Journal of Ethnobiology and Ethnomedicine

RESEARCH

Open Access

Ethnobotanical study of wild edible plants in the mountainous regions of Semnan Province, Iran

Majid Jalali[1], Mehdi Abedi[1*], Farshid Memariani[2,3] and Abdolbaset Ghorbani[4]

Abstract

In mountainous areas, wild edible plants are an important part of the local diet. Climate change and anthropogenic activities have profound effects on wild edible plants in these areas. Ethnobotanical studies are important for understanding the use patterns and harvest impacts on these plants. In this regard, the Shahrood region, with its diverse historical/ethnic background, is an appropriate starting point to investigate exploitation patterns and impacts of harvest of wild edible plants. During 2021–2022, ethnobotanical surveys were conducted in 12 villages in the region using semi-structured interviews and participatory observations. Data collection included assessing wild edible plant species diversity, their habitats, collection time and quantities, plant parts used and methods of consumption and preparation. The data were analyzed using use report indicators, relative frequency of citations, and use value (UV). A total of 1086 use reports were documented from a total of 44 interviews. A total of 67 wild species (66 plants and 1 fungus) belonging to 54 genera and 24 families were used as edible in the study area. Rosaceae (9 species), Apiaceae (8), Lamiaceae (8), Asteraceae (7), and Amaryllidaceae (5) were the families with the most reported species. *Allium* (5 species) was the most diverse genus in terms of species diversity. Herbs were the most commonly used life form (79.1%), followed by shrubs (13.4%) and trees (6%). The most consumed plant parts were young leaves (25%) and young aerial parts (21.4%). There were 13 use categories identified. The majority of edible plants were collected in April–May, mainly from areas nearby villages (37.7%) and rangelands (33.7%). The most important edible plants in the study area were *Allium iranicum* (Wendelbo) Wendelbo (UV = 1.7), *Mentha longifolia* (L.) Huds. (1.5), *Allium umbilicatum* Boiss. (1.47), *Tragopogon graminifolius* DC. (1.38), *Lepidium draba* L. (1.27), *Urtica dioica* L. (1.18), *Falcaria vulgaris* Bernh. (1.13), *Malva neglecta* Wallr. (1.11) and *Eremurus* sp. (1.09). Our results showed diverse and valuable knowledge for wild edible plants in this region, which should be considered in the conservation and management plans in the region.

Keywords Rangelands, Multiple use, Shahrood, Ecosystem services, Food security

*Correspondence:
Mehdi Abedi
mehdi.abedi@modares.ac.ir; abedimail@gmail.com
Full list of author information is available at the end of the article

Introduction

Plant biodiversity provides a variety of services to humans in the ecosystem, such as environmental services, food, medicine, fodder and wood [1–3]. Wild edible plants (WEPs) are plant species that grow naturally without being cultivated but may be used as a source of food [4–6]. They are an important part of local communities' household food baskets [7, 8], and most rural communities in mountainous areas rely on these plants to meet their nutritional needs [3, 9–15]. They are also regarded as a means of survival for these local communities, particularly during times of drought, famine, and danger [7, 16]. WEPs play a vital role in local communities' livelihoods, ensuring both food security and cultural preservation as well as cash generation [1, 3, 7, 8, 17–20]. They not only contribute material resources but also help to preserve local knowledge systems, traditions, and food cultures. Collecting and consuming WEPs not only provides cultural ecosystem services and promotes and strengthens social relationships [6, 21] but also alleviates the stress caused by environmental conflicts [8]. These plants and the food they produce are integral to the cultures of these societies, playing a crucial role in their lives [9, 22–24]. Additionally, these plants are easily accessible and provide low-cost food options [25].

Despite the numerous benefits these plants bring to local communities, many plant species and wild fungi are declining, with studies indicating the risk of extinction for some of these plants [2, 26, 27]. Several factors are at work in this case, including climate change, which is having an increasing impact on the abundance, distribution, and phenology of wild edible plants [28]. WEPs are generally threatened by threats to biodiversity [3]. As a result, understanding indigenous knowledge about WEPs is critical for assessing plant services, reducing the risk of knowledge extinction, recognizing local communities' rights, and improving biodiversity conservation efforts [29]. Studying these plants is necessary not only to preserve them so that they are not forgotten, but also to preserve the plants' valuable genetic resources for the health of future generations [3, 8, 30, 31].

Wild plant knowledge is an important component of traditional knowledge [5] because older generations of villagers have a wealth of knowledge about useful plants [32]. Therefore, it is critical to document sources of information, focusing particularly on wild edible plants [14, 33]. However, there is a notable absence of comprehensive reports documenting the usage of WEPs in east Semnan province, specifically Shahrood city. Despite the potential widespread consumption of WEPs by people residing in natural habitats such as Rangeland and forests in the region, the associated ethnobotanical knowledge remains largely unknown, particularly outside of Semnan Province. On the other hand, indigenous knowledge of WEPs use has only been passed down from generation to generation through oral communication. Most of the available ethnobotanical knowledge in Iran is limited to only medicinal aspects, and edible use has received very little attention. This study aimed to (a) document WEPs used by the people of Southeast of Alborz mountain in Shahrood, (b) record indigenous knowledge related to WEPs use, patterns of harvest and consumption by the local people of the region, (c) identify locally important species and marketed species and traditional foods in the region and (d) compare the WEPs of Shahrood with previously published studies on WEPs in Iran.

Materials and methods

The study area

Semnan Province, with an area of 97,491 square kilometers, is the sixth largest province in Iran. It is located between 34 degrees and 13 min to 37 degrees and 20 min north latitude and 51 degrees and 51 min east longitude. Shahrood is the province's largest city, bordering the Alborz mountain range to the north and the desert plain to the south. The Shahrood municipality is located on the southern slope of the Alborz mountain chain, and its altitude decreases from north to south and leads to the desert plain. Bastam and Biyarajmand are the two central parts of Shahrood municipality. In this study, 12 villages in the Bastam district were chosen, including Tash, Negarman, Abarsij, Ali Kahi, Hossein Abad, Meyghan, Qale Nokharqan, Proo, Abr, Khij, Mazj, and Jilan (Fig. 1). This area has the highest plant diversity in the Shahrood municipality, including a variety of habitats, including grasslands, mountain steppes and forests, which are the dominant habitats because of their locations between the two Hyrcanian and Irano-Turanian floristic regions.

Data collection

Ethnobotanical data collection was carried out in 12 villages of Bastam district, Shahrood municipality, between April 2021 and May 2022 (Tables 1, 2). Local people, including local shepherds, village officials, housewives, farmers, and locals who collect WEPs for sale in urban markets, were interviewed (Fig. 2). Data were collected using participatory observations, free-listing and semi-structured interviews [7]. Research goals were explained to the participants, and verbal informed consent was obtained prior to interviews. The International Society of Ethnobiology Code of Ethics was followed (ISE Code 2006). Information about the plant's local name, the parts used, collection time, collection location, and details of uses were recorded. Demographic and socioeconomic data on the informants, such as gender, age, official education level and

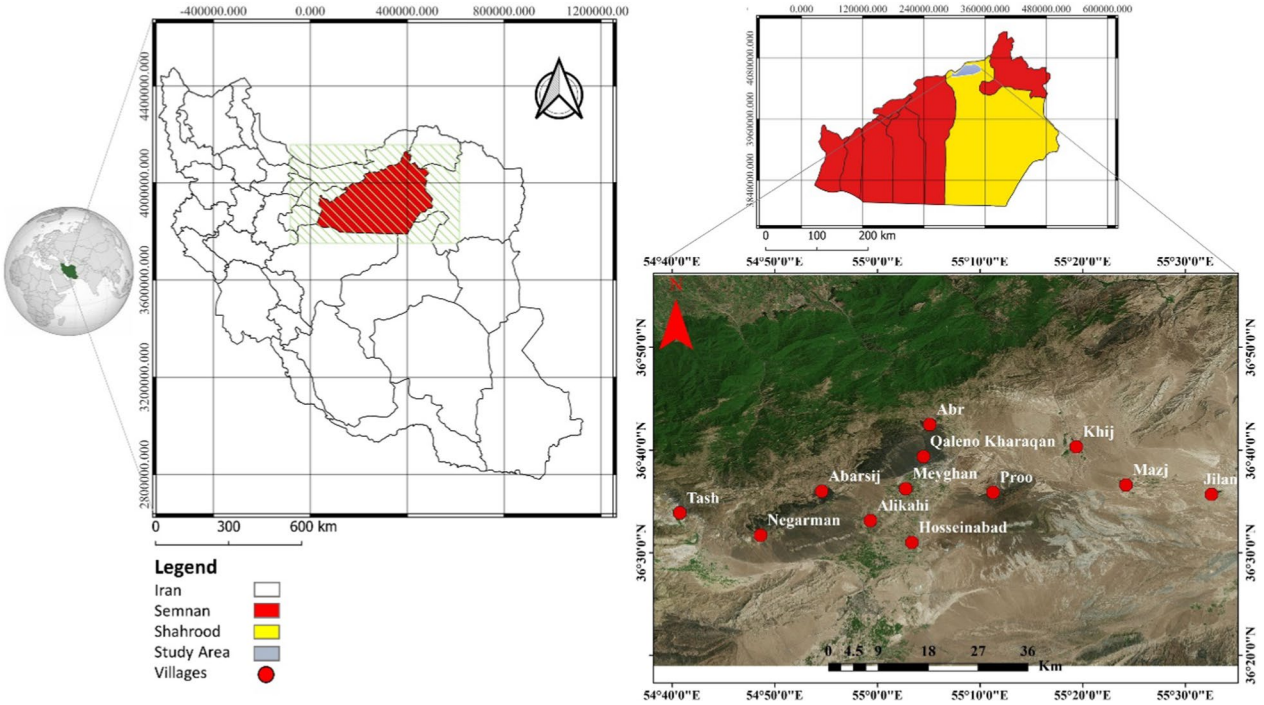

Fig. 1 Map of the study area and village locations

Table 1 Demographic characteristics of the interviewees from rural areas of Shahrood

	Village	Education level		Age				Gender			
		Female	Male	≥29	30–49	50–69	≤70	Illiterate	Primary	Secondary	High school and above
	Tash	1	2	0	2	0	1	1	0	1	1
	Negarman	3	1	0	1	3	0	1	0	1	2
	Abarsij	8	3	1	4	6	0	1	4	3	3
	Ali Kahi	1	1	0	0	1	1	1	0	1	0
	Hosseinabad	0	1	0	1	0	0	0	0	1	0
	Meyghan	2	1	0	0	2	1	1	1	1	0
	Qaleh Now-e Kharaqan	1	2	0	1	2	0	1	1	0	1
	Proo	2	1	0	2	1	0	1	1	1	0
	Abr	4	3	0	2	4	1	0	3	2	2
	Khij	1	3	0	0	4	0	1	3	0	0
	Mazj	1	1	0	1	0	1	0	1	1	0
	Gilan	0	1	0	0	1	0	0	1	0	0
Total	12	24	20	1	14	24	5	8	15	12	9
Percentage	100	54.5	45.5	2.3	31.8	54.5	11.4	18.2	34.1	27.3	20.4

occupation, were also recorded. WEPs collection sites were visited several times during the data collection [34]. Used WEPs were photographed during the flowering or seeding time, and herbarium samples were collected and prepared. All plant samples were identified and deposited at the herbarium of Ferdowsi University of Mashhad (FUMH). Plant scientific names were checked with WFO Plant List [35].

Table 2 Characteristics of the targeted localities and study participants

Village	Latitude (N)	Latitude (E)	Altitude (m)	Min_T (°C)	Max_T (°C)	Mean_T (°C)	Mean_P (mm)	Ecology	Ethnicity	Language	Religion	Inhabitants (households)	Subsistence activities
Tash	36° 33′ 419″	54° 40′ 39″	2247	−8.85	22.25	6.95	585.4	Mg	Persians	Persian	Shia Islam	138	Pastoralism and Horticulturaism
Negarman	36° 32′ 019″	54° 50′ 269″	2063	−7.85	23.75	8.05	484.6	Mg	Persians	Persian	Shia Islam	89	Pastoralism, Horticulturaism, and and Beekeeping
Abarsij	36° 34′ 559″	54° 55′ 089″	1770	−5.45	26.05	10.45	458.7	Mg	Persians	Persian	Shia Islam	1193	Pastoralism, Horticulturaism, Handicrafts and Beekeeping
Ali Kahi	36° 33′ 059″	54° 59′ 209″	1457	−3.65	28.35	12.45	297.2	Mg	Persians	Persian	Shia Islam	88	Horticulturaism, Agronomy
Hossein abad	36° 33′ 279″	55° 02′ 129″	1399	−3.35	28.95	12.85	263.5	Mg	Persians	Persian	Shia Islam	455	Horticulturaism, Agronomy
Meyghan	36° 36′ 149″	55° 01′ 359″	1492	−4.25	27.55	11.85	322.1	Mg	Persians	Persian	Shia Islam	2207	Pastoralism, Cattle farm Horticulturaism, Beekeeping, Urban occupations, and Agronomy
Qaleno-e-Kharaqan	36° 37′ 479″	55° 04′ 279″	1442	−4.15	27.65	11.95	315.8	Mg	Persians	Persian	Shia Islam	3927	Pastoralism,Horticulturaism, Handicrafts, Urban occupations and Agronomy
Proo	36° 35′ 499″	55° 06′ 019″	1415	−3.85	28.45	12.45	267.6	Mg	Persians	Persian	Shia Islam	1371	Pastoralism and Horticulturaism, Agronomy
Abr	36° 42′ 329″	55° 05′ 069″	1721	−6.25	25.25	9.85	351.9	Mg	Persians-Turkic	Persian-Turkish	Shia Islam	1383	Pastoralism, Horticulturaism, Handicrafts and Beekeeping
Khij	36° 40′ 059″	55° 19′ 269″	1464	−5.05	28.05	11.55	276.2	Mg	Persians	Persian	Shia Islam	2852	Pastoralism, Horticulturaism, Cattle farm and Handicrafts
Mazj	36° 36′ 299″	55° 24′ 269″	1246	−3.65	30.15	13.25	212.4	Mg	Persians	Persian	Shia Islam	666	Pastoralism, Agronomy
Jilan	36° 35′ 379″	55° 32′ 399″	1130	−3.15	31.45	14.15	191.8	Mg	Persians	Persian	Shia Islam	698	Pastoralism, Agronomy

Min_T min temperature of coldest month, *Max_T* max temperature of warmest month, *Mean_T* annual mean temperature, *Mean_P* mean Annual precipitation, *Mg* mountain grasslands

Environmental variables related to the habitats studied in Table 2 Provided, These variables include: coordinates, It was bioclimatic variables, and altitude data. All climate data for the current period are obtained from World Climate Data (https://www.wordclim.org)

Fig. 2 Interviews with local people to collect information

Data analysis

The collected data were structured based on use reports in an Excel spreadsheet. The ethnobotanical importance indices, including usage reports (URs), relative frequency of citation (RFC), and usage value (UV), were calculated. The use report (UR) per species is the count of the number of informants who mention each use category for the species and the sum of all uses in each use category [36]. The frequency of citation (FC) per species is the sum of informants that cite a use for the species in the dataset [36]. The RFC is calculated by dividing the FC of a species by the total number of informants using the following formula:

$$RFC = FC/N$$

$$(0 < \mathrm{RFC} < 1).$$

The usage value (UV) of WEPs was calculated using the following formula:

$$UV = \left(\sum Ui\right)/N$$

where Ui is the count of uses mentioned by each informant for a specific wild edible plant, and N is the total number of informants [37]. All importance indices were calculated using the ethnobotany R package in R [38].

