Ethnobotany of plants used by indigenous communities in Birjand, a dry region with rich local traditional knowledge in eastern Iran

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Research

Abstract

Background: Despite locating in a dry region with a mostly homogeneous ethnic group, South Khorassan province has a high diversity of medicinal plant uses and rich cultural background. The current study was conducted in Birjand (South Khorassan province) and its 18 adjacent villages to document information concerning the plants used and introduce important plant species using ethnobotanical indices.

Methods: In total, 59 people were interviewed about local plants and their utilizations using a semi-structured questionnaire and personal observations between 2018 to 2020. All of the documented plants were collected and identified. The obtained data were analyzed using quantitative ethnobotanical indices.

Results: A total of 119 plant species belonging to 93 families were identified. Asteraceae, Apiaceae, and Lamiaceae were the most used plant families. The most frequently plant part used was the aerial part. Decoction was reported as the most common preparation method. The highest UV and RFC values were recorded for *Sclerorhachis leptoclada*, *Scrophularia leucoclada*, and *Nepeta saturejoides*. The highest ICF was reported for digestive system disorders. 35 species showed fidelity level value of 100%.

Conclusions: The present study reveals that the people in Birjand and the adjacent areas have a rich indigenous knowledge regarding the plants. Moreover, plants still maintain their place in people's lives, especially as medicine and food. Older people were more knowledgeable than young ones. The results of this study can be used for screening plant species for future phytochemical and pharmacological studies. The present study will facilitate the protection programs of the endangered plants in Birjand area.

Keywords: Conservation, Food, Medicinal plants, Pharmacology, Traditional knowledge

Background

Humans have always employed plants for various uses, including food, medicine, housing, fibers, cosmetics, and religious ceremonies, and this knowledge has been passed down from generation to generation. Plants were the oldest and most widespread form of medicine used and they continue to play a significant role in drug discovery (Bussmann 2002, Gertsch 2009, 2011, Harvey *et al*. 2015, Jain 1986, Newman & Cragg 2007, Rahman *et al*. 2018, Salehi *et al*. 2018, Senanayake 2006). It has been estimated that between 70–80% of the world's population relies on plants for their basic healthcare (Biagi *et al*. 2016). The interactions between humans and plants form their scientific discipline "Ethnobotany" covering both ancestral and current plant knowledge (Bussmann 2002, Jain 1986, Kathambi *et al*. 2020). In recent decades, there has been a resurgence of interest in plants among patients, researchers, industry, and trade, and ethnobotanical studies have become common worldwide (Kunwar *et al*. 2009, 2020, Pandey & Tripathi 2017), and Iran is no exception (Salmerón-Manzano *et al*. 2020). Iran harbors over 8100 plant species (25% of which were endemic) (Noroozi *et al*. 2019), among which over 2300 are medicinal (Motahhari *et al*. 2022, Sheibani *et al*. 2018). Moreover, in both rural and urban parts of Iran, the practice of using medicinal plants has a long history (Mehrnia *et al*. 2021, Naghibi *et al*. 2005, Sadeghi *et al*. 2014) and is still prevalent today (Broushaki *et al*. 2016, Motahhari *et al*. 2022, Salmerón-Manzano *et al*. 2020). A variety of ethnobotanical investigations have been carried out in Iran, primarily in the western part of the Zagros Mountains and in northern Iran on the Alborz Mountain range (Bahmani *et al*. 2014, Ghasemi *et al*. 2013, Heydari *et al*. 2016, Hosseini *et al*. 2022, Madjidi Khameneh 2012, Mehrnia *et al*. 2021, Miraldi *et al*. 2001, Mosaddegh *et al*. 2012). However, some parts of the country, such as South Khorassan province in eastern Iran, have not been well investigated. The distinctive socioeconomic and environmental background and isolated mountainous areas with many endemic species make this area fascinating to be examined from an ethnobotanical standpoint. The province of South Khorassan is one of Iran's major producers and suppliers of medicinal herbs. The use of medicinal herbs is widespread throughout this province and the majority of people still rely on home remedies and traditional medicine for primary healthcare and disease treatment (Mohammadi *et al*. 2020). Birjand, the capital city of South Khorassan province, and its surrounding villages were located in a region historically called "Qohestan" or "Kohistan." The region is separated from central Iran by Siah-Kuh Mountain range. This geographical isolation has kept the study area relatively pristine so that its inhabitants retain high loyalty to their ancestors' culture and customs (Ivanov 1926, Mohammadi *et al*. 2020). Ahmadi and Eslam (2009) showed that rural people in the region do not consider their quality of life very favorable and it can lead to some social consequences such as increasing migration from villages to cities which gradually would cause changes in lifestyle and the loss of traditional knowledge of these people. Therefore, it is necessary to record and preserve this knowledge before it is lost. The only ethnobotanical study in Birjand area has been published by Ganjali and Khaksafidi (2016) where they introduced only 36 medicinal plant species used by local people. Ghollasi Mood (2008) presented a list of 160 species as components of Birjand Flora among which only 40% were cited as being used by local people. The later studies lack several fundamental requirements of a conventional ethnobotanical survey (e.g., information related to interviews, informants, voucher specimens, non-medicinal uses of the plants, application modes, and quantitative analyses). Given the floristic diversity and richness of this region, the number of locally used plants in the mentioned studies is underestimated. Therefore, undertaking a comprehensive ethnobotanical study in Birjand and the surrounding villages was of high importance. This study aimed to collect and document information concerning the plants used by indigenous inhabitants in Birjand and surrounding villages and introduce important plant species in the area using ethnobotanical indices.

Material and Methods

Study area and ethnic overview

Birjand is the capital city of South Khorassan province located in eastern Iran (32° 51' 58.61''N 59° 13' 16.10''E) with an average altitude of 1400 meters above sea level, and an area of 31704 km^2. Birjand is limited to Shakarab mountains from the north, Momen-Abad mountains from the east, Baqeran mountains from the south, and the Kavir Desert from the west. These mountainous barriers have played a significant role in maintaining Birjand against attacks by outlanders. As a result, the culture and ethnic knowledge of the people were rather intact. The major ethnic group in South Khorassan province is Persian. However, other ethnic groups such as Arabs and Balochs constitute minor ethnicities in the region. The religion of the people of Birjand is Islam, and they speak the Persian language with a specific dialect called the "Birjandi" (Ivanov 1926, Izady 2006, Mohammadi *et al*. 2020). Most of the inhabitants of the villages around Birjand were farmers sometimes engaged also in animal husbandry, while South Khorassan province ranks first in the production of barberry and jujube products in Iran. Only a few of the villages in the province have healthcare centers that offer limited facilities and primary medical services provided by midwives and health assistants on certain days of the week. Makhunik (known as the Lilliput or dwarves' land; Fig. 1) and Chenesht (known as the land of colors; Fig. 1) are among the well-known village around Birjand. Makhunik is famous for its short men and women who lived in the past in houses with short roofs. Today the traces of their miniature

life can still be observed in this village (Fig. 1; A–B). The people of Makhunik have a traditional lifestyle and have their own beliefs about the use of plants. Chenesht is also considered as one of the well-known villages in South Khorassan province due to its natural attractions, historic caves, and cultural fascinations (colorful local clothes) (Fig. 1; C–D).

Figure 1. Makhunik and Chenesht: two wonderful villages around Birjand. **A:** A view of the houses with short roofs in Makhunik, **B:** A local boy in Makhunik is standing in front of a home's door wearing a native outfit, **C–D:** Indigenous people with colorful local clothes in Chenesht (Photos by T. Mohammadi).

Climate and vegetation
The average temperature and the rainfall in the last 20 years in Birjand city were 16.9 °C and 102.44 mm, respectively. Birjand has an arid climate with hot summers, cool winters, and a remarkable difference between day and night temperatures (Masoudi *et al*. 2018, Nakhaee Nezhad Fard *et al*. 2013). The Ambrothermic curve in Birjand city is shown in Fig. 2 (Data were obtained from ClimateCharts.net (https://climatecharts.net/). The city is located in the driest region of Khorassan province and does not have a permanent river. Therefore, groundwater resources were used for supplying drinking water. Due to the decrease in precipitation, increased withdrawals from wells, and contamination caused by agricultural pesticides, the quality the quality of water in the area has decreased (Izadi et al., 2022).

Birjand is located in the Irano-Turanian floristic region, which is characterized by great diversity and abundance of species. Moreover, climatic factors, soil type, elevations, and temperature variation have created different vegetation types. Typical vegetation types of this area include semi-steppe vegetation, foothills, and mountainous vegetation with dominant genera such as *Artemisia* L., *Astragalus* L., *Ephedra* Tourn. ex L., *Lactuca* L., *Pistacia* L., *Salsola* L., and *Tamarix* L. The *Artemisia-Astragalus* vegetation type has covered the majority of this area, mixed with *Prunus lycioides* (Spach) C.K. Schneid. and *Pistacia atlantica* Desf. found at higher elevations. Halophile vegetation types such as *Zygophyllum* L., *Salsola*, and *Atriplex*

L. can be found in some parts of the region. The most valuable plants exported from this area are saffron, jujube, and barberries. Moreover, asafetida represents a major medicinal product of Birjand (Izadi *et al*. 2022).
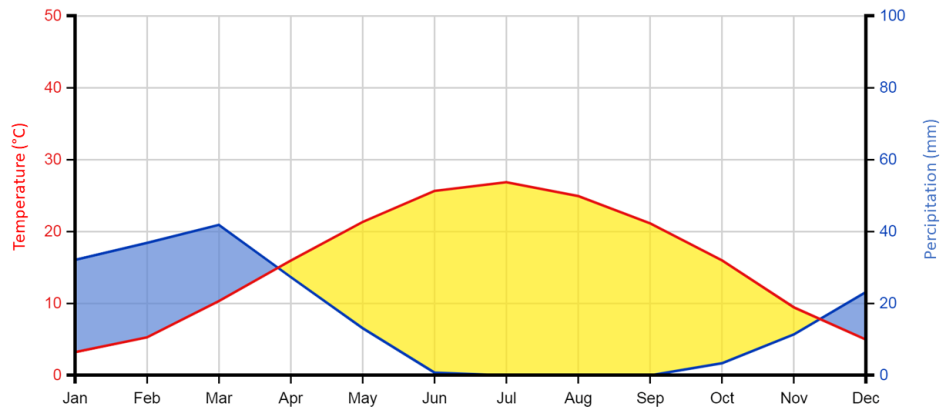

Figure 2. Ambrothermic curve of Birjand. Monthly data were mean values for the period AD 1988-2017.

Data collection

To document the indigenous knowledge of the people in the Birjand about different uses of plants, field surveys were conducted from 2018 to 2020 in both villages and urban areas of the study area. A local person served as a native guide during the fieldwork. Birjand city and its 18 adjacent villages were surveyed (Fig. 3; Table 1). The surveyed villages were selected based on interviews with village organizations and participatory observation to check if there were any knowledgeable people about plant uses. The distribution of herbal markets in different districts of Birjand city was identified using information from local people and https://www.filebank.org/. A total of 15 local herbal markets as well as traditional healers, other knowledgeable locals, and vendors of edible and medicinal plants were visited. The informants were selected randomly or by snowball sampling technique irrespective of age, occupation, sex, religion, and education level and interviewed using semi-structured questionnaires, and oral and personal observations after obtaining their prior informed consent. The gender, age, occupation, educational background, and methods of knowledge transmission of the informants were documented (Table 2). Open-ended questions were used during the interviews. The people were asked about plants they use for different purposes, the local name of the plants, plant part used, mode of preparation and uses, and any other information they would like to share. The code of ethics of the International Society of Ethnobiology (International Society of Ethnobiology 2006) was strictly followed. We received verbal permission from local people for recording interviews and the publication of photographs taken during the field survey.
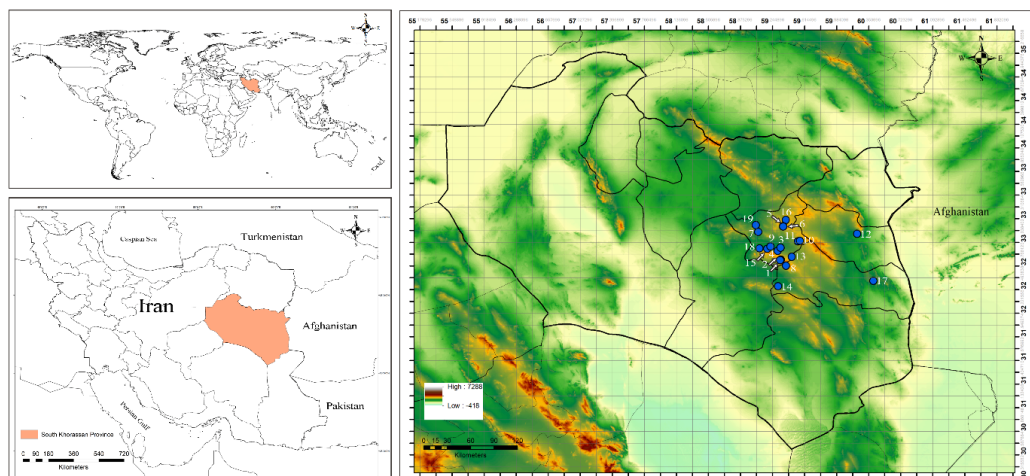
Figure 3. Map of Iran showing the South Khorassan province and the study area. The number of villages corresponds to Table 1.

