnapnetwork.com/Default.aspx; https://about.worldfloraonline.org/), reference voucher specimens, expert assistance at Addis Ababa University, and various books on the Flora of Ethiopia and Eritrea. Vernacular names of all documented WEP species were also recorded. The identification process was conducted at the National Herbarium (ETH) of Ethiopia, located at Addis Ababa University, and at the Herbarium of the University of Gondar, under the guidance of a botanical taxonomic expert. After the identification process was completed, the verified plant specimens were dried, pressed, and mounted on herbarium sheets. They were then deposited at the Herbarium of the Department of Biology, University of Gondar, in Gondar, Ethiopia, for future reference and study.

Data analysis

The collected data were analyzed using descriptive statistical methods and ethnobotanical indices. Percentages, proportions, and frequencies were calculated to summarize and characterize the WEPs data using Microsoft Excel spreadsheet software version 2013. To compare knowledge of WEPs among different social groups, statistical analyses were conducted using IBM SPSS Statistics software, version 29. The Kruskal–Wallis H test, a nonparametric alternative to the one-way ANOVA, was performed to examine the relationships among age, and ethnic background categories. The Mann–Whitney U test, a nonparametric alternative to the independent sample t-test, was carried out to compare gender, informant type, education level, study districts, and settlement history. WEP knowledge was determined in terms of the number of wild edible plants mentioned by different respondents. The quantitative analyses included calculating ethnobotanical indices as described below:

Preference ranking

The preference ranking of the WEPs was performed according to Martin [24] and Cotton [25]. In the preference ranking process, values from 1 to 10 were assigned to each of the 24 key informants. For the preference ranking exercise, informants were given the names of the ten most preferred wild edible plants based on various factors, including taste, availability, accessibility, cultural significance, and income generation potential, and ranked accordingly. The wild edible plant that was believed to have the sweetest taste was assigned the highest value of 10, and the plant with the least sweetness was assigned a value of 1. Preference classification was based on the total score for each species. The total rank of the preferences was obtained by adding the number given by each informant.

Direct matrix ranking

In addition to food, local people have used edible wild plants for various purposes, such as house construction, furniture, livestock fodder, medicine, fuelwood, and farm tools. The seven use values recorded for the eight plant species were totaled and ranked. DMR was performed to compare the multipurpose properties of WEPs commonly reported by informants [24, 25]. Twenty-four key informants were asked to assign usage values based on seven categories, with values ranging from zero to five. The average use values for each multipurpose species in each use category were recorded, averaged, and summed for ranking purposes.

Priority ranking of threats

For the preference ranking of major threats to these plants, 24 key informants evaluated eight major threats based on their degree of destructive effects [24, 25]. Values from 1 to 8 were assigned and the total values provided by each key informant were summed to identify the most relevant factors.

Jaccard index

The Jaccard index (JI) was calculated to determine the similarity or dissimilarity of the WEPs used between the present and previous studies from surrounding regions and other areas by analyzing the percentages of quoted species and their uses. It is calculated as follows [75]:

$$JI = c/(a + b - c) * 100$$

where JI is Jaccard's index, a is the number of species in the study area only, b is the number of species in other areas only, and c is the number of species common to both areas a, and b.

Ethical consideration

The researchers obtained formal approval to conduct the study through a letter from the Vice President for Research and Technology Transfer at the University of Gondar (clearance number 1059/2022). This letter was subsequently presented to the district administration offices of Metema and Quara, where permission was granted to conduct the survey. Verbal consent was obtained from the informants after elaborating the aim of the study with the assistance of native translators when needed.

Results and discussion

Wild edible plant knowledge of the informants

The inhabitants of Metema and Quara districts have accumulated extensive traditional knowledge about the various WEP resources they use for food, medicinal purposes, and other applications. However, ethnobotanical knowledge was not uniformly distributed among different groups of informants. Statistical analyses were conducted to examine the distribution (Table 2).

Analysis of the Mann–Whitney U test outcomes revealed no statistically significant variations ($p > 0.05$) between males and females, indicating that both genders have comparable knowledge of WEPs. This outcome is consistent with comparable findings from the Maale and Debub Ari regions in Southern Ethiopia [33] and the Raya-Azebo area in Northern Ethiopia [13]. Our findings also corroborate studies conducted in Nepal [48], Brazil [50], and China [56], suggesting that the equal access to WEP resources in riverine and agricultural areas, which are frequented by both men and women, contributes to similar levels of WEP knowledge across genders.

The Mann–Whitney U test also indicated no significant differences ($p > 0.05$) in knowledge of WEPs based on the level of education. This finding is in agreement with a study conducted in the Hula District of the Sidama Zone, which indicated a lack of significant differences among education levels in the knowledge of WEPs [35]. A significant difference ($p < 0.05$) was observed based on the informant category using Mann–Whitney U test, with key informants identifying a greater number of WEPs than general informants, highlighting the greater experience and connection of key informants to these plants.

Table 2 Wild edible plant knowledge of the informants

Parameters	Informant categories	Number of informants	Mean rank	Chi-Square	*p*-value
Gender	Male	267	198.96	17,099.0	0.908
	Female	129	197.55		
Education level	Illiterates	180	199.08	19,335.0	0.926
	Literates	216	198.01		
Informant type	Key informants	55	327.63	2,275.5	0.000*
	General informant	341	177.67		
Settlement history	Local	146	213.31	16,087.5	0.045*
	Settlers	250	189.85		
Study Districts	Quara	286	198.36	15,796.00	0.969
	Metema	110	198.85		
Age (Years)	20–39	170	174.57	19.506	0.000*
	40–59	123	198.88		
	≥ 60	103	237.54		
Ethnic background	Amhara	319	177.72	60.601	0.000*
	Gumuz	43	313.58		
	Agew	34	247.93		

*$p < 0.05$ showed significance differences

This observation is consistent with studies conducted in Ethiopia [12, 45], Guatemala [47], and Nepal [48].

Statistical analysis using a Mann–Whitney U test revealed a significant disparity ($p < 0.05$) in the identification of WEPs based on settlement history. Indigenous residents identified more WEPs compared to settlers. This outcome implies that, despite harmonious coexistence, native inhabitants possess a more extensive knowledge of WEPs. This finding aligns with research conducted in northern Ethiopia, which observed that long-term residents demonstrated greater familiarity with WEPs than those who had returned from resettlement programs[31]. The increased number of WEP citations by local inhabitants can be attributed to their extended residency, which has allowed for a deeper understanding of the local flora. Interestingly, the Mann–Whitney U test showed no significant variations in knowledge ($p > 0.05$) across the studied districts. This suggests a free flow of information among communities, notwithstanding the existing agroecological differences between Quara District, which encompasses both midland and lowland agroecology, and Metema District, which consists exclusively of lowland agroecology.

Statistical analysis using Kruskal–Wallis H test indicated notable variations ($p < 0.05$) among different age groups, with elderly participants demonstrating greater familiarity with WEPs compared to middle-aged (40–59 years), and younger (20–39 years) individuals. This pattern aligns with findings from Ethiopia [12, 35, 40, 44] and global studies [48, 50, 55]. The enhanced knowledge among older generations likely stems from their first-hand experience with WEPs, including those consumed during periods of food scarcity. Moreover, older informants expressed reluctance to share information about potentially poisonous species with younger people, concerned that the latter might lack the necessary patience to properly prepare these plants for safe.

The Kruskal–Wallis H test indicated statistically significant variations ($p < 0.05$) among ethnic groups. The Gumuz people reported the highest number of WEPs, followed by the Agew and Amhara groups. This finding aligns with a study conducted in Southern Ethiopia, which also noted differences in WEP knowledge between Maale and Ari ethnic communities [33]. The discrepancy may stem from the heavy reliance of the Gumuz people on wild flora and fauna for their daily sustenance in contrast to the practices of other ethnic groups in the area.

Wild edible plant knowledge of the informants

This study comprehensively documented 51 species of WEPs classified into 39 genera and 26 families (Table 3). The number of WEPs documented in the Metema and Quara districts surpasses the findings of other ethnobotanical studies in various regions of Ethiopia. For example, previous studies have reported 29 WEPs in the Bule Hora district [29], 32 in the Yilmana Densa and Quarit districts [11], 44 in the Adiarkay, Debark and Dejen districts [43], 50 in the Midakegn district [12], and 41 in the Mieso district [44]. In contrast, some studies have documented higher numbers of WEPs than those found in

Table 3 List of WEPs including local names, families, growth habits, edible part, mode of consumption, additional use, and their habitats

Scientific name	Local name	Family	GH	EP	MD	Use diversity	H	HM	IR	RA	Citations in Ethiopia	Voucher number
Abelmoschus ficulneus (L.) Wight & Arn	Yebereha Wayka (A)	Malvaceae	H	F	Ck, Po	F0, Hu, M	Fl	Oct-Dec	76	LL	[26]	DTK11
Adansonia digitata L	Diza (A)	Malvaceae	T	F L	Dr, J Ck	Bht, Sd, M	F, Fl, Gl, Hg, Ow, Rv	Feb-May All months	160	LL	[16, 18, 27]	DTK64
Amaranthus caudatus L	Aluma (A)	Amaranthaceae	H	L	Ck	Bf, M	Fl, Gl	Jul-Sep	5	LL	[26, 28–30]	DTK21
Amaranthus hybridus L	Aluma (A)	Amaranthaceae	H	L	Ck	Bf, M	Fl, Gl	Jul-Sep	5	LL	[12, 13, 26, 31, 32]	DTK20
Ampelocissus schimperiana (Hochst. ex A. Rich.) Planch	Andera (A) Antsiginie (G)	Vitaceae	C	F T	Fr Fr	Fo, M	Fl, Rv	Jul-Sep	72	LL	[26, 28]	DTK35
Balanites aegyptiaca (L.) Delile	Lalo (A)	Zygophyllaceae	T	F S	Fr, J Ck, R	Au, Bht, Ch, Co, Ft, Fo, Fw, Hu, Sc, Sd, Sf, Ti, M	Fl, Rv	Oct-Feb	311	LL	[13, 16, 18, 27, 29–31, 33, 34]	DTK88
Corchorus olitorius L	Kudra (A)	Malvaceae	H	L	Ck	Fo, M	Fl	Jun-Sep	239	LL	[16, 18, 26, 28, 29, 31, 34]	DTK25
Carissa spinarum L	Agam (A)	Apocynaceae	S	F	Fr	Bf, Co, Df, Fw, M	Rv, Gl	Mar-Jun	227	B	[11–13, 26, 28–35]	DTK83
Cucumis ficifolius A. Rich	Yemidir embuay (A)	Cucurbitaceae	H	F	Fr	M	Fl	Seo-Oct	7	B	[16]	DTK78
Cordia africana Lam	Wanza (A)	Boraginaceae	T	F	Fr	Au, Bht, Ch, Co, Fo, Fw, Hu, M, Sd	Fl, Hg	Jan-Mar	231	B	[11–13, 18, 26–35]	DTK110
Dioscorea bulbifera L	Mujir (G)	Dioscoreaceae	C	T	Bo	-	Ow, Rv	All months	19	LL	[26, 30, 36]	DTK144
Dioscorea dumetorum (Kunth) Pax	Chibalia (G)	Dioscoreaceae	C	T	Bo	-	Ow, Rv	All months	47	LL	[37]	DTK145
Dioscorea praehensilis Benth	Sinsa (A)	Dioscoreaceae	C	T	Bo, Fr, Dr, R	M	Ow, Rv	All months	206	LL	[16, 26, 28, 29, 34, 36]	DTK12
Diospyros mespiliformis Hochst. ex A. DC	Serkin (A)	Ebenaceae	T	F	Fr	Au, Bht, Ch, Co, Fo, Fw, Hu, Sc, Sd, Tb, M	RV	Oct-Jan	303	LL	[13, 16, 27, 33, 34]	DTK90
Ficus sur Forssk	Shola (A)	Moraceae	T	F	Dr, Fr	Ch, Bht, Fo, Hu, M, Sc, Sd	Gl, Rv	Jan-Apr	140	B	[11–13, 16, 18, 26–28, 30–35]	DTK67
Ficus sycomorus L	Bamba (A)	Moraceae	T	F	Fr	Au, Ch, Co, Bht, Fo, Hu, M, Sd	Gl, Rv	Nov-Jan	251	B	[12, 16, 27–29, 31, 33, 34]	DTK65
Ficus thonningii Blume	Chibha (A)	Moraceae	T	F	Dr, Fr	Ch, Bht, Fo, Fw, Hu, M, Sc, Sd	Gl, Rv	Dec-Apr	154	B	[12, 16, 31]	DTK66
Ficus vasta Forssk	Warka (A)	Moraceae	T	F	Dr, Fr	Bht, Hu, M, Sd	Gl, Rv	Mar-Apr	133	ML	[11, 13, 26–29, 31–35]	DTK68