Jaccard index is calculated by comparison between present and previous studies from surrounding regional and other areas by analyzing the percentages of quoted species and their uses using the following formula [39]:

$$\mathrm{JI} = \frac{\mathrm{c} * 100}{(\mathrm{a} + \mathrm{b} - \mathrm{c})}$$

Results

In total, 44 informants provided data, with 24 women (54.5%) and 20 men (45.5%) providing information (Table 1). The respondents ranged in age from 27 to 83 years, with the majority being between the ages of 50 and 69 (54.5%). Furthermore, the general level of education was low, whereas younger people had a higher level of education (Table 2).

Diversity of WEPs in the study area

In total, 67 wild edible plant species from 54 genera and 24 families and one mushroom were recorded to be used in the study area (Figs. 10 and 11). Table 4 summarizes the details of the plant species, life forms, parts used, collection times, and collection locations. Most of the plants used were herbs with 53 species (79.1%), followed by shrubs with nine species (13.4%), trees with four species (6%), and one mushroom species (1.5%) (Fig. 3a). Rosaceae was the dominant family with xx species (13.4%), followed by Apiaceae and Lamiaceae with eight species each (11.9%), Asteraceae with seven species (10.4%), Amaryllidaceae with five species (7.5%), Amaranthaceae and Caryophyllaceae with four each (5.9%), and Brassicaceae with three species (4.5%) (Fig. 4). At the genus level, Allium was the most common genus, with five species, followed by *Ferula, Elwendia, Scorzonera, Vicia, Ziziphora, Stachys, Plantago, Crataegus,* and *Prunus*, each with two species. While most of the species had one local name in the studied areas, some of them had more than one, such as *Falcaria vulgaris*, which had three local names (Table 4). Figure 10 shows images of some wild edible plants found in the study area.

Table 3 Thirteen types of main local food categories with the number of species and URs for each use and examples of wild edible plants for each use category

Use category	Synthetic explanation	Use reports (URs)	No. of species	Examples of plants involved
Rice veg	Boiled in water with rice	268	37	*Malva neglecta*
Coco sabzi	Fried in oil with egg	186	28	*Allium iranicum*
Soup	Boiled with water with beans	162	39	*Stellaria media*
Herb stew	Fried in oil and boiled with water with meat and legumes	120	32	*Eremurus* sp.
Yogurt	Added to yogurt in steamed and mashed, or enhanced taste	75	16	*Suaeda acuminate*
Kashk	Fried in oil or raw to enhance the taste of curd	71	8	*Urtica dioica*
Salad	Fresh and raw or flavoring	47	11	*Allium paradoxum*
Herbal tea	Processed and boiled with water with natural sweetener	43	5	*Stachys lavandulifolia*
Veg bread	Preparation of bread with flour, water and added toasted herb with spices	40	10	*Allium umbilicatum*
Pickled	Fermented in vinegar	23	9	*Ferula* sp.
Ripe fresh fruit	Ripe fruits without any cheeks preparing as dessert	23	9	*Crataegus pentagyna*
Snack	Dried fruits and edible flowers	22	10	*Celtis caucasica*
Jam	Cooked in sugar	6	3	*Prunus divaricata*
Total	13	1086	217	

Plant parts used

Young leaves (25%), with 28 reported species, were the most commonly used plant part, followed by young aerial parts (24 species, 21.4%), leaves (17 species, 15.2%), fruits (14 species, 12.5%), aerial parts (7 species, 6.2%), flowering aerial parts (5 species, 4.4%), seeds and stems (4 species each, 3.6%), and whole plants and flowers (3 species each, 2.7%). The bulb (2 species, 1.8%) and tuber (1 species, 0.9%) were the least used plant parts (Figs. 3b and 5a).

Given the prevalence of herbaceous plants, it appears that young leaves and young aerial parts (46.4%) are the most edible parts of plants. Both are used at the early stage of the growth season when the plant parts are tender. Toward the end of the growth season, when the plant parts become less tender, leaves and aerial parts do not contribute greatly to the local diet. A number of species, such as *Descurainia sophia* (L.) Webb ex Prantl, provide two or more edible parts during their growth cycle. The young aerial parts of the plant were used at the beginning of the vegetative stages, and seeds were used toward the end of the growth cycle. Some plants, such as *Scorzonera paradoxa* Fisch. & C. A.Mey., provide both the young leaves and the bulbs as edibles.

Diversity of use categories

In this study, 1086 consumption reports based on the eating habits of people in the study area were classified into thirteen usage categories (Table 3 and Fig. 5b). Among these categories, rice veg was the most cited consumption category with the most usage reports (37 species, 268 usage reports, 24.7%), followed by coco sabzi (28 species, 186 use reports, 17.1%), soup (39 species, 162 use reports, 15%), herb stew (32 species, 120 use reports, 11%), yogurt (16 species, 75 use reports, 7%), kashk (8 species, 71 usage reports, 6.5%), salad (11 varieties, 47 reports of use, 4.3%), herbal tea (5 varieties, 43 reports of use, 4%), veg bread (10 varieties, 40 reports of use, 3.7%), pickled (9 varieties, 23 reports of use, 2.1%), ripe fresh fruit (9 types, 23 usage reports, 2.1%), snack (10 types, 22 usage reports, 2%) and finally jam (3 species, 6 reports of use, 0.5%).

Table 4 List of wild edible plants used by local people in Semnan Province (Shahrood), Iran. Families were presented in bold and species in italic

Family[a] Scientific name[b]. Herbarium Number [c]	Local name[d]	Life form[e]	Used parts[f]	Consumption mode[g]	Use categories[h]	Collection Time[i]	Gathering areas[j]	Indices [k]			Edible plants use previously reported in Iran[l]
								URs	RFC	UVs	
Amaryllidaceae *Allium grande* Lipsky (9873)	Mamado	Herb	Young leaves, Young aerial parts, Leaves	C	Rice veg, Coco sabzi, Soup, Herb stew, Kashk, Veg bread, Yogurt	March–April	RA, FO	21	0.182	0.477	NR
Allium iranicum (Wendelbo) Wendelbo (9860)	Sebi	Herb	Whole plant [41]: Leaves, Stem, Flowe [93]: Leaves, bulb	C, D, R, P	Rice veg, Coco sabzi, Soup, Herb stew, Kashk, Yogurt, salad, Veg bread, Pickled ([41, 55]: edible)	May–June	RA	75	0.432	1.705	[41,, 51, 93]
Allium paradoxum) M.Bieb.) G.Don (9826)	Alahzo	Herb	Young leaves, Young aerial parts [42]: Leaves	C, R	Rice veg, Coco sabzi, Herb stew, salad, Veg bread ([42]: edible)	March–April	RA, FO	20	0.136	0.455	[42, 51]
Allium sp. (9889)	Siyr kuhi	Herb	Young leaves, Bulb	C, R	Soup, Yogurt	April–June	RA, FO	3	0.045	0.068	NR
Allium umbilicatum Boiss. (9840)	Siyr kelagh-Siyr se kohe	Herb	Whole plant	C, D, R	Rice veg, Coco sabzi, Soup, Herb stew, Kashk, salad, Veg bread	April–June	AV	65	0.523	1.477	NR
Amaranthaceae *Amaranthus retroflexus* L. (9861)	Eshkeno-Taj Khorus	Herb	Young leaves	C, D	Rice veg, Coco sabzi, Soup	April–July	AV	6	0.068	0.136	NR
Atriplex micrantha Ledeb. (9879)	Shalme-Salmeh-Selmoo	Herb	Young leaves, Leaves	C, D, R	Coco sabzi, Soup, Herb stew, Yogurt, salad, Veg bread	April–June	AV, RA, HS	43	0.386	0.977	NR
Blitum virgatum L. (9874)	Esfenaj kuhi	Herb	Young leaves, Leaves	C	Soup, Herb stew, Yogurt	April–June	RA, FO, SP	6	0.091	0.136	NR
Suaeda acuminata (C.A.Mey.) Moq. (9883)	Kakel shor	Herb	Young aerial parts	C	Rice veg, Soup, Yogurt	April–May	AV, RA	10	0.136	0.227	NR
Apiaceae *Daucus carota* L. (9875)	Havijoo	Herb	Young leaves, Tuber [59]: Stem, root	C, R	Rice veg, Soup, Snack ([59]: edible)	April–June	AV	5	0.045	0.114	[59]
Elwendia cylindrica (Boiss. & Hausskn.) Pimenov & Kljuykov (9852)	Sar gazero, Shen ghazero	Herb	Young leaves, Young aerial parts	C, D	Rice veg, Coco sabzi, Soup, Veg bread	April–May	RA, SP	11	0.136	0.25	NR
Elwendia sp. (9887)	Ziyreh kuhi	Herb	Seed	D	Rice veg,	May–June	RA	7	0.114	0.159	NR

Table 4 (continued)

Family[a] Scientific name[b]. Herbarium Number [c]	Local name[d]	Life form[e]	Used parts[f]	Consumption mode[g]	Use categories[h]	Collection Time[i]	Gathering areas[j]	Indices [k]			Edible plants use previously reported in Iran[l]
								URs	RFC	UVs	
Falcaria vulgaris Bernh. (9841)	Panjeh kolago-Sag-Pakelagh	Herb	Young aerial parts, Leaves [58]: Whole plant [41]: Leaves, Stem [59]: Aerial part, Stem, Leaf, Seed [43]: Aerial parts [87]: Leaves, Seed [90]: Seed [49]: Plant limbs	C, D, R	Rice veg, Coco sabzi, Soup, Herb stew ([41, 43, 46, 49, 58, 59, 87]: edible) ([90]: in bread & soup)	April–June	AV, RA	50	0.591	1.136	[41, 43, 46, 49, 51, 58, 59, 87, 90]
Ferula foetida (Bunge) Regel (9888)	Koma-Kema	Herb	Stem [90]: Aerial parts	C	Rice veg ([90]: Coo mixed with fried onion)	March	RA	4	0.091	0.091	[90]
Ferula sp. (9886)	Eshtelghaz	Herb	Young leaves, Flower [90]: Aerial parts	C, P 69: Raw	Rice veg, Soup, Pickled ([90]: in bread)	May–June	RA	7	0.114	0.159	[90]
Foeniculum vulgare Mill. (9842)	Shirin beydiyon	Shrub	Young aerial parts, Aerial parts, Seed [40]: Leaves, Stem [41]: Leaves, Stem, Root [45]: Fruit	C, D	Rice veg ([40, 41, 45, 89: edible)	May–July	AV	4	0.091	0.091	[40, 41, 45, 89]
Scandix stellata Banks & Sol. (9827)	Shevidoo	Herb	Young aerial parts	C, D	Rice veg, Coco sabzi, Herb stew	April–May	AV	9	0.159	0.205	NR
Asphodelaceae *Eremurus* sp. (9828)	Serishu-Seriysh-Cheresh	Herb	Young leaves, Leaves	C	Rice veg, Coco sabzi, Soup, Herb stew, Kashk, Yogurt, Veg bread	April–May	RA	48	0.341	1.091	NR
Asteraceae *Achillea wilhelmsii* K. Koch (9863)	Marembo	Herb	Flowering aerial part [88]: Whole plant [46]: Leaves, Flowers	D 67: Raw	Herbal tea ([88, 90]: edible) ([46]: Herbal tea (edible))	May–July	AV, RA	2	0.045	0.045	[46, 88, 90]
Centaurea cyanus L. (9876)	Ali barkato	Herb	Young leaves	C, D	Rice veg, Soup	April–May	AV, RA	3	0.045	0.068	NR

Table 4 (continued)