The vernacular names, different uses, utilized parts, and modes of preparation and application of plants were detailed in Appendix 1. Plant species mentioned by informants were collected to be checked and approved. The nomenclatures follow the Plants of The World Online (http://www.plantsoftheworldonline.org/) and the International Plant Name Index

(http://www.ipni.org/). The voucher specimens were deposited at Herbarium FUMH at the Ferdowsi University of Mashhad (Appendix 1). Voucher samples in Appendix 1 were presented in two different forms: herbarium specimens which were presented with numerical and non-herbarium material such as roots, leaves, flowers, etc. which were differentiated with "E."

Table 1. Studied areas in the South Khorassan province.

Name of the village	Area	Altitude(m)	Number of informants
Akbar-abad	Baqeran Rural District	1980	2
Bijar	Baqeran Rural District	1920	3
Birjand	The capital city of South Khorassan province	1600	19
Bojd	Baqeran Rural District	1550	2
Borj-ziad	Alqurat Rural District	2005	2
Bozghoj	Alqurat Rural District	1990	1
Chahowz	Fasharud Rural District	1815	4
Chenesht	Naharjan Rural District	2150	3
Esfahroud	Baqeran Rural District	1730	3
Eshtakhan	Kahshang Rural District	2050	1
Elghar	Kahshang Rural District	1910	3
Gazik	Kahshang Rural District	1415	1
Hasan-abad	Baqeran Rural District	1910	3
Islam-abad Shokri	Naharjan Rural District	1505	2
Kase-sangi	Baqeran Rural District	1685	1
Mahouk	Alqurat Rural District	1977	3
Makhounik	Doroh Rural District	1600	2
Rokat	Baqeran Rural District	1690	2
Shoushoud	Fasharud Rural District	1620	2

Table 2. Demographic information of the informants interviewed.

Variables	Categories	Abundance	Percentages (%)
Gender	Female	32	56
	Male	27	44
Age	20-40	12	20
	40-60	16	27
	60-80	28	48
	>80 years	3	5
Educational status	Illiterate	15	25
	Primary education	10	17
	Middle education	6	10
	Secondary education	11	17
	University	3	7
Professions	Farmers	9	15
	Housewives	19	33
	Plant vendors (fresh herbs sellers)	5	8
	Attars (dried plant & plant-based products sellers)	15	25
	Others	11	19

Data analysis
The collected ethnobotanical data were analyzed using quantitative ethnobotanical indices including use value (UV), relative frequency of citations (RFC), informant consensus factor (ICF), fidelity level (FL) and Jaccard index (JI).

Use value shows the relative importance of reported plant species in the study area calculated by the following formula:

$$UV = \frac{\sum U_i}{N}$$

where "U_i" is the number of uses cited by every informant for a certain species; and "N" refers to the total number of informants mentioned to a certain species (Phillips & Gentry 1993).

Relative frequency of citation shows the harmony among the informants about the uses of plants in the study area. It is calculated with the given formula:

$$RFC = \frac{FC}{N}$$

where "FC" is the number of informants mentioning the use of a given species, and "N" shows the total number of informants participating in the survey. RFC value varies from 0 (when anybody not mentioned to a plant species as useful) to 1 (if all of the informants would consider it as useful) (Tardío & Pardo-De-Santayana 2008).

In this study, the categories suggested for diseases were classified under Economic Botany Data Collection Standard (EBDCS) (Cook 1995), and they were grouped into 20 use categories.

ICF represents the agreement between the informants regarding the use of plants for curing different groups of ailments, and it is calculated as follows:

$$ICF = \frac{N_{ur} - N_t}{N_{ur} - 1}$$

Where" N_{ur} "is the number of use citations in a selected category of diseases, and "N_t "is the number of species used to treat various diseases of that category (Trotter & Logan 2019).

Fidelity level shows the priority of a specific plant species by informants to treat a particular disease which is calculated by the following formula:

$$FL = \frac{I_p}{I_u} \times 100$$

where " I_p" is the number of informants reporting a specific use for certain plant species, and "I_u" is the total number of informants participating in the study.

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 medicinal uses using the following formula (González-Tejero *et al*. 2008):

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

Where "a" is the number of species of the neighboring area, "b" is the number of species of the study area, and "c" is the number of species common to both areas. We compared our results with eight published papers from neighboring regions of South Khorassan province using Jaccard index. High similarity reflects the similarity in vegetation types of two areas due to similar geographic or climatic conditions, the similarity of cultures, and the increased exchange of traditional knowledge between the two regions. In contrast, the lowest value of JI indicates that the areas do not show common cultural values and traditional knowledge (Amjad *et al*. 2020, Faruque *et al*. 2018).

Finally, the statistical analyses were done using Microsoft Excel 2016 and the "ethnobotanyR" package in R version 4.0.2 (Oksanen *et al*. 2017).

Cluster analysis
We applied the most commonly used clustering method, i.e., the unweighted pair group method with arithmetic mean (UPGMA), to demonstrate the relationship between species abundance and similarity among herbal markets in the urban areas and villages around Birjand. We considered areas with at least five species in common in this analysis. The UPGMA dendrogram was generated using Mesquite 3.70 (Maddison & Maddison 2021).

Results

Demographic information

A total of 59 people from four groups participated in the study: (1) "Knowledgeable locals," from different age groups and different occupations, who had acquired traditional knowledge information from elders, parents, empirically, or through books and medicinal plant websites (2) "Sellers" who marketed herbal products but did not have much information about them, (3) "Herbalists," known in Iran as "Attar," who sold the products and had good knowledge about plants, and (4) "Local doctors" (mostly elders), who were known as local traditional healers, to whom the people of the villages referred for the treatment of diseases.

Thirty-two of the informants were women (56%), and 27 were men (44%) (Table 2). Women had a broader knowledge about plants and their uses than men. All interviewees were Persian. The age of the informants ranged from 20 to 90 years, with an average of 56 years old (Table 2). The majority of the participants (49%) were between 60-80 years old. Most of the informants (78%) obtained their knowledge from a relative (grandparents or parents) or elders, and the others obtained it through other means (e.g., studying, national and international medicinal plant websites, and taking courses).

Diversity of species

A total of 119 plant species belonging to 93 genera in 44 families were recorded. According to the APG IV system, nine species (7.56% of the documented species) arranged in seven families were monocotyledons and 110 (92.44% of the total species) belonging to 37 families were eudicots. There was not any report of mosses, ferns, and gymnosperms in the present study. The scientific name, local name, plant part used, modes of preparation and administration, different uses of the documented plants, UV, RFC, and FL values were listed in Appendix 1. Asteraceae and Apiaceae each with 13 species and Lamiaceae with 11 species represent the most used families.

Use categories

Four use categories—medical (Fig. 4), food (Fig. 5), customs and beliefs (Fig. 6), and industrial were used to categorize the ethnobotanical applications of plants in this study. These categories were listed in Appendix 1.

Plants with medicinal applications were used to treat ailments in humans and rarely in livestock. The plants classified in the food category were used as fruits, vegetables, nuts, animal feed, flavoring in bread, yogurt, food, and tea, or as a food component. The use of plants in the custom and beliefs category is mainly restricted to ceremonial customs. Plants classified as industrial were used in construction, perfumery, cleaning, basket weaving, and dyeing (Fig 5. I–K).

Plant part(s) used and preparation modes

The most used plant parts were aerial parts (32%), followed by seeds (20%), flowers (15%), fruits (10%), leaves (9%), latex (4%), root (3%), and stem (2%). The usage of other plant parts (bulb, gum, rhizome, bark, inflorescence, and tuber) was lower than 2% (Fig. 7).

In the present study, decoction was the most common preparation method (33%), followed by raw (fresh or dried) (24%), infusion (15%), powdered and pulverized (10%), cooked (6%), soaking (moisturized in water) (4%), syrup (3%), smoking (2%), and oil (1%) (Fig. 8). In some cases, interviewees recommended a decoction of a mixture of two or more plant species to treat a specific disease (Appendix 1). For example, the decoction of the flowers of *Nepeta bracteata* with the aerial parts of *N. saturejoides* and the seeds of *Cydonia oblonga* was suggested for the treatment of asthma. The most common administration route was oral (87%), followed by topical (ointment and poultice) (9%), inhalation (2%), rinsing (2%), and also in one case, anal use of the plant was recommended, as consistent with comparable investigations.
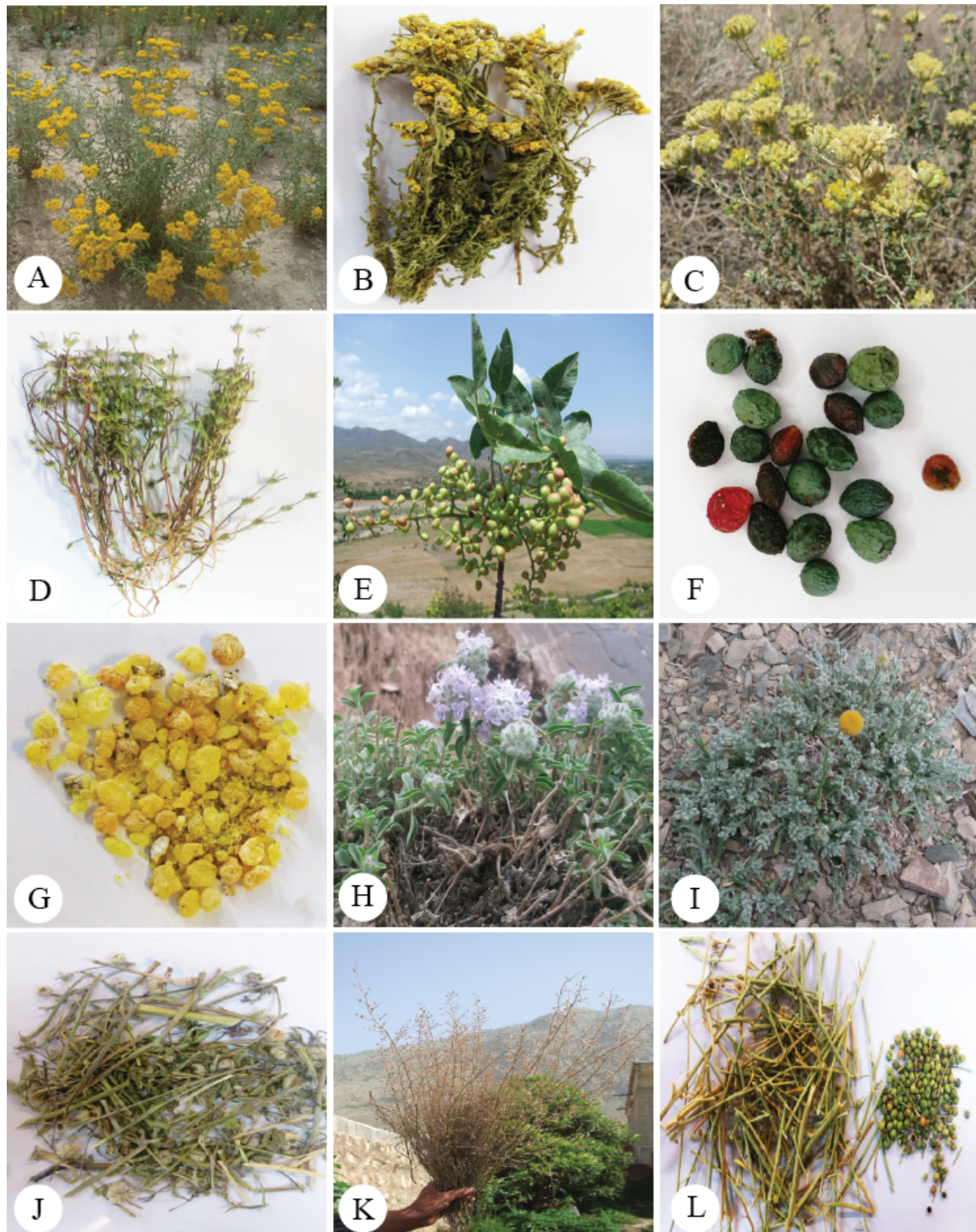
Figure 4. Plants used in the medicinal category with highest UV. **A–B**: *Achillea santolinoides* K. Koch; **A**: habit, **B**: aerial part. **C**: *Achillea eriophora* DC., aerial parts, **D**: *Nepeta saturejoides* Boiss., whole plants, **E–G**: *Pistacia atlantica* Desf.; **E**: aerial parts, **F**: fruit, **G**: gum., **H**: *Ziziphora clinopodioides* subsp. *pseudodasyantha* (Rech. f.) Rech. f., aerial parts, **I–J**: *Sclerorhachis leptoclada* Rech. f.; **I:** habit, **J:** aerial part, **K–L**: *Scrophularia leucoclada* Bunge; **K:** habit, **L:** aerial parts and fruit (Photos by T. Mohammadi and H. Moazzeni).

Figure 5. Plants used in the food category. **A**: *Atriplex moneta*, **B–C**: *Beta vulgaris*, **D–F**: *Ferula foetida*, **D:** aerial parts, **E:** *F. foetida* sold in local markets of Birjand, **F**: Local food made from *F. foetida*, **G**: *Juglans regia*, **H**: *Scorzonera paradoxa*, **I**: *Tulipa undulatifolia* var. *micheliana* (Photos by T. Mohammadi).

