



Ethnobotanical study of medicinal plants in the Fez-Meknes region of Morocco

[Estudio etnobotánico de plantas medicinales en la región de Fez-Meknes de Marruecos]

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Abstract

Context: The region of Fez-Meknes has a wide variety of aromatic and medicinal plants that can be explored in different ways to draw their virtues and overcome human health problems.

Aims: To identify ethnobotanically the main medicinal plants and collect data about their uses in the region of Fez.

Methods: During each interview, both the personal information and the plants used were collected. The questionnaire revealed the use frequency of each part of the plants (VPP). It also sheds light on the importance of each species (RFC). Furthermore, it showed the relative importance of the families and the method of preparation (FIV).

Results: The results disclosed the richness of the region in terms of medicinal plants. A total of 57 species were identified and grouped into 24 families. The most abundant families were *Lamiaceae* (FIV = 5.461), *Compositae* (FIV = 6.085), and *Apiaceae* (FIV = 6.307). The most cited species were *Plantago major* L. (RFC = 27.3%), *Olea europaea* L. (RFC = 31.3 %), and *Daphne gnidium* L. (RFC = 32.6%). The leaves are the most plant part used (VPP = 0.416). The most used preparation method was decoction (32%). The most declared pathologies were digestive (16%), dermatological (15%), and respiratory affections (13%).

Conclusions: The ethnobotanical study showed the region's floristic richness and allowed the identification of the different plants involved in many recipes to overcome human health problems.

Keywords: aromatic and medicinal plants; ethnobotanical study; Fez-Meknes region; natural remedies.

Resumen

Contexto: La región de Fez-Meknes cuenta con una gran variedad de plantas aromáticas y medicinales que se pueden explorar de diferentes formas para aprovechar sus virtudes y superar los problemas de salud humana.

Objetivos: Identificar etnobotánicamente las principales plantas medicinales y recoger datos sobre sus usos en la región de Fez.

Métodos: Durante cada entrevista se recogió tanto la información personal como las plantas utilizadas. El cuestionario reveló la frecuencia de uso de cada parte de las plantas (VPP), también arrojó luz sobre la importancia de cada especie (RFC). Además, mostró la importancia relativa de las familias y el método de preparación (FIV).

Resultados: Los resultados dieron a conocer la riqueza de la región en cuanto a plantas medicinales, se identificaron un total de 57 especies, agrupadas en 24 familias. Las familias más abundantes fueron *Lamiaceae* (FIV = 5,461), *Compositae* (FIV = 6,085), luego *Apiaceae* (FIV = 6,307). Las especies más citadas fueron *Plantago major* L. (RFC = 27,3%), *Olea europaea* L. (RFC = 31,3%) y *Daphne gnidium* L. (RFC= 32,6%). Las hojas fueron la parte de la planta más utilizada (VPP = 0,416). El método de preparación más utilizado fue la decocción (32%). Las patologías más declaradas fueron afecciones digestivas (16%), dermatológicas (15%) y respiratorias (13%).

Conclusiones: El estudio etnobotánico mostró la riqueza florística de la región y también permitió identificar las diferentes plantas involucradas en multitud de recetas para superar los problemas de salud humana.

Palabras Clave: estudio etnobotánico; Región de Fez-Meknes; plantas aromáticas y medicinales; remedios naturales.

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Abbreviations: FC: The number of respondents having cited the species; FIV: The family importance value index; ha: Hectare; N: The total number of respondents; NS: The number of species within each family; RFC: The relative frequency of citation; RU: The sum of reported uses per plant part; RU plant part: The number of reported uses for all plant parts; VPP: The value of the plant part used.

INTRODUCTION

In Morocco, in addition to suitable climatic and edaphic conditions, there is a rich and diversified flora with a high rate of endemism. One of the strong points of the aromatic and medicinal plant sector consists of the country's historical traditions in the use of aromatic and medicinal plants (Neffati and Sghaier, 2014). Indeed, the Moroccan population has a rich and ancient tradition in phytotherapy (Bellakhdar, 1997; Scherer et al., 2005). The use of medicinal plants in the treatment of several diseases is an integrated part of Moroccan culture (Bellakhdar, 1997). Thus, on a regional scale, Morocco constitutes a real phyto-genetic reservoir and occupies a privileged position among Mediterranean countries (Scherer et al., 2005).

This study consists of enhancing the natural and traditional heritage of the Fez-Meknes region. An ethnobotanical study was carried out for this purpose by collecting as much information as possible about therapeutic and cosmetic uses and constituting a database that will be useful in various fields for researchers.

Indeed, the local resources of rural territories offer tangible assets for rural and territorial development based on rural innovation and the socio-economic valorization of local know-how (Sghaier and Gam-moudi, 2007). Therefore, the present study is part of

the global framework of research and development programs for medicinal plants, aiming to increase their added value. Our specific objective is the evaluation/valorization, through a series of ethnobotanical surveys, of the medicinal plant potentials available in the region of Fez-Meknes.

MATERIAL AND METHODS

Study area

The region of Fez-Meknes has a population of 4,236,892 (13% of the national population), and it is exposed to three types of climates: A continental climate, very hot and dry in summer, cold and humid in winter; a cold and humid climate in the mountainous areas, very cold and snowy in winter and temperate in summer; and a semi-arid climate in the high hills of Boulemane. Winter is very cold and snowy.

