Traditional knowledge and use of wild edible plants in Sidi Bennour region (Central Morocco)

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Ethnobotany Research and Applications 23:11 (2022)

Research

Abstract

Background: This study aimed to protect the knowledge related to the traditional uses of wild plant resources which constituted untapped potential as dietary supplements and therapeutic products

Methods: An ethnobotanical survey based on the Semi-Structured Interview method was carried out among the Sidi Bennour region from February 2019 to February 2020.

Results: The results showed that a total of 56 plant species representing 56 genera and 27 families were used to make different food dishes and in the treatment of various diseases. The most cited wild edible plants (WEPs) families were Asteraceae (16%). The leaves (38%) and stems (32%) were the most parts commonly used in food. Four utilization categories were cited, vegetables, for seasoning, as a drink, and Other (plants used to decorate or flavor traditional dishes). The use of these WEPs as vegetables was the most cited mode of consumption (37.5%) by the local population. The leaves were the most commonly used part (35%) for medicinal uses of WEPs. Decoction (27.27%) was the most common method of preparing traditional medicines. The majority of preparations were administered orally (80.25%). The study results showed also that local people have sufficient information on the safe use of WEPs.

Conclusions: The present study demonstrated that the people of the Sidi Bennour region, hold rich traditional knowledge of a large number of WEPs, however, the study population underlined the sharp decline in the consumption of most of the species recorded consequently the detailed documentation may effectively prevent knowledge loss through time.

Keywords: ethnobotanical survey, Wild edible plants, relative frequency index of citation, phytotherapy, ***beqoula***, Sidi Bennour, Morocco

Background

Wild Edible Plants (WEP) are defined as plant species that are neither cultivated nor managed, but accessible from various natural types of natural vegetation and used as food (Bhatia *et al.* 2018), These plants have always been an important part of the human diet and were the basis of preserving human survival for thousands of years before

Manuscript received: 01/09/2021 – Revised manuscript received: 31/01/2022 - Published: 10/02/2022
http://dx.doi.org/10.32859/era.23.11.1-18

the development of agriculture. With the development of agricultural methods, the process of domestication of some of these plants began to produce sufficient amounts of food throughout the year instead of being limited to seasons and climatic conditions. The status of WEPs began to decline with the current dependence of the agricultural system on productive crops, causing a sharp decline in varieties and the level of agricultural diversification.

Morocco benefits from one of the richest plant diversities in the Mediterranean basin (Nassif & Tanji 2013), because of its exceptional position, with the Mediterranean Sea in the north, the Atlantic Ocean in the west, and the Sahara Desert in the south and east. Wild Edible Plants are part of this diversity. In Morocco, the tradition of using WEPs continues to be part of the dietary habits of local populations, particularly those in rural areas (Aboukhalaf et al, 2020). Most ethnobotanical studies in Morocco focus on medicinal and aromatic plants. By contrast, ethnobotanical research on WEPs has been somewhat neglected with only a few reports documenting the traditional use of these plants, (Hmamouchi 1997, Nassif & Tanji 2013, Powel et al 2014, Tbatou *et al.* 2016a, Tbatou *et al.* 2016b). hence the need for further systematic studies to collect data in this regard. In addition, WEPs are an alternative source of income for many populations (Bhatia *et al.* 2018, Samant & Dhar 1997, Shrestha & Dhillion 2006). They could play an important role in food insecurity. They can be used to fight against malnutrition given their high content in nutrients and vitamins (Burlingame 2000, Glew *et al.* 2005, Sarfo *et al.* 2020). Indeed, the fact that WEPs are rich sources of bioactive molecules is now argued (Aboukhalaf *et al.* 2020, Morales *et al.* 2014). In addition, these plants are valuable genetic resources that can be used for the development of new crop species (Shrestha & Dhillion 2006).

However, the tradition of using WEPs and the associated knowledge decline with urbanization, modernization of traditions, industrialization, the temptation of fast food, deforestation, and the lack of interest in the young generation, etc. (Bhatia *et al.* 2014, Bhatia *et al.* 2018, Łuczaj *et al.* 2013, Tbatou *et al.* 2016b), It is therefore essential to document this valuable traditional knowledge before it is lost. This study aims to report the various wild edible plants of the Sidi Bennour region and the traditional practices related to their use, to evaluate and compare the cultural importance of these plants in the local population and, finally to assess and compare the trend of exploitation of these plants in the study area.

Materials and Methods

Study area

Morocco, bounded by the Atlantic Ocean to the west and the Province of El-Jadida in the northwest (DRACS 2018). The province climate is semi-arid, with a humid temperate winter and generally hot and dry summer (HCP 2014), The dominant soil types are Vertisols (30%), chestnut and red (25%) and sandy loam (25%) (DRACS 2018). The average annual rainfall is around 300 mm per year (DRACS 2018). The Province of Sidi Bennour, which covers an area of 300.733 km², encompasses 25 municipalities, 2 urban and 23 rural (DRACS 2018). According to the 2014 General Population and Housing Census, the Province population was 460.000 inhabitants, with an urbanization rate not exceeding 17% (HCP 2014). The economic activity in this province depends largely on the agricultural sector; it is one of Morocco's leading suppliers of red meat, milk, sugar, and other agriculture products (DRACS 2018) (Fig. 1).