Figure 6. **A–H**: Plants used in the custom and beliefs category. **A**: *Acanthophyllum laxiusculum*, **B**: The soap obtained from roots of *Acanthophyllum* spp. (retrieved from https://www.sepahantourism.ir/ on 17 Aug 2019), **C–F:** *Peganum harmala*, **G–H:** *Muscari neglectum*, **I–K**: Plants used in the industrial category; **I–J**: *Prunus scoparia* (**J** retrieved from https://www.mehrnews.com/ on 23 Feb 2020), **K**: *Pistacia atlantica* (Photos by T. Mohammadi and H. Moazzeni).
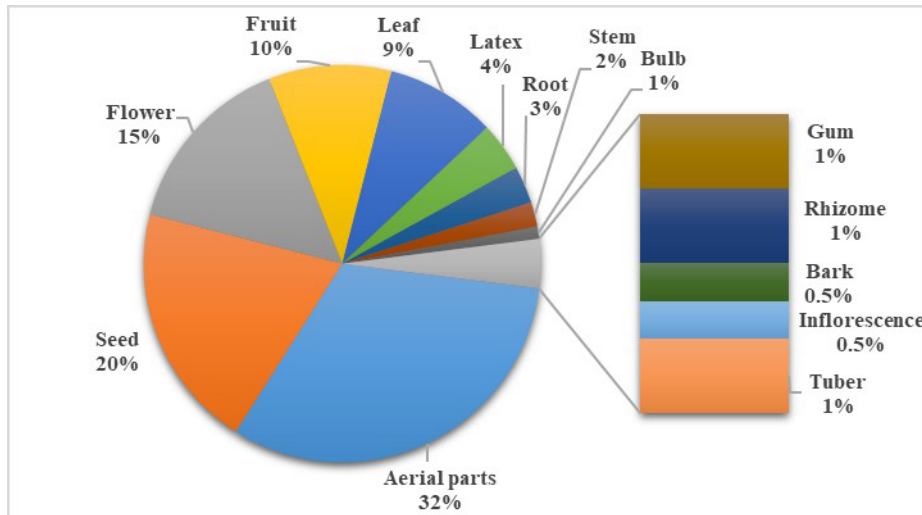
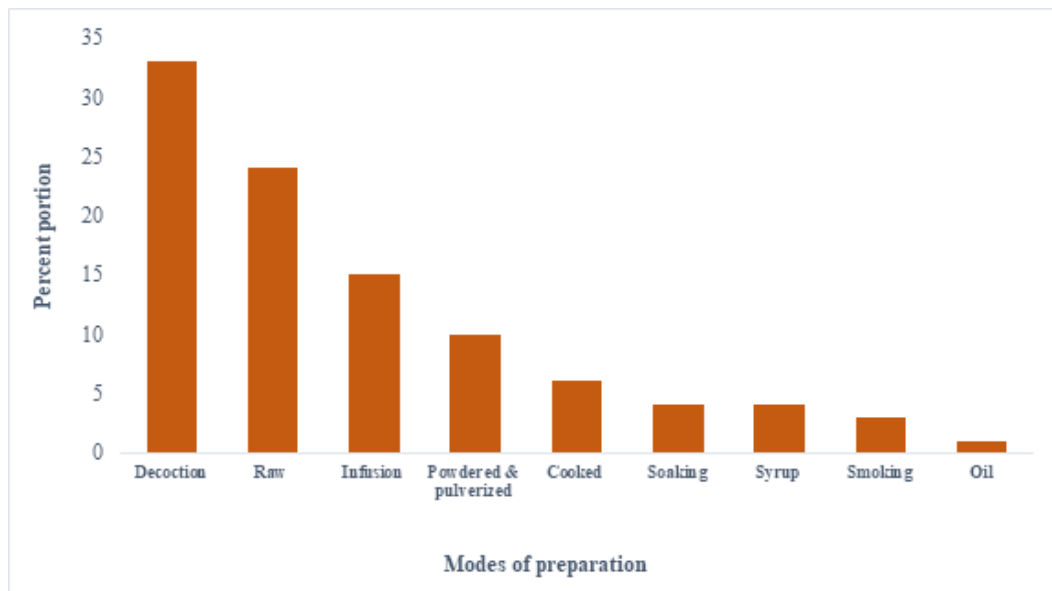Figure 7. Plant part used by local people in the study area.

Figure 8. Modes of preparation of herbal recipes.

Quantitative analysis

In this study, UV values varied from 0.525 to 0.017 (Appendix 1). *Sclerorhachis leptoclada* (0.525), *Nepeta saturejoides*, *Scrophularia leucoclada* (0.322), *Ziziphora clinopodioides* subsp. *pseudodasyantha* (0.305), *Achillea eriophora* and *Pistacia atlantica* (0.271) obtained the highest UV values. These species were often used for therapeutic purposes, and most of the local people were familiar with them.

The value of RFC ranged from 0.4 to 0.01 in the present study. *Sclerorhachis leptoclada* had the highest RFC (0.4), followed by *Scrophularia leucoclada* (0.25), *Nepeta saturejoides* (0.24), *Ziziphora clinopodioides* subsp. *pseudodasyantha* (0.22), and *Achillea eriophora* (0.2).

ICF values ranged from 0 to 1. A high ICF value indicates that local people have a high agreement about the use of plants in a particular disease category, while lower values show less accord (Chaachouay et al., 2019, Amjad et al., 2020). A total of 424 recorded medicinal uses were classified into 20 ailment categories based on the EBDCS (see Material and methods section). The ICF values varied from 0 to 0.71. The maximum ICF value was calculated for digestive system disorders (0.71), followed by infections/infestations (0.58) and mental disorders (0.5), while the minimum value of 0 was obtained for blood system disorders, inflammation, neoplasms, poisoning, and skin/subcutaneous cellular tissue disorders (Table 3).

Table 3. Informant consensus factor (ICF) of reported plants for different ailment categories. *N_{ur}: the number of used citations in a selected category of diseases, **N_t: the number of species used to treat various diseases of that category, ***ICF: Informant Consensus Factor.

Category of Diseases	*N_{ur}	**N_t	***ICF
Blood system disorders	2	2	0
Circulatory system disorders	28	17	0.4
Digestive system disorders	152	45	0.71
Endocrine system disorders	10	9	0.11
Genitourinary system disorders	18	14	0.23
Infections	58	25	0.58
Inflammation	4	4	0
Injuries	10	9	0.11
Mental disorders	13	6	0.5
Metabolic system disorders	19	18	0.05
Muscular-skeletal system disorders	14	12	0.15
Neoplasms	1	1	0
Nervous system disorders	8	7	0.14
Nutritional disorders	11	10	0.1
Pain	39	24	0.37
Poisonings	5	5	0
Pregnancy/birth/puerperium disorders	9	7	0.25
Respiratory system disorders	17	16	0.05
Sensory system disorders	4	3	0.33
Skin/subcutaneous cellular tissue disorders	2	2	0

The fidelity value reflects the locals' claimed preference for a specific plant species for treating a specific condition in the area. The FL value ranged from 12.5 to 100% (Appendix 1). FL values of 35 species such as *Coriandrum sativum*, *Medicago sativa*, *Peganum harmala*, *Rosa × damascena* were reported 100%. These species were used to treat hyperlipidemia, high blood sugar, stomach disorders, and women's menstrual disorders. Other medicinal plants with a high value of FL were *Ziziphora clinopodioides* subsp. *pseudodasyantha* (78.58%) used for treating the common cold, *Achillea eriophora* (65%) used to cure stomachache, and *Prunus scoparia* (60%) is used for the treatment of foot pains.

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, were shown in Table 4. The JI ranged from 4.96 to 26.76. The highest degree of similarity was found in the study of the herbal markets in Mashhad (Khorassan-e-Razavi province) (Motahhari *et al.* 2022). The lowest degree of similarity was found with the study conducted in Khabr and Rouchon (Kerman province) (Mohamadi *et al.* 2015).

Table 4. Comparison between present and previous studies, as performed by Jaccard Index (JI). **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.

Province	Study area	Indices	JI	Citation
Kerman	All cities of Kerman province	a: 402	14.50	(Hosseini et al., 2021)
		b: 119		
		c: 66		
	Khabr	a: 156	12.24	(Sharafatmandrad and Khosravi Mashizi, 2020)
		b: 119		
		c: 30		
	Khabr and Rouchon	a: 50	4.96	(Mohamadi et al., 2015)
		b: 119		
		c: 8		
	Sirjan	a: 43	20	(Khajoei Nasab et al., 2014)

		b: 119		
		c: 26		
	South of Kerman	a: 115	9.34	(Sadat-Hosseini et al., 2017)
		b: 119		
		c: 20		
Khorassan-e Razavi	Mashhad	a: 61	26.76	(Motahhari et al., 2022)
		b: 119		
		c: 38		
Sistan and Baluchestan	Saravan	a: 64	9.58	(Sadeghi et al., 2014)
		b: 119		
		c: 16		
	Taftan Mountain and surrounding villages	a: 106	13.63	(Maleki and Akhani, 2018)
		b: 119		
		c: 27		

Clustering of herbal markets and villages

An analysis of the diversity and similarity among districts, based on the herbal markets in the urban areas and villages around Birjand was carried out by hierarchical clustering using species abundance (Fig. 9). The analysis resulted in two main clusters. The cluster A included herbal markets in Birjand, Bijar, Cheneshet, and Esfahroud villages and the cluster B contained the rest of the herbal markets surveyed (Fig. 9). The herbal markets clustered in Clade A showed higher similarities compared to the ones in clade B. The cluster A contained areas with the highest use of plant species (with a minimum of 37 and a maximum of 56 plant species), while the villages in clade B had a lower use of plant species (with a minimum of five and a maximum of 21 plant species).
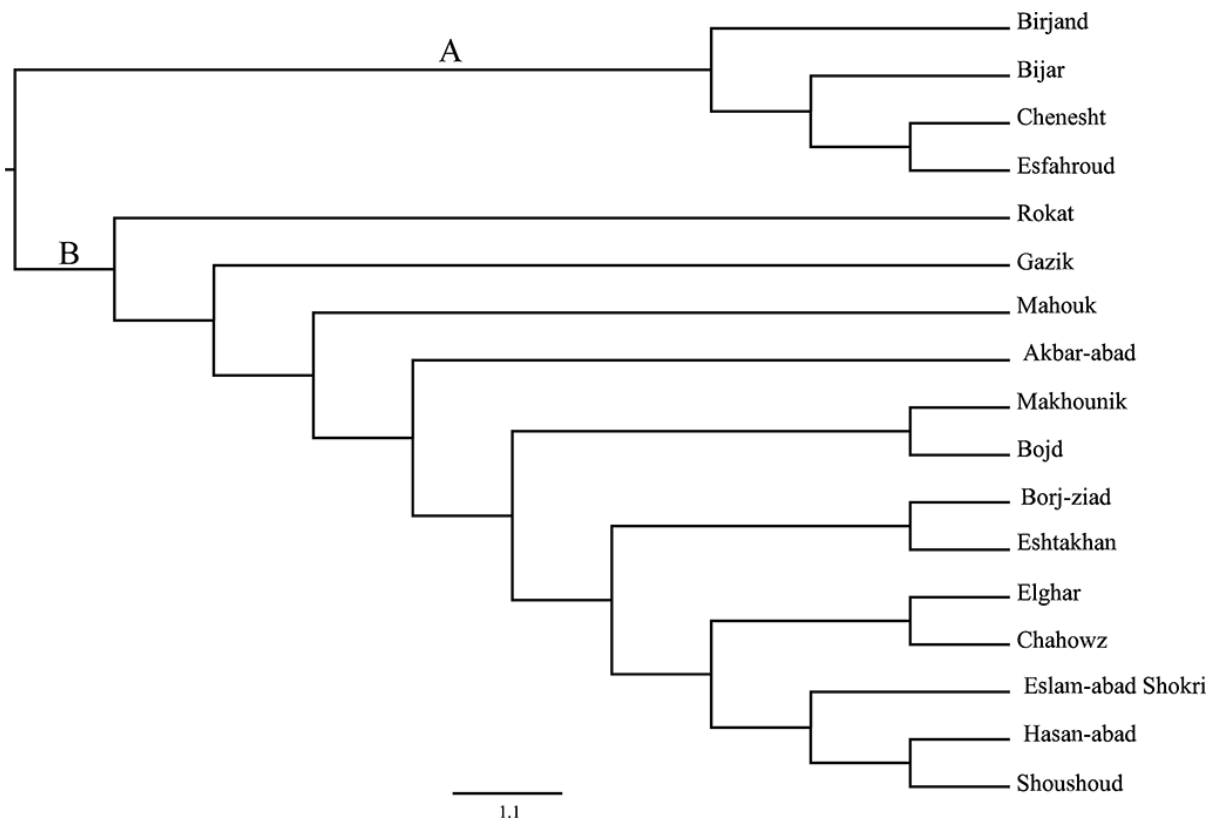

Figure 9. Dendrogram showing UPGMA clustering based on the 18 districts using species abundance.

New reports and new uses

A comparison of the recorded species from this study with other studies conducted in Iran showed that 17 species had not been previously recorded in the ethnobotanical literature of Iran.

The use of *Acanthophyllum laxiusculum* Schiman-Czeika, *Artemisia santolina* Schrenk, *Astragalus goreanus* Aitch. & Baker, *Atriplex moneta* Bunge ex Boiss., *Cousinia eryngioides* Boiss., *Crambe cordifolia* subsp. *kotschyana* (Boiss.) Jafri, *Hymenocrater platystegius* Rech.f., *Muscari neglectum* Guss. ex Ten., *Nepeta saturejoides* Boiss., *Onosma longiloba* Bunge, *Paracaryum rugulosum* (DC.) Boiss., *Prunus armeniaca* L.*, Sclerorhachis leptoclada* Rech. f., *Scrophularia leucoclada* Bunge, *Tragopogon gaudanicus* Boriss., *Tulipa lehmanniana* Merckl., and *Tulipa undulatifolia* var. *micheliana* (Hoog) Wilford is recorded for the first time in this study. These species were used medicinally (10 uses), as food (9 uses), believe (3 uses) and two industrially (2 uses; see Appendix 2).