Table 3 (continued)

Scientific name	Local name	Family	GH	EP	MD	Use diversity	H	HM	IR	RA	Citations in Ethiopia	Voucher number
Flueggea virosa (Roxb. ex Willd.) Royle	Shasha (A)	Phyllanthaceae	S	F	Fr	Fo, M	Gl, Ow	Jul-Oct	14	LL	[18, 27, 28, 34]	DTK43
Garcinia livingstonei T Anderson	Homtit (A)	Clusiaceae	T	F	Fr	Fw, Sd	F	Jun-Sep	74	ML	[31, 33]	DTK153
Gardenia ternifolia Schumach. & Thonn	Gambilo (A)	Rubiaceae	T	F	Fr	Au, Ch, Fw, Hu, Ip, O, Ti, M	Fl, Gl, Ow	May-Jun	9	LL	[12, 16, 26–28, 34]	DTK84
Grewia ferruginea Hochst. ex A. Rich	Lenquata (A)	Malvaceae	T	F	Dr	Hb, M	F, Rv	Jan-Apr	4	B	[28, 32]	DTK109
Grewia flavescens Juss	Betre musie (A)	Malvaceae	S	F	Dr, Fr	Fw, M	Rv	Sep-Nov	29	LL	[30]	DTK24
Hyphaene thebaica (L.) Mart	Selien (A)	Arecaceae	T	F S	Fr Fr	Co, Hu, M, Tb	F, Rv	Nov-Feb	15	LL	[27]	DTK92
Ipomoea biflora (L.) Pers	Selselo (A) Eigteha (G)	Convolvulaceae	H	L	Ck	M	Rv, Fl	Jul-Oct	19	LL	[30]	DTK27
Keetia gueinzii (Sond.) Bridson	Telengita (A)	Rubiaceae	S	F	Fr	M	Fl, Rv	Jun-Aug	62	ML	Not reported	DTK32
Lannea welwitschii (Hiern) Engl	Dergeja (A)	Anacardiaceae	T	F	Dr, Fr	Au, Ch, Fw, Sd, Ti	F	Mar-Jun	1	LL	[38]	DTK129
Mimusops kummel Bruce ex A. DC	Eshe (A)	Sapotaceae	T	F	Fr	Bf, Fo, Fw, M	Rv	Nov-Feb	103	ML	[11, 12, 27–29, 31, 33, 34]	DTK117
Momordica foetida Schumach	Yequra hareg (A)	Cucurbitaceae	H	L F	Bo, Fr Fr	Fo, M	Hg, Rv	Aug-Nov	21	B	[16, 28, 30, 35]	DTK08
Oxytenanthera abyssinica (A. Rich.) Munro	Yebereha shimel (A)	Poaceae	H	Ys	Ck	Au, Bm, Co, Df, Hu, M	Hg, Ow, Rv	Jun-Aug	12	LL	[28]	DTK108
Peponium vogelii (Hook.f.) Engl	Tikur Leza (A)	Cucurbitaceae	S	F	Fr	Au, M	F	Sep-Nov	4	ML	[26]	DTK41
Piliostigma thonningii (Schumach.) Milne-Redh	Yekola wanza (A)	Fabaceae	T	F	Dr	Au, Bf, Co, Fo, Fw, Hu, IP, M	Ow, Fl, Gl	Jan-Jun	32	LL	[16, 26, 28, 29]	DTK60
Rumex nepalensis Spreng	Yewisha milas (A)	Polygonaceae	H	L	Ck, Fr	M	Fl	Jun-Oct	27	LL	[31]	DTK42
Rumex nervosus Vahl	Embacho (A)	Polygonaceae	S	Ys	Fr	-	Gl, Hg	Jul-Nov	5	ML	[11, 12, 27, 28, 32]	DTK134
Saba comorensis (Bojer ex A.DC.) Pichon	Ashama (A)	Apocynaceae	C	F	Fr	Bf, Bm, Fw, Co, M	Rv	Oct-Nov, May-Jul	196	B	[12, 16, 18, 26–28, 33, 34]	DTK82
Searsia glutinosa (Hochst. ex A. Rich.) Moffett	Qamo (A)	Anacardiaceae	S	F	Dr, Fr	Fw, M	Rv	Sep-Nov	47	ML	[12, 28]	DTK18

Table 3 (continued)

Scientific name	Local name	Family	GH	EP	MD	Use diversity	H	HM	IR	RA	Citations in Ethiopia	Voucher number
Senegalia polyacantha (Willd.) Seigler & Ebinger	Gmarda (A)	Fabaceae	T	G	Fr	Co, Fw, Ch, Hu, Ti, M	Fl, Rv	All months	5	LL	[34]	DTK55
Sterculia setigera Delile	Darlie (A)	Malvaceae	T	S	R	Bht, M	F, Fl	Nov-Apr	9	LL	[57]	DTK94
Strychnos innocua Delile	Kudkuda (A)	Loganiaceae	T	F	Dr,Fr	Ch, Co, Fw, M, O	Ow, Rv	Mar-Jun	111	LL	[27–29, 33]	DTK91
Syzygium guineense (Willd.) DC. sub sp. Macrocarpum (Engl.) F. White	Dokma (A)	Myrtaceae	T	F	Fr	Bf, Fw, M	Rv, Ow	May-Jun	159	B	[11, 12, 16, 18, 26–30, 33–35]	DTK38
Tamarindus indica L	Kumer (A)	Fabaceae	T	F	Dr, J	Au, Bht, Ch, Co, Fo, Fw, Hu, Sd, Sf, Wb, M	Rv	Dec-Apr	252	LL	[13, 16, 18, 26, 27, 29–31, 33, 34]	DTK61
Terminalia leiocarpa (DC.) Baill	Kikira (A)	Combretaceae	T	G L	Dr, Fr Ck	Ch, Au, Fw, Co, Df, Bht, M	F, Gl	All months	4	LL	[34]	DTK73
Vachellia nilotica (L.) P.J.H. Hurter & Mabb	Tikur girar (A)	Fabaceae	T	F	Dr	Ch, Co, Fw, M	Fl	Jan-Mar	2	LL	[39]	DTK57
Vachellia seyal (Schweinf.) Kyal. & Boatwr	Qey girar (A)	Fabaceae	T	G	Fr	Ch, Co, Fw, M	Fl	All months	15	LL	[13, 30, 31]	DTK58
Vachellia sieberiana (DC.) Kyal. & Boatwr	Nech girar (A)	Fabaceae	T	G	Fr	Ch, Co, Fw, M	Fl	All months	2	LL	[40]	DTK59
Vigna membranacea A. Rich	Yebere kolet (A)	Fabaceae	H	T	Fr	Fl	Fl	Jun-Aug	15	LL	[41]	DTK141
Vigna vexillata (L.) A. Rich	Yegider wotet (A) Cheha/Enchesie (G)	Fabaceae	H	T F L	Bo, Fr, R Bo, Fr, R Bo, Fr	M	Fl	Aug-Nov	13	LL	[36]	DTK03
Vitex doniana Sweet	Alinguagua (A)	Lamiaceae	T	F	Dr, Fr	Bf, Bht, Ch, Co, Fo, Sd	Fl, Gl, Ow	Mar-Apr	100	ML	[26–28, 33]	DTK149
Ximenia americana L	Enkoy (A)	Olacaceae	S	F	Fr	Au, Ch, Co, Df, Fo, Fw, M, Sd	Rv, Ow	Feb-Apr	285	LL	[11–13, 16, 18, 26–29, 31, 33, 34]	DTK89
Ziziphus abyssinica Hochst. ex A. Rich	Ahya gava (A)	Rhamnaceae	S	F	Dr	Au, Ch, Co, Df, Fo, Fw, Hu, M	Fl, Gl, Ow	Jan-Apr	40	LL	[26–28, 34]	DTK70
Ziziphus spina-christi (L.) Desf	Gava (A)	Rhamnaceae	S	F S	Dr Dr	Au, Ch, Co, Df, Fo, Fw, Hu, M, Sd	Fl, Gl, Ow, Lf	Dec-Apr	278	LL	[13, 16, 18, 27, 31–34]	DTK71

Local name: A = Amharic; Ag = Agew; G = Gumuz; GH = Growth habit; C = Climber; H = Herb; Sh = Shrub; T = Tree; EP = Edible parts; F = Fruit; G = Gum; S = Seed; Tu = Tuber; L = leaf; Ys = Young shoot; MD = Mode of consumption; Bo = Boiled; Ck = Cooked; Dr = Dry raw; Fr = Fresh raw; J = Juice; Po = Porridge; R = Roasted; Use diversity; Au = Agricultural utensil; Bf = Bee forage; Bht = Beehive hanging tree; Bm = Beehive materials; Ch = Charcoal; Co = Construction; Df = Dead fence; Fo = Forage; Ft = Fish trap; HU = Household utensil; Fw = Fuel wood; Hb = Hair beautification; Ip = Indigenous perfume; M = Medicine; O = 0rnamental; Sd = Shade; Sc = Shade for cultivation; Sf = Soil fertilizer; Ti = Timber; Tb = Tooth brush; Wb = Wind break; H = Habitats; F = Forest; Fl = Farmland; Gl = Grazing land; Hg = Home garden; Lf = Live fences = Ow = Open woodland; Rv = Riparian vegetation; HM = Harvesting months; IR = Informant reports; RA = Reported agroecology: ML = Midland; LL = Lowland; B = Both this study, including studies by other authors [13, 26, 28, 29, 45]. Additionally, Morocco [46], India [5], and China [6], have reported greater richness of WEPs. The variation in reported WEP numbers across different studies may result from several factors, including differences in agroclimatic conditions [27, 45], size of the study areas [45], cultural variations [11, 27], vegetation cover [11], and intensity of research efforts [45]. In this study, the relatively higher utilization of WEPs can be linked to the richness of plant species, the deep indigenous knowledge associated with the area's diverse ethnic groups, varied agroecological conditions, and easy availability of WEPs.

The family with the highest representation was Fabaceae, which contributed eight species (15.7%) to the overall richness of the WEPs. Following closely were Malvaceae and Moraceae each contributed five species (9.8%), and Cucurbitaceae and Dioscoreaceae each contributed three species (5.9%). Six families were represented by two WEP species, whereas the remaining 15 families were represented by a single species. Overall, 37.9% of the documented families (11 of 26) contained more than one WEP species, accounting for 36 species (70.6%) of the total WEP richness. The dominance of the Fabaceae family in this study is consistent with the findings of other ethnobotanical studies conducted in Ethiopia [13, 26, 37–39], China [58], and India [66]. Comprehensive national reviews of WEPs by [7] and [9] have also identified Fabaceae as having the highest number of edible species in the Ethiopian flora. This abundance likely contributes to the widespread use of WEPs within this family, as noted by [9], as well as the remarkable adaptability of Fabaceae species to the lowland areas of the study sites.

The diverse range of WEPs in the study area can supply crucial nutrients, enhance food security, and support a well-balanced diet [64]. Incorporating WEPs into dietary practices is advantageous for bolstering food security as it can substantially improve overall health and wellness [65, 66]. Moreover, the identified WEPs in the study region play a vital role in addressing health concerns, underscoring the strong link between health outcomes and nutritional benefits derived from WEPs [66].

Growth habits of wild edible plants

The documented species of WEPs exhibit a wide range of growth habits. Based on their growth characteristics, WEPs were categorized into four main groups: trees, shrubs, herbs, and climbers. Trees constituted the largest proportion, encompassing 25 species (49%) of the total WEP richness, indicating that most WEPs in the study area were woody species. In contrast, shrubs (11 species, 21.6%), herbs (10 species, 19.6%), and climbers (five species, 9.8%) contributed to smaller shares.