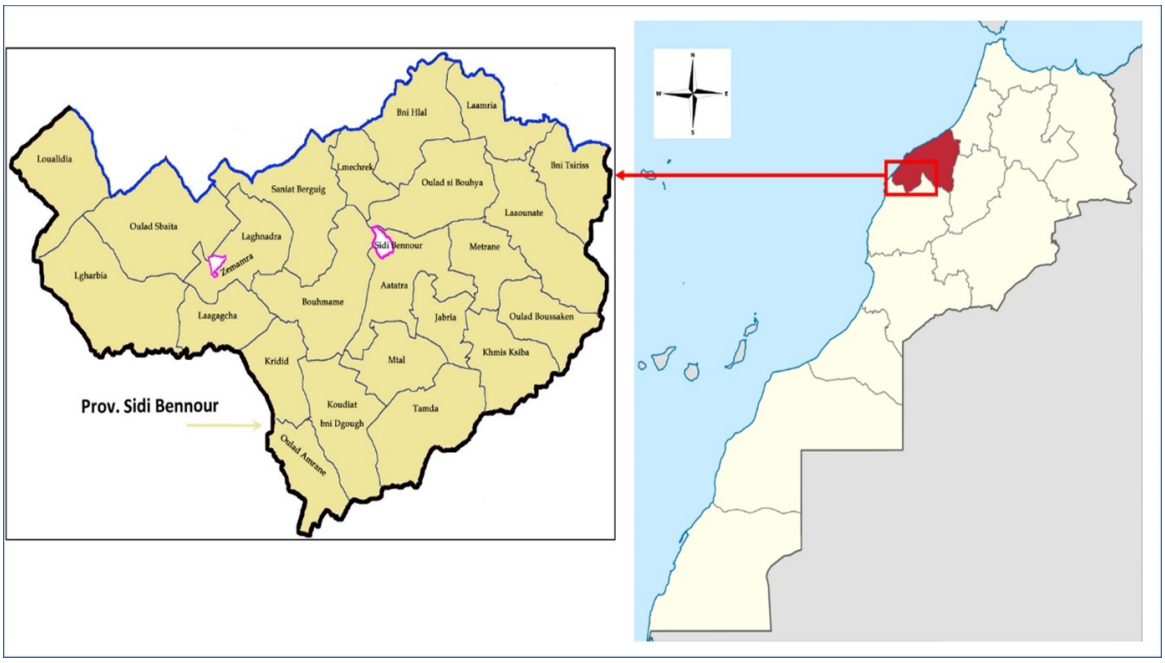

Figure 1. Location of the study area (DRACS 2018)

Data collection tools and procedures

The ethnobotanical survey was conducted from February 2019 to February 2020, using a questionnaire to collect information on the socio-demographic profile of the people surveyed (age, sex, academic level, etc.), information details on the traditional knowledge of WEPs and their different types of use (food, medicinal, etc.), as well as the dynamics of their use over time. For each species mentioned, the local name, the part used, and the preparation method were recorded. For medicinal uses, the mode of administration and the diseases treated were also recorded. A list with photos was also prepared for the WEPs used as a source of food or as medicine in areas close to the study area to facilitate the interview (Vitalini *et al.* 2013). Only plants mentioned by 3 or more respondents were taken into account (Ali-Shtayeh *et al.* 2008). As our objective was to collect as much information as possible on the WEPs used traditionally, we relied for the selection of informants who were knowledgeable about wild edibles plants using the purposive sampling technique (sukenti *et al.* 2016) to get the required important information about these plants. The key informants were selected based on recommendations of local dwellers and local guides, the majority of them were females and above 40 years old. Before conducting interviews, the aim of the study was explained clearly, and informants were asked for their consent.. The sample size surveyed was 200 people. The surveys were based on the Semi-Structured Interview method (Martin 1995). The approach of the interviewed population was based on dialogue in the local language. The time spent on each interview was approximately 40 minutes to an hour.

Plant identification

Field visits were organized with the help of informants to collect specimens of plants for identification and deposit in a herbarium. The taxonomic identification of the species was carried out by comparing our samples with those kept in the herbarium of our laboratory (biotechnology, biochemistry, and nutrition laboratory of Chouaib Doukkali University) and with the help of a botanist. Scientific names were reviewed online using the Plant List Database (www.theplantlist.org) and some literature references of botanical data on Morocco (Bellakhdar *et al.* 1991, Bellakhdar 1997, Tanji 2005, Valdés 2002). When discrepancies in taxonomy were found, accepted names by the Plant List Database were used.

Data analysis

The data recorded on the survey forms were entered into a spreadsheet and presented in graphs and tables. The data analysis was carried out using simple descriptive statistics methods. Furthermore, to assess the local importance of each species and to determine the most preferred species, the Relative Citation Frequency Index (RFC) was used calculated using the following formula (Tardío and Pardo-de-Santayana 2008)

$$\boldsymbol{RFC} = \frac{\mathbf{FC}}{\mathbf{N}} \ (0 \leq \text{RFC} \leq 1) \text{ where:}$$

FC = Number of informants mentioning the uses of the species.

N = Total number of informants in the study.

Results and Discussion

Sociodemographic characteristics

In this work, most selected informants were over 40 yr old, , these informants collect plants for medicinal and food purposes more frequently and still preserve the traditional knowledge, Similar studies also found that traditional knowledge increases with age and length of residence in a region (Guimbo *et al.* 2011, Vitalini *et al.* 2013, Mugisha et *al* 2014). Indeed, Tbatou et *al* (2016b), Silva et *al* (2011), and Rangel et *al* (2010) confirmed that practical knowledge, or skills for identifying wild plants, increased with age as a result of long experience accumulated and passed down from generation to generation.

Most of those selected for the survey were women (86%) (Table 1), as several previous studies reported that women knew more about plants for household use, including food and medicinal plants (Ayantunde *et al.* 2008, Silva *et al.* 2011). Moreover, Nassif et Tanji (2013) have shown that it is women who know most about edible plants, when to pick them and how to turn them into good foods throughout the year.

In addition, the majority of the population selected for the present survey (95%) (Table 1) lived in rural areas. The use of wild plants for human consumption is rared in Moroccan urban areas (Nassif & Tanji 2013). The majority of the study population was not educated (89%) (Table 1), indicating that the origins of their knowledge about the use of wild edible plants came from ancestors or from personal experiences.

Table 1. Socio-demographic characteristics of the respondents

Categories	Frequency	Percentage
Age		
40 to 59 years	86	43%
60 to 80 years	98	49%
> 80 years	16	8%
Gender		
F	172	86%
M	28	14%
Family situation		
Single	8	4%
Married	146	83%
Divorced	2	1%
Widower	44	22%
Study level		
Illiterate	178	89%
Koranic	6	3%
Primary	12	6%
Secondary	4	2%
Area of residence		
Rural	190	95%
Urban	10	5%

Diversity of wild edible plants

We registered 56 species of wild edible plants in the study area. Of these species, 13 had only food use. In contrast, the other 43 species have both food and medicinal uses. The latter belong to 56 genera and 27 families (Table 2). Among the most cited botanical families the Asteraceae come in first with 10 species (17.86%). The family is also the largest in the Moroccan vascular flora with 550 species, 131 of which are endemic (Fennane & Tattou 2008). Apiaceae are in second place with 7 species (12.5%), Lamiaceae with 4 in third (7.14%), followed by Fabaceae, Amaranthaceae, Caryophyllaceae and Brassicaceae with 3 species each (5.36%). The remaining families were represented by one or two species (Fig. 2). The most cited WEPs with at least one use mentioned by more than 75% of informants, were in descending order: *Malva multiflora* (Cav.) Soldano, Banfi & Galasso. (RFC = 0.99), *Portulaca oleracea* L. (RFC = 0.95), *Astragalus boeticus* L. (RFC = 0.93), *Chenopodium murale* L. (RFC = 0.84), *Ridolfia segetum* (L.) Moris (RFC = 0.82), *Scolymus hispanicus* L. (RFC = 0.80), *Calendula stellata* Cav. (RFC = 0.76) and *Oxalis pes-caprae* L. (RFC = 0.75). Ethnobotanical studies carried out in other regions of Morocco have already reported *S. hispanicus* L, *C. murale* L and *Foeniculum vulgare* Mill. as the most cited wild food plants in the region of the present study (Tbatou *et al.* 2016b). Other authors have also mentioned *P. oleracea* L as being a plant often cited in Morocco (Hadjichambis *et al.* 2008) (Table 2).