In the present study, we also reported new uses for 19 known plant species. e.g.; The use of *Artemisia aucheri* Boiss. for preparation of perfume, *Beta vulgaris* L. as nuts, *Crocus sativus* L. as mark the book of the Qur'an and prayers, *Eruca vesicaria* (L.) Cav. as greenery during Nowrouz, *Prunus cerasus* L., *Prunus persica* (L.) Batsch, *Prunus scoparia* (Spach) C.K. Schneid and *Trachyspermum ammi* (L.) Sprague as kohl for blackening the eyes of babies and women, *Prunus scoparia* (Spach) C.K. Schneid for basket weaving, and plant shrubs as roofing materials for houses. The new uses documented in the present study were compared to those previously reported in Appendix 2.

Folk remedies and related knowledge cases of non-plant substances

During this study some non-plant substances of therapeutic or nutritional value were mentioned by informants. The non-plant substances and their local uses were summarized in Appendix 3.

Because non-plant based folk remedies were a part of traditional medicine, we present them in this study alongside plants as follows:

Alum (Zomeh /zɔɪme/)

Alum is a colorless, clear, and crystalline mineral substance (Fig. 10A) that has been used since ancient times in medicine (as a blood coagulant), cloth industry, papermaking, dyeing, perfumery, and toothpaste (Zeenat *et al*. 2018). In Birjand and its adjacent areas, it was used to treat tooth infections (as placed on the tooth). Moreover, it was used to lighten the color of the rice grain before cooking.

Momenaei (/mɔɪmenaːjiː) or Moumiaei (/muːmɪaːjiː/)

Moumiaei is a bitumen-like secretion that exists in cracks and fractures of the ground or caves and its bituminous appearance is due to the presence of hydrocarbons in its composition (Aynechi 1986, Dehkhoda 1995). It is used either as an ointment or orally (mixed with tea).

Avicenna and Rasis (Persian physicians) recommended "Moumiaei" for the treatment of dislocations and fractures of joints, headaches, sore throats, hiccups, epilepsy, liver and stomach disorders (Door & Ghavam 2016, Rasis 2012). Clinical studies have also shown that it is effective in wound healing as well as the treatment of bone fractures (Rezvanipour *et al*. 2007) (Fig. 10B).

Somarouq (/sɔɪmaːrɔɪk/)

An edible mushroom typically growing in the spring. Locals in the area chopped this mushroom, fried it with onions and consumed it as food. Interestingly, in the Dari Persian language of Afghanistan, "Somarouq" refers to a variety of mushrooms. Because the language of Iran and Afghanistan is Persian and Iran shares an east border with Afghanistan, probably it is a common word between this region and Afghanistan (Fig. 10C–D). We were not able to identify this fungus.

Rabbit hair

An ointment (topical application) made from a combination of *Roemeria* sp. flowers and rabbit hair was used to treat burns and wounds. Persian medicine has utilized various rabbit body parts from ancient times. Because of its anticoagulant characteristics, which were considered in Persian medicine, locals may use rabbit hair.
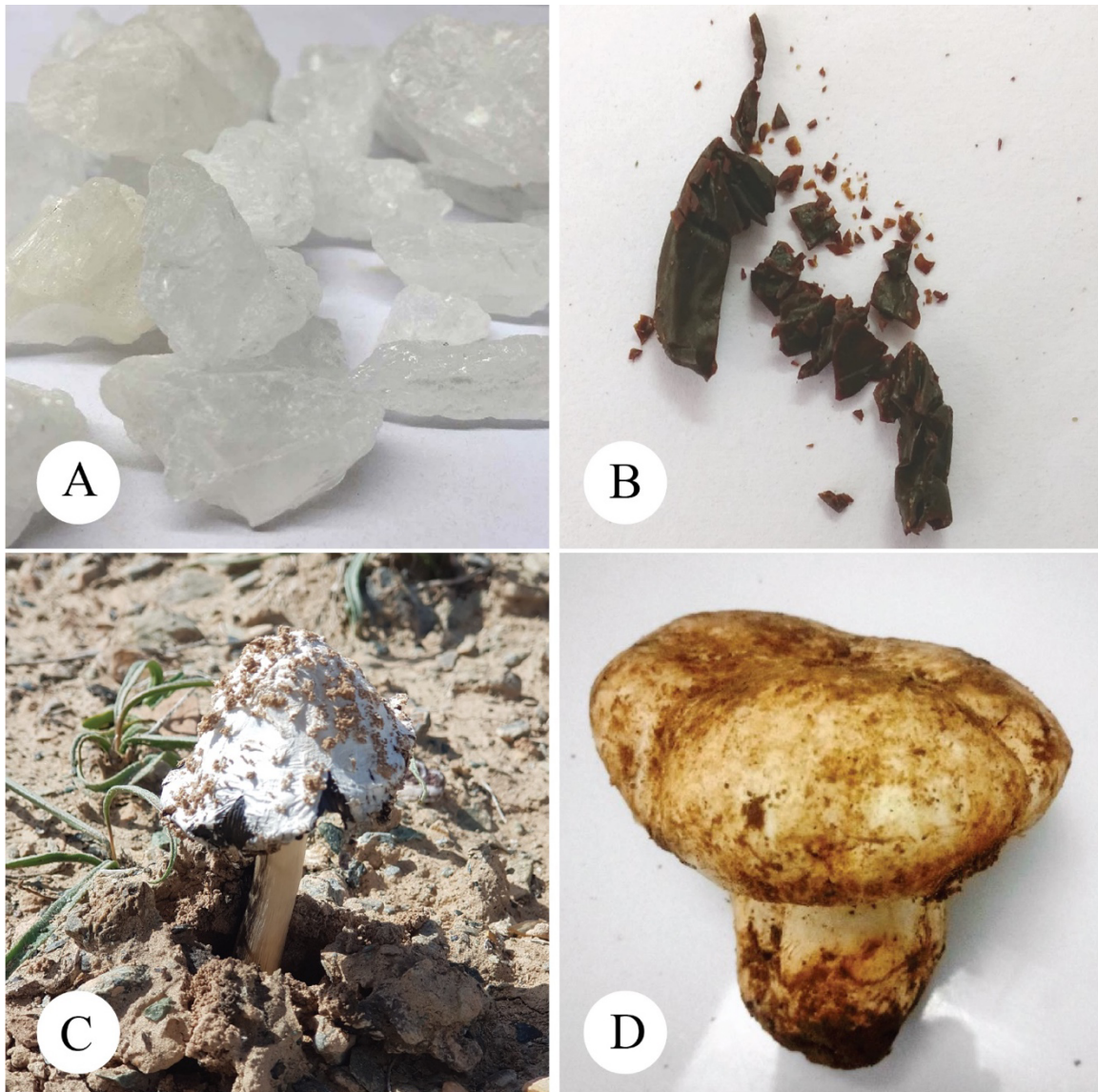
Figure 10. Non-plant cases. **A:** Alum (a mineral substance) (retrieved from http://digishimi.com/administrator/files/UploadFile/%D8%B2%D8%A7%D8%AC%D8%B3%D9%81%DB%8C%D8%AF.jpg on 17 Feb 2020), **B:** Moumiaei, **C–D**: Somarouq (a kind of mushroom), **C:** habitat, **D:** edible form (Photos by T. Mohammadi and Marzieh Sirousi).

Discussion

The present study showed that female informants have a broader knowledge of plants and their uses. Men usually manage the fieldwork, while women were often involved in domestic activities, which were sometimes associated with the use of plant species or their products to keep the family healthy. Some recent ethnobotanical studies have also reported richer female knowledge of plant uses (Mohamadi *et al*. 2015, Mosaddegh *et al*. 2012, Sharafatmandrad & Khosravi Mashizi 2020).

The majority of the interviewees were illiterate and obtained their knowledge from older relatives (e.g., parents and grandparents). Most of the obtained information was shared by elder informants aged between 60-80. This group of interviewees was more knowledgeable about plants and their utilization and shared most of the documented information. Other ethnobotanists have reported similar results (Bendif *et al*. 2018, Sharafatmandrad & Khosravi Mashizi 2020).

Younger informants had less knowledge about plants, which could be attributed to the changes in their lifestyle following the progress of urbanization and industrialization. The wider ethnobotanical knowledge of illiterate or low-literate informants may be due to their deeper belief in herbal medicine, cheapness, and availability of plants.

The plant list mentioned by Attars did not exactly match the list of other participants. The imported plants (22 species marked with an asterisk in Appendix 1), were not distributed in the study area, their use and application mode were only mentioned by Attars. *Astragalus hamosus* is the only exception among the imported plants that were known by almost all participants and thus is not marked with an asterisk. In the case of the rest of the documented species, Attars mentioned some additional uses not mentioned by the other interviewees. These differences were shown in Appendix 1 where the additional uses mentioned by Attar were underlined. As Attars were professional plant sellers who come from the same region as the other participants, there were not many differences in the application of the documented plants between these two groups. This is almost the same about documented knowledge of the local traditional healers where few medicinal plants (e.g., *Amaranthus* spp. and *Daucus carota*) as well as some additional applications were mentioned only by this group of informants (see Appendix 1).

Despite dry climate and poor vegetation of Birjand and surrounding villages, a notable number of 119 plant species used by indigenous people were recorded which could be attributed to high reliance of locals on plants for basic health care, nutrition, and customs. The high usage of the families Asteraceae, Apiaceae and Lamiaceae is most likely due to their abundance and species richness in the study area (Kunwar *et al*. 2020, Mohammadi *et al*. 2020). Also, they contain various active ingredients, including essential oils, which often inhibit the growth of bacteria and have anti-inflammatory, anti-flatulence, sedative, appetizing, and expectorant properties (Mohammadi *et al*. 2020, 2021, Naghibi *et al*. 2005, Spinozzi *et al*. 2021, Zofia *et al*. 2020) which contribute to their medicinal value. This result is also in agreement with the discoveries of previous ethnobotanical studies conducted in other parts of Iran where these families appeared as the mostly used (Ghorbani 2005, Hosseini *et al*. 2022, Mehrnia *et al*. 2021, Mosaddegh *et al*. 2012, Sadeghi *et al*. 2014).

Aerial parts of the utilized plants appeared as the mostly used plant parts. The frequent use of aerial parts can be attributed to the fact that these parts were involved in the photosynthesis and production of secondary metabolites and were easily accessible (Chaachouay *et al*. 2019). Many seeds were edible and provide a lot of calories for humans (Sabelli and Larkins 2009), which interprets the high usage of seeds in the area. Seeds were also rich in nutrients such as oil, starch, and protein and provide most of the cooking oils, therapeutic oils, drinks, and spices (Iqbal *et al*. 2006, Ramadan 2007, Venskutonis & Kraujalis 2013, Welch & Graham 2004).

In the present study, decoction was documented as the most common preparation method. Similar research suggested that the decoction was the most dominating popular preparation mode in Iran (Hosseini *et al*. 2022, Mehrnia *et al*. 2021, Sadat-Hosseini *et al*. 2017) or throughout SW Asia (Abbas *et al*. 2017, Ahmed 2016, Farooq *et al*. 2019, Özdemir & Alpinar 2015) to prepare herbal medicines. The decoction is considered an effective method for extracting the active ingredients of medicinal plants (Gao *et al*. 2022), and it can also lessen or eliminate the negative effects of some recipes (Chaachouay *et al*. 2019, Iwaka *et al*. 2022). Moreover, it is cheap and also easy (Adigwe *et al*. 2022) to prepare by mixing the plant with water, tea, milk, and so.

The reason for the preference of oral administration could be the high prevalence of internal disorders in this area. Furthermore, the plants that were used as food could only be taken orally. In the present survey, the interviewees often did not prescribe specified dosages for the use of herbs. At the same time, excessive consumption of any plant or chemical could be harmful to the human body (Alinejad *et al*. 2017, Calixto 2000, George 2011, Nasri & Hedayatollah 2013, Ullah *et al*. 2019).

Use categories
The present results show that in the study region plants were mainly used for medicinal purposes (80%), followed by 14% as food, 3% for ceremonial and 3% for industrial uses.

Among the four use categories documented in the present study, the medicinal use of plants is still entirely prevalent. Therefore, documenting and preserving ethnomedicinal and ethnopharmacological knowledge of the local people in this region is very important because such information could be considered as a basis for finding new pharmaceutical compounds (Fig. 4). *Schlerorhachis leptoclada* and *Achillea eriophora*, both endemic to Iran, were among the mostly used medicinal plants in the study area that were traditionally applied for treatment of a wide range health problems (Mohammadi *et al*. 2020, 2021).

Today, the use of edible plants is widespread worldwide because many of them were suitable sources of protein, minerals, vitamins, fibers, carbohydrates, essential fatty acids, and antioxidants. Some of the highly used food plants in the present

study were *Atriplex moneta*, *Ferula foetida*, *Scorzonera paradoxa*, and *Tulipa undulatifolia* var. *micheliana* (Fig. 5). Plants classified in the food category were mainly used for preparing local food, while the minimum usage was recorded for use as vegetable and fruit.