Fig. 2 Venn diagram of WEPs among the studied agroecology

The predominance of trees as the dominant growth habit among the reported WEPs aligns with several previous studies conducted in Ethiopia [28, 34, 42, 45], Guatemala [47], Nepal [67], and Uganda [68]. However, other ethnobotanical studies have identified shrubs and herbs as predominant growth forms of WEPs. For instance, studies by [12, 26, 30] have found shrubs to be the most common growth habit. Similarly, studies in China [6], Ethiopia [11, 32], Nepal [48], and India [49] documented herbs as the dominant form of WEP. The higher abundance of trees in the current study may be attributed to their superior adaptation to lower altitudes compared to other growth forms. This dominance highlights the importance of prioritizing the conservation of tree species over other growth forms. The dominance of the growth form as the primary source of WEPs may be explained by the utilization categories of plant parts [69]. In the present study, trees and shrubs were predominant, largely because of the greater number of consumable fruits. Conversely, other studies have shown that herbs dominate because of the abundance of edible succulent stems and leaves [70]. The variation in these findings can be attributed to agroecological conditions and cultural practices specific to each region [6].

Habitats of wild edible plants

The habitat distribution of WEPs spans a broad ecological range, from low-to mid-land altitudes (Fig. 2). A total of 33 WEPs (64.7%) were identified in the lowland areas, whereas eight WEPs (15.7%) were found in the midland regions. Additionally, 10 WEPs (19.6%) thrived in both agroecological zones. These plants were collected from diverse habitats including forest patches, open woodlands, riverine areas, grasslands, farmlands, live fences, and home gardens. The results indicated that the majority of WEPs (28 species, 29.5%) were found in riverine vegetation, followed by farmlands (24 species, 25.3%), grazing lands (16 species, 16.8%), and open woodlands (14 species, 14.7%) (Table 4). Notably, a single WEP species may inhabit multiple habitat types: nearly two-thirds of the WEPs (33 species, 64.7%) were found in two or more habitats, whereas 18 species (35.3%) were restricted to a single habitat (Table 3).

Table 4 Habitats of wild edible plants

Habitat type	Number of species	Percentage (%)
Riverine	28	29.5
Farmland	24	25.3
Grazing land	16	16.8
Open woodland	14	14.7
Forest	7	7.4
Home garden	7	5.3
Live fence	3	1.0

The higher collection of WEPs in riverine and farmland areas is consistent with findings from several previous ethnobotanical studies in other regions [13, 16, 28, 50]. In contrast, some studies have indicated that most WEPs are collected from forest habitats [12, 33, 44]. In addition, farmlands have been recognized as significant sources of WEPs [13], suggesting that local communities actively recognize the benefits of these species and maintain them on their farms, grazing lands, and adjacent riverine areas. The prevalence of WEPs in riverine habitats may be attributed to higher soil moisture levels that support their growth. However, the current study observed minimal cultivation of WEPs in home gardens and their use in live fences. To enhance the availability of these valuable resources, communities should cultivate multipurpose and commonly used WEP species in their home gardens, integrate them within crop fields, and incorporate them into live fences. This approach promotes the sustainable use and conservation of WEPs.

Edible parts of wild edible plants

In this study, we identified six distinct edible parts of WEPs, highlighting their usage in local communities. Fruit emerged as the most commonly utilized plant part, accounting for 29 species (57%). This was followed by leaves from five species (9%), whereas edible gums and tubers each represented four species (8%). Young shoots and seeds were the least frequently harvested, reflecting their lesser role in the local diets (Fig. 3).

The prominence of fruits as the preferred edible parts aligns with numerous ethnobotanical studies conducted across various regions of Ethiopia [11–13, 28, 30, 42]. Similar trends in fruit consumption have been observed in countries such as Guatemala [47], Nepal [48], India [49], Brazil [50], China [51], Uganda [68], and Kenya [73],. The higher prevalence of fruit consumption can be attributed to their convenience as raw foods that require no processing, along with their availability during the dry season. This aligns with previous findings that note the appeal of fruits owing to their longer shelf life and palatable flavors, making them a favored choice among WEPs [28, 35].

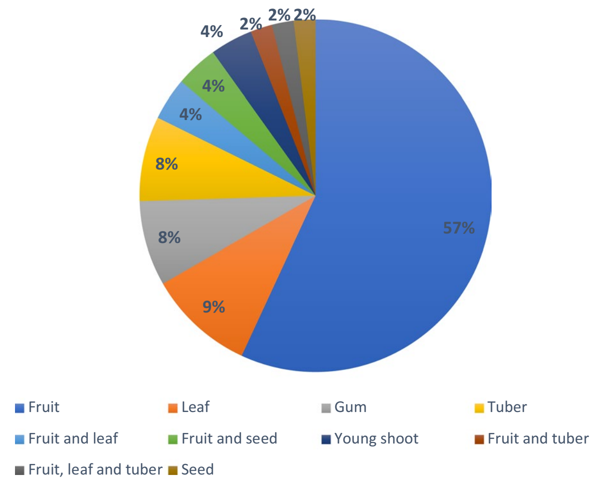

Fig. 3 Proportions of edible parts of wild edible plants in Metema and Quara Districts

Additionally, six WEPs were noted to have multiple edible parts, enhancing their value in local diets (Table 3). These include the tubers, fruits, and leaves of *Vigna vexillata*; the leaves and fruits of *Momordica foetida* and *Adansonia digitata*; the fruits and seeds of *Balanites aegyptiaca* and *Hyphaene thebaica*; and the fruits and tubers of *Ampelocissus schimperiana*. Notably, the Gumuz community consumes the leaves of *Adansonia digitata* year-round, whereas various ethnic groups, including the Gumuz, harvest its fruit from February to May. The presence of WEPs with multiple edible parts can significantly bolster food security by providing diverse edible options throughout the year. The consumption of multiple parts of some WEP species is in agreement with studies conducted in China [62] and Kenya [73].

Edible fruits were reported to exhibit varying tastes (sweet, sour, and bitter), although the majority were noted for their sweetness. Interestingly, the wild edible leaves *of Ipomoea biflora* and *Rumex nepalensis* displayed contrasting flavors; they were bitter when raw but sweet when cooked. These characteristics underscore the culinary versatility of these plants and reinforce the findings of previous studies that highlight the nutritional and cultural importance of WEP [7, 28]. Fresh fruits are primarily consumed for their health benefits because they provide essential nutrients such as ascorbic acid, provitamin A carotenoids, minerals, and nutraceuticals, which offer various health-promoting advantages [72]. Furthermore, fruits have gained increased recognition for their role in promoting health because of the protective

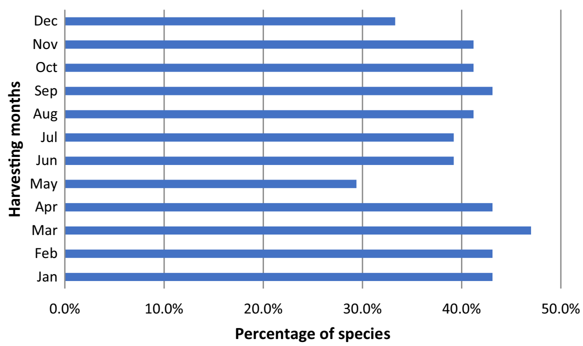

Fig. 4 Harvesting months of wild edible plants

Table 5 Mode of consuming wild edible plants

Mode of consumption	Number of WEPs	Percentage
Fresh raw	40	48.8
Dry raw	17	20.7
Cooked	9	11.0
Boiled	7	8.5
Roasted	5	6.1
Juice	3	3.7
Porridge	1	1.2

qualities of their non-bioactive compounds. This recognition has led to an increase in their incorporation into the human diet [72].

Seasonal availability of wild edible plants

This study revealed that the edible parts of WEPs in the surveyed areas were harvested and consumed at various times throughout the year (Fig. 4). Most WEPs were harvested in March (47%), followed closely by January, February, April, and September, accounting for 43.1% each. Among the identified species, 44 were seasonal, meaning they were harvested during specific months, whereas seven species were available year-round. Key WEPs collected from January to April included *Ziziphus spina-christi*, *Ziziphus abyssinica*, *Tamarindus indica*, and *Ficus thonningii*. The tubers of *Dioscorea praehensilis*, *Dioscorea dumetorum*, and *Dioscorea bulbifera* were consumed throughout the year, becoming notably sweeter when harvested during the dry season. Additionally, gums from *Senegalia polyacantha*, *Terminalia leiocarpa*, *Vachelia sieberiana*, and *Vachelia seyal* were collected year-round.

The seasonal availability of WEPs varies according to the species and their edible parts. The interviews and focus group discussions highlighted the significance of these food resources during the dry season, particularly from January to April. This period coincided with increased free time for community members to gather wild plants as there were no field crops to manage. The availability of most WEPs during the dry season, when food shortages are common, plays a crucial role in mitigating famine. Similar findings regarding the importance of WEPs during the dry and early rainy seasons have been documented in other regions of Ethiopia [28, 33, 43]. However, regional differences exist; some studies indicate peak WEP harvesting seasons in September–October [13] or June–August [16]. These variations likely stem from differences in agro-ecological and climatic conditions [27, 35] as well as plant species composition [43] across the different study sites in Ethiopia. Seasonal availability of WEPs is affected by the growth habit and plant part consumed, as most of the WEPs in the current study were trees whose fruits were consumed. Supporting this insight, a study from India reported that leafy vegetables were the most frequently consumed plant parts harvested by the local people from April to September, as these months are the main rainy season in the country [66].

In this investigation, herbaceous WEP species, such as *Vigna vexillata, Corchorus olitorius, Ipomoea biflora*, *Rumex nepalensis,* and *Vigna membranacea,* were primarily available during the rainy season. This aligns with previous reports that highlight the prevalence of such herbs in rainy months [32]. Efforts have been made to cultivate *Corchorus olitorius* through irrigation during the dry season, providing a year-round supply. As the rainy season begins in May, focus group discussions indicate a shift in availability from fruits during the dry season to herbaceous plants as rain arrives. Some WEP, including *Abelmoschus ficulneus*, *Tamarindus indica*, *Adansonia digitata*, *Ziziphus spina-christi*, and *Balanites aegyptiaca*, can be stored and made available throughout the year. This year-round availability of diverse WEP is crucial for supplementing food and nutritional needs, as well as providing trade opportunities for local communities. Overall, understanding the seasonal availability of WEPs not only highlights their importance in local diets, but also underscores the need for effective management and conservation strategies to ensure their sustainability and continued contribution to food security.

Mode of consumption of wild edible plants

Local communities possess a wealth of traditional knowledge about the consumption of WEPs. The majority of WEPs were consumed fresh and raw (48.8%), whereas a smaller percentage was consumed dried and raw (20.7%). The remaining 30.5% required some form of processing, such as cooking, boiling, roasting, or preparation as porridge or juice (Table 5). This preference for fresh and raw consumption aligns with findings from studies in Ethiopia [12, 13, 28, 29, 33, 43, 45], neighboring Sudan [52], China [58, 62], Pakistan [60], and Uganda [68] where it has been reported that most WEPs are consumed in their natural state. The popularity of fresh fruits is attributed to their ease of consumption, appealing taste, and daily nutritional requirements [32]. Raw fruits are particularly favored because preservation often diminishes taste quality, making immediate consumption more desirable [51].

In practice, most fruits were consumed directly, either fresh or dried, in various settings such as outdoors or at home. Few require additional processing; however, some, such as *Adansonia digitata*, *Tamarindus indica*, and *Balanites aegyptiaca*, are made into juices, which are especially popular among children and youths. This practice echoes reports from other regions of Ethiopia, where similar juice preparations from *Tamarindus indica* have been documented [33, 43] and Tanzania [74]. Pulps of *Adansonia digitata* were reported to be consumed as juice in Sudan [52]. Juice preparation typically involves the addition of cold water and sugar, if available. The juice is often kept for 12–24 h before consumption.

Leafy WEPs are predominantly prepared through cooking and are commonly served with local bread, consistent with previous reports [13, 28]. These included the leaves of *Corchorus olitorius*, *Rumex nepalensis*, *Adansonia digitata*, and *Ipomoea biflora*. Some leaves were consumed either boiled or fresh, indicating diverse culinary practices (Table 2). Additionally, certain WEPs, such as *Abelmoschus ficulneus, Dioscorea bulbifera, Dioscorea dumetorum, Dioscorea praehensilis, Tamarindus indica, Adansonia digitata, Ziziphus spina-christi, Balanites aegyptiaca,* and *Strychnos innocua*, can be stored for extended periods under dry conditions, if kept in dry conditions. This storage capability not only extends their availability, but also enhances food security for local communities.