Family[a] Scientific name[b]. Herbarium Number [c]	Local name[d]	Life form[e]	Used parts[f]	Consumption mode[g]	Use categories[h]	Collection Time[i]	Gathering areas[j]	Indices [k]			Edible plants use previously reported in Iran[l]
								URs	RFC	UVs	
Gundelia tournefortii L. (9878)	Kangar	Herb	Stem [40]: Stem [43]: Roots, Latex [87]: Flowers, Seed [44]: Stem [91]: Stem, Aerial parts [92]: Stem [94]: Fruit [50]: Leaf	C 62: Raw 71: Raw	Herb stew, Yogurt ([40, 43, 87, 94]: edible) ([44]: Yogurt and Stew) ([91]: with yogurt and as stew) ([92]: Raw in salad and yogurt, stew) ([50]: Boiled, stew)	April	RA	11	0.159	0.25	[40, 43, 44, 50, 51,87, 91, 92, 94]
Scorzonera meyeri (k.k.och) Lipsch. (9885)	Shengi mar	Herb	Young leaves, Young aerial parts	C, D	Rice veg, Coco sabzi, Herb stew	April–May	AV, RA	15	0.205	0.341	NR
Scorzonera paradoxa Fisch. & C.A.Mey. (9853)	Goseh bareh	Herb	Young leaves, Bulb [90]: Leaf [50]: Corm	C, R 69: Raw (fresh)	Rice veg, salad ([90]: local food) ([50]: Raw vegetables)	April–May	RA	7	0.091	0.159	[50, 90]
Sonchus oleraceus L. (9862)	Kaho	Herb	Young leaves	C	Rice veg, Coco sabzi	April–May	AV	3	0.045	0.068	NR
Tragopogon graminifolius DC. (9843)	Shengi	Herb	Whole plant [87]: Young leaves, Root	C, D, R	Rice veg, Coco sabzi, Soup, Herb stew, salad ([87]66: edible)	April–July	AV	61	0.659	1.386	[87]
Berberidaceae *Berberis integerrima* Bunge (9829)	Zereshk	Shrub	Young leaves, Fruit [58]: leaves, Fruit, Root, Skin [45, 50]: Fruit [90, 99]: Fruit, Root [46]: Leaves, fruits, roots and bark [49]: Leaves, fruits, roots and bark	C, F, P	Pickled, Ripe fresh fruit, Jam ([46, 49, 58]: Barberry juice, syrup, jam) ([45, 99]: edible) ([90]: jam) ([92]: syrup) ([50]: Flavoring)	September – November	AV, RA, FO	21	0.136	0.477	[45, 46, 49, 50, 58, 90, 92, 99]
Boraginaceae *Anchusa azurea* Mill. (9859)	Gozebon	Herb	Young aerial parts, Flower, Stem, Young leaves	C, R		April–June	AV, RA, RO	14	0.227	0.318	NR
Brassicaceae *Capsella bursa-pastoris* (L.) Medik. (9830)	Kelachepa-kal chopaa	Herb	Young leaves, Young Aerial parts, Leaves [85]: Aerial part	C, D	Rice veg, Coco sabzi, Soup, Herb stew ([85]: edible)	April–May	AV	18	0.25	0.409	[51, 85]

Table 4 (continued)

Family[a] Scientific name[b]. Herbarium Number [c]	Local name[d]	Life form[e]	Used parts[f]	Consumption mode[g]	Use categories[h]	Collection Time[i]	Gathering areas[j]	Indices [k]			Edible plants use previously reported in Iran[l]
								URs	RFC	UVs	
Descurainia sophia (L.) Webb ex Prantl. (9845)	Khakeshir	Herb	Young leaves, Young Aerial parts, Seed [44, 45, 50, 88, 90, 94]: Seed	C, D 67: Raw	Rice veg ([44, 88, 90]: syrup) ([58, 88, 94, 95]: edible) ([50]: Drink)	April–June	AV, RO	4	0.045	0.091	[44, 45, 50, 51, 58, 88, 90, 94]
Lepidium draba L. (9844)	Jajo,Maqo,Jiyjo	Herb	Young leaves, Young Aerial parts, Leaves [44]: Leaves, Young Aerial parts [85]: Aerial part [95]: Aerial parts, Laef and flowe [99]: Leaves, Seeds [50]: Laef	C, D, R 62: Raw, Cooked	Rice veg, Coco sabzi, Soup, Herb stew, salad, Veg bread ([85]: Young leaves are cooked with rice) ([44]: Raw and cooked with dairy) ([90]: local food) ([99]: Edible leaves) ([50]: Pottage, omelet, boiled, herb rice pilaf)	April–June	AV, RA, RO	56	0.477	1.273	[44, 50, 85, 90, 95, 99]
Cannabaceae *Celtis caucasica* Willd. (9877)	Teyfor	Tree	Fruit	D, F	Ripe fresh fruit, Snack	October–November	AV, FO	6	0.068	0.136	NR
Capparaceae *Capparis spinosa* L. (9872)	Hendoaneh abojahl	Shrub	Fruit [84]: Flowers, Fruit, leaves, Root [43, 45, 50]: Fruit, Flowers [85]: Fruit	P	Pickled ([43, 45, 89]: edible) ([84, 85]: Fruit as pickle) ([50]: Omelet, pickle)	July–August	AV, RA, GR	4	0.091	0.091	[43, 45, 84, 85, 89]
Caryophyllaceae *Gypsophila* sp. (9846)	Gandemoo	Herb	Young leaves	C, D	Rice veg, Coco sabzi, Soup, Herb stew	April–May	AV	8	0.091	0.182	NR
Lepyrodiclis stellarioides Schrenk. ex Fisch. & C.A Mey. (9831)	Gandem sheloo	Herb	Young leaves, Young aerial parts	C, D	Rice veg, Soup, Herb stew	April–May	AV	4	0.068	0.091	NR
Silene conoidea L. (9847)	Mar gandemoo	Herb	Young aerial parts	C, D	Soup, Herb stew	April–May	AV	4	0.068	0.091	NR

Table 4 (continued)

Family[a] Scientific name[b]. Herbarium Number [c]	Local name[d]	Life form[e]	Used parts[f]	Consumption mode[g]	Use categories[h]	Collection Time[i]	Gathering areas[j]	Indices [k]			Edible plants use previously reported in Iran[l]
								URs	RFC	UVs	
Stellaria media (L.) Vill. (9832)	Piyloo	Herb	Young aerial parts	C	Soup, Herb stew	April–June	SP, AF	5	0.091	0.114	NR
Convolvulaceae *Convolvulus arvensis* L. (9864)	Ey roo	Herb	Young aerial parts [44]: Leaves, Aerial parts	C	Soup, Herb stew, Yogurt ([44]: edible)	April–May	AV, SP	8	0.091	0.182	[44]
Fabaceae *Vicia faba* L. (9848)	Kharoo	Herb	Leaves, Fruit [95]: Seed	C, R	Rice veg ([95]: edible)	May–June	AV	2	0.045	0.045	[95]
Vicia tenuifolia Roth (9849)	Nakhodo	Herb	Young leaves, Fruit	C, R	Soup, Snack	April–June	AV	1	0.023	0.023	NR
Ixioliriaceae *Ixiolirion tataricum* (Pall.) Schult. & Schult.f. (9823)	Khiyarak-Gol khiyar	Herb	Young aerial parts, Flower [86]: Flower, leaves [50, 90, 92]: Flower [93]: Gland, fowers, shoot	C, R 69: Fresh	Rice veg, Soup, Herb stew, Snack ([86, 90, 92, 93]: edible) ([50]: Raw vegetables)	April–May	AV, RA, HS	3	0.045	0.068	[50, 86, 90, 92, 93]
Lamiaceae *Lallemantia royleana* (Benth.) Benth. (9857)	Koti	Herb	Young aerial parts	D	Soup ([45]: edible)	May	AV	1	0.023	0.023	[45]
Lamium amplexicaule L. (9866)	Chesh chaqholoo-Chesm chaqok	Herb	Young aerial parts, Leaves	C, D	Rice veg, Coco sabzi, Soup, Herb stew	April–May	AV, RA	34	0.409	0.773	NR
Mentha longifolia (L.) Huds. (9865)	Poneh kuhi	Herb	Leaves, Aerial parts [40, 44]: Leaves, Stem [43, 45, 48, 50]: Leaves [90]: Root, Seed [98]: Leaf, flower	D, R 70: Raw	Coco sabzi, Soup, Kashk, Yogurt, salad, Veg bread, Herbal tea ([40, 43, 44, 45, 48, 89, 91, 96]: edible) ([90]: in soup, bread or as herbal Tea) ([98]: Flavoring of food and yogurt flavor) ([50]: Raw vegetables, herbal tea, flavoring)	April–October	AV, RA, SP, AF	66	0.659	1.5	[40, 43–45, 48, 50, 51, 89, 90, 91, 96, 98]

Table 4 (continued)

Family[a] Scientific name[b]. Herbarium Number [c]	Local name[d]	Life form[e]	Used parts[f]	Consumption mode[g]	Use categories[h]	Collection Time[i]	Gathering areas[j]	Indices [k]			Edible plants use previously reported in Iran[l]
								URs	RFC	UVs	
Nepeta sacharata Bunge (9850)	Osta qhodos	Herb	Young aerial parts, Aerial parts, Flowering aerial part	D	Rice veg, Yogurt, Herbal tea	May–June	AV, RA, HS	7	0.136	0.159	NR
Stachys lavandulifolia Vahl (9858)	Chayi kuhi-Pash pasho	Herb	Aerial parts, Flowering aerial part [44]: Aerial parts	D	Herbal tea ([44]: edible)	May–June	RA	8	0.182	0.182	[44]
Stachys sp. (9871)	Charbe poneh	Herb	Young leaves	D	Rice veg, Coco sabzi, Soup	May–October	AV, RA, SP, AF	7	0.091	0.159	NR
Ziziphora clinopodioides Lam. (9880)	Eiyshem	Herb	Leaves, Flowering aerial part [40]: Leaves [58]: Leaves, Flowering [44]: Leaves, Stem [90]: Aerial parts, Leaves	D	Kashk, Yogurt, salad, HT ([40, 44]: edible) ([58]: Tea, spices and leaves dried in buttermilk) ([90]: powdered leaf mixed with tea, yogurt, and local food)	May–June	RA	31	0.455	0.705	[40, 44, 58, 90]
Ziziphora tenuior L. (9833)	Kokol kuti	Herb	Aerial parts, Flowering aerial part [44]: Leaves, Stem [45]: Leaves, Flower [90]: Aerial parts, Leaves [50]: Leaf	D	Coco sabzi, Kashk, Yogurt, salad ([44, 45: edible) ([90]: powdered leaf mixed with tea, yogurt, and local food) ([50]: Herbal tea, flavoring)	May–July	AV, RA	20	0.341	0.455	[44, 45, 50, 90]
Malvaceae *Malva neglecta* Wallr. **(**9851)	Meleki-Non kelaghi	Herb	Young leaves, Young aerial parts, Leaves, Fruit [40]: leaves, Stem [87]: Flower, leaves [91]: Flower, Seed [48]: leaves [50]: Leaf and fruit	C, D 70: Raw, cooking	Rice veg, Coco sabzi, Soup, Herb stew ([40, 87, 91]: edible) ([48]: Drink) ([50]: Omelet, boiled)	April–September	AV, RA	49	0.545	1.114	[40, 48, 50, 87, 91]
Papaveraceae *Papaver dubium* L. (9824)	Naneh biya	Herb	Young leaves	C, D	Rice veg, Coco sabzi, Soup	April–May	RA, HS	7	0.114	0.159	NR

Table 4 (continued)

Family[a] Scientific name[b]. Herbarium Number [c]	Local name[d]	Life form[e]	Used parts[f]	Consumption mode[g]	Use categories[h]	Collection Time[i]	Gathering areas[j]	Indices [k]			Edible plants use previously reported in Iran[l]
								URs	RFC	UVs	
Plantaginaceae *Plantago major* L. (9856)	Gadisho barg gerd-Bartang	Herb	Young leaves, Seed [44]: leaves [88, 97]: Seed [46, 49]: Roots, Leaves, Seeds	C, D	Rice veg, Coco sabzi ([62, 88, 97]: edible) ([46, 49]: Drink, syrup and drops)	April–October	AV, RA, SP	8	0.114	0.182	[44, 46, 49, 51, 88, 97]
Plantago lanceolata L. (9867)	Gadisho barg deraz-Kardi	Herb	Young leaves [44]: Leaves, Seed [48]: Leaves	C, D	Rice veg, Coco sabzi, Soup ([44]: edible) ([48]: Drink)	April–October	AV, RA, SP	7	0.091	0.159	[42, 44,]
Pleurotaceae *Pleurotus ostreatus* (Jacq.) P.Kumm. (9834)	Gharch kuhi	Fungus	Aerial parts	C	Soup	May	RA	5	0.014	0.114	NR
Polygonaceae *Polygonum* sp. (9869)	Qhoppeoo	Herb	Young aerial parts, Leaves	C, D	Soup, Herb stew, Yogurt	April–May	AV, SP	18	0.25	0.409	NR
Rumex sp. (9855)	Telpa-Tershe selef	Herb	Young leaves, Young aerial parts, Leaves	C, D	Rice veg, Coco sabzi, Soup, Herb stew, Yogurt, Veg bread	April–September	AV, RA, SP	40	0.477	0.909	NR
Portulacaeae *Portulaca oleracea* L. (9835)	Khorfeh-Kholfeh	Herb	Leaves, Aerial parts, Stem [44]: Leaves, Stem [47, 50, 94]: Seed, Leaves [69]: Aerial parts	C, R, P 96: Raw (fresh)	Soup, Herb stew, salad, Pickled ([44, 69, 94]: edible) ([47]: edible as vegetable) ([50]: Pastry, pickle, raw vegetables)	June–October	AV	9	0.091	0.205	[44, 47, 50, 69, 94]
Rosaceae *Crataegus pentagyna* Waldst. & Kit. ex Willd. (9882)	Velek siyah	Shrub	Fruit [42]: Fruit	F	Ripe fresh fruit ([42]: edible)	September–December	AV, FO	6	0.068	0.136	[42]
Crataegus pseudoheterophylla Pojark. (9884)	Velek ghermez	Shrub	Fruit	F	Pickled, Ripe fresh fruit	September–December	AV, FO	7	0.068	0.159	NR
Malus sieversii f. *niedzwetzkyana* (9839)	siyb too sorkh	Tree	Fruit	F, P	Ripe fresh fruit, Jam	May, August	AV, RA	2	0.023	0.045	NR

Table 4 (continued)

Family[a] Scientific name[b]. Herbarium Number [c]	Local name[d]	Life form[e]	Used parts[f]	Consumption mode[g]	Use categories[h]	Collection Time[i]	Gathering areas[j]	Indices [k]			Edible plants use previously reported in Iran[l]
								URs	RFC	UVs	
Mespilus germanica L. (9836)	Kondes	Shrub	Fruit [58]: Leaves, Seed [42]: Fruit	F, P 46: Raw	Pickled, Ripe fresh fruit ([58]: Raw fruit, syrup and paste) ([42]: edible)	October–November	FO	6	0.045	0.136	[42, 58]
Prunus divaricata Ledeb. (9868)	Alocheh jangali	Shrub	Fruit [42]: Fruit	C, D, F, P	Soup, Herb stew, Pickled, Ripe fresh fruit, Snack, Jam ([42]: edible)	September–October	FO	11	0.045	0.25	[42]
Prunus microcarpa C.A.Mey. (9881)	Eiyl viylo vahshi	Shrub	Fruit	F	Ripe fresh fruit	September	RA	4	0.045	0.091	NR
Pyrus boissieriana Buhse (9870)	Golabi jangali	Tree	Fruit	F	Ripe fresh fruit	October–November	FO	4	0.045	0.091	NR
Rosa canina L. (9837)	Sag teloo	Shrub	Fruit [87]: Fruit, Flower [42]: Fruit	D, F, P	Herbal tea, Pickled ([87]: edible) ([42]: making jam	October–November	AV, RA	4	0.045	0.091	[42, 51, 87]
Sanguisorba minor Scop. (9854)	Tonban zan ghazi-Kerafs	Herb	Young aerial parts, Leaves [44]: Leaves [88]: Whole plant [94]: Fruit, Leaf	C, D	Rice veg, Coco sabzi, Soup, Herb stew ([44, 88]: edible) ([94]: Boiled and edible raw Raw use, boiled)	April–July	AV, RA, SP	24	0.295	0.545	[44, 88, 94]
Ulmaceae *Ulmus minor* Mill. (9825)	Happo	Tree	Flower	F	Snack	April	AV, FO	2	0.045	0.045	NR