Within the customs and beliefs category, 14 species were listed which mostly used in ceremonial customs such as the New Year ceremony (which is called Nowrouz) and the ritual of the Yalda night (the first night of the winter named Yalda night). Four distinctive representatives of this category were *Muscari neglectum*, *Acanthophyllum laxiusculum*, *A. sordidum*, and *Peganum harmala* (Fig. 4). Two different species of *Acanthophyllum* were used for a traditional ceremony of the winter solstice, called "Yalda," as follows: the roots of these species were cleared and boiled two or three times, and the boiled water was thrown away until it had a nice taste. Then, the liquid was poured into a great cauldron called "Teghar," and men shook the liquid with batches of *Tamarix* trees for hours until it gets stiff (Fig. 4 A–B). Finally, the prepared foam is mixed with walnuts, saffron, sugar, or grape juice and served. During the ceremony, people also threw the foam to each other or scrubbed it on the others' faces for fun.

A total of 11 species were placed in the industrial use category with the maximum use in construction. Three examples of highly used plants with industrial applications were *Seidlitzia rosmarinus* used as detergent, *Pistacia atlantica*, whose wood is used to make house doors in Makhunik village (Fig. 4K), and *Onosma longiloba* used for dyeing.

Quantitative analysis

The UV evaluates the potential of using a plant. Therefore, the plants with higher UV values (*Sclerorhachis leptoclada*, *Nepeta saturejoides*, *Scrophularia leucoclada* (0.322), *Ziziphora clinopodioides* subsp. *pseudodasyantha*, *Achillea eriophora* and *Pistacia atlantica*) were proper candidates for phytochemical and pharmacological analyzes (Vitalini *et al*. 2013). However, the plants with higher UV may gradually be prone to extinction due to over-harvesting. Therefore, conservation planning for these groups of species is needed (Chaachouay *et al*. 2019). The lowest UV (0.017) was recorded for some species such as *Artemisia santolina*, *Beta vulgaris*, *Zataria multiflora*, and *Ficus johannis* subsp. *afghanistanica*. Plants with low UV, on the other hand, should not be dismissed because, while UV may be constant in a region, its value will fluctuate due to changes in indigenous people's knowledge of plants from one location to another or within the same area (Amjad *et al*. 2020).

There is a correlation between RFC value and occurrence status of the documented species in the study area. Most of the species with a high value of RFC, were native to the study region and also well-known among the local people. In contrast, the species with lower RFC (such as *Amomum subulatum*, *Cinnamomum verum*, *Lavandula angustifolia*, and *Syzygium aromaticum*) were not among the natural components of the flora of the study region and often imported to this area. Among the recorded ailment categories, digestive system disorders obtained the highest ICF value. The low quality of water in the study region (Naghizadeh *et al*. 2019), could be a contributing factor to the prevalence of stomach issues (Ghaffari *et al*. 2019). High ICF values in specific ailment categories may be due to the high confidence of the local people in the use of medicinal plants regarding these ailment categories. It also shows that the informants share their knowledge about well-known medicinal plants to treat common diseases. Recent ethnobotanical studies have also recorded digestive problems as the most common illnesses (Faruque *et al*. 2018, 2019, Khajoei Nasab & Esmailpour 2019, Mosaddegh *et al*. 2012, Motahhari *et al*. 2022, Murad *et al*. 2013, Panmei *et al*. 2019, Rajaei *et al*. 2012). ICF values represent illnesses in the research area and may serve as the basis for healthcare policies (Savić *et al*. 2019).

A considerable number of documented species obtained a FL value of 100%. In general, plant species with high FL value have great therapeutic potential and can be subjected to further biological, pharmacological, and phytochemical studies to seek new drugs or new plant products (Giday *et al*. 2009, Umair *et al*. 2019). *Apium graveolens* (12.5%), *Pistacia atlantica* (14.28%), and *Fumaria asepala* (15.38%) obtained the lowest FL value. However, future generations should not overlook species with low FL values, as this increases the risk of indigenous knowledge fading away over time (Chaachouay *et al*. 2019).

The degree of species-related similarity between our study and other studies conducted in nearby locations was estimated using JI. The highest degree of similarity was found with the study of the herbal markets in Mashhad (Khorassan-e Razavi province) and the lowest with the study conducted in Khabr and Rouchon (Kerman province) (Mohamadi *et al*. 2015). One of the determinative similarity factors between two regions is distance. Among all compared regions, Mashhad (490 km) has the shortest distance to the study area. Khabar and Rochan (780 km) were the farthest regions. On the other hand, some part of the present study was conducted in herbal markets of Birjand, that corresponds the survey of Mashhad which was also conducted in the herbal markets. Moreover, medicinal plants sold in markets were usually common. For example, *Aloysia citriodora* Palau, *Curcuma longa* L., *Camellia sinensis* (L.) Kuntze, etc. were commonly found in most herbal markets

of East Iran. The mentioned points as well as location in the same floristic (Irano-Turanian) region and cultural similarities contribute to the similarity in traditional medical knowledge and consequently increase the similarity concerning the taxa used for traditional healing in these regions.

Clustering of herbal markets and villages

The analysis of the diversity and similarity among districts revealed that among the 17 herbal markets in the urban areas and surveyed villages around Birjand, the herbal markets clustered in Clade A including Birjand, Bijar, Cheneshet, and Esfahroud villages have higher similarities. It could be said that these areas constitute the core region in which traditional knowledge is preserved, while the traditional knowledge of using plants in areas clustered in Clade B, including the rest of the surveyed areas, is getting forgotten to a greater extent. Moreover, Esfahrud village is close to Birjand city (14 km), and Chenshet village is also a tourist area (see "Study area and Ethnic overview"), which results in the high interaction between these villages and Birjand city.

New reports and new uses

A total of 17 species documented by the present study had not been previously recorded in the ethnobotanical literature of Iran. Some of these species which show high UV value and were mostly used in the study area are described below:

Sclerorhachis leptoclada is locally known as "Mastar" (mæstɑːr), and widely used by local people as medicinal and edible plant. Its aerial parts and the leaves (Fig. 4 I–J) were used for increasing lactation, treatment of digestive disorders, blood purification, headache, body pains, common cold, food poisoning, and treating herpes. Also, fresh and dried leaves of this species were used for preparing foods such as soup and stew (Mohammadi *et al*. 2020).

Nepeta saturejoides (Fig. 4D), locally called "Ostokhodous," is an aromatic and medicinal plant traditionally considered as carminative and used for treating common cold and sinusitis (Emami *et al*. 2017, Hadian *et al*. 2006). Local people utilized *N. saturejoides* as herbal tea and sedative, and also for treatment of mental problems, foot pain, sore throat, anemia, asthma, common cold, kidney stones, cramps, and muscle injuries.

Another well-known species with a broad range of medicinal applications in the study area was *Scrophularia leucoclada* (Fig. 4K–L) which is locally called "Mokhallaseh." The participants believed that this plant eliminates any disease from the human body. The aerial parts of *S. leucoclada* were used for the treatment of foot pain, heartburn, anorexia, hypertension, scorpion, and insect bites, both internally and externally (see Appendix 1). Rajaei and Mohamadi (2012) also reported *S. leucoclada* as "Mokhallaseh" with similar uses for Kerman province. However, "Mokhallaseh" is referred to *S. striata* Boiss. in other regions such as Khorassan-e Razavi province (Amiri & Joharchi 2013b, Motahhari *et al*. 2022), Kerman province (Hosseini *et al*. 2021, Sharafatmandrad & Khosravi Mashizi 2020), Kohghiluyeh va Boyer Ahmad province (Mosaddegh *et al*. 2012) and Ilam province (Pirani et al., unpublished data) (Table 4).

In Birjand, *Ziziphora clinopodioides* subsp. *pseudodasyantha* (Fig. 5H) was frequently used for food, industrial applications, and therapeutic (such as treating a sore throat, headache, or common cold) purposes. Locals called this species "Owshan (A'avisha'n in Persian)," while in other parts of Iran, "A'avisha'n" is referred to *Thymus* species. Given that *Thymus* species were absent in the region, the similarity due to local uses may be the cause of their shared common name. *Ziziphora clinopodioides* subsp. *pseudodasyantha* is collected in large quantities and sold fresh in local markets. Over-harvesting of this plant without proper supervision and planning can lead to a decrease in the population of this species.

Pistacia atlantica with the local name of "Ba'ne" or "Ka'sourg" was another well-known plant in this region. Different parts of this plant such as fruits (Fig. 4F), gum (Fig. 4G), bark, and leaves, were used for various purposes. The wood of *P. atlantica* was used for the construction of houses in ancient times and in manufacturing a special kind of shoes in Makhunik village. Moreover, a popular local food called Qatoq-e Baneh is made with fruits of this species. The fruits of this species are a good source of phenolic compounds and unsaturated fatty acids (Mahjoub *et al*. 2018). Different parts of *P. atlantica* were medicinally used to treat bone fractures, sinusitis, sore throats, toothaches, etc. Recent investigations have shown gastro-duodenal protective, nephroprotective, hepatoprotective, antihyperlipidemic, antidiabetic, and antioxidant effects for *P. atlantica* (Hamelian *et al*. 2020, Mahjoub *et al*. 2018, Mosaddegh *et al*. 2012).

Status of the species

About 19% of used plants in this study were imported plants (such as: *Amomum subulatum* and *Lavandula angustifolia*; Appendix 1) that were brought to this region from other countries or cities. These imported plants were attributed to the

lower RFC values, suggesting that the local population does not place much value on them. Moreover, a significant percentage (50.83%) of the plants used by people in the study area grew wild. The high percentage of wild plants and the lack of limitations on the harvesting of these plants may lead to a decrease in the population of these plants in the region (Motahhari *et al*. 2022). Almost 30% of plants were cultivated and more frequently used for food and medicine (such as *Anethum graveolens* and *Foeniculum vulgare*; Appendix 1). According to estimates from the World Health Organization (WHO), the annual demand for medicinal plants is currently close to 14 billion USD, and by 2050 it will be more than 5 trillion USD (Kala *et al*. 2006). Considering the increase in the world's population, followed by an increase in the demand for plants (especially medicinal plants) and the phenomenon of global warming (which currently is affecting the study region), it is necessary to pay more attention to the cultivation of plants for medicinal and food purposes in the surveyed area.

Conservation status

Based on present results, three endemic species in the study area including *Achillea eriophora*, *Sclerorhachis leptoclada* and *Hymenocrater platystegius* were widely used for medicinal and culinary purposes (Table 2). Therefore, proper conservation programs should be considered for these species. Among the other heavily harvested species with edible use is *Ferula foetida* (see Table 2, Fig. 5 D–F). Despite existing rules that limit the harvesting of *F. foetida*, it is collected in large quantities, and sold in local markets of Birjand. Due to the high nutritional and medicinal value of F. *foetida*, it seems that more effective decisions should be made for its conservation. Another valuable species harvested and sold in large quantities in local markets is *Ziziphora clinopodioides* subsp. *pseudodasyantha* (Table 2). According to the statements of local people and our field observations, populations of this plant have decreased in the area which shows the necessity of including *Z. clinopodioides* subsp. *pseudodasyantha* in conservation plans.

Some medicinal plants may respond to increasing environmental stresses as a result of changes in climate, temperature, and precipitation by reducing the amount of biomass or changes in chemical content, which potentially affects the quality and even the safety of medicinal plant products (Applequist *et al*. 2020). South Khorassan province has been affected by climate changes in recent years. Masoudi *et al*. (2018) reported that from 1989 to 2012, about 76% of the area of South Khorassan province has been affected by drying. They also showed that 69% of the province is under very severe hazard, and 31% of the area is classified under severe hazard, based on the trends of temperature and aridity of De Martonne index. This phenomenon most probably has also led to the change in biomass or chemical content of some medicinal plants in the region.

Conclusions

The present ethnobotanical survey of plant species displayed a rich variety of traditional culture and knowledge in Birjand and its adjunct areas. Despite the hot and dry climate of the region, recent droughts, poor vegetation, and low species richness in this area, a considerable number of plant species (119 species) used by indigenous people were reported for various medicinal, food, beliefs, and industrial purposes. Considering the high average age of the knowledgeable people as well as the positive attitudes of local people towards using medicinal plants in the region, additional ethnobotanical studies in other parts of South Khorassan province should be done to preserve such valuable heritage. Most of the documented species were wild and some were even widely sold in local markets. Thus, excessive harvesting during the growing season could lead to the premature death of the plant. Therefore, it is recommended to educate the local people about the sustainable use of plants.

Several endemic or sub-endemic species such as *Sclerorhachis leptoclada*, *Scrophularia leucoclada*, *Nepeta saturejoides*, *Ziziphora clinopodioides* subsp. *pseudodasyantha*, and *Achillea eriophora* showed maximum UV and RFC values. Unauthorized harvesting of endemic and subendemic species, on the other hand, must be handled in order to prevent them from becoming endangered or extinct. For example, cultivating these plants can help safeguard these widely utilized indigenous medicinal species. Although these species might be an important source of income for people of rural areas in Birjand, they have not been examined for phytochemical, pharmacological, and further clinical practices. Also, screening for biologically active ingredients in offered medicinal plant species with high FL value could be remarkable for future pharmaceutical studies.