The primary agricultural sector ranks Fez-Meknes among the most productive regions on the national level. The total useful agricultural area is 1,340,826 ha representing 15% of the national useful agricultural area. As for the forest area of the region, estimated at 1,246,255 ha, it stands for 14% of the national area (Kingdom of Morocco Ministry of Equipment, Transport, Logistics, and Water) (Fig. 1).



Figure 1. Map of the study area.

Google maps, edited by Sara Tlemcani.

Ethnobotanical survey

An ethnobotanical study was carried out in the region of Fez-Meknes from April 2020 to May 2021, using a closed-ended questionnaire, face-to-face interviews and adopting the standard methodology described by El Rhaffari and Zaid (2002) and validated by members of the Laboratory of Molecular Organometallic Materials Engineering and Environment, Faculty of Sciences, University Sidi Mohamed Ben Abdellah. The surveyed herbalists were informed that their participation would contribute to purely scientific ethnobotanical research with confidentiality. The approach to the herbalists interviewed was based on dialogue in the local language, with each interview lasting about 30 minutes. The choice of herbalist shops was based on the size of their stalls.

In this sense, 325 questionnaires were carried out among herbalists, parapharmacists, and the local population of the Fez-Meknes region. This questionnaire is divided into three main titles:

- Personal questions: concerning the profile of the informant (vernacular identity), including age (under 30, 30-40, 40-50, and over 50), gender (men and women), level of education, and profession. (Es-Safi et al., 2020; Mechchate et al., 2020).

- Questions on phytotherapy: about plants present in the region, used part, method of preparation, period of harvest, type of plant, therapeutic and traditional uses (El Khomsi et al., 2022; El-Assri et al., 2021; El Hilah et al., 2016).

- Questions on remedies: the combination of plants and natural products (Es-Safi et al., 2020; Sghaierand and Gammoudi, 2007).

Data analysis

The ethnobotanical information collected during the surveys was entered, processed, and statistically analyzed in a database using Microsoft Office Excel, SPSS software, and MacBook numbers.

Relative frequency of citation (RFC)

The RFC is an index that shows the importance of each species in the region studied. It was obtained by dividing the number of respondents who cited the species (FC) by the number of respondents (N) according to the formula [1] (Tardío and Pardo de Santayana, 2008).

$$RFC = FC/N \quad (0 < RFC < 1) \quad [1]$$

Family Importance Value (FIV)

The FIV represents the relative importance of families. It was used to evaluate the biological taxo-

nomic value of plants and is determined by dividing the number of respondents revealing the family (FC family) by the number of species within each family (NS) according to the formula [2] (Sreekeesoon and Mahomoodally, 2014).

$$FIV = FC \text{ family}/NS \quad [2]$$

Value of the plant part (VPP)

VPP indicates the frequency of use of each plant part. It was calculated by dividing the number of reported uses for all plant parts (RU plant part) by the sum of reported uses per plant part (RU) according to the formula [3] (Gomez-Beloz, 2002).

$$VPP = RU \text{ plant part}/RU \quad [3]$$

RESULTS AND DISCUSSION

Age and gender

The survey of the local population of 325 people revealed that both women and men are concerned with aromatic and medicinal plants. However, the female gender predominates with 65%, compared to 34% for men (Table 1), which is explained by the fact that women are more attached to traditional practices than men and exchange information between them easily. Similarly, women are concerned with treating themselves and their families and preparing recipes for care.

All age groups are concerned by the use of medicinal plants, with a predominance of the 40-50 age group with a rate of 40%, followed by the 30-40 and >50 age groups, which are close with percentages of 29% and 21% respectively, and the lowest percentage of 8% for the <30 age group (Table 1).

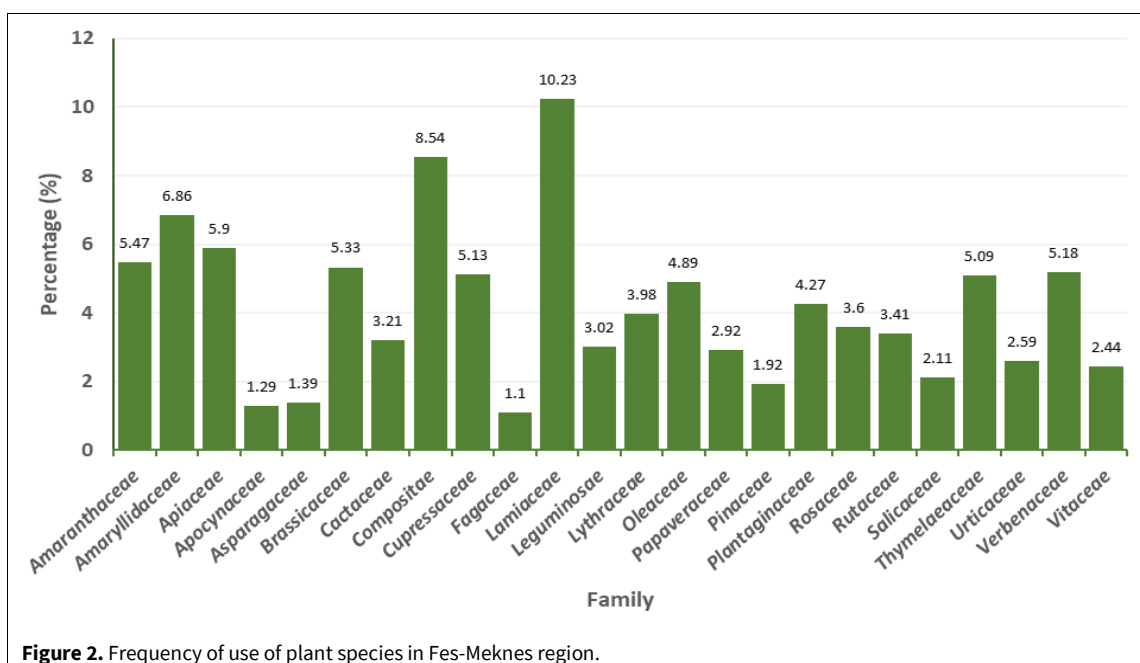
These results confirmed other ethnobotanical studies carried out at the national level (Benkhniguet et al., 2011; Boutabia et al., 2020; El Hilah et al., 2016; Jdaidi and Hasnaoui, 2016; Mehdioui and Kahouadji, 2007) showed that women are more knowledgeable about traditional herbal medicine.