Table 4 (continued)

Family[a] Scientific name[b]. Herbarium Number [c]	Local name[d]	Life form[e]	Used parts[f]	Consumption mode[g]	Use categories[h]	Collection Time[i]	Gathering areas[j]	Indices [k]			Edible plants use previously reported in Iran[l]
								URs	RFC	UVs	
Urticaceae *Urtica dioica* L. **(**9838)	Ghazeneh	Herb	Young leaves, Young aerial parts, Leaves [58]: Leaves, Flowering aerial part [41]: Leaves,Stem [43, 48]: Leaves [44]: Leaves, Aerial parts [87]: Young leaves, Stem [88]: Whole plant [46, 49]: Leaves, Flowers, Lowering branches	C, D 46: Dried	Coco sabzi, Soup, Herb stew, Kashk, Yogurt ([41, 43, 44, 48, 58, 87, 88]: edible) ([46, 49]: In food preparation, dried and boiled (edible)	April–October	AV, RA, SP	52	0.523	1.182	[41, 43, 44, 46, 48, 49, 58, 87, 88]

Consumption mode: C Cooked, D Dried, R Raw, F Fresh, P Processed. Gathering areas: AV Around the village, RA Rangeland, FO Forest, SP Shady places, HS Hilly slopes, AF Around the fountain, RO Roadside, GR Graveyard. UR_S: use reports. RFC: relative frequency of citation. Not reported: NR

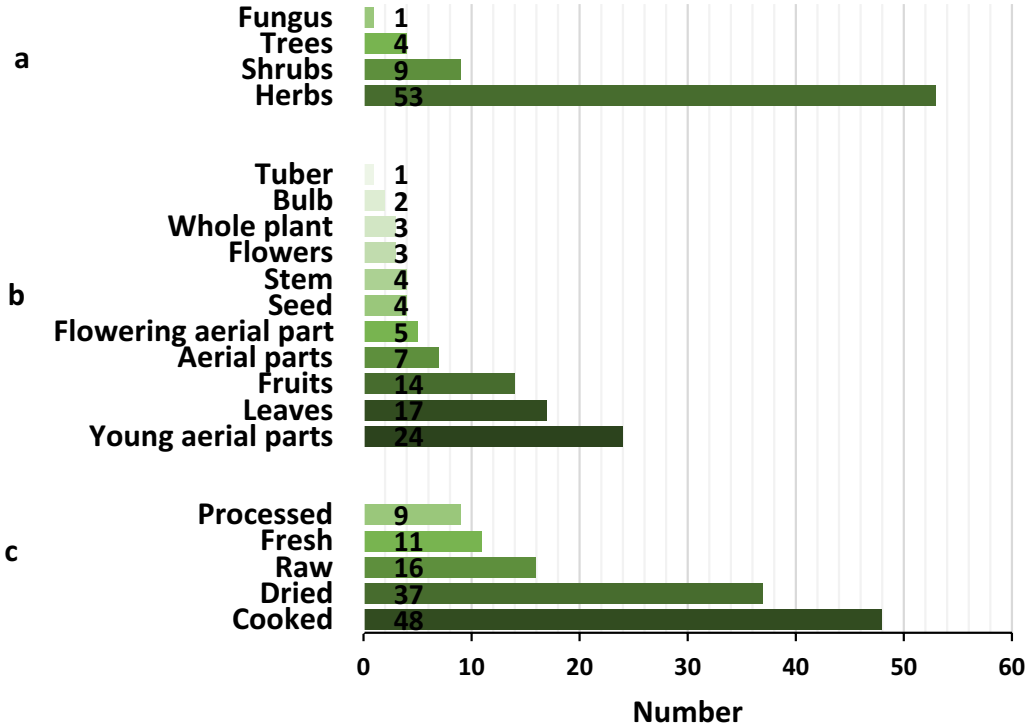

Fig. 3 **a** Life form contributions of wild edible plants in the study area (number of species), **b** plant parts used by locals, **c** modes of preparation of edible plants by the local community in the study area

To prepare rice veg, 37 edible species were used in which each of these plants was consumed with rice after boiling in water. Rice veg primarily consists of young aerial parts and young leaves of plants such as *Tragopogon graminifolius*, which had the most reported species for this category (29 usage reports) (Table 5 and Fig. 6a). Twenty-eight 28 species were also used to prepare coco sabzi, including *Falcaria vulgaris* (18 usage reports). This category contained the most reported species, which were typically used in combination with other plants (Table 5 and Fig. 6b and i). Most species reported to be used in soup preparation are *Rumex* sp. (18 usage report) and *Lepidium draba* (15 use report). This category also includes all soups and noodle soups (Table 5 and Fig. 6c and d). To prepare the herb stew, a total of 32 species were used in different forms (Fig. 6f and m).

There were 16 varieties of plants that were used for yogurt. Fresh leaves and young aerial parts of *Blitum virgatum* L. are boiled in water and then spitted and added to yogurt (boryni) (Fig. 6j). There were also herbs in this consumption category that are added to cooked rice with yogurt, such as *Suaeda acuminata* (C.A.Mey.) Moq (Fig. 6h), and finally, there are plants that are added to yogurt to improve its flavor, such as *Mentha longifolia.* There are also eight species used to make kashk, with five of them providing raw materials, such as *Urtica dioica* (Fig. 6g). *Mentha longifolia* is one of three species used to flavor kashk.

There are two types of plants used in the preparation of salad (11 species), including a number of plants that are consumed raw in the local people's tradition, such as *Allium paradoxum* (M.Bieb.) G. Don and *Tragopogon graminifolius* and plants that are added to the salad in a dry form to increase the taste, such as *Ziziphora clinopodioides* Lam. and *Mentha longifolia* plants used to make vegetable bread (9 species), including *Allium umbilicatum* and *Atriplex micrantha* Ledeb. or *Lepidium draba* are mostly cooked before being added to the dough with spices (Fig. 6e and k).

Other categories are considered (5 types of herbal tea, 10 types of snacks, 9 types of fruits, 3 types of jams, and 9 types of pickles). Drinks were traditionally made from herbs such as *Ziziphora clinopodioides* and *Stachys lavandulifolia* Vahl, which are consumed as herbal tea. Some wild edible plants are consumed as snacks, such as dried fruits such as *Celtis caucasica* Willd. or edible flowers such as *Ixiolirion tataricum* (Pall.) Schult. & Schult.f. with children primarily collecting and consuming them.

Furthermore, ripe fruits are another food source that is consumed as a seasonal fruit with no special preparation. The fruits are mostly collected from shrublands and forest areas and are mostly consumed raw and fresh, such

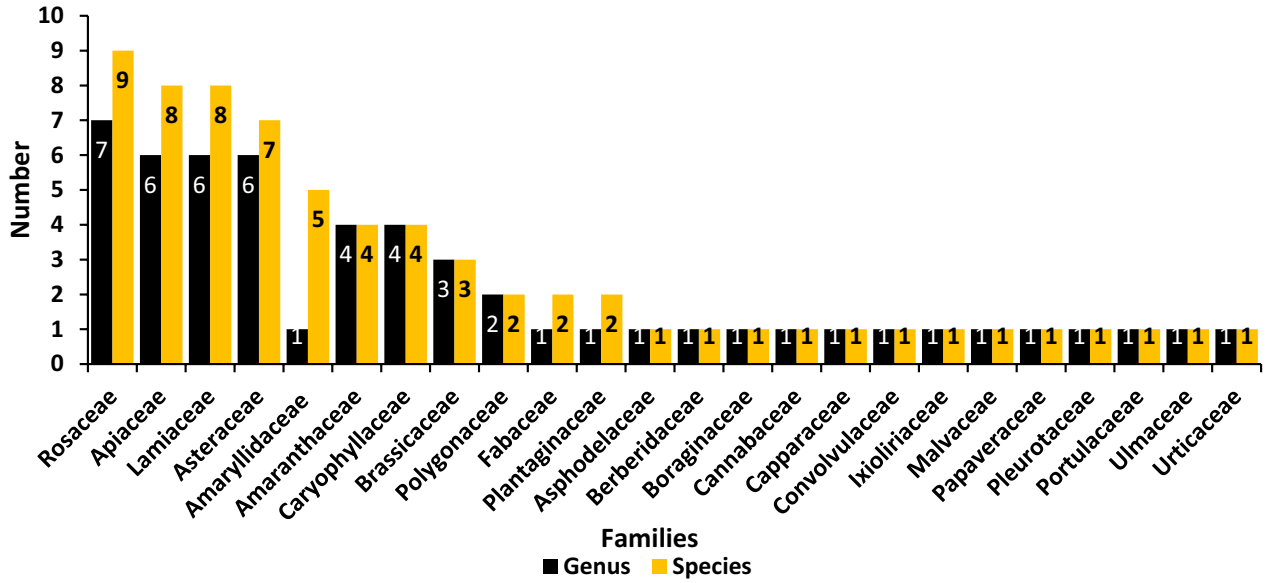

Fig. 4 Plant families, along with the number of plant genera and species in each family, are used by local communities

as *Mespilus germanica* L. Waldst. *Crataegus pentagyna* & Kit. ex Willd., *Crataegus pseudoheterophylla* Pojark, and *Pyrus boissieriana* Buhse, as well as fruits such as *Prunus divaricata* Ledeb and *Berberis integerrima* Bunge, which are used to make jam in addition to eating fresh, or species such as *Mespilus germanica,* which is used in the making of pickles.

In general, many plants are classified as having multiple uses, with the majority of them having two or more uses. For instance, *Urtica dioica* serves as an example where the young parts of the plant are used to make Coco sabzi, and the leaves are used to make Kashk.

Method of plant preparation

Locals in the studied area prepare and consume plants in a variety of ways (Fig. 3c). The majority of edible plants, nearly half of the plants (48 species, 39.7% of the species), are cooked. This category includes edible plants such as *Suaeda acuminata* and *Allium grande* Lipsky. Cooked plants, such as *Eremurus* sp. and *Ferula foetida* (Bunge) Regel, can be roasted in oil or boiled in water, such as *Anchusa azurea* Mill.

The second category includes plants that are dried and used after drying (37 species, 30.6%), such as *Elwendia* sp. and *Mentha longifolia* or plants that are dried for storage and consumption in the fall and winter seasons, such as *Allium iranicum* and *Falcaria vulgaris* (Fig. 7a, b). The third category includes plants that are consumed raw (16 species, 13.2%), such as *Allium paradoxum*, and edible species that are used fresh (9.1% species) and without any process, such as *Pyrus boissieriana*, *Crataegus pentagyna* Waldst. & Kit. ex Willd., and *Crataegus pseudoheterophylla*. Finally, plants that are processed after certain processes (9) species (7.4%) are generally consumed as pickles. *Ferula* species and *Prunus divaricata*, for example, as well as *Capparis spinosa* L. Of course, the plant species mentioned above are not consumed in the same way. A species can be used in a variety of ways.

Harvest season and plant availability

Most of the WEPs (66.4%) are collected during spring with a pick in May (51 species). Figure 8 shows the harvest calendar of WEPs in the study region. Plant vegetative parts are best collected during April-July, and fruits are collected between September and November. Almost no edible plants are collected or available between December and February. During winter, only dried (Fig. 7) and processed edible plants are used. Edible plants, such as *Prunus divaricata,* are used both fresh during the collection season and dry during the other seasons (Fig. 7c). Because of the nutritional value and pleasant taste of edible plants, locals have a strong belief in using them all year round. Dried parts of species such as *Mentha longifolia, Ziziphora clinopodioides*, *Ziziphora tenuior* L., *Tragopogon graminifolius, Allium iranicum, Allium umbilicatum, Suaeda acuminate, Falcaria vulgaris*, *Elwendia cylindrical*, *Eremurus* sp., *Scorzonera meyeri* (K.Koch) Lipsch., *Achillea wilhelmsii* K.Koch, *Lepidium draba*, *Lamium amplexicaule* L., *Stachys lavandulifolia*, *Urtica dioica* and dried fruits such as *Celtis caucasica*, *Rosa canina* L. or fruit juices such as *Berberis integerrima* and edible seeds such as *Elwendia*

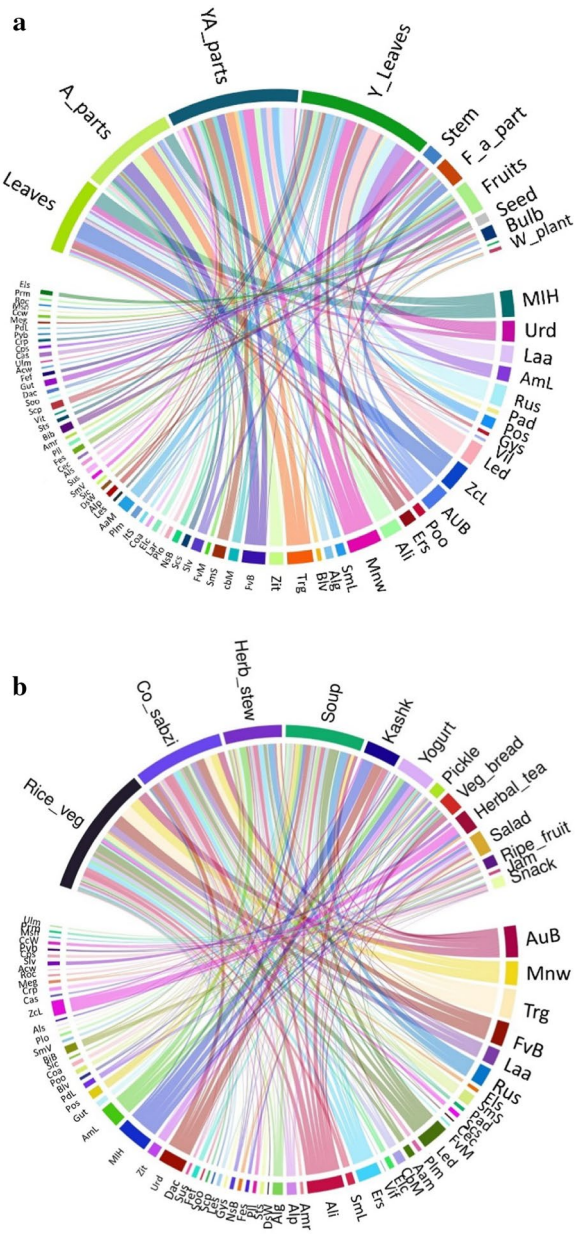

Fig. 5 Chord diagram, representing the distribution of 533 usage reports for 67 WEPs by 44 interviewees, **a** representing the types of WEPs for the use of different organs and **b** different consumption categories

sp., *Descurainia sophia* or pickles such as *Capparis spinosa*, *Portulaca oleracea* L., *Mespilus germanica*, *Ferula* sp. are popular during winter.