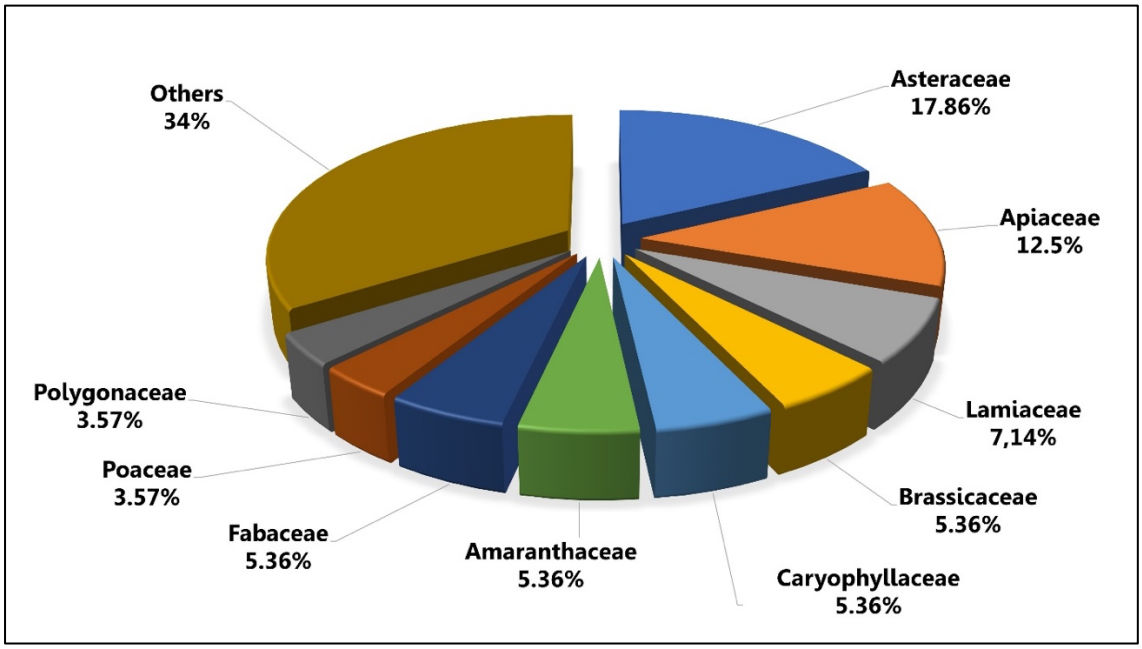

Figure 2. Most representative families.

Table 2. List of wild edible plants used in the region of Sidi Bennour

Family	Species (Voucher specimen)	Local name	Type of use	Purpose of use	Part used	Method of preparation	Number of citations
Amaranthaceae	*Beta macrocarpa* Guss (BM7)	***Boumselli***	F		Tender stems	Raw (**Snacks)**	0.16
					Young leaves, tender stems	Used to prepare *beqoula* dish (**Vegetables**)	0.14
Amaranthaceae	*Dysphania ambrosioides* (L.) Mosyakin & Clemants (MZ5)	***Mkhinza***	F		Leaves	Used to prepare *beqoula* dish (**Vegetables**)	0.08
						Chopped leaves are added to the bread dough (**Other:** perfuming)	0.29
						Cooked in the soup (**Other: perfuming**)	0.66
			Me	Fever	Leaves	**Oral:** mixed with orange juice	0.93
						Oral: infusion	0.75
						Oral: mixed with the onion juice	0.68
						Skin application: poultice	0.28
Amaranthaceae	*Chenopodium murale* L (BR5)	***Berremram***	F		Young leaves, tender stems	Used to prepare *beqoula* dish (**Vegetables**)	0.84
					Seeds	Cooked in the soup (**Other:** perfuming)	0.25
			Me	Rheumatism	Leaves	**Oral:** infusion	0.09
				Cold	Leaves, stems	**Inhalation:** fumigation	0.11
Amaryllidaceae.	*Allium roseum* L (KR12)	***Korrita***	F		Bulbs	used as a vegetable in corn couscous (**Vegetables**)	0.15
						Raw (**Snacks**)	0.09
			Me	Cold,jaundice	Bulbs	**Oral:** decoction	0.08
				Rheumatism		**Skin application:** poultice	0.06
				Stomach disorders		**Oral:** raw	0.18
				Jaundice	Leaves, stems	**Oral:** fumigation	0.03
						Oral: cooked	0.12
				Cold		**Inhalation:** fumigation	0.05
Apiaceae	*Ammi majus* L (TR2)	***Trilal***	F		Leaves, stems	Spices (**Seasoning**)	0.06
						Powder mixed with bread flour (**Other:** perfuming)	0.07
			Me	Fractures	Whole plant	**Skin application:** poultice	0.08
Apiaceae	*Elaeoselinum asclepium* (L.) Bertol (KH13)	***Kolikha***	F		Roots	Porridge in soup (**Other:** perfuming)	0.19
						Raw (**Snacks)**	
						Spices (**Seasoning**)	0.22
			Me	Fever, headache	Roots	**Oral:** decoction	0.13
				Postpartum pain, infertility	Leaves, stems	**Oral:** cooked with bean or lentils	0.15
				Stomach disorders		**Oral:** decoction	0.21
				Cold, back pain, improve sexual ability		**Oral:** decoction	0.16