Occasions of consuming wild edible plants

The study area featured a diverse array of WEPs, which were predominantly harvested and consumed as supplementary foods (80.4%). A smaller proportion of these plants was used as main dishes (11.8%) or consumed during periods of famine or drought (7.8%). This finding aligns with those of several other studies conducted in Ethiopia [12, 13, 16, 28, 45]. However, there were some notable exceptions to this general pattern. For instance, the leaves *of Ipomoea biflora* and *Rumex nepalensis* were reported to be eaten as the main dish, particularly for breakfast, by the Gumuz community while they drank local beer. Additionally, the fruits of *Abelmoschus ficulneus*, the tubers of *Dioscorea praehensilis,* and the leaves of *Corchorus olitorius* were previously consumed as main dishes by the Gumuz people but are now becoming either main dishes or seasonal food gap fillers for a few other ethnic groups. In agreement with the current report, Dioscorea *praehensilis* had been previously identified as a seasonal food gap tuber in Ethiopia [28]. This study revealed that *Dioscorea bulbifera* and *Dioscorea dumetorum*, both containing toxic tubers, were utilized as famine foods when conventional food sources were depleted. The toxicity of these two WEPs raises doubts and concerns about their safety, in agreement with a previous report [62]. This finding further aligns with observations in China [59], where they documented various tuberous WEPs employed as carbohydrate substitutes during periods of scarcity and economic hardship, functioning as emergency food sources.

These findings elucidate the multifaceted roles of WEPs in the dietary practices of local communities, encompassing both supplementary and primary nutritional sources. The observed transformation in the utilization of specific WEPs, such as *Abelmoschus ficulneus*, *Dioscorea praehensilis*, and *Corchorus olitorius*, underscores the dynamic and evolving nature of WEP consumption patterns. These alterations may be attributed to various factors including shifting food preferences, resource availability, and the need to adapt to seasonal food scarcity. This study provides a crucial understanding of the complex and subtle ways in which WEPs are utilized and relied upon by local populations. This underscores the importance of understanding and recording these time-honored practices to ensure long-term food security and to protect biodiversity.

Popular wild edible plants

Certain WEPs were cited more frequently than others, highlighting their importance to the local communities. Notably, more than 50% of the informants mentioned ten WEPs (19.6%) (Table 6). The most frequently cited WEPs in the two districts were *Balanites aegyptiaca* (311 citations), *Diospyros mespiliformis* (303 citations), *Ximenia americana* (285 citations), *Ziziphus spina-christi* (278 citations), and *Tamarindus indica* (252 citations). For a comprehensive list of citations of all WEPs, please refer to Table 2.

The prominence of these ten species, cited by more than half of the respondents, indicates their significant value in the local context. Among them, *Balanites aegyptiaca*, *Ximenia americana*, *Ziziphus spina-christi,* and *Tamarindus indica* have also been recognized as widely preferred in other regions of Ethiopia [13, 16]. Additionally, these species are noted for their popularity in neighboring Sudan [52], further emphasizing their regional

Table 6 Popular wild edible plants

Scientific name	Part(s) eaten	No. of informant citations	Percentage
Balanites aegyptiaca	Fresh raw fruit, raw seed, and cooked seed	311	78.5
Diospyros mespiliformis	Fresh raw fruit	303	76.5
Ximenia americana	Fresh raw fruit	285	71.9
Ziziphus spina-christi	Dry raw fruit	278	70.2
Tamarindus indica	Dry raw fruit	252	63.6
Ficus sycomorus	Fresh raw fruit	251	63.4
Corchorus olitorius	Cooked leaves	239	60.4
Cordia africana	Fresh raw fruit	231	58.3
Carissa spinarum	Fresh raw fruit	227	57.3
Dioscorea praehensilis	Boiled tuber, fresh raw tuber, dry raw tuber, roasted tuber	206	52.0

Table 7 Marketability and collectors of wild edible plants

Species	Measuring Unit	Price in Ethiopian birr*	Collector and seller group	
			Age	Sex
Abelmoschus ficulneus	Cup	15–20 birr/cup	Youth	Women
Adansonia digitata	Kg	50 birr/kg	All age groups	Both sexes
Balanites aegyptiaca	Cup, kg	5 birr, 20 birr/kg	Child and Young	Both sexes
Corchorus olitorius	Fistful	10–15 birr/handful	All age groups	Women
Dioscorea praehensilis	Number	5birr/piece	All age groups	Both sexes
Diospyros mespiliformis	Cup	5birr/cup	Child and Youth	Both sexes
Saba comorensis	Number	5birr/3 pieces	Child and Youth	Both sexes
Strychnos innocua	Number	5birr/ 3 pieces	Child and Youth	Both sexes
Syzygium guineense	Cup	5birr/cup	Child and Youth	Both sexes
Tamarindus indica	Kg	30–100 birr/kg	All age groups	Both sexes
Ximenia americana	Cup	5 birr/cup	Child and Youth	Both sexes
Ziziphus spina-christi	Cup	5 birr/cup	Child and Youth	Both sexes

*1 US Dollar = 113.40 Ethiopian birr

importance. The widespread appeal of these WEPs can be attributed to several factors, including palatable taste, marketability, diverse uses, and availability during the dry season.

The frequent mention of certain WEPs by more than half of the respondents highlights their nutritional importance to local populations. These plants can enhance dietary variety, especially in areas with limited food options. The resilience of popular WEPs in hot climates can mitigate food scarcity and help communities to endure seasonal shortages. The importance of certain WEPs emphasizes the need to preserve these species and their habitat. Protection of these plants boosts biodiversity, which is vital for healthy ecosystems. Recognizing the ecological value of the commonly cited WEPs can encourage responsible harvesting and ensure sustainable resource management for local populations.

Marketability of wild edible plants

WEPs not only serve as vital food sources, but also play a significant role in generating income for local communities. Through market surveys and informant interviews, it was discovered that 12 WEPs (23.52%) were sold as food in local markets and towns and even exported to neighboring Sudan (Table 7).

Among these marketable WEPs, *Abelmoschus ficulneus*, *Adansonia digitata*, *Balanites aegyptiaca*, *Corchorus olitorius*, *Dioscorea praehensilis*, *Diospyros mespiliformis*, *Tamarindus indica*, and *Ziziphus spina-christi* emerged as common commodities. In contrast, species such as *Saba comorensis*, *Strychnos innocua*, *Syzygium guineense*, and *Ximenia americana* are rarely sold in local markets. Fruits from five key WEPs, *Abelmoschus ficulneus*, *Adansonia digitata*, *Balanites aegyptiaca*, *Tamarindus indica* (Fig. 5), and *Ziziphus spina-christi*, were also exported to the Republic of Sudan

Fig. 5 *Tamarindus indica* fruit with pod collected from Metema, Ethiopia, and being sold at Gelabat market, Sudan. Picture taken by the author. The first picture was taken on March 12, 2022, and the second on February 25, 2023

through informal channels. Previous studies have indicated that certain WEPs, namely *Tamarindus indica*, *Balanites aegyptiaca*, and *Adansonia digitata*, have been sent to the Republic of Sudan for commercial purposes [16, 18]. This finding is consistent with a study conducted in China which demonstrated that cross-border trade has enabled the exchange and marketing of wild plants from various regions [58]. This has led to expanded availability and range of wild plant species, subsequently promoting their widespread consumption.

The study found that all marketable WEP species were fruits, apart from *Corchorus olitorius* (leaves) and *Dioscorea praehensilis* (tubers). Previous research has documented the marketability of several fruit species in Ethiopia, such as *Syzygium guineense* [12, 29], *Adansonia digitata* [16], *Tamarindus indica* [16, 29, 44], *Balanites aegyptiaca* [13, 16, 32], *Diospyros mespiliformis* [13], *Saba comorensis* [16, 28], *Ximenia americana* [11–13, 16, 28, 32] and *Ziziphus spina-christi* [13, 44]. This study identified four additional marketable WEPs for the first time: the fruits of *Abelmoschus ficulneus* and *Strychnos innocua*, tubers of *Dioscorea praehensilis*, and leaves of *Corchorus olitorius.*

The market chain for WEPs sold locally is relatively short and involves collectors, retailers, and consumers. However, the chain for exported WEPs was longer, incorporating informal formal transporters at the border between Ethiopia and Sudan. Several factors contribute to the marketability of WEPs, including their taste, quantity, and ease of collection. However, some WEPs are less marketable, potentially because of their shorter shelf-lives. These findings underscore the potential for further research into the value chains, profitability, and sustainable utilization of these marketable WEPs. Consistent with previous studies in the Ethiopian districts of Quara [16] and Metema [18], the export of certain WEPs, including *Adansonia digitata*, *Balanites aegyptiaca*, and *Tamarindus indica*, to Sudan reaffirmed the economic significance of these plants.

Marketable WEPs were gathered and sold by youth and children, with participation from both genders, reflecting a community-wide engagement in the commercialization of these plants, consistent with findings from earlier studies carried out in various regions of Ethiopia [28, 32]. Despite the opportunities presented by marketable WEPs, it is noteworthy that approximately 77.36% of WEPs cannot be sold as food. Instead, many of these were utilized for other purposes, including timber, agricultural utensils, fuelwood, charcoal, and construction materials. This aligns with earlier studies indicating that most WEPs are not commercially viable owing to limited availability and lower preference compared to domesticated plants [11, 28]. Youth and children's involvement in collecting and selling WEPs demonstrates community-wide engagement with both positive and negative environmental impacts. Sustainable WEP harvesting can support biodiversity by fostering appreciation for indigenous species, whereas extensive non-food use, such as timber and fuel, raises concerns about overexploitation and ecosystem degradation. This dual use requires careful management to ensure the viability of the plant population and ecosystem protection.

Market exploitation of WEPs has mixed effects on food security. Although participation in WEP markets can provide supplementary income, approximately 77.36% of these plants are not sold as food, highlighting the gap in addressing nutritional needs. Many WEPs can improve local diets but are underutilized owing to low market demand. Promoting the consumption of marketable WEPs could enhance dietary diversity and food security,

Table 8 WEPs with undesirable effects and communities control strategies in Metema and Quara districts, Northwestern Ethiopia

Species	Edible part	Undesirable effect	Causes	Recommended strategies for consumption
Garcinia livingstonei	Fruit	Toung souring	Excessive consumption	Eating moderate amount
Ziziphus spina-christi	Fruit	Stomachache, vomiting	Excessive consumption	Eating moderate amount
Balanites aegyptiaca	Fruit	Stomachache, Diarrhea	Excessive consumption	Eating moderate amount
Tamarindus indica	Fruit	Diarrhea	Excessive consumption	Eating moderate amount
Dioscorea bulbifera	Tuber	Death, closure of the throat	If the poison is not removed through processing	Wash with wood ash and water and then cooking
Dioscorea dumetorum	Tuber	Death, inability to control saliva, shouting	If the poison is not removed through processing	Wash with wood ash and water and then cooking

particularly in regions with limited access to cultivated food. Children and youth engagement in WEP activities has significant public health implications. Involvement in traditional practices can foster knowledge about nutrition and biodiversity, potentially leading to healthier diets. However, the predominant non-food use of WEPs may limit their availability for consumption, potentially affecting the community health. Ensuring the safety of the collected plants and educating the community on the nutritional benefits and safe harvesting methods could improve health outcomes and support sustainable livelihoods.

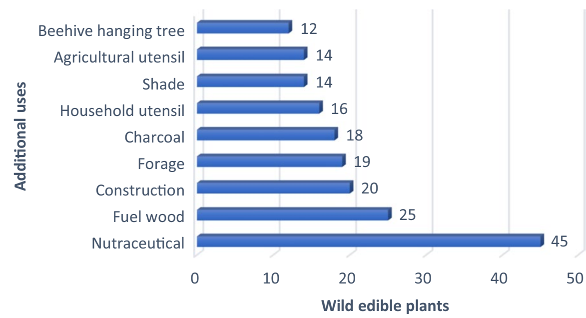

Fig. 6 Multiple uses of wild edible plants

Side effects of wild edible plants

Traditional knowledge of WEPs is crucial for maintaining a healthy diet and for the prevention and treatment of the potential adverse effects associated with their consumption. Table 8 provides detailed information on the six WEPs, including their edible parts, undesirable effects, and recommended safe consumption strategies. It is important to note that excessive consumption of specific WEPs can lead to gastrointestinal issues, such as stomachaches, diarrhea, and vomiting. In particular, the tubers of *Dioscorea bulbifera* and *Dioscorea dumetorum* can be toxic and even deadly if poisonous components are not adequately removed through proper preparation techniques.