Declarations

List of abbreviations: Ap, Aerial Parts; Bk, Bark; Bl, Bulb; Fl, Flower; Fr, Fruit; Gm, Gum; In, Inflorescence; Lt, Latex; Lf, Leaf; Rh, Rhizome; Rt, Root; Sd, Seed; St, Stem; Tb, Tuber; Coo, cooked; Dec, decoction; Inf, infusion; Pow, powder; Pul, pulverize; Smo, smoking; Soa, soaking; Syr, syrup; in, internal; ex, external; Med, medicinal; Ind, industrial; Blv, believed; Cul, cultivated;

Im, imported; W, wild; N_{ur}, the number of used citations in a selected category of diseases; UV, use value; RFC, relative frequency of citations; ICF, informant consensus factor; FL, fidelity level; N_t, the number of species used to treat various diseases of that category; ICF, Informant Consensus Factor; JI, Jaccard index.

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Appendix 1. Plant species used by the local people in Birjand and its adjunct areas. Scientific names and nomenclature follow POWO and IPNI (accessed 7/11/2022). The voucher specimens are deposited at FUMH.

Family / Botanical name	Local name	Part(s) used	Mode of preparation/application	Uses	Status	UV	RFC	FL	Voucher number
Amaranthaceae (including Chenopodiaceae)									
Amaranthus spp.	Taj-Khorous	Ap	"Dec mixed with 77, 15, 60, 64, 69; in"	"Med: women's menstrual disorders"	Cul	0.017	0.01	100	E1219
Atriplex moneta Bunge ex Boiss.	Salmeh-Shoor	Lf	Coo mixed with fried onion and garlic; in	Food (local food)	W	0.017	0.01	-	12317
Beta vulgaris L.	Pokhtouk	Tb	Coo and then dried; in	Food: as nuts	Cul	0.017	0.01	-	12318
Chenopodium album L.	Salmeh	Lf	Coo (alone or mixed with 46, and fried onion & garlic; in	Food (local food)	W	0.017	0.01	-	12321
Dysphania botrys (L.) Mosyakin & Clemants (=*Chenopodium botrys* L.)	Dermaneh Torki	Ap Sd	Dec, Pow, Syr; in Raw; in	Med: bone pain, diarrhea, vomiting, stomachache, **bellyache**, headache, flank pain, food poisoning, bloating, cold, digestive disorders	W	0.153	0.12	43.75	12320
Seidlitzia rosmarinus Bunge ex Boiss.	Alaf-e Shoor	Ap	The ash obtained from burning the plant called "Eshkhar"; ex	Ind: As a detergent for vegetables, hands, head, and clothes	W	0.051	0.05	-	E1208
Amaryllidaceae									
Allium cepa L.	Piaz	Bl	Dec; in Fried or raw; ex	Med: cold and severe coughs, as a poultice for neonatal pneumonia and burns	Cul	0.068	0.03	25	12322
Allium leucosphaerum Aitch. & Baker (=*Allium fibrosum* Rydb.)	Sirmouk	Lf	Coo; in	Food (local food)	W	0.034	0.03	-	12364
Anacardiaceae									
Pistacia atlantica Desf.	Baneh / Kasourg	Bk Fr Lf Gm	Fruit as raw or Coo; in Leaf as Dec, Smo; ex Latex mixed with 90 as Smo; ex Latex as Raw or Dec; in	Food: Qatoq-e-Baneh (local food), pickles, leaf as livestock feed Med: poultice for **bone fractures**, **cold**, sinusitis, sore throats, **toothaches**, burns, bloating, gum infections, internal infections, vaginitis Ind: wood as materials for LILIPUT's houses (doors and roofs) and summer shoes	W	0.271	0.12	14.28	12355
Apiaceae									
Anethum graveolens L.	Showt / Shabit	Lf Sd	Raw (dried); in Pow mixed with rock candy, in	Food: in yogurt and bread Med: **bellyache**, hypertension, hyperlipidemia, instead of tea for	Cul	0.153	0.15	50	12325

Species	Local name	Part	Preparation	Uses	Source				Voucher
			Dec mixed with 12, 14, 20, 100, and 101; in Smo (from the burning of the powdered mixture with 105 on cotton soaked in sheep tallow, kohl is obtained); ex	the woman who gave birth, dyspnea Blv: preparation of kohl					
Apium graveolens L.	Keresm	Lf Sd	Coo; in Raw or Coo; in	Food: leaf in a stew, seed in local bread and soup Med: stomach reflux, diarrhea, bellyache, gastrointestinal disorders, slimming, gout, stomach problems	W	0.186	0.12	12.5	12323
Coriandrum sativum L.	Geshniz	Sd	Raw; in	Food: in bread & pickle Med: hyperlipidemia	Cul	0.068	0.07	100	E1197
Cuminum cyminum L.	Keravieh / Keravie	Sd	Raw (alone or mixed with 14, 20, and rock candy= Sofouf) Dec mixed with 10, 12, 20, 100, and 101; in Coo; in	Food: in soup, rice, and local bread Med: bellyache, diarrhea and vomiting, digestive disorders, bloating, as a brew for the woman who has childbirth	Cul	0.119	0.1	20	E1194
Daucus carota L.	Zardak	Sd	"Dec mixed with 77, 1, 60, 64, 69; in"	"Med: women' menstrual disorders"	Cul	0.017	0.01	100	12324
Elwendia persica (Boiss.) Pimenov & Kljuykov (=*Bunium persicum* (Boiss.) B. Fedtsch	Zire / Zireh-Kouhi / Zire Siah	Sd	Raw (alone or mixed with 14, 20, and rock candy= Sofouf) Dec mixed with 10, 14, 20, 100, and 101; in Coo; in	Food: in bread, soup, and rice Med: **bellyache**, cold, hypertension, digestive problems, dyspnea, as a brew for the woman who has childbirth, anorexia	W	0.220	0.15	40	E1227
Ferula ammoniacum (D. Don) Spalik, M. Panahi, Piwczynski & Puchalka (=*Dorema ammoniacum* D. Don)	Owshik	Gm	Pow; ex	Med: hemorrhoids	W	0.017	0.01	100	E1204
Ferula sp.	Oshtor-e-Qaz	Ap Lt	Raw; in	Food: in bread Med: parasites of digestive system	W	0.017	0.01	100	-
Ferula foetida (Bunge) Regel	Kama	Ap	Coo mixed with fried onion & garlic; in	Food (local food) Med: bloating	W	0.034	0.1	100	-
Ferula gummosa Boiss.	Berije / Barijae / Kamaa	Gm St	Raw; in Smo; ex	Med: cancer, MS, vaginitis, ear infection, wound healing	W	0.068	0.03	25	E1202
Foeniculum vulgare Mill.	Badian	Sd	Raw (alone or mixed with 14, 20, and rock candy= Sofouf) Dec mixed with 10, 12, 14, 100, and 101; in Coo; in	Food: in bread & soup Med: **bellyache** (especially for newborn women and babies), anorexia, digestive disorders, hypertension, dyspnea, as a brew for the woman gave birth	Cul	0.169	0.15	33.33	E1196
Pycnocycla spinosa Decne.	Qalamfour / Ghalamfer	Fl Fr	Dec; in	Med: diarrhea and vomiting	W	0.017	0.01	100	12326

Species	Local name	Part	Preparation	Uses	Source				Code
Trachyspermum ammi (L.) Sprague (= *Trachyspermum copticum* (L.) Link)	Ajgoun/Zenian	Sd	Raw; in Syr; in Smo (from the burning of the powdered mixture with 103, 104, and 105 on cotton soaked in sheep tallow, kohl is obtained); ex	Med: bellyache, stomachache, **stomach reflux**, bloating, hypertension, hyperlipidemia, eye problems Blv: kohl for blackening the eyes of babies and women	W	0.102	0.08	37.5	E1232
Phoenix dactylifera L.	Khorma	Fr	Raw (fresh) mixed with flour, sheep tallow, and 116; ex (as an ointment)	Med: pain	Cul	0.017	0.01	100	-
Asparagaceae									
Muscari neglectum Guss. ex Ten.	Sonbol	In	Raw (fresh)	Blv: instead of hyacinth flowers in Nowrouz (Persian New Year)	W	0.017	0.07	-	-
Asteraceae									
Achillea eriophora DC.	Kalpoureh / Kalpoureh Biabani / Zavolk	Fl Fr	Pow / Syr / Dec; in	Med: **bellyache**, stomachache, diarrhea and vomiting, body pain, diabetes, digestive disorders, foot pain	W	0.271	0.2	65	12315
Achillea wilhelmsii K. Koch)	Gol-e Boumadaran / Gol-e Boumadaroo	Fl Fr	Dec; in Dec (Sifting the decoction of the plant and pour it into a large bowl and sit in it), ex Inf mixed with 71 & 72; in Pow / Soa / Syr; in Coo mixed with soup; in	Med: kidney stone, headache, cold, diarrhea and vomiting, stomach reflux, **bellyache**, flank pain, digestive problems, vaginitis Food: as a drew or in a local food	W	0.220	0.2	46.15	12314
Anthemis rhodocentra Iranshahr	Gol-e-Mamiran	Ap	Inf / Coo; in	Med: stomach reflux, bellyache, diarrhea, and vomiting Food: in soup	W	0.051	0.03	50	12305
Artemisia aucheri Boiss.	Terekh-e Kouhi	Ap	Inf / Dec / Syr / Pow; in Raw (mashed fresh plant); ex	Med: **bellyache**, stomach reflux, stomach disorders, diarrhea & vomiting, digestive problems, neonatal body pain (due to diarrhea and vomiting), for a woman who has childbirth Ind: preparation of perfume	W	0.169	0.13	41.66	12304
Artemisia santolina Schrenk	Terekh	Ap	Dec; in	Med: pains	W	0.017	0.01	100	12312
Artemisia sieberi Besser	Terekh-e Biabani	Ap	Raw (fresh / dried); in	Med: stomach reflux Ind: as material for the roof of the houses with straw & mud	W	0.034	0.03	100	12302
Cichorium intybus L.	Kashneh	Fl Rt	Dec / Syr; in	Med: fever, fatty liver, blood purification	W	0.051	0.05	25	12311

Scientific name	Local name	Part	Preparation	Uses	Source				
Cousinia eryngioides Boiss.	Jaj	Fl St	Raw (fresh: the inner part of the stem and flower of the plant after peeling); in	Food Med: iron deficiency anemia	W	0.051	0.05	50	-
Pulicaria gnaphalodes (Vent.) Boiss.	Gol-e Bou, Gol-e Araqi / Ga'nde Bou / Gol e Za'rdo / Gol e Zardan / Alaf Lashouk	Fl Fr	Inf / Syr; in Dec (alone or mixed with 109); in	Med: **bellyache**, diabetes, stomach reflux, stomach disorders, diarrhea & vomiting, <u>food poisoning</u>, foot pain, women's menstrual disorders, digestive problems Food: in soup	W	0.254	0.2	26.66	12306
Scorzonera paradoxa Fisch. & C.A. Mey. ex DC.	Naqoudeshk	Lf	Raw (fresh); in Coo; in	Food (local food)	W	0.034	0.03	-	12310
Sclerorhachis leptoclada Rech. f.	Mastar	Fl Lf	Inf mixed with 92, 119, and tea; in Raw (as fresh is more effective); in Dec / Syr; in Pow; ex Coo; in	Med: bellyache, sore throat, body pain, headache, anorexia, cough, stomach problems, galactagogue, <u>heat exhaustion</u>, nausea, **diarrhea & vomiting**, blood purification, cold, stomach reflux, <u>food poisoning</u>, digestive problems Food (local food)	W	0.525	0.4	21	12309
Tragopogon gaudanicus Boriss.	Panbeh-Qouk	Fl Lf	Raw (fresh); in	Food	W	0.034	0.03	-	12363
Tripleurospermum disciforme (C.A.Mey.) S ch.Bip.	Babouneh	Fl	Inf; in	Med: stomach reflux	Im	0.017	0.01	100	E1230
Berberidaceae									
Berberis integerrima Bunge	Zereshk-e Danedar / Zereshk-e Kouhi	Fr Rt	Inf mixed with 39, 81, 113, and 114); in Dec of a large number of roots for a long time; in	Med: digestive disorders, stomach problems, <u>diabetes</u>, foot pain, hypertension, <u>hyperlipidemia</u> Food: jam	W	0.102	0.07	20	E1192
Berberis integerrima var. *asperma*	Zereshk	Fr	Dec; in Raw (fresh / dried); in	Med: bellyache, **hypertension**, blood purification Food: to garnish on cooked rice or as jam	Cul	0.102	0.07	50	E1199
Boraginaceae									
Onosma longiloba Bunge	Hava Choubeh	Rt St	Pul mixed with oil; ex	Med: bone fracture Ind: dyeing	Im	0.034	0.03	100	E1190
Paracaryum rugulosum (DC.) Boiss.	Cheshm-e Gorg	Fr	Raw (fresh); in	Food	W	0.034	0.03	-	12341
Brassicaceae									
Brassica rapa L.	Qalieh, Shalqam	Tb	Raw / Coo; in	Food: as nuts, in soup, and livestock feed	Cul	0.017	0.01	-	-