Educational level and profession

As for the cultural level of people using aromatic and medicinal plants in the study area, the obtained results showed that most users are illiterate, with a rate of 48%. However, people at the primary school level have a significant percentage of use of these plants. They represent a rate of 29%, while those with no profession were 76%, and only 24% have a profession (Table 1). These results are similar to those reported by (Ammor et al., 2020; Barkaoui et al., 2017; El Hilah et al., 2016).

Table 1. Sociodemographic profile.

Variable	Choice	Number	Percentage %
Age	<30 years	28	8.6
	30 - 40 years	97	29.8
	40 - 50 years	131	40.3
	50 years	69	21.2
Gender	Women	212	65.2
	Men	113	34.8
Academic level	Analphabet	157	48.3
	Primary	95	29.2
	Secondary (College)	38	11.7
	Secondary (High School)	19	5.8
	University	16	4.9
	Profession	With	78
Without		247	76

**Figure 2.** Frequency of use of plant species in Fes-Meknes region.

Floristic analysis

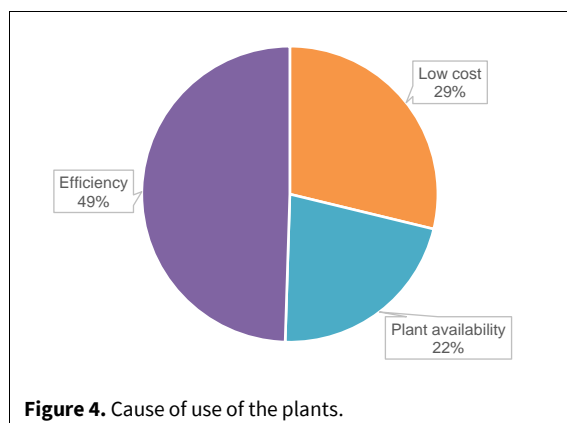
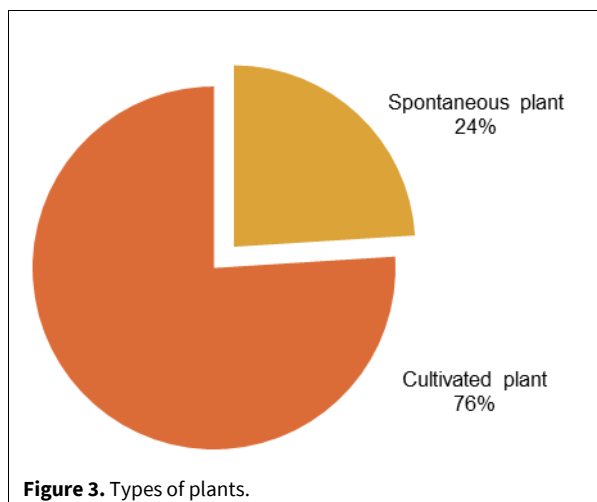
The data collected allowed us to identify 57 species belonging to 24 families used in phytotherapy (Fig. 2). Table 2 shows *Lamiaceae* was the most represented

family group with 12 species (FIV = 5.461), followed by *Compositae* 9 species (FIV = 6.085), then *Apiaceae* 6 species (FIV = 6.307) and *Leguminosae* 4 species (FIV = 4.846). An ethnobotanical study in the same region

also showed that *Lamiaceae* was the dominant family, with 38% (Saibari et al., 2021).

Harvest period and types of plants

In the study area, almost all the plants used are spontaneous 76% (Fig. 3). Some of them are harvested in spring (52%), some throughout the year (19%), and others can be harvested in summer (18%) (Fig. 4).

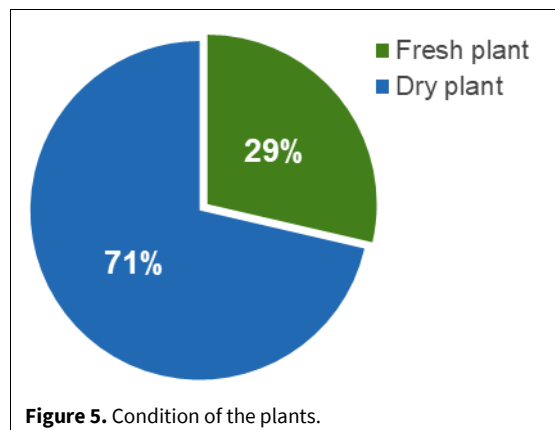


State and parts of the plants used

According to the ethnobotanical survey, it could be seen that dry plants are widely used (71%) as compared to fresh plants with only 29% (Fig. 5) due to their unavailability.