This finding aligns with a previous study that reported adverse effects linked to the consumption of *Balanites aegyptiaca* and *Tamarindus indica*. For instance, consuming these fruits alongside meat or in excessive quantities can result in symptoms such as diarrhea, stomachache, and vomiting [33]. Furthermore, the literature broadly acknowledges the risks associated with certain WEPs, emphasizing the need for caution [29].

Preserving and documenting traditional knowledge regarding WEP identification and preparation is vital for public health, enabling the safe and effective use of WEPs, enhancing dietary habits, and reducing adverse health outcomes. Public education and awareness campaigns are essential because of the potential negative effects of consuming WEPs. Educating communities on proper preparation and consumption methods can mitigate health risks, particularly for plants that require specific cooking techniques to remove toxins. Ongoing studies on their health impacts are necessary to evaluate their safety and nutritional benefits. Effective public health communication must consider the cultural context of WEP consumption, with culturally appropriate approaches that respect local food-related practices and beliefs and enhance community participation and adherence to health guidelines.

Use diversity of wild edible plants

Local communities utilize a diverse array of WEPs for purposes other than food consumption. Of the 51 WEPs reported, only 3 species (5.9%) were exclusively consumed as food. The remaining 48 species (94.1%) exhibited multiple uses, demonstrating their multifunctionality across the districts (Table 3). Common uses included nutraceuticals (45 species), fuelwood (25 species), and construction materials (20 species) (Fig. 6). Notably, 10 WEPs possessed more than 7 distinct uses beyond edibility, including *Piliostigma thonningii*, *Tamarindus indica*, *Ficus sycomorus*, *Ficus thonningii*, *Ziziphus* *spina-Christi*, *Gardenia ternifolia*, *Balanites aegyptiaca*, *Ximenia americana*, *Diospyros mespiliformis*, and *Cordia africana* (Table 3).

The current study showed a remarkable diversity of uses for WEPs that extend past their nutritional value, aligning with findings from various studies across Ethiopia [11, 26, 28, 32, 33], China [59, 62], and Uganda [68]. The use of WEPs as nutraceuticals is particularly common in Ethiopia [11, 12, 28, 45], which parallels practices observed in Morocco [46], Brazil [50], China [59, 62], India [66], and Tanzania [74]. The significant number of reported WEPs utilized for medicinal purposes underscores their critical role in supporting human health and well-being, reinforcing the broader recognition of wild edibles as vital sources for medicinal applications globally [51, 53].

The diversity of applications, ranging from nutrition to medicine and beyond, highlights the multifaceted value that these plants offer to local communities. This reflects a deep reservoir of traditional knowledge and reliance on wild plant resources, particularly in areas where access to domesticated foods and modern healthcare may be limited. Documenting and understanding this diversity of uses is crucial for developing comprehensive strategies for sustainable management and conservation of WEPs. By leveraging their nutraceutical properties and various applications, WEPs can be effectively integrated into local food systems and health practices, thereby enhancing food and nutrition security. This integration not only supports local livelihoods, but also contributes to the resilience of communities in the face of changing environmental and economic conditions.

Preference ranking of wild edible plants

A preference ranking was conducted with twenty-four key informants to evaluate ten commonly used WEPs based on various factors, including taste, availability, accessibility, cultural significance, and income generation potential. The informants assigned values from 1 to 10 to the selected plants, where 10 indicated the most preferred WEP and 1 represented the least preferred WEP. The results showed that *Corchorus olitorius*, *Ximenia americana*, and *Diospyros mespiliformis* were ranked 1st, 2nd, and 3rd, respectively (Table 9).

Table 9 Preference ranking of selected wild edible plants

Wild edible plants	Total score	Rank
Ximenia americana	171	2nd
Ziziphus abyssinica	144	5th
Balanites aegyptiaca	135	6th
Ficus sycomorus	84	8th
Tamarindus indica	84	8th
Carissa spinarum	70	9th
Diospyros mespiliformis	164	3rd
Cordia africana	94	7th
Corchorus olitorius	215	1st
Dioscorea praehensilis	159	4th

The scores in the preference ranking reflect individual opinions, highlighting the variability in WEP usage among the community members. Among the evaluated plants, the leaves of *Corchorus olitorius* received the highest score, which was attributed to their favorable taste, marketability, appetizing nature, availability, and palatability. These leaves are particularly valued in lowland areas, where they serve as a staple in stews, often accompanied by *injera*, which is a traditional bread. In contrast, stew ingredients sourced from highland areas are usually more expensive, making *Corchorus olitorius* a more accessible option for local households. The fruits of *Ximenia americana* and *Diospyros mespiliformis* were ranked second and third, respectively, primarily because of their pleasant taste and widespread use as supplementary food.

Preference ranking highlights the importance of specific WEPs in local diets. Promoting the consumption of these preferred species can enhance dietary diversity and improve the nutritional outcomes in communities. The popularity of *Corchorus olitorius* as a more accessible and cost-effective option than highland stew ingredients suggests that it can play a critical role in food security, especially for low-income households. This accessibility can help mitigate food insecurity during the lean seasons. Preference ranking provides valuable insights into which WEPs are valued the most by the community. Conservation programs can prioritize these species and ensure their protection and sustainable management, which are crucial for maintaining local biodiversity. The involvement of key informants in the ranking process underscores the importance of local conservation knowledge. Engaging communities in the identification and management of preferred WEPs can enhance the effectiveness of conservation initiatives and foster stewardship of natural resources.

Priority ranking of threats to wild edible plants

A priority ranking exercise with 24 key informants further elucidated the most pressing threats to these resources (Table 10). Agricultural land expansion was viewed as the primary threat, followed by fuel wood collection and use in construction. This finding is consistent with other studies that have recognized agricultural land expansion as a significant challenge for WEP conservation in various regions of Ethiopia [13, 28, 33, 41, 42, 45]

Table 10 Priority ranking of threats to WEP conservation

Major threats	Total score	Rank
Human-induced fire	101	5th
Construction	122	3rd
Household utensils	106	4th
Fuel wood	165	2nd
Agricultural land expansion	178	1st
Over grazing	73	7th
Use of herbicides and pesticides	89	6th
Informal export to Sudan	30	8th

and Tanzania [74]. This expansion is largely driven by increasing demands for human settlements, arable land, and grazing areas, consistent with threats to medicinal plants in the Quara district of Northwestern Ethiopia [9] and comparable studies elsewhere in the country [27, 32, 54]. These threats jeopardize plant species and their ecosystems, potentially leading to reduced biodiversity and natural resource degradation. The primary reasons for the top-ranked threats are attributed to an influx of people migrating from highland and midland areas to lowland regions in search of farmland as well as the utilization of these resources for cooking and house construction.

Jaccard's index

We compared our results with 58 published ethnobotanical papers in Ethiopia using the JI (Table 11). The calculated values of the JI, indicating the degree of species-related similarity between our study and other studies, ranged from 1.09 to 72.73. The highest degree of similarity was observed in an ethnobotanical survey of WEPs in Dibatie (72.73%), Bullen (52%), Chilga (51.52%), and Quara (47.22%) districts. The lowest degree of similarity was found in a study conducted in an ethnobotanical survey of WEPs in the Adiarkay, Debark, and Dejen districts [43].

The study area shared 26 wild edible plant species with Bullen district [71] and 24 with Dibatie district [28]. The higher similarity of wild edible plants in the study area to those in the Bullen and Dibatie districts may be attributed to vegetation cover, indigenous knowledge practices among communities, and language and cultural similarities, as the Gumuz people inhabit our study area and these two districts. Furthermore, the two districts are located in the Benishangul Gumuz Regional state, which borders the Amhara Regional state in which our study sites are situated. The least similarity was observed with Adiarkay, Debark and Dejen districts [43], and Maale and Debub Ari districts, as they shared only 1 and 2 overlapping wild edible plant species, respectively (Table 11). These two areas are geographically distant from the study area.

Direct matrix ranking of wild edible plants

The DMR method assessed eight WEPs across seven categories, using insights from 24 key informants (Table 12). The results showed that *Ziziphus spina-christi*, *Cordia africana*, and *Balanites aegyptiaca* ranked 1st, 2nd, and 3rd, overall utilization. The extensive use of these plants raises concerns regarding their overexploitation. *Ziziphus spina-christi* is highly valued for livestock forage, furniture, and fuelwood. The demand for Cordia africana in furniture and construction has reduced its population in natural forests, which are now mainly found in home gardens. The Ziziphus spina-christi population remains stable, as livestock, especially goats, favor its fruits, aiding seed dispersal. Additionally, it is commonly used as a live fence near farmlands because of its thorny structure that deters herbivores.

Studies conducted in various regions of Ethiopia have consistently identified *Cordia africana* as the most frequently utilized plant species in Ethiopian communities [12, 28, 42, 45, 64, 69]. This extensive utilization has resulted in a significant reduction in *Cordia africana* populations within natural forests, as evidenced by both the present study and other investigations conducted in Ethiopia. The widespread exploitation and subsequent decline of this species underscores the urgent need for conservation measures to protect *Cordia africana*, given its diverse and valuable functions within the country [69].

Food, fuelwood, livestock forage, and medicinal use are the most frequently reported use categories for WEPs. However, their extensive use for fuelwood and medicinal purposes threatens these multipurpose plants. Similar findings on the threatening use categories of WEPs have been reported in other Ethiopian regions [34, 54]. Due to their diverse applications and risk of overexploitation, prioritizing the conservation of high-utility WEPs is essential. Implementing sustainable management practices and raising awareness about their importance can help mitigate decline risks, ensuring future availability.

Threats and conservation of wild edible plants

WEPs face numerous threats, which contribute to their declining availability. The focus group discussions identified key threats, including agricultural expansion for crop cultivation and livestock production, application of herbicides and pesticides, human-induced fires, use in house construction and utensils, fuelwood, informal cross-border trade, overgrazing, farming tools, deforestation, seasonal migration from highland to lowland areas for farming, and climate change-induced drought.

Table 11 Jaccard's WEP similarity index between the study districts and other study areas

Study areas (districts)	Other report	Species no. (a)	Species no. (b)	Common species (c)	JI (%)	Citations
Dibatie	54	27	30	24	72.73	[28]
Bullen District	77	25	51	26	52.00	[71]
Chilga	33	34	16	17	51.52	[34]
Quara	36	34	19	17	47.22	[16]
Bulen and Dibati	46	33	28	18	41.86	[77]
Kamash	60	31	40	20	39.22	[26]
Tigray region (3 districts)	41	36	26	15	31.91	[57]
Maale and Debub Ari	52	35	36	16	29.09	[33]
Six regions (10 districts)	88	30	67	21	27.63	[27]
Boosat and Fantalle	37	38	24	13	26.53	[78]
Tigray region (Ten districts)	44	37	30	14	26.42	[79]
Nech Sar National Park	51	36	36	15	26.32	[76]
Midakegn	50	37	36	14	23.73	[12]
Baso Liben and Debre Elias	52	37	38	14	22.95	[80]
Guangua, Jawi and Ankasha	39	39	27	12	22.22	[54]
Liben and Wadera	54	37	40	14	22.22	[81]
Libo Kemkem	33	40	22	11	21.57	[82]
Sedie Muja	33	40	22	11	21.57	[83]
Soro	64	36	49	15	21.43	[45]
North Wollo	66	36	51	15	20.83	[84]
Bule Hora	29	41	19	10	20.00	[29]
Derashe and Kucha	66	37	52	14	18.67	[32]
Chelia	58	38	45	13	18.57	[85]
Hula	50	39	38	12	18.46	[35]
Metema	44	40	33	11	17.74	[18]
Tigray (6 districts)	53	39	41	12	17.65	[86]
Berehet	53	39	41	12	17.65	[40]
Tach Gayint	36	41	26	10	17.54	[87]
Amaro and Gelana	80	36	65	15	17.44	[88]
Jibat, Chelia and Dendi	71	38	58	13	15.66	[89]
Adola	46	41	36	10	14.93	[90]
Konso	127	33	109	18	14.52	[30]
Hamer and Konso	109	35	93	16	14.29	[91]
Nole Kaba	39	42	30	9	14.29	[92]
Raya-Azebo	59	40	48	11	14.29	[13]
Benna Tsemay	30	43	22	8	14.04	[93]
Aba'ala	20	44	13	7	14.00	[94]
Mieso	41	42	32	9	13.85	[44]
Yilmana Densa and Quarit	32	43	24	8	13.56	[11]
Awash National Park	22	44	15	7	13.46	[95]
Dire Dawa City	22	44	15	7	13.46	[96]
Review of literature	203	27	179	24	13.19	[37]
Awash National Park	55	41	45	10	13.16	[39]
Berek	34	43	26	8	13.11	[42]
Dugda Dawa	71	40	60	11	12.36	[97]
Delanta	49	42	40	9	12.33	[31]
Yalo	16	45	10	6	12.24	[98]
Tigray region (3 districts)	17	45	11	6	12.00	[99]
Guna, Tiyo, and Sire	30	44	23	7	11.67	[100]