Crambe cordifolia subsp. *kotschyana* (Boiss.) Jafri	Tateroun	Lf Rt	Raw; in Coo (soaking of roots for a week, then boil it twice and wash it by "Eshkhar" to be soften, and finally cook it.	Food: leaf as livestock feed, cooked roots are mixed with yogurt Ind: roots as fattening livestock	W	0.068	0.03	-	12336
Descurainia Sophia (L.) Webb ex Prantl	Khakshir	Sd	Soa; in	Med: heatstroke, **heart problems**, constipation, vomiting Food: in the syrup	W	0.085	0.05	33.33	E1223
*Eruca vesicaria (L.) Cav.	Mandab	Sd	Oil / Soa	Ind: preparation of oil Blv: the germinated seeds of the plant are used as greenery during Nowrouz	Im	0.017	0.01	-	E1212
Lepidium draba L. (=*Cardaria draba* (L.) Desv.)	Bejend	Lf	Coo (after washing the leaves with "Eshkhar", cooked with 4, and then fried with garlic and onion); in	Food (local food)	W	0.017	0.01	-	12337
Lepidium sativum L.	Taretizak	Lf	Raw (fresh); in	Food: as a vegetable	W	0.017	0.01	-	-
Raphanus sativus var. *niger* (Mill.) J. Kern.	Torob-e Qahveie	Tb	Raw (fresh); in	Med: stomachache, kidney disease	Cul	0.034	0.01	50	-
Cannabaceae									
*Cannabis sativa L.	Shahdaneh	Sd	Coo with salt	Food: as nuts	Im	0.017	0.03	-	E1216
Caryophyllaceae									
Acanthophyllum laxiusculum Schiman-Czeika	Bikh / Choubak / Kaf / Roushouyeh / S'arshouyeh	Rh	Dec (of the inner part of the rhizome, then shaked by 112 for a long time until it looks like foam; alone or mixed with walnuts, saffron, sugar, or grape juice for Yalda celebration); in / ex	Food: as a winter ice cream Blv: one of the rituals of Yalda night is the foaming ceremony	W	0.034	0.1	-	12301
Acanthophyllum sordidum Bunge ex Boiss.	Bikh, Choubak	Rh	Dec (of the inner part of the rhizome, then shaked by 112 for a long time until it looks like foam; alone or mixed with walnuts, saffron, sugar, or grape juice for Yalda celebration); in / ex	Food: as a winter ice cream Blv: one of the rituals of Yalda night is the foaming ceremony	W	0.034	0.1	-	E1203
Cucurbitaceae Juss.									
Citrullus colocynthis (L.) Schrad.	Hendevaneh-Aboujahl	Sd	Raw (2 seeds per night); in	Med: bone pain, diabetes, anorexia Food (local food)	Cul	0.051	0.03	33.33	E1231
Citrullus lanatus (Thunb.) Matsum. & Nakai	Hendevaneh	Fr	Dec; in	Med: kidney stone	Cul	0.017	0.01	100	-

Elaeagnaceae									
Elaeagnus angustifolia L.	Senjed	Fr Lt	Raw; in Pow; ex	Med: strengthen bones, foot pain, foot cracks	Cul	0.068	0.07	33.33	12329
Fabaceae									
Alhagi maurorum Medik. (=*Alhagi persarum* Boiss. & Buhse)	Khar-e Angabin	Gm	Soa; in Inf; ex	Med: dyspnea, diarrhea & vomiting, heartburn, neonatal jaundice, insomnia	W	0.051	0.03	20	E1187
Alhagi pseudalhagi (M. Bieb.) Desv. ex Wangerin	Gol-e Khar	Fl	Inf; in	Med: kidney stone	W	0.017	0.01	100	12343
Astragalus goreanus Aitch. & Baker	Shakh-e Gav / Abrou Kamaan	Fr	Dec (for a long time); in	Med: prostate, strengthen of bone marrow, iron deficiency anemia	W	0.051	0.05	50	-
Astragalus hamosus L.	Nakhonak / Shakh-e Gav	Fr	-	Med: <u>MS, Parkinson's</u>, cold	Im	0.034	0.01	33.33	E1189
Medicago sativa L.	Spest	Lf	Raw (fresh); in	Med: diabetes	Cul	0.017	0.01	100	12344
Trigonella foenum-graecum L.	Shalmideh	Lf Sd	Coo; in "Dec mixed with 77, 15, 1, 64, 69; in"	Med: **"women' menstrual disorders"**, anorexia Food: in soup, stew, and local food	Cul	0.085	0.07	66.66	E1209
Fagaceae									
*Quercus sp.	Mazou	Lt	Raw; ex	Med: tooth infection	Im	0.017	0.01	100	-
Iridaceae									
Crocus sativus L.	Zaferan	Fl	Inf; in / ex	Food: as a flavor and food coloring Ind: in ancient times, it was used to mark the book of the Qur'an and prayers	Cul	0.017	0.03	-	E1221
Ixioliriaceae									
Ixiolirion tataricum (Pall.) Schult. & Schult.f.	Khiar-e Kouhi	Fl	Fresh	Food	W	0.017	0.01	-	12361
Juglandaceae									
Juglans regia L.	Jowz	In Lf	"Dec mixed with 77, 15, 1, 60, 69; in" Syr; in Coo; in	Med: **"women' menstrual disorders"**, constipation, anorexia, diabetes Food (local food)	Cul	0.102	0.1	50	E1211
Lamiaceae									
Hymenocrater calycinus (Boiss.) Benth.	Gol-e Armoune	Fl	Dec / Inf / Syr; in	Med: **hard diarrhea & vomiting** (followed by herpes), body pain, sedative, infection, fever, headache, dyspnea, cold, digestive problems	W	0.136	0.08	20	-
Hymenocrater elegans Bunge)	Gol-e Armoune	Fl	Dec / Inf / Syr; in	Med: diarrhea & vomiting, body pain, **sedative**, fever	W	0.034	0.01	25	E1201
Hymenocrater platystegius Rech. f.	Gol-e Armoune	Fl	Dec / Inf / Syr; in	Med: infection, headache, dyspnea, **cold**, digestive problems	W	0.034	0.01	20	E1201

Species	Local name	Part	Preparation	Use						Voucher
Lavandula angustifolia Mill.	Ostekhodous-e Badali	In	Inf; in	Med: as sedative	Im	0.017	0.01	100		E1181
Mentha longifolia (L.) L.	Pedine	Rt Sd	"Dec mixed with 77, 15, 1, 64, 60; in" Coo / Inf; in	Med: "women' menstrual disorders" Food: in soup, bread or as herbal Tea	W	0.051	0.05	100		12350
Mentha × piperita L.	Nanae	Lf St	Dec (of syrup mixed with 95 on low flame for a few minutes); in Dec of the stem; in	Med: for most digestive problems (bloating, stomach reflux, bellyache)	Cul	0.017	0.01	33.33		E1222
Nepeta bracteata Benth.	Gol-e Zoufa	Fl	Inf; in Dec (alone or mixed with 26, 72, 102, and 109); in	Med: **cold**, body infections, sedative, expectorant, dysphonia, asthma, bellyache, anorexia, heart problems, foot pain Food: as herbal tea	W	0.220	0.15	33.33		12351
Nepeta saturejoides Boiss.	Ostokhodous-e-Mahali	Ap	Inf; in Dec (alone or mixed with 71 & 102); in	Med: **sedative**, mental and psychological problems, foot pain, sore throat, anemia, asthma, cold, kidney stones, cramps, and muscle injury Food: as herbal tea	W	0.322	0.24	44.44		12346
Zataria multiflora Boiss.	Avishan-e Tabasi	Lf	Inf / Syr; in	Med: cold, digestive problems	Im	0.017	0.01	100		E1215
Ziziphora clinopodioides subsp. *pseudodasyantha* (Rech.f.) Rech.f.	Owshan	Ap Lf	Inf; in / ex Dec (alone or mixed with 100 & 102); in Raw (as dried mixed with yogurt)	Med: sore throat, headache, **cold** Food: leaf in yogurt Ind: as disinfection of poultry environment	W	0.305	0.22	78.57		12349
Ziziphora tenuior L.	Kakouti / Kakouti-e Mahali	Ap Lf	Raw (as dried alone or mixed with tea & yogurt) / Coo mixed with Qorout-Birjandi / Dec; in	Med: foot pain, bellyache, food poisoning, cooling nature Food: powdered leaf mixed with tea, yogurt, and local food	W	0.136	0.12	25		12354
Lauraceae										
Cinnamomum verum J.Presl	Darchin	Bk	Soa in water; ex	Med: disinfectant of wounds, knee pain	Im	0.017	0.01	100		E1226
Liliaceae										
Tulipa lehmanniana Merckl.	Laleh	Fl	Dec mixed with 1, 15, 60, 64, 69; in	Med: women's menstrual disorders	Im	0.017	0.01	100		E1213
Tulipa undulatifolia var. *micheliana* (Hoog) Wilford	Laleh	Bl	Raw (fresh); in	Food	Im	0.017	0.01	-		12345
Lythraceae										
Lawsonia inermis L.	Hanna	Lf	Soa mixed with 92; ex	Med: cooling nature, foot pain, hand pain, edema of an area of the body	Im	0.068	0.07	25		-
Malvaceae										
Alcea sp.	Khatmi	Fl	Dec; in Soa; ex (anal)	Med: constipation when the livestock eats inappropriate food	Cul	0.034	0.03	100		12358

Hibiscus sabdariffa L.	Chai-e Torsh	Fl	Inf mixed with 38, 39, 113, and 114); in	Med: hypertension, hyperlipidemia	Im	0.034	0.01	50	E1184
Malva neglecta Wallr.	Nan-e Kalaq / Panje Kalaq	Fr	Dec; in Smo; ex	Med: expectorant, foot pain	W	0.034	0.03	50	-
Malva sylvestris L.	Gol-e Banafshouk	Fl	Dec / Inf; in	Med: dysphonia, expectorant, cold	W	0.034	0.03	50	E1206
Tilia sp.	Zirfoun	Fr Lf	Inf for a long time; in	Med: hypertension, sedative, stomach problems	Im	0.051	0.01	33.33	-
Moraceae									
Ficus carica L.	Anjir	Fr Lt	Raw; in Raw (fresh); ex	Med: wart Food	Cul	0.017	0.01	100	-
Ficus johannis subsp. *afghanistanica* (Warb.) Browicz	Anjir-e Kouhi	Fr	Raw (fresh); in	Food	W	0.017	0.01	-	12356
Morus alba L.	Toot	Fr	Raw (fresh); in	Food	Cul	0.017	0.01	-	-
Morus nigra L.	Shatoot	Fr	Raw (fresh); in	Food	Cul	0.017	0.01	-	-
Myrtaceae									
Syzygium aromaticum (L.) Merr. & L.M. Perry	Qalamfour	Fl	Raw (dried); ex Inf mixed with tea; in	Med: toothache Food: as an herbal tea	Im	0.034	0.01	100	E1195
Nitrariaceae									
Peganum harmala L.	Espand	Fr Sd	Raw; in Smo; ex	Med: stomach problems Blv: as a home disinfectant, and home decoration	W	0.051	0.05	100	12330
Paeoniaceae									
Paeonia sp.	Oud-Salim	Rt	Raw (dried); ex Dec; in	Med: stomach problems Blv: a neonatal toothpick	Im	0.017	0.01	100	-
Papaveraceae									
Fumaria asepala Boiss.	Shahtareh	Ap	Inf (alone or mixed with 35 & 119) / Dec / Syr; in Soa (alone or mixed with 79); ex	Med: fever, bellyache, **cold, diarrhea & vomiting, diabetes**, fatty liver, cooling nature, foot pain, hand pain, edema of an area of the body	W	0.153	0.13	15.38	12338
Papaver somniferum L.	Teryak	Lt Sd	Smo; ex Raw; in	Med: bone formation (due to high calcium), body cramps, burn wounds Food: on the bread	Cul	0.068	0.03	33.33	E1183
Roemeria sp.	Shaqayeq	Fl	Raw (as freshly mixed with rabbit hair); ex	Med: wounds and burns healing	W	0.017	0.01	50	-
Plantaginaceae									
Plantago major L.	Bortang / Barhang	Sd	Dec (of syrup mixed with 70 on low flame for a few minutes); in Raw (mixed with yogurt); in	Med: dyspnea, cold, most digestive problems (bloating, stomach reflux), children's diarrhea	Cul	0.051	0.03	20	12359
Poaceae									

Species	Local name	Part	Preparation	Use	Status				Voucher
Triticum aestivum L.	Gandom	Sd	Pow mixed with 23, 116, and sheep tallow as a poultice; ex Pow mixed with yeast & oil as a poultice; ex "Dec (the mucilage from boiling it as a poultice); ex" Coo; in	Med: **body pain**, "bone or joint dislocation", anorexia Food (local food)	Cul	0.068	0.07	50	E1201
Polygonaceae									
Rheum iranshahrii Taheri & Assadi	Rivas	Lf	Raw (fresh); in	Food	W	0.017	0.01	-	-
Portulacaceae									
Portulaca oleracea L.	Kholfeh	Ap	Coo mixed with yogurt or in food; in Raw (fresh mixed with 13 & carrot as a pickle); in	Food: in yogurt, local food, and pickle	W	0.017	0.03	-	-
Ranunculaceae									
Nigella sativa L.	Siah Daneh	Sd	Raw; ex (oil)	Med: foot pain, back pain, hair strengthening	Im	0.034	0.01	33.33	E1200
Rhamnaceae									
Ziziphus jujuba Mill.	Annab	Fr Lf	Raw (fresh / dried); in Dec (alone or mixed with 11, 12, 20, 74, 101, and 102); in	Med: **hypertension**, hyperlipidemia, blood purification, dyspnea, **cold**, liver problems, leaf for the diarrhea of livestock Food: the fruit as nuts	Cul	0.136	0.1	22.22	12357
Rosaceae									
Cydonia oblonga Mill.	Beh	Sd	Dec mixed with 71, 72, 74, and 100; in	Med: dyspnea, cold	Cul	0.034	0.03	50	-
Prunus amygdalus Batsch (= *Amygdalus communis* L.)	Badam	Sd	Dec mixed with 11, 12, 20, and 100); in	Med: asthma	Cul	0.017	0.01	100	12334
Prunus armeniaca L.	Zard Alou	Sd	Smo (from the burning of the powdered mixture with 22, 106, 104, and 105 on cotton soaked in sheep tallow, kohl is obtained); ex	Med: eye problems Blv: kohl for blackening the eyes of babies and women	Cul	0.051	0.03	100	E1217
Prunus cerasus L.	Albalou	Sd	Smo (from the burning of the powdered mixture with 22, 106, 103, and 105 on cotton soaked in sheep tallow, kohl is obtained); ex	Med: eye problems Blv: kohl for blackening the eyes of babies and women	Cul	0.034	0.01	100	E1217
Prunus persica (L.) Batsch	Shaftalou	Sd	Smo (from the burning of the powdered mixture with 22, 106, 103, and 104 on cotton soaked in sheep tallow, kohl is obtained); ex	Med: eye problems Blv: kohl for blackening the eyes of babies and women	Cul	0.068	0.05	100	E1217