The habitat of plants

Figure 9 shows collection sites and different vegetation types and habits from which the WEPs were collected. Most of the used species are collected around the villages or areas nearby (37.7% of species), followed by rangelands (33.7%). Because nearly all of the studied areas are hilly and adjacent to rangeland, this has a significant impact on the use of edible plants, particularly in the spring. Both forests and shrublands provide 9.8% of the species that are mainly appreciated for their fruits (Fig. 10). Hilly slopes, mountain areas, roadsides, and graveyards together provide only 9% of WEPs. The details of all habitats and collected species in each habitat are listed in Table 4.

Fungus

Although our main focus was on plants, we added one species of hornbill (*Pleurotus ostreatus* (Jacq.) P.Kumm.) to our collection due to the widespread consumption of this species by local people and its collection in the rangelands of the study area (Fig. 11b). This mushroom is important in the food baskets of locals in the preparation of various local dishes, such as soups and spring meals.

Quantitative ethnobotanical indices

While all species are valued as food sources, there were ten species with widespread use reports (Table 4). *Allium iranicum* has been the most reported species (UR = 75) with various uses. This plant is well known and widely consumed among locals. Local people collect *A. iranicum* for a variety of reasons; all parts of the plant, both cooked and raw, are used in various use categories, followed by *Mentha longifolia* (UR = 66), *Allium umbilicatum* (UR = 65), *Tragopogon graminifolius* (UR = 61), *Lepidium draba* (UR = 56), *Urtica dioica* (UR = 52), *Falcaria vulgaris* (UR = 50), *Malva neglecta* (UR = 49), *Eremurus* sp. (UR = 48) and *Atriplex micrantha* (UR = 43). *Mentha longifolia* and *Tragopogon graminifolius* had the highest registered RFC (RFC = 0.65), followed by *Falcaria vulgaris* (RFC = 0.59), *Malva neglecta* (RFC = 0.54), *Allium umbilicatum* and *Urtica dioica* (RFC = 0.52), *Lepidium draba* and *Rumex* sp. (RFC = 0.47), *Ziziphora clinopodioides* (RFC = 0.45) and *Allium iranicum* (RFC = 0.43) (Table 4). *Allium iranicum* had the highest UV, which shows its importance in the local diet. This night be due to its pleasant taste and various uses. Meanwhile, it was the most commonly used ingredient for preparing the Coco sabzi (f = 17). *Mentha longifolia* showed the second highest UV. This plant is also an important flavoring ingredient in Kashk (f = 17) and Yogurt (f = 15). Other species with high UV were *Allium umbilicatum* (1.47), *Tragopogon graminifolius* (1.38), *Lepidium draba* (1.27), *Falcaria vulgaris* (1.13), *Malva neglecta* (1.11), *Eremurus* sp. (1.09) and *Atriplex micrantha* (0.97) (Table 5). On the other hand, the lowest number of UVs was found for *Vicia tenuifolia* Roth (UV = 0.02), *Lallemantia royleana*

Table 5 Ten WEPs with the highest usage values (UVs)

Ranking	Scientific name	Usage 1 (frequency)	Usage 2 (frequency)	Usage 3 (frequency)	Usage 4 (frequency)	Usage 5 (frequency)	Usage 6 (frequency)	Usage 7 (frequency)	Usage 8 (frequency)	Usage 9 (frequency)	Usage 10 (frequency)	ΣUs	UVs
1	*Allium iranicum*	Rice_veg (11)	Co_sabzi (17)	Herb_stew (10)	Soup (9)	Salad (5)	Kashk (14)	Yogurt (3)	Pickle (1)	Ve_bread (5)	–	75	1.7
2	*Mentha longifolia*	–	Co_sabzi (4)	–	Soup (7)	Salad (6)	Kashk (25)	Yogurt (15)	–	Ve_bread (2)	Herbal_tea (7)	66	1.5
3	*Allium umbilicatum*	Rice_veg (22)	Co_sabzi (15)	Herb_stew (3)	Soup (8)	Salad (3)	Kashk (1)	–	–	Ve_bread (13)	–	65	1.47
4	*Tragopogon graminifolius*	Rice_veg (29)	Co_sabzi (15)	Herb_stew (7)	Soup (1)	Salad (9)	–	–	–	–	–	61	1.38
5	*Lepidium draba*	Rice_veg (18)	Co_sabzi (11)	Herb_stew (6)	Soup (15)	Salad (2)	–	–	–	Ve_bread (4)	–	56	1.27
6	*Urtica dioica*	–	Co_sabzi (15)	Herb_stew (3)	Soup (10)	–	Kashk (21)	Yogurt (3)	–	–	–	52	1.18
7	*Falcaria vulgaris*	Rice_veg (26)	Co_sabzi (18)	Herb_stew(2)	Soup (4)	–	–	–	–	–	–	50	1.13
8	*Malva neglecta*	Rice_veg (24)	Co_sabzi (17)	Herb_stew (2)	Soup (6)	–	–	–	–	–	–	49	1.11
9	*Eremurus* sp	Rice_veg (11)	Co_sabzi (12)	Herb_stew (11)	Soup (3)	–	Kashk (4)	Yogurt (2)	–	Ve_bread (5)	–	48	1.09
10	*Atriplex micrantha*	–	Co_sabzi (2)	Herb_stew (15)	Soup (7)	Salad (1)	–	Yogurt (12)	–	Ve_bread (6)	–	43	0.97

Fig. 6 Food containers prepared from WEPs that are ready for consumption: **a** Rice veg, different organs of *Tragopogon graminifolius*, **b** Coco sabzi, young leaves of *Eremurus* sp., **c** Soup, young aerial parts of *Allium grande*, **d** Soup, young leaves of *Rumex* sp. with different organs of *Allium umbilicatum*, **e** Veg bread, young aerial parts of *Lepidium draba*, **f** Herb stew leaves of *Rumex* sp. and *Polygonum* sp. with the leaves of *Malva neglecta*, **g** Kashk, leaves of *Urtica dioica*, **h** Yogurt, young aerial parts of *Suaeda acuminata* (CAMey.) Moq., **i** Coco sabzi, leaves of *Allium iranicum*, **j** Yogurt leaves of *Blitum virgatum*, **k** Veg bread leaves of *Allium umbilicatum*, along with young leaves of *Lepidium draba*, **l** Pickled, *Ferula* sp. **m** Herb stew, leaves of *Eremurus* sp. Source: research findings

Fig. 7 **a** Storage of dried WEPs for use in seasons when fresh plants are not available. **b** Drying WEPs *Mentha longifolia*، **c** *Prunus divaricata* Source: research findings

(Benth.) Benth. (UV = 0.02), *Vicia faba* L. (UV = 0.04), *Ulmus minor* Mill. (UV = 0.04), *Achillea wilhelmsii* (UV = 0.04), *Sonchus oleraceus* L. (UV = 0.06), *Ixiolirion tataricum* (UV = 0.06), *Allium* sp. (UV = 0.06) and *Silene conoidea* L. (UV = 0.06). Table 5 shows the most important edible species with the highest UVs in the study area.

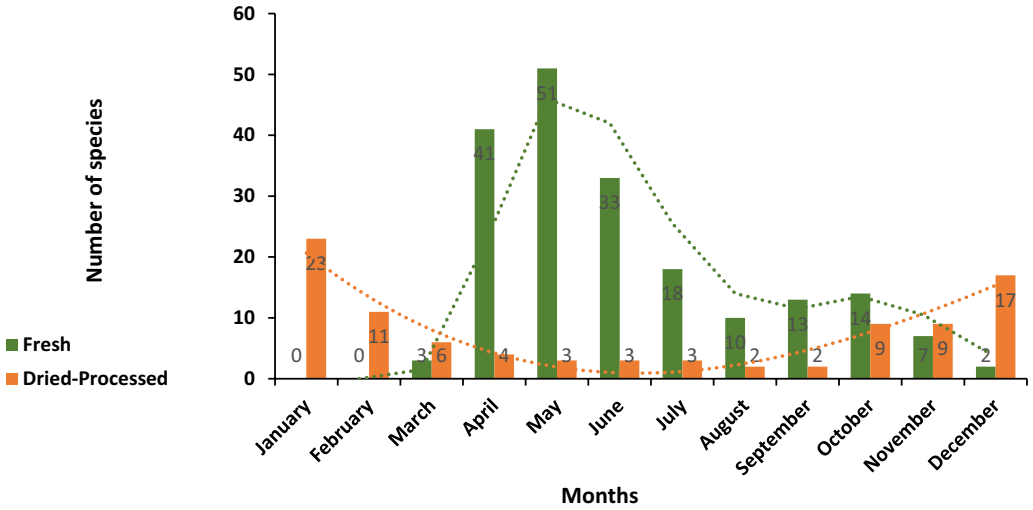

Fig. 8 Time of collection and distribution of plant use in different months of the year

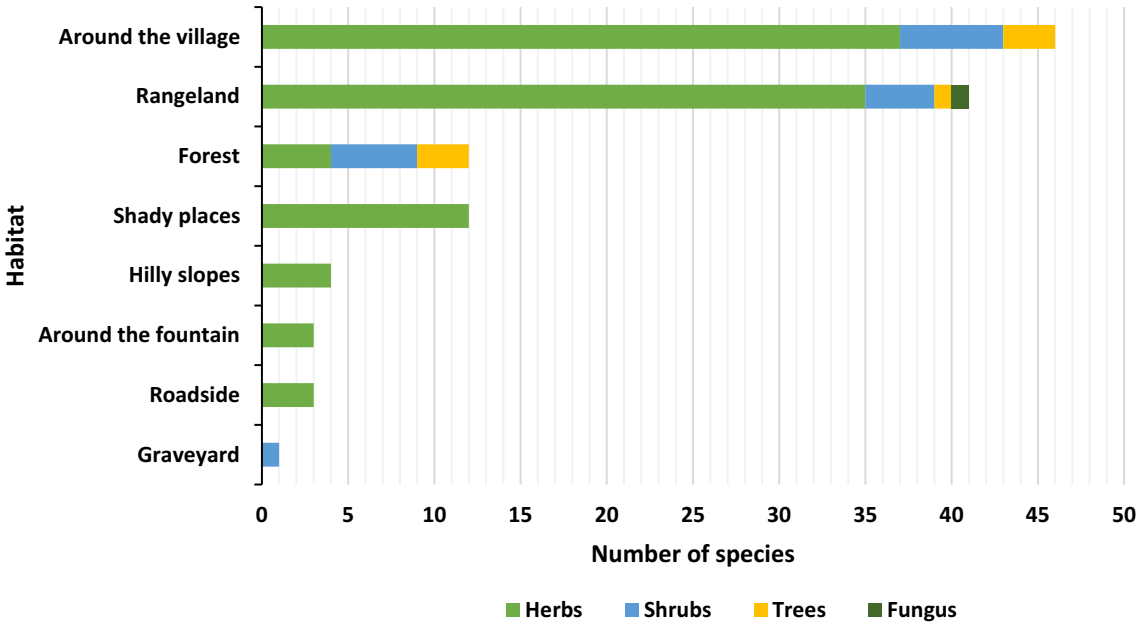

Fig. 9 Habitat of the plants used

Jaccard's coefficient of similarity index (JI)

We compared our results to twelve published papers from neighboring regions of Semnan province using the Jaccard index (Table 6). The estimated values of the Jaccard similarity index, demonstrating the degree of species-related similarity between our study and other studies conducted in nearby locations, JI ranged from 0.84 to 10.63. The highest degree of similarity was found in the study of the An Ethnobotanical Survey of Wild Food Plants in Sirjan (Kerman province) [50]. The lowest degree of similarity was found with the study conducted in an ethnobotanical survey of medicinal plants of Zangelanlo district (Northeast Iran) [47].