Apiaceae	*Foeniculum vulgare* Mill (BS22)	***Besbas beldi***	F		Young leaves and tender stems	Used to prepare *beqoula* dish (**Vegetables**)	0.69
					Tender stems	Couscous garnish (**Vegetabless**)	0.46
					Fruits	Spices (**Seasoning**)	0.13
			Me	Jaundice, anemia	Aerial parts	**Oral:** cooked, powder	0.25
				Digestive disorders	Leaves, stems, Roots	**Oral:** decoction, raw	0.21
				Anemia	Roots, seeds	**Oral:** powder	0.14
					Tender stems	**Oral:** raw	0.31
Apiaceae	*Ridolfia segetum* (L.) Moris (TH12)	***Tebch Chebt***	F		Young leaves, tender stems	Used to prepare *beqoula* dish (**Vegetables**)	0.37
						Raw (**Snacks)**	0.82
					Roots	Spices (**Seasoning**)	0.19
			Me	Anemia, cancer	Leaves and stems	**Oral:** infusion, raw, cooked	0.56
				Jaundice		**Oral:** cooked	0.14
				Rheumatism	Leaves, seeds		0.19
Apiaceae	*Scandix pecten-veneris* L (MT6)	***Mechita***	F		Tender stems	Used to prepare *beqoula* dish (**Vegetables**)	0.09
					leaves	Spices (**Seasoning**)	0.08
			Me	Rheumatism, stomach disorders, cold	Leaves	**Oral:** decoction	0.06
Apiaceae	*Smyrnium olusatrum* L (HR70)	***Elhiyar***	F		Young leaves, tender stems	Raw (**Snacks)**	0.07
						Powder mixed with the bread flour (**Other:** perfuming)	0.05
			Me	Wound healing	Roots	**Skin application:** powder	0.12
Apiaceae	*Thapsia villosa* L (AB35)	***Abo***	F		Roots	Cooked in couscous (**Other:** food decoration)	0.29
			Me	Diabetes	Leaves, stems	**Oral:** decoction	0.06
				Stomach disorders	Roots	**Oral:** decoction	0.1
Araceae	*Arisarum vulgare* O.Targ.Tozz (YN3)	***Yarni***	F		Bulbs	cooked in water for 24 hours to remove its toxicity (**Vegetables**)	0.49
						used as flour for the preparation of bread (**Staple foods**)	0.31
						Dry, grind the plant then put it in the couscoussier and steam it seven times (**Vegetables**)	0.18
						Cooked in porridge (**Vegetables**)	0.09

Asparagaceae	*Asparagus acutifolius* L (SK12)	***Sekoum***	F		Young shoot	cooked in broth (**Vegetables**)	0.28
					Tender stems	Used to prepare *beqoula* dish (**Vegetables**)	0. 14
			Me	Intestinal disorders, vermifuge, hepatitis	Roots	**Oral:** decoction, juice	0.16
Asteraceae	*Anacyclus maroccanus* (Ball) Ball (RN13)	**Rabiana**	F		Leaves	Spices (**Seasoning**)	0.29
			Me	Cold, fever, redness	Flowers	**Oral:** infusion	0.18
				Sedative, digestive disorders			0.09
Asteraceae	*Calendula stellata* Cav (JM1)	***Ejjamra,, Hamra-jamra***	F		Young leaves, Tender stems	Used to prepare *beqoula* dish (**Vegetables**)	0.76
					Flowers	Spices (**Seasoning**)	0.21
					Tender stems	Raw (**Snacks)**	0.22
					Flowers	Used in the preparation of couscous (**Other:** perfuming)	0.16
					Roots	Powder mixed with the bread flour (**Other:** perfuming)	0.63
Asteraceae	*Carthamus lanatus* L (AS45)	***Asfar***	F		Roots	Spices (**Seasoning**)	0.11
					leaves, stems	Cooked with the snail (**Other:** perfuming)	0.08
					Flowers	used in the preparation of margarine (**Other:** perfuming)	0.09
			Me	Redness, anemia	Whole plant	**Oral:** cooked in bean or lentil soup	0.22
				Allergy	Flowers and leaves	**Oral:** decoction	0.19
				Intestinal disorders	Roots	**Oral:** infusion	0.23
Asteraceae	*Rhaponticum acaule* (L.) DC. (TG56)	***Tafgha***	F		Roots	Spices (**Seasoning**)	0.17
						Powder mixed with butter (**Other:** perfuming**)**	0.13
			Me	Intestinal disorders	Roots	**Oral:** powder	0.12
				Aperitif, bronchial diseases		**Oral:** decoction	0.09
				Wound healing	Leaves, roots	**Skin application:** powder	0.11
				Hypocholesterolemic	Roots	**Oral:** powder	0.15
Asteraceae	*Chamaemelum fuscatum* (Brot.) Vasc (BJ12)	***Babounj***	F		Flowers	Condiment in tea (Other: perfuming)	0.15
			Me	sedative, digestive disorders		**Oral:** decoction	0.76
Asteraceae	*Cynara humilis* L (TT23)	***Timta***	F		Tender stems	Raw (**Snacks)**	0.11
					Young leaves,	Us ed to prepare *beqoula* dish (**Vegetables**)	0.13
					Receptacle	Used for making domestic cheese (**Other:** food preservation)	0.43
					Roots	Spices (**Seasoning**)	0.08
			Me	Burns	leaves, roots, stems	**Skin application:** powder	0.84
				Digestive disorders	Roots	**Oral:** decoction	0.12

Asteraceae	*Glebionis coronaria* (L.) Cass. ex Spach (KJ 20)	***Rjel djaja, kraa djaja***	F		Young leaves, tender stems	Used to prepare *beqoula* dish (**Vegetables**)	0.66
					Tender stems	Raw (**Snacks)**	0.25
					Leaves	Cooked in the soup (**Other:** perfuming)	0.15
Asteraceae	*Echinops spinosissimus* Turra (TR56)	***Taskra***	F		Roots	Spices (**Seasoning**)	0.31
			Me	Menstrual cramps, cold, fractures	Whole plant	**Oral:** decoction	0.18
				Anemia	Roots	**Oral:** powder	0.07
Asteraceae	*Scolymus hispanicus* L (GR1)	***El guernina***	F		Young leaves, tender stems	Prepared like spinach (**Vegetables**)	0.26
						Used to prepare *beqoula* dish (**Vegetables**)	0.22
					Roots, tender stems	Cooked in broth with meat (**Vegetables**)	0.80
					Tender stems	Used to prepare salad (**Vegetables**)	0.17
			Me	Cough, cold	Roots	**Inhalation:** fumigation	0.07
Asteraceae	*Silybum marianum* (L.) Gaertn (CH27)	***Choka hmar***	F		Receptacle	Raw (**Snacks)**	0.29
Brassicaceae	*Diplotaxis catholica* (L.) DC (HR 62)	***Kalkaza***	F		Young leaves, tender stems	Used to prepare *beqoula* dish (**Vegetables**)	0.23
			Me	Ear diseases	Whole plant	Pressed and used as ear drops	0.22
				Anemia	Leaves, stems	**Oral:** infusion	0.17
				Hemorrhoids	Whole plant	**Skin application:** poultice	0.09
				Asthma	Flowers	**Oral:** powder	0.19
Brassicaceae	*Raphanus raphanistrum* L (BH12)	***Bouhammou***	F		Leaves, tender stems	Used to prepare *beqoula* dish (**Vegetables**)	0.28
			Me	Shortness of breath	Leaves	**Oral:** infusion	0.12
Brassicaceae	*Sinapis alba* L (HA12)	***Elharra, el-laftiya***	F		Tender stems, leaves	Used to prepare *beqoula* dish (**Vegetables**)	0.10
Caryophyllaceae	*Herniaria hirsuta* subsp. *cinerea* (DC.) Cout. (HL63)	***Harassat lehjar***	F				
			Me	Kidney stones, Intestinal disorders	Leaves	**Oral:** decoction	0.81
Caryophyllaceae	*Paronychia argentea* Lam (MF37)	***Mosuif***	F		Leaves	Spices (**Seasoning**)	0.34
			Me	Wound healing	Leaves	**Skin application:** powder	0.09
Caryophyllaceae	*Silene vulgaris* (Moench) Garcke (TC39)	***Tighecht***	F		Leaves	Used to prepare *beqoula* dish (**Vegetables**)	0.09
			Me	To rid the body of toxins	Whole plant	**Oral:** decoction	0.26
			Other		Roots	Washing of clothing, wool and the laundry	0.89