Concerning the preparation of remedies, the leaves are the most used part with (VPP = 0.416), followed by the whole plant (VPP = 0.197), the flowers (VPP = 0.114), then the roots and stems (VPP = 0.104) and finally the seeds (VPP = 0.062) (Fig. 6). Although these results show some similarities with those of (Jeddi et al., 2021; Salhi et al., 2010), they contrast with those of (Mechchate et al., 2020), which showed that seeds are the most frequently used parts with a percentage of

33%. Indeed, the use of leaves is explained by the fact that they are easy to harvest and constitute the center of photosynthesis and storage of secondary metabolites responsible for biological properties (Slimani et al., 2016; Tahri et al., 2012).



Most respondents (49%) prefer traditional medicine to modern medicine, justifying their preference by the effectiveness of medicinal plants, (29%) by the low cost of plants, and 22% by the availability of plants (Fig. 7). This can be explained by the fact that the Fez-Meknes region has a rich flora and that the population has a great deal of ancestral know-how in therapy, particularly in phytotherapy. In addition, for some respondents, the benefits of using plants in the household allow them to avoid long journeys to health centers. Yet, others argue that the care costs are far beyond their means.

Field of use of aromatic and medicinal plants

In the region studied, the practice of medicinal plants for therapeutic purposes is approximately 54% (Fig. 8). However, as far as cosmetic, and aromatic uses are concerned, they remain less common, with 25% and 14%, respectively.

Preparation methods of plants

The surveyed people confirmed using several methods to prepare medicinal plants to use them as a remedy against different diseases (Fig. 9). Decoction is the most used method by the local population with a percentage of 32%, followed by infusion at 29%, fresh plant at 23%, then poultice and maceration with respective percentages of 13% and 4%. The frequent use of decoction is because it allows collecting of the most active substances and attenuates the toxic effect of some recipes. These results are broadly similar to those of other studies conducted in other regions of Morocco (Belhaj et al., 2020; El Hachlafi et al., 2020; El-Assri et al., 2021).

Table 2. List of medicinal and aromatic plant families and species of the Fes-Meknes region used by the local population.

Families and species	Vernacular name	Type of plant	Part used	Preparation method	FC	RFC	FIV	Treated diseases	Reference
Amaranthaceae							35.076		
<i>Chenopodium ambrosioides</i> L. [synonym of <i>Dysphania ambrosioides</i> (L.) Mosyakin & Clemants]	Mkhinza مخينزة	sp	lv, wp	dec, pl	114	35.07		Dental, digestive, dermatological	(Bellakhdar, 1997; El Hachlafi et al., 2020; Mechchate et al., 2020; Es-Safi et al., 2020; El-Hilaly et al., 2003; Salhi et al., 2010)
Amaryllidaceae							17.075		
<i>Allium cepa</i> L.	Lbesla البصل	cl	rt, fl	fp, dec	47	14.46		Gynecology, dermatological, cancer	(Alami et al., 2021; Barkaoui et al., 2017; Chebat et al., 2014; El Hachlafi et al., 2020; El-Hilaly et al., 2003; Es-Safi et al., 2020; Mechchate et al., 2020)
<i>Allium sativum</i> L.	Touma الثوم	cl	rt	fp, mac	64	19.69		Digestive, metabolic	(Alami et al., 2021; Barkaoui et al., 2017; Eddouks et al., 2017; El-Hilaly et al., 2003; Es-Safi et al., 2020; El Hachlafi et al., 2020; Mechchate et al., 2020; Orch et al., 2015)
Apiaceae							6.307		
<i>Apium graveolens</i> L.	Lekrafes الكرافص	cl	lv, wp	dec, fp	17	5.23		Digestive	(Bellakhdar, 1997; Bouayyadi et al., 2015; El Hachlafi et al., 2020; El-Hilaly et al., 2003; Es-Safi et al., 2020; Mechchate et al., 2020)

Table 2. List of medicinal and aromatic plant families and species of the Fes-Meknes region used by the local population (continued...)

Families and species	Vernacular name	Type of plant	Part used	Preparation method	FC	RFC	FIV	Treated diseases	Reference
<i>Ammodaucus leucotrichus</i> Coss.	Lkamoun sofi الكمون الصوفي	sp	sd	Inf	26	8.00		Digestive	(Bellakhdar, 1997; El-Hilaly et al., 2003; Es-Safi et al., 2020)
<i>Coriandrum sativum</i> L.	Elkasbour القرزير	cl	sd, lv, st	fp, inf, dec	12	3.69		Digestive	(Bellakhdar, 1997; El-Hilaly et al., 2003; Es-Safi et al., 2020)
<i>Ferula communis</i> L.	Boubal البوبال	sp	fl, wp	dec	25	7.69		Rheumatology	(Alami et al., 2021; Hachi et al., 2015)
<i>Foeniculum vulgare</i> Mill.	Besbass البسباس	sp	wp, sd	fp	31	9.53		Anti-inflammatory, diuretic	(Bellakhdar, 1997; Chebat et al., 2014; El Hachlafi et al., 2020; Es-Safi et al., 2020; Mechchate et al., 2020)
<i>Petroselinum crispum</i> (Mill.) Fuss.	Al maâdnou المعدنيس	cl	lv, wp	dec, pl	12	3.69		Articular	(Bellakhdar, 1997; Bouayyadi et al., 2015; El Hachlafi et al., 2020; Es-Safi et al., 2020; Tahraoui et al., 2007)
Apocynaceae							8.307		
<i>Nerium oleander</i> L.	Defla الدفلة	sp	fl, lv	dec, pl	27	8.30		Dental, headaches	(Alami et al., 2021; Bellakhdar, 1997; El-Hilaly et al., 2003; Jaadan et al., 2020)

Table 2. List of medicinal and aromatic plant families and species of the Fes-Meknes region used by the local population (continued...)