Table 11 (continued)

Study areas (districts)	Other report	Species no. (a)	Species no. (b)	Common species (c)	JI (%)	Citations
Arsi Robe	36	44	29	7	10.61	[69]
Debub Omo	38	44	31	7	10.29	[101]
Burji	46	44	39	7	9.21	[102]
Konso	113	42	104	9	6.57	[103]
Alamata, Cheha, Goma, and Yilmana Denssa	130	43	122	8	5.10	[104]
Bullen	29	48	26	3	4.23	[36]
Maale and Debub Ari	30	49	28	2	2.67	[41]
Oromia region (6 districts)	80	48	77	3	2.46	[105]
Adiarkay, Debark and Dejen	44	50	43	1	1.09	[43]

JI Jaccard index

a: The number of species in the study area only, b:The number of species of the other areas only (in Ethiopia), c: number of species common to both areas a and b

Table 12 Direct matrix ranking of eight WEPs in seven use categories

Wild edible plants	Use category							Total score	Rank
	Co	Fu	LF	Md	Fd	FW	FT		
Ziziphus spina-christi	3.2	4.2	5.0	2.7	4.6	4.0	3.5	27.3	1st
Tamarindus indica	2.3	2.2	2.8	3.8	4.8	3.0	1.2	20.0	7th
Ficus sycomorus	1.8	2.8	4.5	3.2	4.3	3.3	2.0	21.9	5th
Balanites aegyptiaca	1.8	2.5	4.4	2.9	4.7	3.7	2.5	22.4	3rd
Diospyros mespiliformis	3.5	4.3	2.0	1.0	5.0	3.6	2.8	22.2	4th
Ximenia americana	1.2	2.0	2.7	3.7	4.9	3.3	2.3	20.1	6th
Cordia africana	3.6	5.0	3.1	3.5	4.8	3.3	3.0	26.4	2nd
Carissa spinarum	1.4	0.6	1.8	3.9	4.0	2.8	0.3	14.8	8th
Total scire	18.8	23.6	26.3	24.7	37.2	26.9	17.6		
Rank	6th	5th	3rd	4th	1st	2nd	7th		

N.B. Scores in the table indicate average values of ranks given to WEPs based on their use diversity. Co, Construction; Fu, Furniture; LF, Livestock forage; Md, Medicinal; Fd, Food; FW, Fuel wood; FI, Farm tools

Informants noted that species such as *Cordia africana*, *Carissa spinarum*, *Ximenia americana*, *Adansonia digitata*, *Hyphaene thebaica*, and *Oxytenanthera abyssinica* are becoming increasingly rare, primarily because of agricultural expansion, direct exploitation, and habitat destruction.

Most WEPs lack effective management practices such as integration into live fences, home gardens, and farmlands. Although local authorities have prohibited the cutting of certain WEP species, including *Adansonia digitata*, *Balanites aegyptiaca*, *Ficus sycomorus*, *Tamarindus indica*, *Ximenia americana*, and *Diospyros mespiliformis*, enforcement is weak at the grassroots level. Transient farmers who migrate from midland and highland areas to rent land for cash crop cultivation are a significant threat, as they often clear trees in farmlands and along borders to maximize their harvest. For the future management of WEPs, focus group participants recommended several practices for both local inhabitants and governmental/non-governmental organizations. These include on-site conservation and domestication of WEPs in home gardens, agricultural lands, and live fences. Although direct management of WEPs is currently limited, some community members have initiated conservation efforts. For instance, species such as *Abelmoschus ficulneus* and *Corchorus olitorius* are allowed to grow spontaneously in home gardens and farmlands, with residents selectively removing weeds. For *Corchorus olitorius*, efforts have been made to collect seeds and cultivate plants during the irrigation season. The limited management practices observed, such as live fences, home gardens, and farmlands, were also reported in a study conducted in South Ethiopia [30].

To promote the conservation of WEPs, focus group participants recommended several strategies, including on-site conservation, domestication in home gardens,

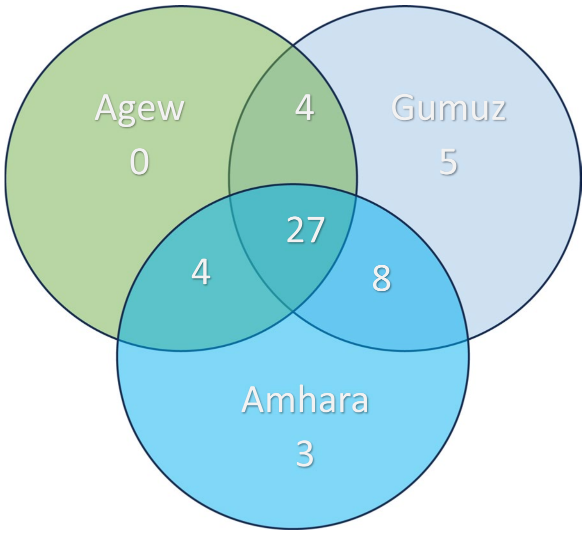

Fig. 7 Venn diagram of WEPs among the studied ethnic groups

agricultural lands, and live fences, awareness-raising campaigns, and the establishment of nurseries for WEP seedlings. Similar recommendations have been made in the Mieso district [44]. Given that threats to biodiversity also pose risks to WEPs, a holistic approach to conservation is essential, encompassing increased awareness, on-site conservation, domestication, seedling establishment, and ongoing monitoring. Importantly, because the conservation status of all documented WEP species remains unassessed, prioritizing their evaluation should be a key focus of future conservation efforts.

Diversity in Ethnobotanical knowledge

This study investigated ethnobotanical diversity among three ethnic groups in Amhara, Agew, and Gumuz districts. Using a Venn diagram (Fig. 7), we found that the Gumuz ethnic group reported the highest number of WEP species (44), followed by Amhara (42) and Agew (35). Collectively, these three groups utilized 27 species of WEPs, representing 52.94% of the plants studied, indicating a significant overlap in ethnobotanical knowledge. Pairwise comparisons revealed that the Amhara and Gumuz ethnic groups exhibited the highest degree of similarity, sharing 15.69% of their WEP species. Meanwhile, Agew and Gumuz, as well as Amhara and Agew, each shared 7.84% of their WEPs. The greater number of WEPs reported by the Gumuz community can be attributed to their heavy reliance on wild flora and fauna for daily survival, because farming and livestock rearing are not their primary sources of income.

Distinct consumption patterns emerged among ethnic groups. Gumuz reported consuming the leaves of *Ipomoea biflora*, the leaves, tubers, and fruits of *Vigna vexillata*, the gums of *Vachellia sieberiana* and *Terminalia leiocarpa*, and the fruits of *Cucumis ficifolius*. In contrast, tubers of *Dioscorea bulbifera*, Dioscorea dumetorum, shoots of Oxytenanthera abyssinica, and Hyphaene thebaica fruits and seeds were consumed by both the Gumuz and Agew ethnic groups. The Amhara group uniquely reported the consumption of the fruits of *Peponium vogelii*, *Lannea welwitschia*, and roots of *Vigna membranacea*. Overall, while fruits were commonly utilized by all three ethnic groups, the Gumuz and Agew communities also consumed leaves, tubers, and gums that were not included in the Amhara diet. These findings highlight the importance of understanding the ethnobotanical diversity across different ethnic groups. The reliance on WEPs, especially among the Gumuz, underscores the need for targeted conservation efforts and sustainable management practices to preserve these resources.

This finding corroborates that diverse ethnolinguistic groups within the same area utilize plant species differently, including variations in the use of different parts of the same plant, as evidenced by studies conducted in Pakistan [60] and Thailand [61]. This investigation highlights the distinct ethnobotanical knowledge of various ethnic communities. The unique dietary practices of each group demonstrate the richness of the traditional plant-based wisdom embedded in their respective cultures. Acknowledging these varied food customs is crucial for preserving the cultural heritage and promoting the use of indigenous food resources. The reliance of the Gumuz people on wild plants for daily nutrition suggests that WEPs can serve as both a vital food source and an income generator. The results of this study emphasize the importance of engaging local communities in conservation initiatives.

Novel ethnobotanical findings

A comparative analysis was conducted to assess the uniqueness of the WEPs identified in this study, in contrast to previous ethnobotanical studies on WEPs in Ethiopia (Table 3). This examination reveals several new findings that contribute to the existing body of knowledge on WEPs within the country. Notably, *Keetia gueinzii* had not been previously recorded as a food source in other regions, whereas the other 50 species are known to be consumed in various parts of Ethiopia (Table 3). Our study found that *Keetia gueinzii* is a shrub with edible fruits, primarily growing in agricultural lands and riverside vegetation. It has 62 informant reports and exhibits medicinal properties. The same researcher previously documented the medicinal use of this plant for treating scabies in Ethiopia [63]. The discovery of *Keetia gueinzii* as a WEP species broadens Ethiopia's WEP inventory and

Table 13 Newly reported edible parts of WEPs

Name of the WEP	Newly reported edible parts of the plant
Ampelocissus schimperiana	Tuber
Balanites aegyptiaca	Seed
Cucumis ficifolius	Fruit
Hyphaene thebaica	Seed
Senegalia polyacantha	Gum
Sterculia setigera	Seed
Terminalia leiocarpa	Gum and leaf
Vigna membranacea	Tuber
Vigna vexillata	Fruit and leaf

underscores the importance of further investigating the country's rich plant diversity.

Additionally, this study documented the new edible parts of nine WEP species for the first time in Ethiopia (Table 13). For instance, while prior studies indicated that the tubers of *Vigna vexillata* were consumed exclusively when cooked [36], our findings highlight that both fruits and leaves are consumed, either cooked or raw. Similarly, although earlier studies recognized the young stems and fruits of *Ampelocissus schimperiana* as edible [26, 28], this study revealed that its tubers are also part of the local diet. These findings not only broaden the spectrum of known WEP species in Ethiopia but also illustrate the variability in the edible parts of certain plants compared to earlier reports. By documenting these novel uses and species, this study underscores the potential to enhance local food security through the promotion of these newly identified edible parts, which can help diversify diets and improve nutrition within local communities.

Conclusions and recommendations

This study indicated a diverse range of WEP species and associated indigenous knowledge in the Quara and Metema districts. Fifty-one WEP species were documented, primarily consisting of trees valued for their edible fruit. Ethnobotanical knowledge and utilization of WEPs were influenced by various factors, such as gender, age, informant category, ethnic background, and settlement history. Several WEP species require urgent conservation owing to their versatility in addition to their use as food, including nutraceutical applications, fuel for fires, building materials, and animal feed. These included *Ziziphus spina-christi*, *Cordia africana*, *Balanites aegyptiaca*, *Diospyros mespiliformis*, *Piliostigma thonningii*, *Tamarindus indica*, *Ximenia americana* and *Diospyros mespiliformis*. These species are not only the most endangered but are also the most favored by local communities. WEPs face increasing risks from human activities, particularly the expansion of agricultural land, gathering firewood, and construction activities.