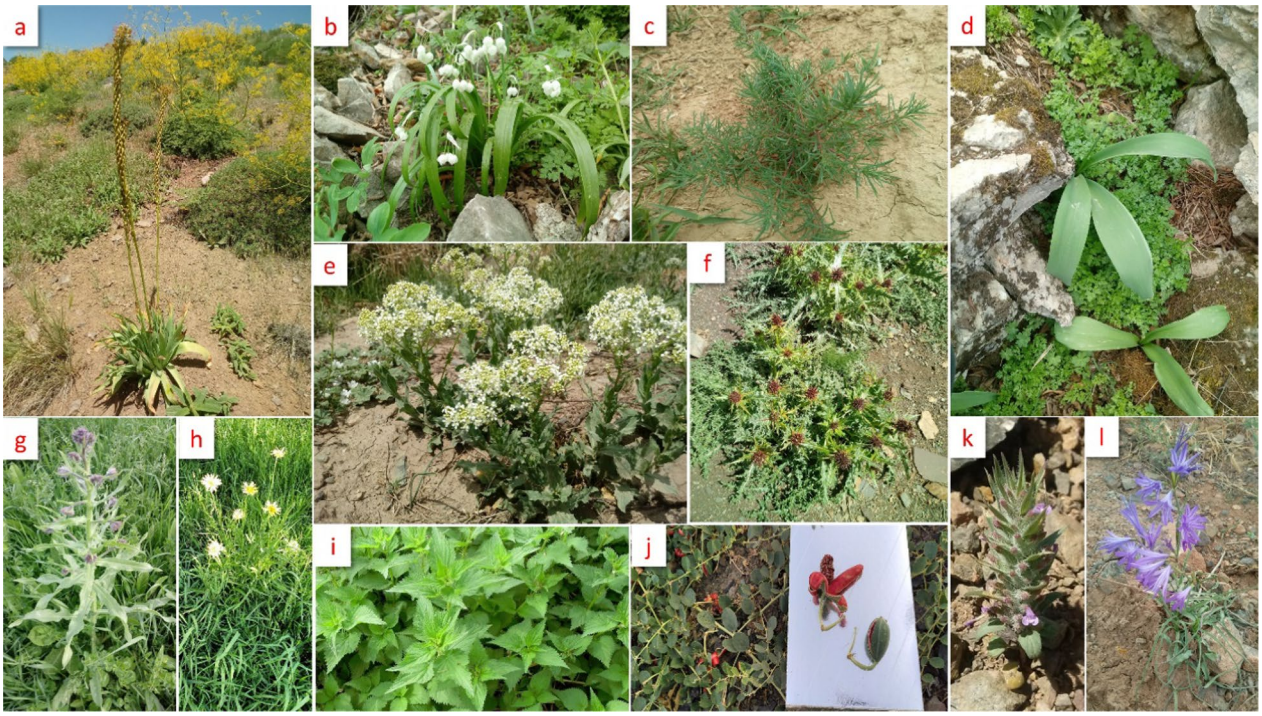

Fig. 10 Pictures of some wild edible plants in the study area. Source: research findings. **a** *Eremurus* sp., **b** *Allium paradoxum* (M.Bieb.) G. Don, **c** *Suaeda acuminata*, **d** *Allium grande*, **e** *Lepidium draba*, **f** *Gundelia tournefortii* L., **g** *Anchusa azurea*, **h** *Tragopogon graminifolius*, **i** *Urtica dioica*, **j** *Capparis spinosa*, **k** *Ziziphora tenuior*, **l** *Ixiolirion tataricum*

Fig. 11 Collection. **a** *Ferula* sp. To prepare pickles, **b** wild edible fungus (*Pleurotus ostreatus* from the Rangeland of Nagarman village by local people

Discussion

High diversity of WEPs in the Northeastern region of Iran

This study showed a high diversity of WEPs, with 66 species belonging to 53 genera and 23 families contributing to the local people's diet. This broad diversity is important in the daily life of local people for a variety of nutritional purposes. These findings are consistent with previous ethnobotanical research highlighting the role of WEPs in ensuring food security [1, 4, 9, 14, 52].

Table 6 Comparison between present and previous studies, as performed by Jaccard Index (JI)

No	Province	Study area	Indices	JI	Citation	Use category
1	Kerman	Sirjan	a: 37 b: 67 c: 10	10.63	Nasab et al. [50]	Wild food plants
2	Western Iran	Hawraman-Mukriyan	a: 44 b: 67 c: 9	8.82	Sulaiman et al. [51]	Wild food plants
3	Kohgiluyeh and Boyer-Ahmad	Dilegan	a: 21 b: 67 c: 5	6.02	Forozeuh et al. [40]	Edible
4	Golestan	Khosh Yeilagh	a: 30 b: 67 c: 6	6.59	Kiasi et al. [46]	Medicinal and edible
5	Gilan	Jubon	a: 34 b: 67 c: 4	4.12	Ghadimi Joboni and Ghavam [41]	Medicinal and edible
6	Golestan	Kechik	a: 45 b: 67 c: 4	3.70	Heshmati et al. [48]	Medicinal and edible
7	Razavi Khorasan	Neyshabur	a: 70 b: 67 c: 13	10.48	Hosseini et al. [44]	Medicinal
8	Golestan	Khosh Yeilagh	a: 84 b: 67 c: 5	3.42	Kiasi et al. 2020 [46]	Medicinal
9	Golestan and Khorasan	Among Turkmens of Iran	a:136 b: 67 c: 5	2.52	Ghorbani [42]	Medicinal
10	Northeast Iran	Zangelanlo	a: 52 b: 67 c: 1	0.84	Amiri et al. [47]	Medicinal
11	North of Iran	Qizilbash Tribe	a: 84 b: 67 c: 4	2.72	Kiasi et al. 2023 [49]	Medicinal
12	Kerman	Sirjan	a: 43 b: 67 c: 7	6.79	Nasab and Khosravi [45]	Medicinal
13	West Azerbaijan	Northwestern Iran	a: 82 b: 67 c: 5	3.47	Salteh et al. [43]	Medicinal

JI Jaccard index. a: The number of species of the neighboring area (in Iran). b: The number of species in the study area. c: number of species common to both areas

The results of this study revealed that the Rosaceae family had the most species used in the region, with 9 species (Fig. 4 and Table 4). This could be attributed to the abundance of wild fruits in the area, which is consistent with other studies on the use of more edible species from this family [7, 9, 10, 12–14, 33, 52, 53]. Following the family Rosaceae, Apiaceae and Lamiaceae had the most species of edible plants, consistent with previous studies [33]. However, some previous studies reported that Compositae [1, 11], Poaceae [8], Asteraceae [23, 35, 54, 55] and Leguminosae [56] were the largest families of edible species. Herbs, with 53 species (79.1%), were the predominant vegetative form in the study area, and these results align with similar studies [3, 7, 8, 12, 14, 32, 53, 56, 57] and in contrast to other

researchers with trees [16] as the dominant vegetative form of WEPs.

Lacks of ethnobotanical research on WEPs in Iran

The northeastern region of Iran, especially the Semnan (Shahrood) province, lacks ethnobotanical studies of edible plants despite its diverse habitat. Therefore, this study makes a valuable contribution to the documentation and preservation of local knowledge about wild edible plants in this region. A relatively high number of WEPs were found in the study area, confirming the area's rich local knowledge and high diversity of wild edible plant species.

Few studies on ethnobotanical knowledge of wild edible plants in Iran have been conducted [40–42, 58, 59], and in the majority of cases, the status and availability of plants, the separation of growth habitats, and the collection and classification of plants for nutritional purposes and preparation have not been thoroughly evaluated. On the other hand, there are several publications on this subject from the neighboring countries such as Turkey [24, 32, 33, 55], Iraq [60, 61], and Pakistan [53]. It is worth noting that many edible plants have been used for medicinal purposes in numerous studies. Similarly, in previous studies, species such as *Ziziphora clinopodioides* and *Capparis spinosa* have been reported to have high medicinal value [42]. However, in the current study, the interviewees mentioned the species' food use. As a result, only studies involving specific species that were used solely for nutritional purposes are mentioned in Table 4. Comparing our results with available studies on wild edible plants with low JI showed that our study present novel data about food plants demonstrating low common cultural values and traditional knowledge. There are only few studies related to wild edible plants with details [40, 50, 51] and three studies which focused on medicinal plants in details only noticed if there are edible or not [41, 46, 48], and other studies in nearby locations were only studied medicinal uses [43–46, 49]. In total, 26 edible species (39.4%) among total 66 species including *A. grande, A. umbilicatum, A. retroflexus, A. micrantha, A. virgatum, S. acuminate, E. cylindrica, S. stellata, C. cyanus, S. meyeri, S. oleraceus, A. azurea, C. caucasica, L. stellarioides, S. conoidea, S. media, V. tenuifolia, L. amplexicaule, N. sacharata, P. dubium, P. ostreatus, C. pseudoheterophylla, M. sieversii, P. microcarpa, P. boissieriana,* and *U. minor* were introduced in current studies. Therefore, more attention is needed in ethnobotanical research of WEPs in Iran to document this valuable information, which is directly related to people's food and health.

Cooked WEPs and local people diet

In this study, we documented a variety of interesting edible plant preparation methods used by locals which half of the plants are cooked. Rice-vegetable preparation (37 species, 268 usage reports, 24.7%) and Coco Sabzi (28 species, 186 reported uses, 17.1%) are the most popular food categories for the use of edible plants followed by soups, herbs stew and yoghurt which confirm the importance of cooked plants. Cooked plants (39.7%) are consumed more frequently than other modes of use, as the majority of consumption categories are rice veg, coco sabzi, soup, and herb stew. This clearly suggests that natives cook edible plants in their diet. These findings are consistent with similar studies [54] and differ from the majority of studies on the use of more plants without special preparation and raw [23, 60, 62, 63] and fresh [16] plants. All mentioned foods are considered as important main food of local people and play important role during times of food scarcity or famine, providing a diverse range of nutritional possibilities.

Young leaves (25%) and young aerial parts (21.4%) were the most commonly used plant parts for nutritional purposes. The fact that the aforementioned organs are the most commonly consumed parts of the plant may be attributed to their widespread use as ingredients in the preparation of herbal rice, herb stew, coco, and raw salad. A diverse range of edible parts collected from various species demonstrates that local communities have gained a wealth of traditional knowledge from the consumption of wild edible plants [8]. Diversity in the use of plant parts has implications for the survival and regeneration of plants as the collection of one specific plant part might affect its regeneration for the next season. However, other ethnobotanical studies have found that the most edible plant parts are tender stems and leaves [8], whole plants [1], tubers [64], leaves [13, 33, 54, 65], leaves and stems [57], fruit and aerial organs [14] and fruits [3, 5, 7, 9, 15, 16, 52, 56]. Fruits are less used in our results, which could be due to a lack of availability or to the local people losing their traditional knowledge of how to use them [1]. We have an edible flower species, *Ixiolirion tataricum*, in our study. We found that this is consistent with similar results in the nutritional consumption of edible flowers [15, 57]. A fungus species of carp (*Pleurotus ostreatus* (Jacq.) P.Kumm.) is also mentioned in our collection, which is consistent with other studies, in the use of edible fungus in the food basket of local people [15]. The majority of fruits are rich in antioxidants and minerals. *Mespilus germanica* is rich in natural antioxidants [66]. Amino acids, minerals, vitamins, and bioactive components (polyphenols, flavonoids, and triterpenoids) are abundant in many "*Crataegus*" species [67]. It has a high nutritional value and contains beneficial components such as polyphenols and minerals for *Capparis spinosa* and *Ferula* sp. (Figs. 6l and 11a) [68], which have been widely used in native people's culture for making pickles.

Locals collect edible plants from natural habitats almost every month of the year except for winter. The time needed to collect WEPs is determined by the maturity of the parts used [52]. Meanwhile, harvesting times, seasons, and frequency vary from plant to plant, depending on the availability of the edible plant and its organs [3]. The majority of the plants were collected in the spring (April, May, and June), which is consistent with other studies on the benefit of edible plants with the onset of spring [60], which peaks in May. Because the study area is in arid and semiarid climates, there is a direct relationship between the number of plant species collected and the harvest season. There are more edible plants to collect in the spring because there is more rainfall and more favorable conditions, which decreases over time due to the decrease in rainfall and increasing temperature. This result is consistent with the findings of other studies on the collection of more plants during the monsoon and spring seasons [3]. Furthermore, our findings are consistent with those of [52], who discovered that the majority of edible plants are collected in May. Plants are generally collected from April to July, and fruits are collected from September to November, which is consistent with other studies [10]. However, our findings contradict previous studies in which WEPs were collected from March to October [7, 52], with the highest proportion of species collected in August [7]. Furthermore, our research found that edible species are consumed all year. Due to a lack of fresh edible plants in the autumn and winter months, communities rely on stored food [3], so locals use dried and processed plants such as fruits, with similar results reported by other researchers in fruit drying for winter use [32]. Meanwhile, January had the highest consumption of dried and processed plants, with 23 species. With the arrival of spring, this amount decreased, and the majority of the plants used included fresh plants from a variety of sources.

Most categories of plant-use knowledge are influenced by different variables including gender [69, 70]. Despite the gender imbalance in studies of neighboring countries [33, 55, 60, 71, 72], due to religious and patriarchal family structures, which prioritize males as family heads and resource holders [72], our study of ethnographic knowledge has shown a significant role of women in this field. They actively participate in the collection of wild edible plants, utilization and contribute to the seasonal household economy by using wild edible plants as a supplemental food source. Also, women in the study area, are also responsible for preparing family meals and can get to know more plants through cooking. Gender equality is seen as a goal and a means in achieving the Sustainable Development Goals (SDGs) [73].

The top ten UVs reported in the region included two species from the Amaryllidaceae family and eight other species from eight different families. *Allium iranicum* from the Amaryllidaceae family is widely used as an edible plant, and because of its wide distribution and the presence of nomads in the region, it has been transformed into a species with high UVs, making it the first choice for consumption and collection [74]. *Mentha longifolia* is significant among locals in different months of the year due to its wide availability and use. The species with the lowest UV were *Vicia tenuifolia* (UV = 0.02), *Lallemantia royleana* (UV = 0.02), *Vicia faba* (UV = 0.045), and *Ulmus minor* (UV = 0.045). Some lamiaceae species such as *Mentha longifolia* and *Ziziphora clinopodioides* and also *Tragopogon graminifolius* and two *Allium* species had the highest relative frequency index of quotation (RFC) among the people of the region, indicating their importance, according to the results. *Mentha longifolia* is significant among locals in different months of the year due to its wide availability and use. Almost all species are mentioned as food sources. *Allium iranicum* is one of the most frequently mentioned (UR = 75), with nine different food uses. This plant is an important food source for locals, and it is available from May to June. It is consumed in a variety of food categories. This high collection and demand for this plant can put more pressure on. The natural populations of the plants. Because the leaves and areal parts of the plants are collected before the plants can set flowers and seeds, it can affect its regeneration and production of offspring. Majority of the UR species (N = 9) were cooked and dried plants, confirming the continued use of cooked plants for nutritional purposes by local people, which is consistent with the findings of other studies in this area [62].