Families and species	Vernacular name	Type of plant	Part used	Preparation method	FC	RFC	FIV	Treated diseases	Reference
Asparagaceae							9.380		
<i>Agave americana</i> L.	Sebbar, Sabra الصَبَّار	sp	lv, st	pl, inf	29	8.92		Dermatological, digestive	(Alami et al., 2021; Hachi et al., 2015)
<i>Asparagus officinalis</i> L.	Sekkoum السَكُّوم	sp	rt, lv	fp, dec	32	9.84		Articular, digestive	(El-Hilaly et al., 2003; Salhi et al., 2010)
Brassicaceae							11.384		
<i>Brassica rapa</i> L.	Left Imahfour الْأَفْتِ المحفور	cl	rt	fp	41	12.61		Respiratory	(Alami et al., 2021; Benlamdini et al., 2014; Bouayyadi et al., 2015)
<i>Brassica napus</i> L.	Left الْأَفْتِ	cl	rt	fp	31	9.53		Respiratory	(Bellakhdar, 1997; Bouayyadi et al., 2015)
<i>Raphanus sativus</i> L. [synonym of <i>Raphanus raphanistrum</i> subsp. <i>sativus</i> (L.) Domin]	Lfjel الفجل	cl	st, lv, rt	dec	39	12.00		Digestive	(Bellakhdar 1997; Bouayyadi et al., 2015)
Cactaceae							20.615		
<i>Opuntia ficus-indica</i> (L.) Mill.	Hendiya هندية	sp, cl	fl, lv, st	inf, dec, pl	67	20.61		Cardiovascular, digestive, cancer, hair, face care	(Bouayyadi et al., 2015; Eddouks et al., 2017; El Hachlafi et al., 2020; El-Hilaly et al., 2003; Es-Safi et al., 2020; Mechchate et al., 2020; Tahraoui et al., 2007)

Table 2. List of medicinal and aromatic plant families and species of the Fes-Meknes region used by the local population (continued...)

Families and species	Vernacular name	Type of plant	Part used	Preparation method	FC	RFC	FIV	Treated diseases	Reference
Compositae							6.085		
<i>Artemisia absinthium</i> L.	Chiba الشيبية	cl	lv, wp	Inf	21	6.46		Diabetes, digestive, antispasmodic	(Alami et al., 2021; El Hachlafi et al., 2020; El-Hilaly et al., 2003; Es-Safi et al., 2020; Jaadan et al., 2020; Mechchate et al., 2020)
<i>Artemisia herba-alba</i> Asso	Chih الشيح	sp	st, lv	inf, dec	25	7.69		Digestive, diabetes, antiseptic, antihypertensive	(Bellakhdar, 1997; El Hachlafi et al., 2020; El-Hilaly et al., 2003; Es-Safi et al., 2020; Mechchate et al., 2020; Tahraoui et al., 2007)
<i>Atractylis gummifera</i> Salzm. ex L. [synonym of <i>Carlina gummifera</i> (L.) Less.]	Addad الداد	sp	wp, fl	inf, fp, pl	11	3.38		Dental, hair and face care, difficult deliveries	(Alami et al., 2021; Benlamdini et al., 2014; Bouayyadi et al., 2015)
<i>Calendula arvensis</i> M.Bieb.	Azwiwel ازويول	sp	fl, wp	inf, dec, fp	18	5.53		Digestive, dermatological	
<i>Cynara humilis</i> L.	Taymet تيمت	sp	rt	pl	31	9.53		Burns and wounds	(Alami et al., 2021; Bellakhdar, 1997; Benkhniqie et al., 2010; Bouayyadi et al., 2015)
<i>Dittrichia viscosa</i> (L.) Greuter [<i>Innula viscosa</i> (L.) Aiton is a synonym]	Tirehla, Magr aman مكرمان ترهلا	sp	lv, rt, ap	fp, inf, pl	38	11.69		Articular, wounds, burns, dental	(Alami et al., 2021; Bellakhdar, 1997; Bouayyadi et al., 2015; Es-Safi et al., 2020)

Table 2. List of medicinal and aromatic plant families and species of the Fes-Meknes region used by the local population (continued...)

Families and species	Vernacular name	Type of plant	Part used	Preparation method	FC	RFC	FIV	Treated diseases	Reference
<i>Matricaria chamomilla</i> L.	El babounj البابونج	cl	wp, fl	inf, dec	14	4.30		Anti-inflammatory, digestive, hair care	(Alami et al., 2021; El Assri et al., 2021; Jaadan et al., 2020; Labiad et al., 2020)
<i>Rhaponticum acaule</i> (L.) DC.	Tafgha تافغا	sp	rt	fp, inf	15	4.61		Genito-urinary, digestive	(Alami et al., 2021; Bellakhdar, 1997; Benkhniqie et al., 2010; Bouayyadi et al., 2015)
<i>Silybum marianum</i> (L.) Gaertn.	Chouklahmir شوك لحمير	sp	rv	dec, mac	5	1.53		Digestive, genito-urinary	(Bellakhdar, 1997; Bouayyadi et al., 2015; El Hachlafi et al., 2020; Orch et al., 2015)
Cupressaceae							32.923		
<i>Tetraclinis articulata</i> (Vahl) Mast.	Aâraâr العرعار	sp	lv	dec	107	32.92		Digestive	(Alami et al., 2021; Bellakhdar, 1997; Bouayyadi et al., 2015; El Hassani et al., 2013; El-Hilaly et al., 2003; Jaadan et al., 2020)
Fagaceae							7.076		
<i>Quercus suber</i> L.	El ballot البَلُوط	sp	lv	inf, dec, fp	23	7.07		Digestive, anti-inflammatory	(Alami et al., 2021; Bouayyadi et al., 2015; El-Hilaly et al., 2003)

Table 2. List of medicinal and aromatic plant families and species of the Fes-Meknes region used by the local population (continued...)