Consequently, there is a pressing need for sustainable management and preservation strategies that involve all relevant parties and local populations, both in-situ and ex-situ. Future studies should focus on analyzing the nutritional content, phytochemical composition, and economic value of the most promising WEPs in the research area. This study significantly contributes to preserving traditional ethnobotanical knowledge and promoting the sustainable use of WEPs.

Abbreviations

DMR	Direct matrix ranking
ETH	National Herbarium of Addis Ababa University
JI	Jaccard index
WEPs	Wild edible plants
WEP	Wild edible plant

Acknowledgements

The authors would like to express their heartfelt appreciation to the office of the Vice President for Research and Technology Transfer at the University of Gondar. Their financial support through the postgraduate Research Strengthening Award enabled us to carry out this important ethnobotanical research. We are also deeply grateful to the staff of the Metema and Quara District Agriculture Offices, along with the development agents from the respective kebeles, for their invaluable assistance during the data collection process. Most importantly, we extend our sincere gratitude to the informants who generously shared their extensive knowledge and insights about the use of wild edible plants in the two districts. Additionally, we would like to thank Melaku Wondafrash, the Herbarium Specialist at the National Herbarium (ETH) of Addis Ababa University, whose invaluable support in identifying plant specimens was crucial for the scientific accuracy of this study. Finally, our thanks go to Tadesse Mucheye for creating the map of the study areas.

Author contributions

DT was responsible for the proposal write-up, field data collection, specimen identification, investigation, and drafting of the initial manuscript. GM contributed valuable insights and comments during the proposal write-up, field data collection, and the final manuscript preparation. EL assisted with the proposal write-up, field data collection, specimen identification, and the final manuscript preparation. AA was involved in the proposal write-up and the final manuscript preparation. All the authors read and approved the final manuscript.

Funding

This study was funded by the Office of the Vice President for Research and Technology Transfer at the University of Gondar through a Postgraduate Research Strengthening Award.

Availability of data and materials

The datasets used and analyzed during the current study are available from the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate

Permission for this research was granted by the Vice President for Research and Technology Transfer at the University of Gondar, as well as by the Offices of Metema and Quara District Administrations.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

Received: 21 October 2024 Accepted: 20 January 2025
Published online: 07 February 2025

References

1. Hamayun M. Ethnobotanical profile of Utror and Gabral valleys, district Swat, Pakistan. Ethnobot Leafl. 2005;1:9.
2. Maqbool M, Ajaib M, Ishtiaq M, Azam S, Hussain T. Ethnomedicinal study of plants used in phytotherapeutics among indigenous communities of District Bhimber, Azad Kashmir and migrants to United Kingdom. Proc Pak Acad Sci Part B. 2019;56(2):57–76.
3. Bhatia H, Sharma YP, Manhas RK, Kumar K. Traditionally used wild edible plants of district Udhampur, J & K, India. J Ethnobiol Ethnomed. 2018;14:1–14.
4. Deshmukh S, Rathod V. Nutritional evaluation of some wild edible tuberous plants. Asian J Pharm Clin res. 2013;6(2):58–60.
5. Nayak J, Basak UC. Analysis of some nutritional properties in eight wild edible fruits of Odisha, India. Int J Curr Sci. 2015;14:55–62.
6. Ghorbani A, Langenberger G, Sauerborn J. A comparison of the wild food plant use knowledge of ethnic minorities in Naban River Watershed National Nature Reserve, Yunnan, SW China. J Ethnobiol Ethnomed. 2012;8:1–10.
7. Lulekal E, Asfaw Z, Kelbessa E, Van Damme P. Wild edible plants in Ethiopia: a review on their potential to combat food insecurity. Afr Focus. 2011;24(2):71–121.
8. Gizachew GT. Spacial–temporal and factors influencing the distribution of biodiversity: a review. Sci Rep Life Sci. 2024;2(4):1–19.
9. Tadesse D, Masresha G, Lulekal E, Wondafrash M. A systematic review exploring the diversity and food security potential of wild edible plants in Ethiopia. Sci Rep. 2024;14:1–17.
10. Kebebew M, Mohamed E. Indigenous knowledge on use of medicinal plants by indigenous people of Lemo District, Hadiya Zone, Southern Ethiopia. Int J Herb Med. 2017;5(4):124–35.
11. Alemneh D. Ethnobotany of wild edible plants in Yilmana Densa and Quarit Districts of West Gojjam Zone, Amhara Region, Ethiopia. Ethnobot Res Appl. 2020;20:1–14.
12. Guzo S, Lulekal E, Nemomissa S. Ethnobotanical study of underutilized wild edible plants and threats to their long-term existence in Midakegn District, West Shewa Zone, Central Ethiopia. J Ethnobiol Ethnomed. 2023;115:1–7.
13. Giday M, Teklehaymanot T. Use of wild edible and nutraceutical plants in Raya-Azebo District of Tigray Region, northern Ethiopia. Trop Med Health. 2023;51(1):58.
14. Adamu H, Bekele T, Dalle G. Floristic diversity, regeneration status, and vegetation structure of woodlands in Metema Area, Amhara National Regional State, Northwestern Ethiopia. J For Res. 2012;23(3):391–8.
15. Lemenih M, Kassa H, Kassie GT, Abebaw D, Teka W. Resettlement and woodland management problems and options: a case study from North-Western Ethiopia. L Degrad Dev. 2014;25(4):305–18.
16. Tebkew M, Gebremariam Y, Mucheye T, Alemu A, Abich A, Fikir D. Uses of wild edible plants in Quara district, northwest Ethiopia: Implication for forest management. Agric Food Secur. 2018;7:1–14.
17. CSA. Population and Housing Census 2007 Report of Central Statistical Agency. 2007.
18. Masresha G, Melkamu Y, Walle GC. Ethnobotanical study on wild edible plants in Metema District, Amhara Regional State, Ethiopia. Int J For Res. 2023;1:9243343.
19. Ayeneshet B, Wondifraw Z, Abera M. Survey on farmers husbandry practice for dairy cows in Alefa and Quara districts of North Gondar Zone, Amhara National Regional State, Ethiopia. Int J Anim Sci. 2017;1(2):1–13.
20. Friis I, Demissew S, van Breugel P. Atlas of the potential vegetation of Ethiopia. The Royal Danish Academy of Sciences and Letters. Biologiske Skrifter. 2010;58:1–315.
21. Eshete A, Sterck F, Bongers F. Diversity and production of Ethiopian dry woodlands explained by climate- and soil-stress gradients. For Ecol Manag. 2011;261(9):1499–509.
22. Cochran WG. Sampling techniques. Hoboken: Wiley; 1977.
23. Albuquerque UP, da Cunha LVFC, Lucena RFP, Alves RRN (Eds.). *Methods and techniques in ethnobiology and ethnoecolgy.* 2014.
24. Martin GJ. Ethnobotany: a methods manual. London: Earths can Publications Ltd; 2004.
25. Cotton C. Ethnobotany: principles and applications. New York: Wiley; 1996.
26. Ayele D. Ethnobotanical survey of wild edible plants and their contribution for food security used by Gumuz people in Kamash Woreda; Benishangul Gumuz Regional State, Ethiopia. J Food Nutr Sci. 2017;12(1):217–24.
27. Dejene T, Agamy MS, Agúndez D, Martin-Pinto P. Ethnobotanical survey of wild edible fruit tree species in lowland areas of Ethiopia. Forests. 2020;11(2):1–17.
28. Anbessa B, Lulekal E, Getachew P, Hymete A. Ethnobotanical study of wild edible plants in Dibatie district, Metekel zone, Benishangul Gumuz Regional State, western Ethiopia. J Ethnobiol Ethnomed. 2024;20:1–18.
29. Anbessa B. Ethnobotanical study of wild edible plants in Bule Hora Woreda, Southern Ethiopia. Glob J Bot Sci. 2016;4:37–45.
30. Addis G, Asfaw Z, Woldu Z. The role of wild and semi-wild edible plants in household food sovereignty in Hamer and Konso communities, South Ethiopia. Ethnobot Res Appl. 2013;11:251–71.
31. Meragiaw M, Asfaw Z, Argaw M. Indigenous knowledge (IK) of wild edible plants (WEPs) and impacts of resettlement in Delanta, Northern Ethiopia. Res Rev J Herb Sci. 2015;4(3):8–26.
32. Balemie K, Kebebew F. Ethnobotanical study of wild edible plants in Derashe and Kucha Districts, South Ethiopia. J Ethnobiol Ethnomed. 2006;2:1–9.
33. Kidane B, van der Maesen LJG, van Andel T, Asfaw Z, Sosef MSM. Ethnobotany of wild and semi-wild edible fruit species used by Maale and Ari ethnic communities in southern Ethiopia. Ethnobot Res Appl. 2014;12:455–72.
34. Tebkew M, Asfaw Z, Zewudie S. Underutilized wild edible plants in the Chilga District, northwestern Ethiopia: focus on wild woody plants. Agric Food Secur. 2014;3:1–16.
35. Sina B, Demissie H. Knowledge and use of wild edible plants in the Hula District of the Sidama Zone. Int J Bio-resour Stress Manag. 2015;6(3):352–65.
36. Mosissa D, Abraha B. Tuberous wild plant of Shinasha people as food and medicine in Bullen District Northwest of Ethiopia. Am J Life Sci Res. 2018;6:30–9.
37. Asfaw Z, Tadesse M. Prospects for sustainable use and development of wild food plants in Ethiopia. Econ Bot. 2001;55:47–62.
38. Awas T, Asfaw Z, Nordal I, Demissew S. Ethnobotany of Berta and Gumuz people in western Ethiopia. Biodiversity. 2010;11(3):45–53.
39. Bahru T, Asfaw Z, Demissew S. Wild edible plants: sustainable use and management by indigenous communities in and the buffer area of Awash National Park Ethiopia. Ethiop J Sci. 2013;36(2):93–108.
40. Alemayehu G, Asfaw Z, Kelbessa E, Getu AC. Plant diversity and ethnobotany in Berehet District, North Shewa Zone of Amhara Region (Ethiopia) with emphasis on wild edible plants. J Med Plants Stud. 2015;3(6):93–105.
41. Kidane B, van der Maesen LJG, Asfaw Z, Sosef MSM, van Andel T. Wild and semi-wild leafy vegetables used by the Maale and Ari ethnic communities in southern Ethiopia. Genet Resour Crop Evol. 2015;62(2):221–34.
42. Kidane L, Kejela A. Food security and environment conservation through sustainable use of wild and semi-wild edible plants: a case study in Berek Natural Forest, Oromia special zone, Ethiopia. Agric Food Secur. 2021;10:1–16.
43. Fentahun MT, Hager H. Exploiting locally available resources for food and nutritional security enhancement: wild fruits diversity, potential and state of exploitation in the Amhara region of Ethiopia. Food Secur. 2009;1(2):207–19.
44. Tahir M, Abrahim A, Beyene T, Dinsa G, Guluma T, Alemneh Y, et al. The traditional use of wild edible plants in pastoral and agro-pastoral communities of Mieso District, eastern Ethiopia. Trop Med Health. 2023;51:1.