WEPs conservation and food sovereignty

Study areas are located in mountain habitats with high species diversity. These areas mainly include natural ecosystems which their diversity and function are strongly influenced by ecological and anthropogenic factors. We found that almost all habitats (including villages, rangelands, forests, shady areas, hilly slopes, mountains, roadsides, and graveyards) are used to collect WEPs. Other researchers have reported similar results when collecting plants from various habitats [3, 9, 16]. Access to plant collection sites has a significant impact on plant collection [9, 11]. As a result, the highest number of plants collected in our study area was near villages, which had easier access to edible plants, with 46 species (37.7%), followed by rangelands, which had 41 species (33.7%). As a result, plant collection may be influenced by availability [11]. Simultaneously, studies have shown that the richness of a species increases as altitude decreases. This pattern is

primarily influenced by access to places and plant cultural values [9]. As a result of the greater diversity of plant species, lowland areas are more likely to be considered. However, a number of interviewees stated that because of the decrease in local shepherds, nonnative shepherds did not recognize or desire to collect edible plants from high-altitude areas. The majority of these species were found in areas near villages and rangelands, which are heavily influenced by local human activities. Therefore, conservation efforts should prioritize the protection of these wild edible plants. Intensive grazing, especially during drought years, the removal of shrubs for fuel, and the harvesting of species with roots can significantly impact the sustainable harvest and conservation of these plants [75]. Some key WEPs such as *Urtica dioica, Allium iranicum, Allium umbilicatum, Tragopogon graminifolius* need more attentions because of harvesting by roots in our study area. The ecological significance of wild edible plants lies in their role in ecosystem-based adaptation, their contribution to food security during times of scarcity, and their potential to enhance the nutritional quality of diets, especially in rural areas.

The cultural significance of wild edible plants is evident in how they are used and transformed within local communities. Wild edible plants are not only just eaten, but also incorporated into traditional dishes that have been adapted to meet evolving cultural influences and tourism needs. For instance, *Tragopogon graminifolius* has been noted for a long time because of the tendency to prepare the local food "Shengy Pelo" (Fig. 6a), which has been accepted in the national heritage of Iran from Semnan province (N. 2097) due to its long history of preparing and cooking as an intangible work of Shahrood city.

Wild edible plants could become preferred food crops in the future, having adapted to changing climates. They are important to local communities for creating livelihood security and ensuring food and nutrition sovereignty. We need to recognize their potential in ensuring a resilient food system and explore their integration while maintaining their natural habitats and responsible harvesting practices [76]. Wild edible plants are a great resource that can considerably help to food sovereignty, especially in areas where traditional food supplies are scarce [77]. These plants can supplement diets during times of food scarcity or famine, providing a diverse range of nutritional possibilities [78, 79]. The Shahrood communities in Northeast of Iran have incorporated the eating, preservation, and management of wild edible plants into their cultural practices, demonstrating the value of traditional knowledge in sustainable food systems.

The usage of wild edible plants not only diversifies diets, but also empowers communities to control their own food supplies, enabling resilience in the face of food shortages [80, 81]. The incorporation of wild edible plants into local diets allows communities to keep their traditional meals while producing or harvesting them at their convenience, harmonizing with the concepts of food sovereignty, which states that communities have the authority to pick and access their preferred foods [76, 82].

In essence, including wild edible plants into diets helps to promote food sovereignty by providing nutritional security to communities, preserving cultural heritage, and increasing resistance to food insecurity concerns [83]. This use of wild edible plants stresses the importance of traditional knowledge and practices in promoting sustainable food systems and guaranteeing food security at the community level.

Conclusion

The study is the first investigation of WEPs in Shahrood and among a few comprehensive studies of WEPs in Iran, revealing indigenous knowledge of local peoples in the use of wild edible plants. However, valuable knowledge that has been passed down verbally from generation to generation is being lost among the younger generation, emphasizing the need for documentation. WEPs in this region showed a wide range of variation, not only in the number of species, but also in different categories of consumption and different parts of the plant used for nutritional purposes. The local people's WEPs collection calendar demonstrates valuable indigenous knowledge rooted in their rich culture of edible plant utilization. WEPs usage values were calculated, documenting the species with the highest utilization value, which can contribute significantly to the preservation of nutritious food. According to the index URs of species, *A. iranicum, M. longifolia, A. umbilicatum, T. graminifolius, L. draba, U. dioica, F. vulgaris, M. neglecta and Eremurus* sp.) constituted a considerable portion of the plants used by locals. Nonetheless, these species are facing growing threats, emphasizing the urgency of implementing stronger protection measures and adopting sustainable management practices. Notably, our study sheds light on how collaborative activities in rural settings are especially important for women.

Abbreviations

URs	Usage reports
RFC	Relative frequency of citation
UV	Usage value
FC	Frequency of citation
WEPs	Wild edible plants
N	Number
Note	Consumption mode
C	Cooked
D	Dried
R	Raw
F	Fresh

P	Processed
AV	Around the village
RA	Rangeland
FO	Forest
SP	Shady places
HS	Hilly slopes
AF	Around the fountain
RO	Roadside
GR	Graveyard
URS	Use reports
RFC	Relative frequency of citation
NR	Not reported
JI	Jaccard index

Acknowledgements
We thank the people of Bastam for their cooperation in documenting their information and assistance along the way and Tarbiat Modares University for support.

Author contributions
M. J collected data, F. M identified plant species, and A. G and M. A conceived of the research idea. All authors discussed the results and commented on the manuscript.

Funding
Not applicable.

Availability of data and materials
All data generated or analyzed during this study are included in this article. Plant samples were stored at the herbarium of Ferdowsi University, Mashhad.

Declarations

Ethics approval and consent to participate
Before conducting interviews, prior informed consent was obtained from all.

Consent for publication
Prior and informed consent of local people's pictures had been obtained.

Competing interests
The authors declare that they have no competing interests.

Author details
[1]Department of Range Management, Faculty of Natural Resources and Marine Sciences, Tarbiat Modares University, Noor, Mazandaran Province, Iran. [2]Department of Range and Watershed Management, Faculty of Natural Resources and Environment, Ferdowsi University of Mashhad, Mashhad, Iran. [3]Herbarium FUMH, Ferdowsi University of Mashhad, Mashhad, Iran. [4]Department of Organismal Biology, Uppsala University, Norbyvägen 18D SE, 75236 Uppsala, Sweden.

Received: 4 December 2023 Accepted: 13 September 2024
Published online: 04 October 2024

References

1. Guo CA, Ding XY, Addi YW, Zhang Y, Zhang XQ, Zhuang HF, et al. An ethnobotany survey of wild plants used by the Tibetan people of the Yadong river valley, Tibet, China. J Ethnobiol Ethnomed. 2022;18(1):1–25.
2. Hunter D, Borelli T, Gee E. Biodiversity, food and nutrition: a new agenda for sustainable food systems. In: Issues in agricultural biodiversity. 1st ed. Oxon: Routledge; 2020. p. 296.
3. 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(10):e0258905.
4. Fongnzossie EF, Nyangono CFB, Biwole AB, Ebai PNB, Ndifongwa NB, Motove J, et al. Wild edible plants and mushrooms of the Bamenda Highlands in Cameroon: ethnobotanical assessment and potentials for enhancing food security. J Ethnobiol Ethnomed. 2020;16(1):1–10.
5. Sachula G, Zhang YY, Hui ZK. Wild edible plants collected and consumed by the locals in Daqinggou, Inner Mongolia, China. J Ethnobiol Ethnomed. 2020;16:1–16.
6. Motti R. Wild edible plants: a challenge for future diet and health. Plants. 2022;11(3):344.
7. Wang J, Seyler BC, Ticktin T, Zeng Y, Ayu K. An ethnobotanical survey of wild edible plants used by the Yi people of Liangshan Prefecture, Sichuan Province. China J Ethnobiol Ethnomed. 2020;16(1):1–27.
8. Cao Y, Li R, Zhou S, Song L, Quan R, Hu H. Ethnobotanical study on wild edible plants used by three trans-boundary ethnic groups in Jiangcheng County, Pu'er, Southwest China. J Ethnobiol Ethnomed. 2020;16(1):1–23.
9. Chen WY, Yang T, Yang J, Qiu ZC, Ding XY, Wang YH, et al. Wild plants used by the Lhoba people in Douyu Village, characterized by high mountains and valleys, in southeastern Tibet, China. J Ethnobiol Ethnomed. 2021;17(1):1–21.
10. Ding XY, Zhang Y, Wang L, Zhuang HF, Chen WY, Wang YH. Collection calendar: the diversity and local knowledge of wild edible plants used by Chenthang Sherpa people to treat seasonal food shortages in Tibet, China. J Ethnobiol Ethnomed. 2021;17(1):1–14.
11. Ding X, Guo C, Zhang X, Li J, Jiao Y, Feng H, et al. Wild plants used by tibetans in Burang town, characterized by alpine desert meadow, in southwestern Tibet, China. Agronomy. 2022;12(3):704.
12. Sun J, Xiong Y, Li Y, Yang Q, Chen Y, Jiang M, et al. Medicinal dietary plants of the Yi in Mile, Yunnan, China. J Ethnobiol Ethnomed. 2020;16(1):1–23.
13. Rana D, Bhatt A, Lal B. Ethnobotanical knowledge among the semi-pastoral Gujjar tribe in the high altitude (Adhwari's) of Churah subdivision, district Chamba, Western Himalaya. J Ethnobiol Ethnomed. 2019;15(1):1–21.
14. Thakur A, Singh S, Puri S. Exploration of wild edible plants used as food by Gaddis-a tribal community of the Western Himalaya. Sci world J. 2020. https://doi.org/10.1155/2020/6280153.
15. Kang J, Kang Y, Ji X, Guo Q, Jacques G, Pietras M, et al. Wild food plants and fungi used in the mycophilous Tibetan community of Zhagana (Tewo County, Gansu, China). J Ethnobiol Ethnomed. 2016;12(1):1–13.
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):1–14.
17. Shin T, Fujikawa K, Moe AZ, Uchiyama H. Traditional knowledge of wild edible plants with special emphasis on medicinal uses in Southern Shan State, Myanmar. J Ethnobiol Ethnomed. 2018;14(1):1–13.
18. Fassil A, Mazengia E, Gebreamanuel B, Dessie Y, Kumera B, Atnkut B, Mullualem D, Tsega A, Van Damme P. Harvesting nature's bounty: exploring the ethnobotanical landscape of wild edible plants in the Awi Agäw community, Northwest Ethiopia. J Ethnobiol Ethnomed. 2024;20(1):1–13.
19. Ahmad K, Weckerle CS, Nazir A. Ethnobotanical investigation of wild vegetables used among local communities in northwest Pakistan. Acta Soc Bot Pol. 2019;88(1):3616. https://doi.org/10.5586/asbp.3616.
20. Da Silva Souza LV, Marques J, de Oliveira Campos LZ, de Freitas Lins Neto EM. Socioeconomic factors influencing knowledge and consumption of food plants by a human group in a mountainous environment in the semiarid region of Bahia, Northeast Brazil. J Ethnobiol Ethnomed. 2022;18(1):1–12.
21. Reyes-García V, Menendez-Baceta G, Aceituno-Mata L, Acosta-Naranjo R, Calvet-Mir L, Domínguez P, Pardo-de-Santayana M. From famine foods to delicatessen: interpreting trends in the use of wild edible plants through cultural ecosystem services. Ecol Econ. 2015;120:303–11.
22. Joseph L, Turner NJ. "The Old Foods Are the New Foods!": erosion and revitalization of indigenous food systems in northwestern north America. Front Sustain Food Syst. 2020;4: 596237.
23. León-Lobos P, Díaz-Forestier J, Díaz R, Celis-Diez JL, Diazgranados M, Ulian T. Patterns of traditional and modern uses of wild edible native plants of Chile: challenges and future perspectives. Plants. 2022;11(6):744.
24. Yeşil Y, İnal İ. Traditional knowledge of wild edible plants in Hasankeyf (Batman Province, Turkey). Acta Soc Bot Pol. 2019;88(3):3633.
25. Gębczyński P, Bernaś E, Słupski J. Usage of wild-Growing plants as foodstuff. In: Hernik J, Walczycka M, Sankowski E, Harris BJ, editors. Cultural heritage—possibilities for land-centered societal development. Switzerland: Springer Nature; 2022. p. 269–83.
26. FAO. The state of the world's biodiversity for food and agriculture. FAO Commission on Genetic Resources for Food and Agriculture Assessments. Available from: http://www.fao.org/3/CA3129EN/ca3129en.pd.2019