Prunus scoparia (Spach) C.K. Schneid (=*Amygdalus scoparia* Spach)	Badoumeshk / Dak	Sd St	Raw (dried or in the form of oil); in Dec of fruit, peeling and soaking in water for 3 days, then it is salted and dried; in Smo (from the burning of the powdered mixture with 22, 103, and 105 on cotton soaked in sheep tallow, kohl is obtained); ex	Med: **foot pain**, hypertension, eye problems Blv: kohl for blackening the eyes of babies and women Ind: basket weaving, plant shrubs as roofing materials for houses Food: seed as nuts	W	0.153	0.08	60	12335, E1217
Rosa × damascena Herrm.	Gol-e Sadbarg	Fl	Dec; in Inf mixed with tea; in Raw (dried) mixed with yogurt; in	Med: women's menstrual disorders Food: as flavor, herbal tea	Cul	0.051	0.05	100	E1229
Rubiaceae									
Rubia tinctorum L.	Roudang	Fr Rt	Dec or Soa of fruit or root powder "Pow of fruit mixed with egg yolks, then as poultice placed at the fracture bone site and covered with cardboard, wood, and a kind of cloth); ex"	"Med: bone fracture" Ind: yarn dyeing Blv: hair dyeing	W	0.034	0.03	100	12340
Scrophulariaceae									
Scrophularia leucoclada Bunge	Mokhallaseh	Ap	Dec (alone or mixed with 33 & 71); in / ex Inf / Syr; in	Med: galactagogue, fever, internal infection (specially vaginitis), diarrhea & vomiting, **foot pain**, back pain, bone pain, heartburn, stomach problems, anorexia, hypertension, digestive disorders, heart disorder, scorpion, and insect bites	W	0.322	0.25	13.63	12331
Solanaceae									
Solanum nigrum L.	Spakhangour	Fr Lf	Raw (fresh or dried); ex	Med: tooth infection, abscess	W	0.034	0.03	50	12360
Solanum tuberosum L.	Sibzamini	Tb	Raw (fresh as grated); ex	Med: temporary ointment for burn wounds	Cul	0.017	0.01	100	-
Tamaricaceae									
Tamarix spp.	Gaz	St	Raw (dried)	Blv: to stir the foam obtained from the *Acanthophyllum* spp.	W	0.017	0.1	-	12354
Theaceae									
Camellia sinensis (L.) Kuntze	Chai Sabz	Lf	Inf mixed with 38, 39, 81, and 114); in	Med: hypertension, hyperlipidemia	Im	0.034	0.01	50	E1191
Verbenaceae									
Aloysia citriodora Palau (= *Lippia citriodora* (Palau) Kunth)	Beh Limou	Lf	Inf mixed with 38, 39, 81, and 113); in	Med: hypertension, hyperlipidemia	Im	0.034	0.01	50	E1207
Zingiberaceae									
Amomum subulatum Roxb.	Hel-e Baad	Fr	Inf; in	Med: for the woman who gave birth	Im	0.017	0.01	100	E1225

		Sd							
Curcuma longa L.	Zardchoubeh	Rh	Pow mixed with flour, sheep tallow, and 23; ex	Med: as an ointment for muscle pain and injury	Im	0.034	0.03	50	E1228
Curcuma aromatica Salisb. (= *Curcuma zedoaria* Roscoe)	Jadva	Rh	Raw (dried); in Pow (alone or mixed with tea)	Med: diarrhea & vomiting, stomach reflux	Im	0.034	0.03	33.33	E1188
Elettaria cardamomum (L.) Maton	Hel	Sd	Raw (dried); in	Med: bellyache	Im	0.034	0.03	100	E1224
Zygophyllaceae									
Tribulus terrestris L.	Khar-e 3-payakh/Khar Spakh / Kharousk	Ap Fr	Dec (alone or mixed with 100); in Inf (mixed with 35 & 92); in	Med: bellyache, stomach reflux, liver problems, hyperlipidemia, **diarrhea & vomiting, kidney stone**	W	0.119	0.08	25	E1186

Part(s) Used: Ap: Aerial Parts, Bk: Bark, Bl: Bulb, Fl: Flower, Fr: Fruit Gm: Gum, In: Inflorescence, Lt: Latex, Lf: Leaf, Rh: Rhizome, Rt: Root, Sd: Seed, St: Stem, Tb: Tuber. **Mode of preparation**: Coo: cooked, Dec: decoction, Inf: infusion, Pow: powder; Pul: pulverize, Smo: smoking, Soa: soaking, Syr: syrup. **Mode of Administration**: in: internal; ex: external. **Uses:** Med: medicinal, Ind: industrial, Blv: believed. **Status:** Cul: cultivated, Im: imported, W: wild. The particular ailment treated by a species with the highest value of FL is written in **Bold**. The imported plants, only mentioned by Attars, are marked with an asterisk. Plant uses mentioned only by Attars are underlined. Plant uses mentioned only by local traditional healer are characterized with quotation marks.

Appendix 2. Comparison of new reports and new therapeutic uses recorded in the present and previous studies. **Uses**: Med: medicinal, Ind: industrial, Blv: believe. The new reports are in **bold**.

Botanical name	New reports / New uses	Previously reported uses	References
Acanthophyllum laxiusculum	Food: as a winter ice cream Blv: one of the rituals of Yalda night is the foaming ceremony		
Amomum subulatum	Med: for the woman who gave birth	Carminative, flavoring, treatment of colic	(Amiri and Joharchi, 2013b)
Anthemis rhodocentra	Med: stomach reflux, bellyache, diarrhea, and vomiting Food: in soup	Sedative, improving digestion, stomach ulcers and gastritis treatment, diuretic and regularizing	(Kiasi et al., 2020)
Artemisia aucheri	Med: bellyache, stomach reflux, stomach disorders, diarrhea & vomiting, digestive problems, neonatal body pain (due to diarrhea and vomiting), for a woman who has childbirth Ind: preparation of perfume	Anti-cough / Abdominal pain / Anti-angel, abdominal parasites, disinfectant	(Khajoei Nasab et al., 2014; Azizi and Keshavarzi, 2015; Sharafatmandrad and Khosravi Mashizi, 2020)
Artemisia santolina	Med: pains		
Astragalus goreanus	Med: prostate, strengthen of bone marrow, iron deficiency anemia		
Atriplex moneta	Food (local food)		
Beta vulgaris	Food: as nuts	Hemorrhoids and constipation	(Azizi and Keshavarzi, 2015)
Chenopodium album	Food (local food)	Laxative	(Mozaffari Nejad et al., 2018)
Cousinia eryngioides	Food Med: iron deficiency anemia		
Crambe cordifolia subsp. *kotschyana*	Food: leaf as livestock feed, cooked roots are mixed with yogurt Ind: roots as fattening livestock		
Crocus sativus L.	Food: as a flavor and food coloring Ind: in ancient times, it was used to mark the book of the Qur'an and prayers	Refrigerant, heart tonic	(Mozaffari Nejad et al., 2018)
Dysphania botrys (=*Chenopodium botrys*)	Med: bone pain, diarrhea, vomiting, stomachache, bellyache, headache, flank pain, food poisoning, bloating, cold, digestive disorders	Beauty of skin and hair	(Hosseini et al., 2021)
Eruca sativa	Ind: preparation of oil Blv: the germinated seeds of the plant are used as greenery during Nowrouz	Sedative, laxative diuretic, stomach tonic	(Amiri and Joharchi, 2013b)
Ferula ammoniacum (=*Dorema ammoniacum*)	Med: hemorrhoids	Scorch, foot pain, stomachache, abortion, fever, skin infections, burn / Disinfectant, edible, infectious wound healing / Toothache, allergy, abscess, kidney pain, dropsy, wound,	(Sadeghi et al., 2014; Maleki and Akhani, 2018; Hosseini et al., 2021)

		gastrointestinal parasitic, skin infection, burns	
Hymenocrater elegans	Med: diarrhea & vomiting, body pain, sedative, fever	Hypnotic, antistress, sedative	(Nadaf et al., 2019)
Hymenocrater platystegius	Med: infection, headache, dyspnea, cold, digestive problems		
Muscari neglectum	Blv: instead of hyacinth flowers in Nowrouz (Persian New Year)		
Nepeta satureioides	Med: sedative, mental and psychological problems, foot pain, sore throat, anemia, asthma, cold, kidney stones, cramps, and muscle injury Food: as herbal tea		
Onosma longiloba	Med: bone fracture Ind: dyeing		
Paracaryum rugulosum	Food		
Phoenix dactylifera	Med: Raw (fresh) mixed with flour, sheep tallow, and *Curcuma longa* L.; ex (as an ointment)	Diabetes / Improvement of male fertility / Kidney stones, anemia, cancer	(Sadeghi et al., 2014; Hosseini et al., 2021; Motahhari et al., 2022)
Pistacia atlantica	Food: Qatoq-e-Baneh (local food), pickle, leaf as livestock feed, Med: poultice for bone fractures, cold, sinusitis, sore throats, toothaches, burns, bloating, gum infections, internal infections, vaginitis Ind: wood as materials for LILIPUT's houses (doors and roofs) and summer shoes	Stomach ulcers and stomach pain / Cough, bone and joint pains	(Azizi and Keshavarzi, 2015; Sadat-Hosseini et al., 2017)
Portulaca oleracea	Food: in yogurt, local food, and pickle	Stomach tonic, reducing thirst, febrifuge, cough, blood purifier / Cholagogue, diuretic, laxative, hypercholesterolemia / Skin	(Moein et al., 2014; Mosaddegh et al., 2016; Hosseini et al., 2021)
Prunus armeniaca	Med: eye problems Blv: kohl for blackening the eyes of babies and women		
Prunus cerasus.	Med: eye problems Blv: kohl for blackening the eyes of babies and women	Kidney stone	(Hosseini et al., 2021)
Prunus persica	Med: eye problems Blv: kohl for blackening the eyes of babies and women	Laxative	(Hosseini et al., 2021)
Prunus scoparia (=*Amygdalus scoparia*)	Med: foot pain, hypertension, eye problems Blv: kohl for blackening the eyes of babies and women, Ind: basket weaving, plant shrubs as roofing materials for houses Food: seed as nuts	Anti-dandruff, preventing of hair loss, earache, health and beauty of the skin, cancer prevention, burned wound healing / Snake bites, branches for making baskets / Hair Loss	(Mosaddegh et al., 2012; Mohamadi et al., 2015; Hosseini et al., 2021)
Pycnocycla spinosa	Med: diarrhea and vomiting	Scorpion bite	(Hosseini et al., 2021)

Sclerorhachis leptoclada	Med: bellyache, sore throat, body pain, headache, anorexia, cough, stomach problems, galactagogue, heat exhaustion, nausea, diarrhea & vomiting, blood purification, cold, stomach reflux, food poisoning, digestive problems Food (local food)		
Scrophularia leucoclada	Med: galactagogue, fever, internal infection (specially vaginitis), diarrhea & vomiting, foot pain, back pain, bone pain, heartburn, stomach problems, anorexia, hypertension, digestive disorders, heart disorder, scorpion, and insect bites		
Trachyspermum ammi (= *Trachyspermum copticum*)	Med: bellyache, stomachache, stomach reflux, bloating, hypertension, hyperlipidemia, eye problems Blv: kohl for blackening the eyes of babies and women	Stomachache / Stomachache, carminative	(Khajoei Nasab et al., 2014; Hosseini et al., 2021)
Tragopogon gaudanicus	Food		
Tulipa lehmanniana	Med: women's menstrual disorders		
Tulipa undulatifolia var. *micheliana*	Food		
Ziziphora clinopodioides subsp. *pseudodasyantha*	Ind: as disinfection of poultry environment	Sedative, carminative, food digestion / Its herbal tea is useful for lowering of blood sugar and is also useful for flatulence and peptic problems. It is appetizing and can be used as body tonic / Sedative	(Ghorbani, 2005; Sadat-Hosseini et al., 2017; Moghanloo et al., 2019)

Appendix 3. Non-plant substances and their application as folk remedies.

Local name	English name	Nature	Origin	Local Uses
Zomeh (/zɔɪme/)	Alum	Crystal stone	Mineral	to treat tooth infections, and to lighten the color of the rice grain
Momenaei (/mɔɪmenɑːjiː)	-	Extract	Mineral or organic	to treat bone fractures, back and foot pain
Somarouq (/sɔɪmɑːrɔɪk/)	-	Mushroom	Organic	used as food
Rabbit hair	Rabbit hair	Animal	Organic	to treat burns and wounds