Cyperaceae	*Cyperus rotundus* L (TM56)	***Tamousayt***	F		Roots	Spices (**Seasoning**)	0.13
			Me	Strengthen the hair		**External application:** poultice	0.66
				Allergy		**Oral:** powder.	0.09
Euphorbiaceae	*Mercurialis annua* L (HS3)	***Horriga lmalssa***	F		Young leaves,	Used to prepare *beqoula* dish (**Vegetables**)	0.20
						Powder mixed with the barley semolina to prepare the couscous (**Other:** perfuming)	0.15
			Me	Cold, Rheumatism	Leaves	**Oral:** cooked in the soup	0.11
				Intestinal Disorders, Kidney Disease, Dysuria Problems	Leaves	**Oral:** decoction	0.16
Fabaceae	*Astragalus boeticus* L (KB40)	***Krenbouch***	F		Seeds	Raw (**Snacks)**	0.93
Fabaceae	*Lathyrus clymenum* L (RN40)	***Rig elhench***	F		Seeds	Raw (**Snacks)**	0.36
Fabaceae	*Scorpiurus muricatus* L (KW37)	***El-kelwa, kelwat rnab***	F		Young leaves, stems	Used to prepare *beqoula* dish (**Vegetables**)	0.31
					Tender stems	Raw (**Snacks)**	0.11
Iridaceae	*Moraea sisyrinchium* (L.) Ker Gawl (SW43)	***Lmessiw***	F		Rhizome	Raw (**Snacks)**	0.32
			Me	Caugh	Roots	**Oral:** decoction	0.06
Juncaceae	*Juncus acutus* L (SE60)	***Essmar***	F		Seeds	Condiment in soup (**Other:** perfuming)	0.10
			Me	Rheumatism		**Oral:** raw	0.08
				Kidney stones	Leaves	**Oral:** infusion	0.17
			Other		Stems	making traditional dishes, rugs, and brooms	0.87
Lamiaceae	*Ajuga iva* (L.) Schreb. (CG5)	***Chendgoura***	F		Young leaves	Powder mixed with the bread flour (**Other:** perfuming)	0.69
						Used to prepare *beqoula* dish (**Vegetables**)	0.27
						Spices (**Seasoning**)	0.42
			Me	Abdominal pain, cold	Leaves	**Oral:** decoction	0.19
Lamiaceae	*Lavandula multifida* L (ZR22)	***Zririka, kohhila***	F		Leaves	Tisane (**Other:** perfuming)	0.24
			Me	Caugh, cold	Whole plant	**Oral:** infusion	0.36
Lamiaceae	*Salvia verbenaca* L (KW50)	***Khwiwita, khiyata***	F			Spices (**Seasoning**)	0.04
			Me	Digestive disorders	Roots	**Oral:** powder	0.25
				Wound healing, skin diseases	Whole plant	**Skin application:** powder	0.75
Lamiaceae	*Thymus broussonetii* Boiss (ZH30)	***Zaatar lhmir***	F		Leaves	Cooked with the snail (**Other:** perfuming)	0.33
			Me	Digestive disorders, cold	Aerial parts	**Oral:** decoction	0.25

Malvaceae	*Malva multiflora* (Cav.) Soldano, Banfi & Galasso (KZ1)	***El-khobbiza, El-bakkoula***	F		Young leaves, tender stems	Used to prepare *Beqoula* dish (**Vegetables**)	0.99
Molluginaceae	*Corrigiola littoralis* subsp. *telephiifolia* (Pourr.) Briq (SG28)	***Serghina***	F		Roots	Powder mixed with bread flour (**Other:** perfuming)	0.34
					Tender stems	Used to prepare *beqoula* dish (**Vegetables**)	0.08
					Leaves	Spices (**Seasoning**)	0.27
			Me	Allergy	Roots	**Oral:** powder	0.28
				To prevent hair loss		**Externe application:** poultice	0.11
				To rid the body of toxins (*tokal*)		**Oral:** infusion	0.12
				Cold, diarrhea	Whole plant	**Oral:** decoction	0.05
			Other		Roots	Encens	0.28
Oxalidaceae	*Oxalis pes-caprae* L (MD10)	***Elhomida safra***	F		Young leaves	Used to prepare *beqoula* dish (**Vegetables**)	0.36
					Tender stems	Raw (**Snacks**)	0.75
Palmaceae	*Chamaerops humilis* L (DD53)	***Eddoum, lghaz***	F		Fruits	Raw (**Snacks**)	0.21
			Me	Digestive disorders		Oral: Raw	0.44
					Roots	**Oral:** powder	0.13
			Other		Leaves	Manufacture of brooms, baskets and traditional hats	0.89
Papaveraceae	*Papaver rhoeas* L (LL12)	***Belaaman***	F		Young leaves,	Used to prepare *beqoula* dish (**Vegetables**)	0.84
			Me	Measles, fever	Flowers	**Oral:** infusion	0.16
					Leaves	**Skin application:** poultice	0.24
				Sedative		**Oral:** infusion	0.14
				Hypocholesterolemic	Flowers	**Oral:** infusion	0.13
Papaveraceae	*Fumaria agraria* Lag (EB39)	***Ennar elbarda***	F		Leaves	Used to prepare *beqoula* dish (**Vegetables**)	0.04
			Me	Wounds, Antipruritic		**Skin application:** extract, powder	0.47
				Fever		**Oral:** infusion	0.14
Plumbaginaceae	*Limonium sinuatum* (L.) Mill (KT35)	***Khnounet ennaja***	F		Tender leaves	Raw (**Snacks**)	0.07
			Me	Skin diseases	Leaves	**Skin application:** poultice	0.19
Poaceae	*Cynodon dactylon* (L.) Pers (EN35)	***Enjem***	F		Roots	Spices (**Seasoning**)	0.23
			Me	Rheumatism, cold		**Oral:** decoction	0.31
Poaceae	*Lolium multiflorum* Lam (MN67)	***El-medhoun***	F		Roots	Spices (**Seasoning**)	0.09