45. Hankiso M, Warkineh B, Asfaw Z, Debella A. Ethnobotany of wild edible plants in Soro District of Hadiya Zone, southern Ethiopia. J Ethnobiol Ethnomed. 2023;19:1–23.
46. Aboukhalaf A, Tbatou M, Kalili A, Naciri K, Moujabbiret S, et al. Traditional knowledge and use of wild edible plants in Sidi Bennour region (Central Morocco). Ethnobot Res Appl. 2022;23(11):265–73.
47. Turreira-García N, Theilade I, Meilby H, Sørensen M. Wild edible plant knowledge, distribution and transmission: a case study of the Achí Mayans of Guatemala. J Ethnobiol Ethnomed. 2015;11:1–17.
48. Khakurel D, Uprety Y, Łuczaj Ł, Rajbhandary S. Foods from the wild: local knowledge, use pattern and distribution in Western Nepal. PLoS ONE. 2021;16:1–24.
49. Meitei LR, De A, Mao AA. An ethnobotanical study on the wild edible plants used by forest dwellers in Yangoupokpi Lokchao Wildlife Sanctuary, Manipur, India. Ethnobot Res Appl. 2022;23(15):1–25.
50. Bortolotto IM, Amorozo MCDM, Neto GG, Oldeland J, Damasceno-Junior GA. Knowledge and use of wild edible plants in rural communities along Paraguay River, Pantanal, Brazil. J Ethnobiol Ethnomed. 2015;11:1–15.
51. Xie J, Liu F, Jia X, Zhao Y, Liu X, et al. Ethnobotanical study of the wild edible and healthy functional plant resources of the Gelao people in northern Guizhou, China. J Ethnobiol Ethnomed. 2022;18(1):72.
52. Salih NKEM, Hassan AA. Wild food trees in Eastern Nuba mountains, Sudan: use, diversity, and threatening factors. J Agric Rural Dev Trop Subtrop. 2014;115:1–7.
53. Menendez-Baceta G, Aceituno-Mata L, Reyes-García V, Tardío J, Salpeteur M, Pardo-De-Santayana M. The importance of cultural factors in the distribution of medicinal plant knowledge: a case study in four Basque regions. J Ethnopharmacol. 2015;161:116–27.
54. Fassil A, Mazengia E, Gebreamanuel B, Dessie Y, Kumera B, et al. Harvesting nature's bounty: exploring the ethnobotanical landscape of wild edible plants in the Awi Agäw community, Northwestern Ethiopia. J Ethnobiol Ethnomed. 2024;20(1):59.
55. Ghanimi R, Ouhammou A, Ahouach A, Cherkaoui M. Ethnobotanical study on wild edible plants traditionally used by Messiwa people, Morocco. J Ethnobiol Ethnomed. 2022;18(11):16.
56. Kang Y, Łuczaj Ł, Kang J, Zhang S. Wild food plants and wild edible fungi in two valleys of the Qinling Mountains (Shaanxi, central China). J Ethnobiol Ethnomed. 2013;9:1–20.
57. Girmay M, Lulekal E, Belay B, Gebrehiwot K. Wild edible plants study in a dryland ecosystem of Ethiopia. Daagu Int J Basic Appl Res. 2022;4:105–19.
58. Liu S, Huang X, Bin Z, Yu B, Lu Z, et al. Wild edible plants and their cultural significance among the Zhuang ethnic group in Fangchenggang, Guangxi, China. J Ethnobiol Ethnomed. 2023;19(1):52.
59. Wang J, Ding X, Guo CA, Zhang X, Feng H, et al. An ethnobotanical study of wild edible plants used by the Tibetan in the Rongjia River Valley, Tibet, China. J Ethnobiol Ethnomed. 2023;19(1):49.
60. Amin M, Aziz MA, Pieroni A, Nazir A, Al-Ghamdi AA, et al. Edible wild plant species used by different linguistic groups of Kohistan Upper Khyber Pakhtunkhwa (KP), Pakistan. J Ethnobiol Ethnomed. 2023;19(1):6.
61. Phumthum M, Balslev H. Use of medicinal plants among thai ethnic groups: a comparison. Econ Bot. 2019;73(1):64–75.
62. Fang Q, Cheng Z, Zhang R, Luo B, Long C. Wild edible plants of the Yao people in Jianghua, China: plant-associated traditional knowledge and practice vital for food security and ecosystem service. J Ethnobiol Ethnomed. 2024;20(1):80.
63. Tadesse D, Masresha G, Lulekal E. Ethnobotanical study of medicinal plants used to treat human ailments in Quara district, northwestern Ethiopia. J Ethnobiol Ethnomed. 2024;20:75.
64. Asfaw A, Lulekal E, Bekele T, Debella A, Tessema S, Meresa A, Debebe E. Ethnobotanical study of wild edible plants and implications for food security. Trees People. 2023;14: 100453.
65. Duguma HT. Wild edible plant nutritional contribution and consumer perception in Ethiopia. Int J Food Sci. 2020;1:2958623.
66. Lalmuanpuii R, Zodinpuii B, Bohia B, Zothanpuia, Lalbiaknunga J, Singh PK. Wild edible vegetables of ethnic communities of Mizoram (North east India): an ethnobotanical study in thrust of marketing potential. J Ethnobiol Ethnomed. 2024;20:58.
67. Aryal KP, Poudel S, Chaudhary RP, Chettri N, Chaudhary P, et al. Diversity and use of wild and non-cultivated edible plants in the Western Himalaya. J Ethnobiol Ethnomed. 2018;14(1):1–18.
68. Tugume P, Nyakoojo C. Traditional use of wild edible plants in the com munities adjacent Mabira Central Forest Reserve, Uganda. Ethnobot Res Appl. 2020;20:1–14.
69. Biri S, Ayenew B, Dida G, Sebsibe A, Gurmessa F, et al. Ethnobotanical study of wild edible plants in Arsi Robe district of East Arsi Zone, Ethiopia. J Ethnobiol Ethnomed. 2024;20(1):70.
70. Cheng Z, Lu X, Lin F, Naeem A, Long C. Ethnobotanical study on wild edible plants used by Dulong people in northwestern Yunnan, China. J Ethnobiol Ethnomed. 2022;18:1.
71. Berihun T, Molla E. Study on the diversity and use of wild edible plants in Bullen District Northwest Ethiopia. J Bot. 2017;1:8383468.
72. Aworh OC. Promoting food security and enhancing Nigeria's small farmers' income through value-added processing of lesser-known and under utilized indigenous fruits and vegetables. Food Res Int. 2015;76:986–91.
73. Oduor FO, Kaindi DWM, Abong GO, Thuita F, Termote C. Diversity and utilization of indigenous wild edible plants and their contribution to food security in Turkana County, Kenya. Front Sustain Food Syst. 2023;7:1113771.
74. Mgalula ME. An ethnobotanical study of wild edible fruits in miombo woodlands of Tabora region in Western Tanzania. J Ethnobiol Ethnomed. 2024;20(1):23.
75. Bhagat N, Upadhyay H, Manhas RK, Gupta SK. Wild edible plants of Purmandal block of District Samba, J & K (UT) India. Ethnobot Res Appl. 2022;24:1–9.
76. Kebebew M, Leta G. Wild edible plant biodiversity and utilization system in Nech Sar National Park, Ethiopia. Int J Resour Stress Manag. 2016;7(4):885–96.
77. Morka AB. Study on wild edible plant used by Shinasha Ethnic Community at Metekel Zone, Northwest Ethiopia. Adv Nutr Food Sci. 2024;9(1):1–11.
78. Feyssa DH, Njoka JT, Asfaw Z, Nyangito MM. Seasonal availability and consumption of wild edible plants in semiarid Ethiopia: implications to food security and climate change adaptation. J Hortic For. 2011;3(5):138–49.
79. Tesfay A, Tewolde-Berhan S, Birhane E, Rannestad MM, Gebretsadik A, et al. Edible indigenous fruit trees and shrubs in Tigray, Ethiopia. Trees For People. 2024;16:100525.
80. Amsalu N. Vascular plant diversity and ethnobotany of medicinal and wild edible plants in BasoLiben and Debre Elias Districts, East Gojjam Zone of Amhara Region, Northwestern Ethiopia. PhD Thesis, Addis Ababa University, 2020.
81. Emire A, Demise S, Giri T, Tadele W. Ethnobotanical study of wild edible plants in Liben and Wadera Districts of Guji Zone, Southern Ethiopia. Glob J Agric Res. 2022;10(3):47–65.
82. Chekole G. An ethnobotanical study of plants used in traditional medicine and as wild foods in and around Tara Gedam and Amba Remnant Forests in Libo Kemkem Wereda, South Gonder Zone, Amhara Region, Ethiopia. Master's thesis, Addis Ababa University, Addis Ababa University Institutional Repository (2011).
83. Abera M. Ethnobotanical study of wild edible plants and their indigenous knowledge in Sedie Muja district, South Gondar Zone, Northwestern Ethiopia. Am J Plant Sci. 2022;13:241–64.
84. Hassen A. Diversity and potential contribution of wild edible plants to sustainable food security in north Wollo, Ethiopia. Biodiversitas. 2021;22(6):2501–10.
85. Regassa T, Kelbessa E, Asfaw Z. Ethnobotany of wild and semi-wild edible plants of Chelia District, West-Central Ethiopia. Sci Technol Arts Res J. 2014;3(4):122–34.
86. Aregay N, Hruy G, Semere T. Potentials and constraints of under-utilized tree fruits and vegetables in Tigray, Northern Ethiopia. J Drylands. 2017;7(2):664–74.
87. Yiblet Y, Adamu E. An ethnobotanical study of wild edible plants in Tach Gayint district, South Gondar zone, Amhara region, Northwestern Ethiopia. Evid Based Complement Altern Med. 2023;1:7837615.
88. Alemayehu G. Plant diversity and ethnobotany of medicinal and wild edible plants in Amaro District of Southern Nations, Nationalities. PhD Thesis, Addis Ababa University, 2017.

89. Regassa T. Vascular plant diversity and ethnobotanical study of medicinal and wild edible plants in Jibat, Gedo and Chilimo Forests, West Shewa Zone of Oromia Region, Ethiopia. PhD Thesis, Addis Ababa University, 2016.
90. Demise S, Asfaw Z. Ethno botanical study of wild edible plants in Adola district, Southern Ethiopia. IJRAR. 2020;7(2):212–28.
91. Addis G, Asfaw Z, Woldu Z. Ethnobotany of wild and semi-wild edible plants of Konso ethnic community, South Ethiopia. Ethnobot Res Appl. 2013;11:121–41.
92. Balemie K. Floristic diversity of Jorgo Wato forest and ethnobotanical study of medicinal and wild edible plants in NoleKaba District, West Wollega, Oromia Region, Ethiopia. PhD Thesis, Addis Ababa University, 2019.
93. Assefa A, Abebe T. Wild edible trees and shrubs in the semiarid lowlands of southern Ethiopia. J Sci Dev. 2010;1(1):5–19.
94. Meragiaw M. Wild useful plants with emphasis on traditional use of medicinal and edible plants by the people of Aba'ala, Northeastern Ethiopia. JMPHTR. 2016;4:1–16.
95. Beche D, Gebeyehu G, Feyisa K. Indigenous utilization and management of useful plants in and around Awash National Park, Ethiopia. J Plant Biol Soil Health. 2016;3(1):1–12.
96. Kebede A, Tesfaye W, Fentie M, Zewide H. An ethnobotanical survey of wild edible plants commercialized in Kefira market, Dire Dawa City, Eastern Ethiopia. Plant. 2017;5(2):42–6.
97. Ashagre M. Vascular plants diversity and ethnobotany with emphasis to traditional medicinal and wild edible plants in Dugda Dawa District of Borana Zone, Oromia Regional State, Ethiopia. PhD Thesis, Addis Ababa University, 2017.
98. Teklehaymanot T. An ethnobotanical survey of medicinal and edible plants of Yalo Woreda in Afar regional state, Ethiopia. J Ethnobiol Ethnomed. 2017;13:1–26.
99. Hishe M. Ecological, floristic and ethnobotanical studies in and around Wejig-Mahgo-Waren Massif Forest Patches in Southern Tigray, Ethiopia. PhD Thesis, Addis Ababa University, 2019.
100. Seyoum Y, Teketay D, Shumi G, Wondafirash M. Edible wild fruit trees and shrubs and their socioeconomic significance in central Ethiopia. Ethnobot Res Appl. 2015;14:183–97.
101. Teklehaymanot T, Giday M. Ethnobotanical study of wild edible plants of Kara and Kewego semi pastoralist people in Lower Omo River valley, Debub Omo Zone, SNNPR, Ethiopia. J Ethnobiol Ethnomed. 2010;6:1–8.
102. Ashagre M, Asfaw Z, Kelbessa E. Ethnobotanical study of wild edible plants in Burji District, Segan Area Zone of Southern Nations, Nationalities and Peoples Region (SNNPR) Ethiopia. J Ethnobiol Ethnomed. 2016;12(32):1–15.
103. Lemessa D, Struik PC, Price LL, Kelbessa E, Kolo K. Assessing the levels of food shortage using the traffic light metaphor by analyzing the gathering and consumption of wild food plants, crop parts and crop residues in Konso, Ethiopia. J Ethnobiol Ethnomed. 2015;8(30):1–16.
104. Addis G, Urga K, Dikasso D. Ethnobotanical study of edible wild plants in some selected districts of Ethiopia. Hum Ecol. 2005;33(1):83–118.
105. Jemal OM. The role of local agroforestry practices for enhancing food and nutrition security of smallholding farming households: the case of Yayu area, south-western Ethiopia. PhD Thesis, Universität Bonn, 2018.