Families and species	Vernacular name	Type of plant	Part used	Preparation method	FC	RFC	FIV	Treated diseases	Reference
Lamiaceae							5.461		
<i>Calamintha officinalis</i> Moench [synonym of <i>Clinopodium nepeta</i> subsp. <i>glandulosum</i> (Req.) Govaerts]	Manta مانتا	cl	lv, wp	inf, dec, fp	22	6.76		Fever, respiratory	(Bouayyadi et al., 2015; El-Hilaly et al., 2003; Mechchate et al., 2020)
<i>Lavandula officinalis</i> Chaix (synonym of <i>Lavandula angustifolia</i> Mill.)	Khezama خزامة	cl	fl, lv, wp	dec, inf	13	4.00		Dermatological, digestive, relaxing effects	(Bouayyadi et al., 2015; El-Hilaly et al., 2003)
<i>Marrubium vulgare</i> L.	Merriwet, merriwa رَبِيوت، مَرِيوا	sp	lv, wp	pl, fp, inf	12	3.69		Diabetes, cardiovascular, antiseptic	(El-Hilaly et al., 2003; Es-Safi et al., 2020; Khabbach et al., 2012; Mechchate et al., 2020; Salhi et al., 2010; Tahri et al., 2012)
<i>Mentha pulegium</i> L.	Fliyou فلايو	sp	lv, st	inf	24	7.38		Respiratory, digestive, antispasmodic	(Benlamdini et al., 2014; El-Hilaly et al., 2003; Khabbach et al., 2012; Mechchate et al., 2020; Tahraoui et al., 2007)
<i>Mentha × rotundifolia</i> (L.) Huds.	Timersat, Mersita تيمر صاط، مر صيطا	sp	lv	inf, dec	18	5.53		Antioxidant, anti-infectious, digestive	(Benkhniqie et al., 2010; El-Hilaly et al., 2003; Salhi et al., 2010)
<i>Mentha viridis</i> (L.) L. (synonym of <i>Mentha spicata</i> L.)	Naânaâ التعناع	cl	lv, st	inf	9	2.76		Digestive	(Alami et al., 2021; Bellakhdar, 1997; Benkhniqie et al., 2010; Bouayyadi et al., 2015; El-Hilaly et al., 2003)

Table 2. List of medicinal and aromatic plant families and species of the Fes-Meknes region used by the local population (continued...)

Families and species	Vernacular name	Type of plant	Part used	Preparation method	FC	RFC	FIV	Treated diseases	Reference
<i>Ocimum basilicum</i> L.	Lehbak الحيق	cl	lv	inf	16	4.92		Digestive, respiratory, antispasmodic, diabetes	(Alami et al., 2021; El Hachlafi et al., 2020; El-Hilaly et al., 2003; Salhi et al., 2010; Tahraoui et al., 2007)
<i>Origanum majorana</i> L.	Merdeddou مردادوش	sp, cl	wp	dec, inf	19	5.84		Digestive, antiseptic, antispasmodic, calming	(Alami et al., 2021; El Hachlafi et al., 2020; El-Hilaly et al., 2003; Es-Safi et al., 2020; Fadil et al., 2015; Khabbach et al., 2012; Salhi et al., 2010; Tahraoui et al., 2007)
<i>Rosmarinus officinalis</i> L.	Azir أزير	cl	wp, lv	dec, inf	17	5.23		Detoxifying, reduces stress, calms rheumatic disorders	(Eddouks et al., 2017; El Hachlafi et al., 2020; El-Hilaly et al., 2003; Es-Safi et al., 2020; Mechchate et al., 2020; Salhi et al., 2010)
<i>Salvia officinalis</i> L.	Salmia السالمية	cl	lv, wp	inf, dec	21	6.46		Anti-inflammatory, digestive, hypoglycemic	(Bouyahya et al., 2017; Bouayyadi et al., 2015; Eddouks et al., 2017; El Hachlafi et al., 2020; Ghourri et al., 2013; Mechchate et al., 2020; Orch et al., 2015)
<i>Salvia verbenaca</i> L.	Khiyata خياطة	sp	lv	inf, dec, pl	23	7.07		Dermatological, anti-rheumatic	(Alami et al., 2021; Benlamdini et al., 2014; Bouayyadi et al. 2015)
<i>Thymus vulgaris</i> L.	Zaater الزعر	sp	lv, wp	dec	19	5.84		Digestive, antiseptic, diabetes, respiratory	(Alami et al., 2021; El Hachlafi et al., 2020; Fadil et al., 2015; Ghourri et al., 2013; Mechchate et al., 2020)

Table 2. List of medicinal and aromatic plant families and species of the Fes-Meknes region used by the local population (continued...)