Polygonaceae	*Rumex pulcher* L (HH12)	***Hommaida mchowka***	F		Young leaves, tender stems	Used to prepare *beqoula* dish (**Vegetables**)	0.17
			Me	Cold	Leaves	**Oral:** infusion	0.11
			Other			rubbing copper utensils	0.36
Polygonaceae	*Emex spinosa* (L.) Campd (HS5)	***Hommaida hamrat-rass***	F		Tender stems	Raw (**Snacks)**	0.15
			Me	Digestive disorders	Fruits, leaves	**Oral:** infusion	0.09
Portulacaceae	*Portulaca oleracea* L (ER5)	***Errejla***	F		Young leaves, tender stems	Used to prepare *beqoula* dish (**Vegetables**)	0.95
Rubiaceae	*Rubia peregrina* L (WW12)	***El fouwwa***	F		Roots	Spices (**Seasoning**)	0.35
			Me	Anemia		**Oral:** decoction, powder	0.79
Scrophulariaceae	*Verbascum sinuatum* L (SH9)	***maslahndar***	F		Leaves	Spices (**Seasoning**)	0.09
			Me	Cataract	Flowers	**External application:** the water that accumulates in the Flowers is used as eye drops	0.12
Solanaceae	*Solanum americanum* Mill (DD76)	***Eneb eddib***	F		Fruits	Raw (**Snacks)**	0.11
			Me	Fever	Leaves	**Skin application:** decoction	0.07
				Hypoglycaemic, digestive disorders	Fruits leaves	**Oral:** cooked	0.08
Urticaceae	*Urtica dioica* L (HH12)	***Horiga harcha***	F		Leaves	Cooked in the soup (**Other:** perfuming)	0.07
			Me	Rheumatism		**Skin application:** rubbing on the skin	0.70
				Cold, anemia, canker sores		**Oral:** infusion	0.22

F= Food, Me= Medicinal

For wild plants of medicinal use, *Dysphania ambrosioides* (L.) Mosyakin & Clemants (RFC = 0.93), *Cynara humilis* L. (RFC = 0.84), Herniaria hirsuta (RFC = 0.81), *Rubia peregrina* L. (RFC = 0.79), *Chamaemelum fuscatum* (Brot.) Vasc. (RFC = 0.76) and *Salvia verbenaca* L. (RFC = 0.75) were the most cited plants in the study area. These results are different from those of the many studies that have cited species such as *Artemisia herba-alba* Asso and *Mentha pulegium* L. as highly recommended plants in various regions of Morocco (Barkaoui *et al.* 2017, Eddouks *et al.* 2017, Fakchich & Elachouri 2014, Teixidor-Toneu *et al.* 2016).

Wild plants for medicinal use: used part, preparation and administration methods, and the various therapeutic uses

For plants for medicinal use in the study region, leaves were the most used parts (35%). Similar results have been found in other regions of Morocco (Chaachouay *et al.* 2019, Eddouks *et al.* 2017, Teixidor-Toneu *et al.* 2016). These results were explained by the central role of the leaves for biochemical reactions, including photosynthesis (Salhi *et al.* 2019). Other parts of the plants were also used: roots (25%), stems (11%), flowers (8%), seeds (4%) and other parts (17%) (Fig. 3).

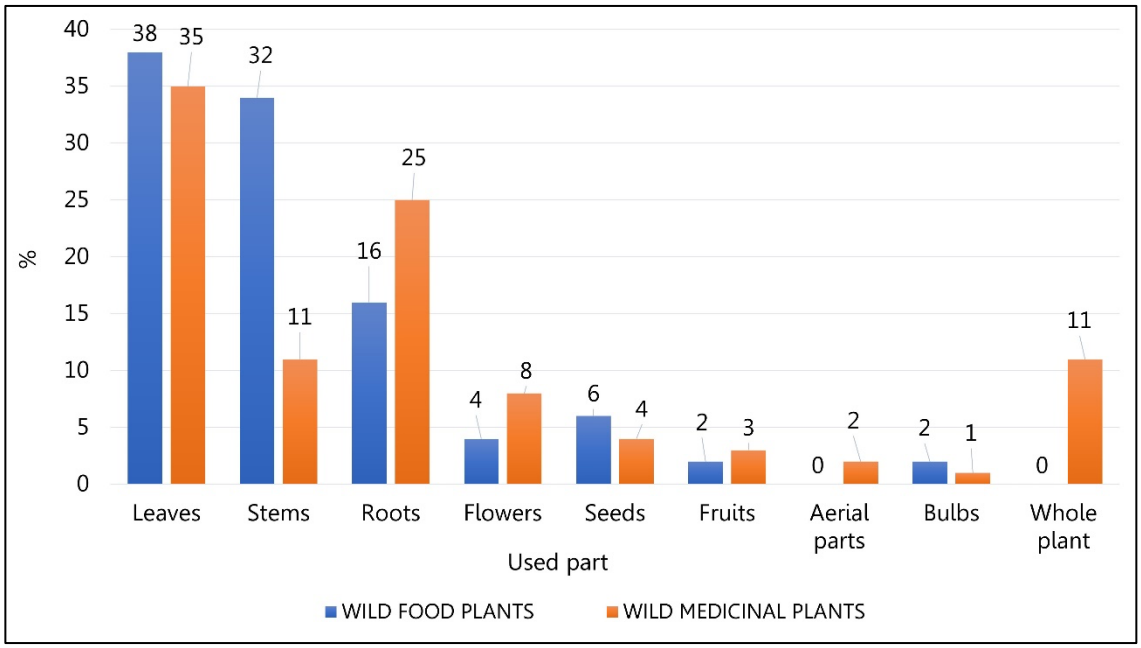

Figure 3. Distribution of the plant parts used.

Decoction was the most frequent method of preparation (27.27%) followed by drying and consumption in powder form (22.73%) and finally the infusion (19.32 %). Other less common preparation methods (poultice, raw, cooked, etc.) combine to make up 30.68% of the total. The appreciation of the decoction as a method of preparation has been mentioned in other ethnobotanical studies carried out in Morocco (Barkaoui *et al.* 2017, El Abbouyi *et al.* 2014, Mrabti *et al.* 2019, Redouan *et al.* 2020).

The majority of preparations were administered orally (80.25%) followed by skin applications (13.58%) and external applications (2.47%). The large proportion of oral administration of wild plants in the present study is in agreement with some other research carried out in the country (Chaachouay *et al.* 2019, El Abbouyi *et al.* 2014, Mrabti *et al.* 2019).