27. Ulian T, Diazgranados M, Pironon S, Padulosi S, Liu U, Davies L, et al. Unlocking plant resources to support food security and promote sustainable agriculture. Plants People Planet. 2020;2(5):421–45.
28. Brown CL, Trainor SF, Knapp CN, Kettle NP. Alaskan wild food harvester information needs and climate adaptation strategies. Ecol Soc. 2021;26(2):44.https://doi.org/10.5751/ES-12509-260244.
29. Porcher V, Carrière SM, Gallois S, Randriambanona H, Rafidison VM, Reyes-García V. Growing up in the Betsileo landscape: children's wild edible plants knowledge in Madagascar. PLoS ONE. 2022;17(2):e0264147.
30. Alam MK, Rana ZH, Islam SN, Akhtaruzzaman M. Comparative assessment of nutritional composition, polyphenol profile, antidiabetic and antioxidative properties of selected edible wild plant species of Bangladesh. Food chem. 2020;320:126646.
31. Yangdon P, Araki T, Rahayu YYS, Norbu K. Ethnobotanical study of wild edible fruits in eastern Bhutan. J Ethnobiol Ethnomed. 2022;18(1):1–17.
32. Yeşil Y, Çelik M, Yılmaz B. Wild edible plants in Yeşilli (Mardin-Turkey), a multicultural area. J Ethnobiol Ethnomed. 2019;15(1):1–19.
33. Hançer ÇK, Altinbaşak B, Sevgi E, Çakir EA, Akkaya M. Traditional knowledge of wild edible plants of Biga (Çanakkale), Turkey. Acta Soc Bot Pol. 2020;89:3633.
34. Ghorbani A, Bussman R, Naghibi F, Kueppers M. Turkmen, Ethnobotany in Northern Iran maintaining traditions in a changing environment. J Ethnopharm. 2006;102(1):65–8.
35. WFO. World Flora Online. Version 2023.12. Published on the Internet; 2023. http://www.worldfloraonline.org. Accessed 1 May 2024.
36. Prance GT, Baleé W, Boom BM, Carneiro RL. Quantitative ethnobotany and the case for conservation in Ammonia. Conser Biol. 1987;1(4):296–310.
37. Luo B, Liu B, Zhang H, Zhang H, Li X, Ma L, et al. Wild edible plants collected by Hani from terraced rice paddy agroecosystem in Honghe Prefecture, Yunnan, China. J Ethnobiol Ethnomed. 2019;15(1):1–22.
38. Whitney C. Quantitative ethnobotany analysis with ethnobotany R. Available from: https://cran.r-project.org/web/packages/ethnobotanyR/vignettes/ethnobotanyr_vignette.html. Accessed 27 May 2022.
39. González-Tejero MR, Casares-Porcel M, Sánchez-Rojas CP, Ramiro-Gutiérrez JM, Molero-Mesa J, Pieroni A, Giusti ME. Medicinal plants in the Mediterranean area: synthesis of the results of the project Rubia. J Ethnopharm. 2008;116:341–57.
40. Forozeuh MR, Heshmati G, Barani H. Traditional knowledge of utilization of automotive plants in preparation of feed (case study: Rangeland Dilegan). Indig Knowl. 2017;3(5):23–58.
41. Ghadimi Joboni M, Ghavam M. Ethnobotany of medicinal and edible plants in Jubon village of Gilan province using descriptive statistics. Iran J Med Arom Plants Res. 2021;37(1):127–44.
42. Ghorbani A. Studies on pharmaceutical ethnobotany in the region of Turkmen Sahra, north of Iran:(Part 1): general results. J Ethnopharm. 2005;102(1):58–68.
43. Salteh SA, Amani M. Ethnobotanical study of medicinal plants from West Azerbaijan, Northwestern Iran. 2020. Preprint (Version 1) available at Research Square. https://doi.org/10.21203/rs.3.rs-55496/v1
44. Hosseini M, Rahim Forouzeh M, Barani H. Identification and investigation of ethnobotany of some medicinal plants in Razavi Khorasan province. J Med Plants. 2019;18(70):212–31.
45. Nasab FK, Khosravi AR. Ethnobotanical study of medicinal plants of Sirjan in Kerman Province, Iran. J ethnopharmacol. 2014;154(1):190–7.
46. Kiasi Y, Forouzeh MR, Mirdeilami SZ, Niknahad-Gharmakher H. Ethnobotanical study on the medicinal plants in Khosh Yeilagh rangeland, Golestan Province, Iran; 2020.
47. Amiri MS, Jabbarzadeh P, Akhondi M. An ethnobotanical survey of medicinal plants used by indigenous people in Zangelanlo district, Northeast Iran. J Med Plants Res. 2012;6(5):749–53.
48. Heshmati G, Barani H, Mirdeylami SZ. Ethnobotanical and ethnoecological survey on medicinal species (case study Kechik Rangelands in the Northeast Golestan Province). Indig Knowl. 2016;1(2):129–54.
49. Kiasi Y, Forouzeh MR, Mirdeilami SZ, Niknahad-Gharmakher H. Ethnobotanical study of medicinal plants used by QizilbashTribe in North of Iran. Environ Resource Res. 2023;11(2):239–56.
50. Nasab FK, Ghotbi-Ravandi AA, Mehrabian AR. An ethnobotanical survey of wild food plants in Sirjan, Kerman, Iran. Acta Bot Hung. 2022;64(3–4):293–311.
51. Sulaiman N, Salehi F, Prakofjewa J, Cavalleri SAE, Ahmed HM, Mattalia G, Rastegar A, Maghsudi M, Amin H, Rasti A, Hosseini SH, Ghorbani A, Pieroni A, Sōukand R. Cultural vs. State Borders: plant foraging by Hawraman and Mukriyan Kurds in Western Iran. Plants. 2024;13(7):1048.
52. 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):1–21.
53. Ijaz S, Perveen A, Ashraf S, Abid R, Kousar S, Abbas Z, et al. Traditional knowledge of wild edible plants used by the people of Lawat, District Neelum, Azad Jammu and Kshmir, Pakistan. Ethnobot Res Appl. 2022;23:1–16.
54. Motti R, Bonanomi G, Lanzotti V, Sacchi R. The contribution of wild edible plants to the Mediterranean diet: an ethnobotanical case study along the coast of Campania (Southern Italy). Econ Bot. 2020;74(3):249–72.
55. Ayaz N. Wild edible plants contributing to the traditional foods of Mardin (Turkey) Province. India J Tradit Knowl (IJTK). 2022;21(3):569–82.
56. 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):1–13.
57. Mishra A, Swamy SL, Thakur TK, Bhat R, Bijalwan A, Kumar A. Use of wild edible plants: Can they meet the dietary and nutritional needs of indigenous communities in Central India. Foods. 2021;10(7):1453.
58. Kiyasi Y, Forouzeh MR, Mirdeilami SZ, Niknahad H. Ethnobotany of edible, medicinal and industrial plant species in Khosh Yeylagh Rangeland, Golestan Province. Indig Knowl. 2019;6(11):151–204.
59. Moazzami Farida SH, Ajani Y, Sadr M, Mozaffarian V. Ethnobotanical applications and their correspondence with phylogeny in Apiaceae-Apioideae. Res J Pharmacol. 2018;5(3):79–97.
60. Pieroni A, Ahmed HM, Zahir H. The spring has arrived: traditional wild vegetables gathered by Yarsanis (Ahl-e Haqq) and Sunni Muslims in Western Hawraman, SE Kurdistan (Iraq). Acta Soc Bot Pol. 2017;86(1).
61. Galalaey AM. Ethnobotanical study of some wild edible plants in Hujran Basin, Kurdistan Region of Iraq. ZJPAS. 2021;33(s1):19–30.
62. Gras A, Garnatje T, Marín J, Parada M, Sala E, Talavera M, et al. The power of wild plants in feeding humanity: a meta-analytic ethnobotanical approach in the catalan linguistic area. Foods. 2020;10(1):61.
63. Bussmann RW, Paniagua Zambrana NY, Ur Rahman I, Kikvidze Z, Sikharulidze S, Kikodze D, et al. Unity in diversity—food plants and fungi of Sakartvelo (Republic of Georgia), Caucasus. J Ethnobiol Ethnomed. 2021;17(1):1–46.
64. Billong Fils PE, Afiong Nana N, Betti JL, Farick Njimbam O, Tientcheu Womeni S, Ávila Martin E, et al. Ethnobotanical survey of wild edible plants used by Baka people in southeastern Cameroon. J Ethnobiol Ethnomed. 2020;16(1):1–15.
65. Ray A, Ray R, Sreevidya EA. How many wild edible plants do we eat—their diversity, use, and implications for sustainable food system: an exploratory analysis in India. Front Sustain Food Sys. 2020;4:56.
66. Sadeghinejad Z, Erfani-Moghadam J, Khadivi A. Bioactive content and phenolic compounds of common medlar (*Mespilus germanica* L.) and Stern's medlar (*M. canescens* Phipps). Food Sci Nut. 2022;10(6):1988–93.
67. Zhang J, Chai X, Zhao F, Hou G, Meng Q. Food applications and potential health benefits of hawthorn. Foods. 2022;11(18):2861.
68. Smanalieva J, Iskakova J, Oskonbaeva Z, Wichern F, Darr D. Determination of physicochemical parameters, phenolic content, and antioxidant capacity of wild cherry plum (*Prunus divaricata* Ledeb.) from the walnut-fruit forests of Kyrgyzstan. Eur Food Res Technol. 2019;245(10):2293–301.
69. Souto T, Ticktin T. Understanding interrelationships among predictors (age, gender, and origin) of local ecological knowledge. Econ Bot. 2012;66:149–64.
70. Gomes CDSR, Gama ADS, da Silva CA, Mata PT, Silva TC, de Medeiros PM. Gender influences on local botanical knowledge: a northeast brazil study. Ethno Res Applic. 2024;28:1–8.
71. Amjad MS, Zahoor U, Bussmann RW, Altaf M, Gardazi SMH, Abbasi AM. Ethnobotanical survey of the medicinal flora of Harighal, Azad Jammu and Kashmir, Pakistan. J Ethnobiol Ethnomed. 2020;16:1–28.
72. Hussain S, Sher H, Ullah Z, Elshikh MS, Al Farraj DA, Ali A, Abbasi AM. Traditional uses of wild edible mushrooms among the local communities of Swat, Pakistan. Foods. 2023;12(8):1705.
73. Duflo E. Women empowerment and economic development. J Econ Lit. 2012;50(4):1051–79.
74. Aryal KP, Poudel S, Chaudhary RP, Chettri N, Chaudhary P, Ning W, et al. Diversity and use of wild and non-cultivated edible plants in the Western Himalaya. J Ethnobiol Ethnomed. 2018;14(1):1–18.

75. Arzani H, Abedi M. Rangeland assessment: survey and monitoring. University of Tehran; 2015.
76. Harlan JR. Crops and man. Madison: American Society Agro; 1975.
77. Baker P, Machado P, Santos T, Sievert K, Backholer K, Hadjikakou M, Lawrence M. Ultra-processed foods and the nutrition transition: global, regional and national trends, food systems transformations and political economy drivers. Obesity Rev. 2020;21(12): e13126.
78. Addis G, Asfaw Z, Woldu Z. The role of wild and semi-wild edible plants to household food sovereignty in Hamar and Konso communities, South Ethiopia. Ethno Res Appl. 2013;11:251–71.
79. Casas A, Farfán-Heredia B, Camou-Guerrero A, Torres-García I, Blancas J, and Rangel-Landa S. Wild, weedy and domesticated plants for food security and sovereignty. In: Ethnobotany of the mountain regions of Mexico. Cham: Springer International Publishing; 2022. pp. 1–31.
80. Sampson D, Cely-Santos M, Gemmill-Herren B, Babin N, Bernhart A, Bezner Kerr R, Wittman H. Food sovereignty and rights-based approaches strengthen food security and nutrition across the globe: a systematic review. Fron Sustain Food Sys. 2021;5: 686492.
81. Farfan JCC, Medina DFR, Ninco YA, Marulanda SC, Torres DA. Food sovereignty and autonomy for indigenous health as resistance to food globalization: scoping review. Glob Food Sec. 2023;37: 100682.
82. Bharucha Z, Pretty J. The roles and values of wild foods in agricultural systems. Philos Trans R Soc Lond B Biol Sci. 2010;365(1554):2913–26.
83. Fontana NM, Pasailiuk MV, Pohribnyi O. Traditional ecological knowledge to traditional foods: the path to maintaining food sovereignty in Hutsulshchyna. Front Sustain Food Sys. 2022;6: 720757.
84. Pourhashemi M, Kakavand M, Panahi P, Mohammadi E, Haidari M. Identifying the traditional relationship between local communities and plant values of Zagros region (Case study: Nourabad Mamasani, Fars Province). For Wood Prod. 2021;74(1):29–42.
85. Mosaddegh M, Naghibi F, Moazzeni H, Pirani A, Esmaeili S. Ethnobotanical survey of herbal remedies traditionally used in Kohghiluyeh va Boyer Ahmad province of Iran. J Ethnopharmacol. 2012;141(1):80–95.
86. Sharifi Far F, Moharam Khani MR, Moatar F, Babakhanlo P, Khodami M. Ethnobotanical study of medicinal plants of Joopar Mountains of Kerman province, Iran. J Kerman Uni Med Sci. 2014;20(1):37–51.
87. Tabad MA, Jalilian N. Ethnobotanical study of medicinal plants in Zarivar region (Marivan), Iran. J Med Plants. 2015;14(54):55–75.
88. Razmjoue D, Zarei Z. Ethnobotanical study (identification, medical properties and how to use) of some medicinal plants of Behbahan city of Khuzestan province, Iran. J Med Plants. 2017;16(64):33–49.
89. Dolatkhahi M, Dolatkhahi A, Nejad JB. Ethnobotanical study of medicinal plants used in Arjan-Parishan protected area in Fars Province of Iran, Avicenna. J phytomed. 2014;4(6):402.
90. Mohammadi T, Moazzeni H, Pirani A, Vaezi J, Motahhari K, Joharchi MR, Bussmann RW. Ethnobotany of plants used by indigenous communities in Birjand, a dry region with rich local traditional knowledge in eastern Iran. Ethno Res Applic. 2023;26:1–40.
91. Yazdanshenas H, Shafeian E, Nasiri M, Mousavi SA. Indigenous knowledge on use values of Karvan district plants, Iran. Environ Dev Sustain. 2016;18:1217–38.
92. Amrollahi A, Forouzeh MR, Barani H, Yeganeh H. Study about Indigenous knowledge of plants in Goghar Baft rangelands, Kerman Province. Indig Knowl. 2020;7(14):369–424.
93. Younessi-Hamzekhanlu M, Abdipour M, Dejahang A, Sabzi-Nojadeh M, Amani M. Herbals used in western iran as food and for health treatments. In: Biodiversity, conservation and sustainability in Asia: Volume 1: prospects and challenges in west Asia and Caucasus. Cham: Springer International Publishing; 2021. p. 547–99.
94. Buso P, Manfredini S, Reza Ahmadi-Ashtiani H, Sciabica S, Buzzi R, Vertuani S, Baldisserotto A. Iranian medicinal plants: from ethnomedicine to actual studies. Medicina. 2020;56(3):97.
95. Hosseini SH, Bibak H, Ghara AR, Sahebkar A, Shakeri A. Ethnobotany of the medicinal plants used by the ethnic communities of Kerman province, Southeast Iran. J Ethnobiol Ethnomed. 2021;17(1):1–35.
96. Naghibi F, Mosaddegh M, Motamed SM, Ghorbani A. Labiatae family in folk medicine in Iran: from ethnobotany to pharmacology. Iran J Pharm Res. 2005;4(2):63–79.
97. Abadi BRH, Neinhuts C, Safaeian R, Lautenschlager T. Ethnobotanical studies of plant resources of Taftan Mountain, Sistan and Baluchestan in southeastern region of Iran. Asian J Ethnobiol. 2023;6(2):75–114.
98. Sadat-Hosseini M, Farajpour M, Boroomand N, Solaimani-Sardou F. Ethnopharmacological studies of indigenous medicinal plants in the south of Kerman, Iran. J Ethnopharm. 2017;199:194–204.
99. Sharafatmandrad M, Khosravi MA. Ethnopharmacological study of native medicinal plants and the impact of pastoralism on their loss in arid to semiarid ecosystems of southeastern Iran. Scic Rep. 2020;10(1):15526.

Publisher's Note