Families and species	Vernacular name	Type of plant	Part used	Preparation method	FC	RFC	FIV	Treated diseases	Reference
Leguminosae							4.846		
<i>Ceratonia siliqua</i> L.	Lkharrob الخروب	sp	lv	fp, dec	13	4.00		Toxin absorbent, intestinal, stop the diarrhea	(Barkaoui et al., 2017; Bouyahya et al., 2017; El Hachlafi et al., 2020; El Hassani et al., 2013; El-Hilaly et al., 2003; Es-Safi et al., 2020; Mechchate et al., 2020)
<i>Glycyrrhiza glabra</i> L.	Arkessous عرق السوس	sp	rt, st	inf, mac	18	5.53		Respiratory, menstrual disorders, sexual impotence	(Alami et al., 2021; Bouayyadi et al., 2015; El Hilah et al., 2016; El Yahyaoui et al., 2015; Es-Safi et al., 2020; Ghourri et al., 2013)
<i>Trigonella foenum-graecum</i> L.	El halba الحلبة	sp, cl	sd, wp	fp, mac	20	6.15		Diabetes, digestive, detoxifying, respiratory, face care	(Barkaoui et al., 2017; El Hachlafi et al., 2020; El-Hilaly et al., 2003; Es-Safi et al., 2020; Lahsissene et al., 2009; Mechchate et al., 2020; Tahraoui et al., 2007)
<i>Vicia faba</i> L.	El fûl الفول	cl	sd, lv	dec	12	3.69		Digestive, dental	(Benlamdini et al., 2014; Bouayyadi et al., 2015; Alami et al., 2021)
Lythraceae							25.538		
<i>Punica granatum</i> L.	Remman الزّمان	cl	lv	dec, fp	83	25.53		Hair care, dermatological, dental	(Alami et al., 2021; Bouyahya et al. 2017; El Hachlafi et al., 2020; El-Hilaly et al., 2003; Es-Safi et al., 2020; Mechchate et al. 2020)
Oleaceae							31.384		
<i>Olea europaea</i> L.	Zitoun الزيتون	sp	lv	inf, dec, fp	102	31.38		Articular, digestive, dermatological, dental, cancer	(Alami et al., 2021; Bouyahya et al., 2017; El Hachlafi et al., 2020; El-Hilaly et al., 2003; Es-Safi et al., 2020; Fadil et al., 2015; Mechchate et al., 2020; Orch et al., 2015)

Table 2. List of medicinal and aromatic plant families and species of the Fes-Meknes region used by the local population (continued...)

Families and species	Vernacular name	Type of plant	Part used	Preparation method	FC	RFC	FIV	Treated diseases	Reference
Papaveraceae							18.769		
<i>Papaver rhoeas</i> L.	Belaâman بلعمان	sp	fl, st, lv	pl, dec	61	18.76		Gynecology, hair care, fever	(Alami et al., 2021; El-Hilaly et al., 2003; El Hassani et al., 2013; Es-Safi et al., 2020; Mechchate et al., 2020)
Pinaceae							12.307		
<i>Pinus halepensis</i> Mill.	Taida Sanaoubar تايدا، الصنوبر	sp	pl	fp	40	12.30		Dermatological	(Bellakhdar, 1997; El-Hilaly et al., 2003)
Plantaginaceae							27.384		
<i>Plantago major</i> L.	Messassa المصاصة	sp	lv, wp	pl, fp	89	27.38		Dermatological	(El-Hilaly et al., 2003; El Hassani et al., 2013)
Rosaceae							23.076		
<i>Rosa centifolia</i> L.	Lward الورد	cl	fl	fp, inf	75	23.07		Hair and face care, digestive	(Alami et al., 2021; Bellakhdar, 1997; El-Hilaly et al., 2003)

Table 2. List of medicinal and aromatic plant families and species of the Fes-Meknes region used by the local population (continued...)

Families and species	Vernacular name	Type of plant	Part used	Preparation method	FC	RFC	FIV	Treated diseases	Reference
Rutaceae							10.920		
<i>Citrus × aurantium</i> L.	Larnej لرنج	cl	lv, fl	inf, dec, fp	59	18.15		Genito-urinary	(Alami et al. 2021; El-Hilaly et al. 2003)
<i>Ruta chalepensis</i> L.	Lfijel الفيجل	sp	lv, wp	inf, dec, pl, fp	12	3.69		Diarrhea, genito-urinary	(Bellakhdar, 1997, El-Hilaly et al., 2003)
Salicaceae							13.538		
<i>Populus alba</i> L.	Sefsaf الصفتصاف	sp	lv	dec	44	13.53		Digestive, tension, headaches	(Bellakhdar, 1997; El-Hilaly et al., 2003; El Hassani et al., 2013)
Thymelaeaceae							32.615		
<i>Daphne gnidium</i> L.	Lezaaz اللزّاز	sp	lv	fp	106	32.61		Hair and face care	(Alami et al., 2021; Hachi et al., 2015)
Urticaceae							16.615		
<i>Urtica dioica</i> L.	Herriga الحريجة	sp	lv, st, sd	inf, dec, pl	54	16.61		Dermatological, digestive, hair care	(Benkhiguet et al., 2010; Bouayyadi et al., 2015; El-Hilaly et al., 2003; Ghourri et al., 2013; Tahri et al., 2012)
Verbenaceae							16.615		
<i>Aloysia citriodora</i> Palau [synonym of <i>Lippia citriodora</i> (Palau) Kunth]	Lwiza اللويزة	cl	lv	inf, dec	85	26.15		Calming, genito-urinary	(Alami et al., 2021, Bellakhdar, 1997, Bouayyadi et al., 2015)

Table 2. List of medicinal and aromatic plant families and species of the Fes-Meknes region used by the local population (continued...)