Wild plants used for food purposes: used part and methods of preparation

Analysis of data for wild plants used as food showed that the leaves (38%) and stems (34%) were the parts most used by the local population. The widespread use of the leaves could be attributed to the abundance and easy access to this organ compared to other organs (Neves *et al.* 2009), similarly the latter were a key determinant in differentiating and identifying these plants (Neves *et al.* 2009). These results also show that the aerial parts of plants play an important role in the culinary preparation of plants for food use in the province of Sidi Bennour. Roots are the third most used plant organ (16%) in the study area, after leaves and stems. They are used as a spice in several preparations.

Four categories of plant use were mentioned. They were used as vegetables, for seasoning, as a beverage and for other uses (which includes plants used to decorate or flavor traditional dishes) (Table 2). Vegetables (37.5%) represent the most common mode of consumption of WEPs. They use these species to prepare traditional dishes such as broth or couscous. However, the majority of WEPs are used to prepare the ***beqoula*** dish, considered to be

the most common method of consuming WEPs in rural Morocco (Nassif & Tanji 2013). This dish is prepared with the *Malva multiflora* plant alone (Fig. 4), with *Portulaca oleracea* L alone, or prepared by a combination of several plants (Fig. 5) depending on the preferred taste. The preparation of this dish uses plants collected at the young stage from uncultivated land, cut and cooked with water or steam after washing, and adds spices such as ginger, pepper and paprika. Other ingredients such as parsley, olive oil, olives, lemon, chilli, and salt are also added to season the dish and improve its taste. The use of the ***beqoula*** dish by the Moroccan population was mentioned by many other studies (Nassif & Tanji 2013, Powell *et al.* 2014, Tbatou *et al.* 2016a, Tbatou *et al.* 2016b).

Figure 4. ***beqoula*** dish

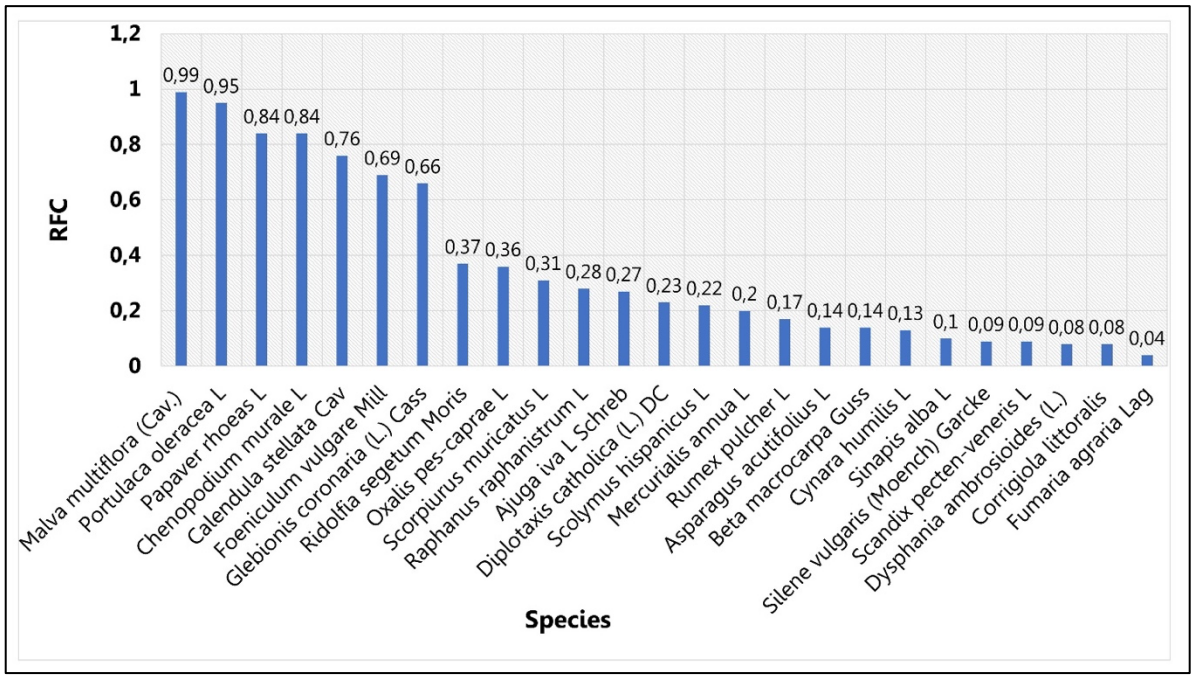

Figure 5. plants used in the preparation of the ***beqoula*** dish according to RFC in the region of Sidi Bennour

In addition to the food and medicinal use of WEPs, other types of uses have been reported by our study. This is the case of *Silene vulgaris* (Moench) Garcke, formerly used to wash clothes and mattresses as cleaning products, *Rumex pulcher* L., that was also used to scrub copper utensils, *Chamaerops humilis* L. and *Juncus acutus* L. have been

exploited to make local products such as brooms, baskets, traditional dishes, and traditional hats (Fig. 6) which will be sold in markets and souks to provide income.

Figure 6. local products made from the leaves of the species *Chamaerops humilis* for sale in the souk of Sidi Bennour

The use of wild plants as a seasoning or spice is also appreciated by the people of this region. Several plants are combined to prepare some seasonings. The major organ for preparing them is the root, but other organs can be used, for example the leaves of the species *Ajuga iva* L. Schreb, the flowers of Calendula stellata Cav and the fruits of *Foeniculum vulgare* Mill. These spices are added to a range of traditional dishes used in winter as a means of warming the body, hence their local name "***Msakhen***". WEPs are also eaten raw as a snack, by the population of the region and more particularly, by shepherds when they are in the field, children when they go to school and women when they collect these plants in the field. The most consumed part in this mode are the young stems after removing the outer layers. Such use has been mentioned in other research (Nassif & Tanji 2013, Tbatou *et al.* 2016a, Tbatou *et al.* 2016b).

The listed wild medicinal plants have been used by locals for the treatment of a number of common diseases and disorders. Forty-two disease types belonging to 13 different pathological groups have been listed. Indeed, the local population declared to use the medicinal plants against dermatological affections, gastrointestinal disorders, respiratory system diseases, rheumatic diseases, hepatic, and metabolic problems, uro-genital disorders, eye diseases, appetite stimulants, antiseptic, febrifuge, haircare, analgesic, and infectious diseases. Most of these plants had more than one therapeutic use. For example, *Allium roseum* L is used to treat jaundice, colds, rheumatism, and stomach upset. The most cited pathologies as shown in Fig. 7 were respiratory system diseases (20.18%), gastrointestinal disorders (18.42%) and hepatic and metabolic problems (17.54%)

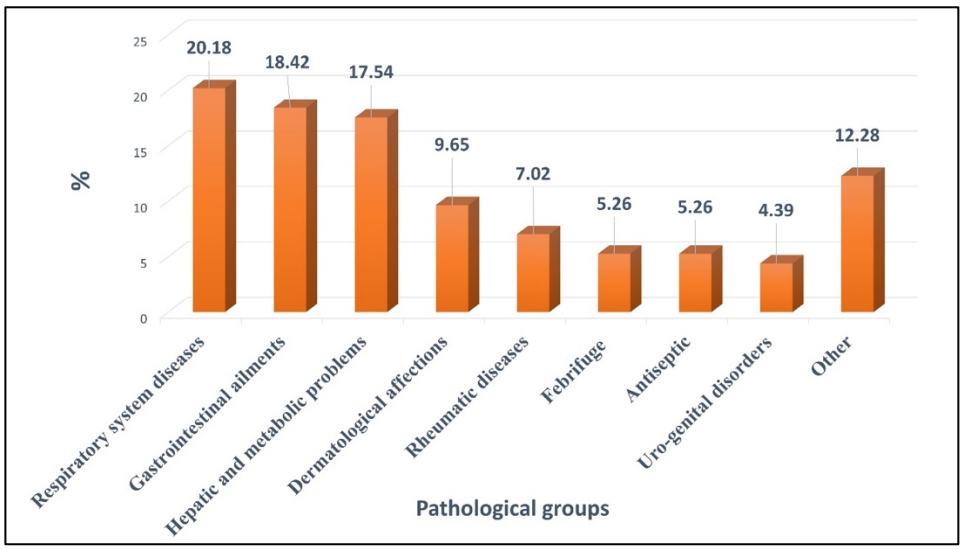

Figure 7. Reported ailment groups.

Safe use of wild edible plants

Despite the low formal educational attainment of the rural population compared to the urban population, the former, especially women and the elderly in rural areas, have sufficient information to allow them to use WEPs safely. An example is that *Arisarum vulgare.* O. Targ-Tozz (***Yarni***) was reported by the study population to be a poisonous plant, but widely used during periods of famine as food. Specific preparation methods to remove this toxicity have been adopted by the population by boiling the bulbs for a long time (24 hrs) or repeatedly (7 times). Previous studies have shown that the toxicity of this plant is due to the presence of alkaloids and mainly a major alkaloid, irniine (Melhaoui *et al.* 1992). Another toxic plant *Citrullus colocynthis* (L.) Schrad., mentioned by the population of Sidi Bennour, has also been reported in several experiments and previous studies (Al-Yahya *et al.* 2000; Bakhiet & Adam 1995; Diwan *et al.* 2000). This medicinal plant is used by the local population to treat diabetes, and to avoid its toxicity, precise quantities of seeds (not exceeding 5) are used by the population.

Exploitation trend of wild edible plants

According to the population surveyed, there is a sharp decline in the consumption of most of the species recorded, whether for food or medicinal use, especially among the younger generation. Several reasons were put forward to explain, at least in part, this phenomenon. According to several interviewees, the use of these plants has decreased because their consumption is no longer necessary, given the availability of cultivated food plants and pharmaceuticals considered to be more effective and with a rapid effect compared to wild plants. In addition, the availability of these plants has decreased due to climate change and overuse of herbicides as these plants are considered weeds. These results corroborate those of Luczaj et *al* (2012), Broegaard et *al* (2017), and Ickowitz et *al* (2019), who suggest that under conditions where food resources are abundant human populations tend to prefer industrialized products. This thus reduces the dietary diversity of these populations, while under conditions of scarcity of resources; they used these wild plants to meet their nutritional and therapeutic needs. Caniago & Stephen (1998) have shown that the increasing use of pharmaceuticals is a fundamental determinant of the decrease in the exploitation of medicinal plants among indigenous populations. However, this decrease does not affect all plants with the same intensity as many WEPs are still widely used today, such as *Malva multiflora* (Cav.) Soldano, Banfi & Galasso*, Portulaca oleracea* L, *Astragalus boeticus* L, *Dysphania ambrosioides* (L.) Mosyakin & Clemants, Herniaria hirsuta subsp. cinerea (DC.) Cout*, Rubia peregrina* L, *Ridolfia segetum* (L.) Moris*, Chamaemelum fusccatum* and *Cynara humilis*.

Conclusion

The Sidi Bennour region is home to an abundant diversity of wild plants with 56 species documented by this study, which have medicinal uses, food uses, or both. The people of this region, especially the elderly women, hold a rich traditional knowledge of a large number of WEPs. They have sufficient information to allow them to use these plants safely. However, this traditional knowledge and know-how is threatened due to the lack of successors. Indeed, there is a lack of interest in these plants among the younger generations who are more drawn to the modern way of life and modern culture. In addition, the populations of many species commonly used as food or medicine is declining in the study area.

Further research on WEPs in other regions of Morocco is recommended to develop methods and decide on strategies for the conservation of these WEPs and the transmission of traditional ethnobotanical knowledge relating to their uses. There is also a need to revitalize traditional practices related to the use of these plants to regain the interest of the younger generation. In addition, it is strongly recommended to determine the nutritional potential, pharmacological and toxic effects of these plants which could offer an alternative for nutritional deficiencies and food insecurity.

Declarations

List of abbreviations: WEPs = wild edible plants, RFC= Relative Citation Frequency Index

Ethics approval and consent to participate: Consent was sought from all participants before any interviews were conducted. Tthey were also informed about the framework in which the work is carried out.

Consent for publication: Not applicable.

Data Availability: Data used to support the findings of this study are available from the corresponding author upon request.

Competing interests: Author declares that there is no conflict of interest.

Funding: This study received no funding.

However, the study benefited from the annual allocation granted by the Ministry of Higher Education and Research (Morocco) for the functioning of Research Structures

Authors' contributions: AA, KN, SM, KS: Study design, ethnobotany surveys conduction, plant collection, AA, MT, AK: data analysis and interpretation, manuscript writing, JMR, RB: Work supervising, contribution to Methodology, manuscript improving, and Review-Editing. All authors read, reviewed, and approved thefinal version of the paper.

Acknowledgements

We would like to thank all the informants who contributed to this study with their valuable traditional knowledge. The study was supported by the Moroccan Ministry of Higher Education and Research. This work is also in line with the work from COST Action 18101 SOURDOMICS—Sourdough biotechnology network towards novel, healthier and sustainable food and bioprocesses (https://sourdomics.com/; https://www.cost.eu/actions/CA18101/, where the author J.M.F.R. is the Chair and Grant Holder Scientific Representative, and the author R.B. is member of Morocco as COST Near Neighbor Country.

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