Families and species	Vernacular name	Type of plant	Part used	Preparation method	FC	RFC	FIV	Treated diseases	Reference
<i>Verbena officinalis</i> L.	Baymutal بيموطل	sp	lv	inf, dec	23	7.07		Calming	(Alami et al., 2021; Bellakhdar, 1997; El-Hilaly et al., 2003)
Vitaceae							15.692		
<i>Vitis vinifera</i> L.	Dalia الدالية	cl	lv	inf	51	15.69		Digestive	(Alami et al. 2021; Benlamdini et al., 2014; Bouayyadi et al., 2015)

Type of plant: cl: Cultivated; sp: Spontaneous.

Part used: wp: Whole plant; fl: Flowers; lv: Leaves; st: Stem; sd: Seeds; rt: Roots.

Preparation method: inf: Infusion; dec: Decoction; mac: Maceration; pl: Poultice; fp: Fresh plant.

Scientific names were checked according to The Plant List website <http://www.theplantlist.org/>

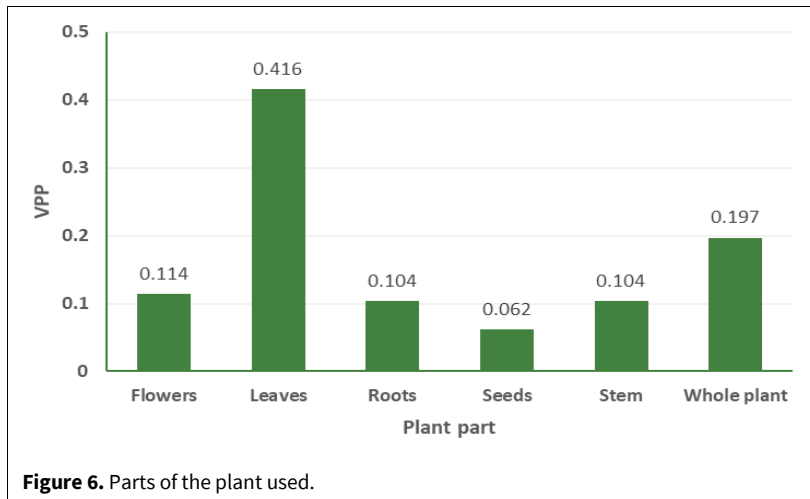


Figure 6. Parts of the plant used.

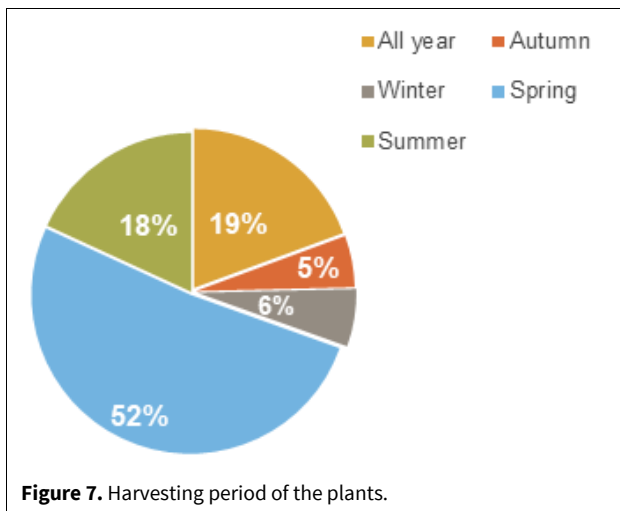


Figure 7. Harvesting period of the plants.

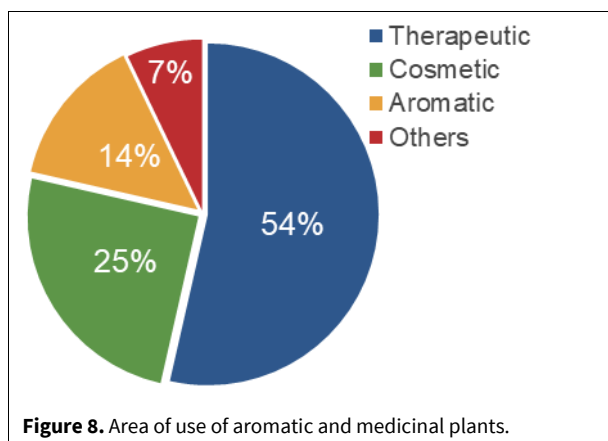


Figure 8. Area of use of aromatic and medicinal plants.

These plant preparations are often combined with other natural products because of their wide benefits in boosting the effectiveness increase of the remedy. Honey, heading these products with a percentage of use of 25%, is widely known for its antiseptic effect and anti-inflammatory properties. It is used to treat wounds, burns, respiratory inflammations, and sore

throats. Propolis (19%) is particularly well known for skincare and its healing action. Oil (15%) is used for its soothing, nourishing, moisturizing, and protective properties. Honey wax (13%) treats skin problems, congestion, and coughs. It relieves rheumatological pain as well. Vegetable coal (11%) is a detoxifier used for dental and skin care. Clay (8%) is known for its skin-regenerating properties. It has healing, detoxifying, anti-aging, and anti-inflammatory properties. Baking soda (6%) helps relieve oral problems, neutralize stomach acidity, and fight fungus (Fig. 10).

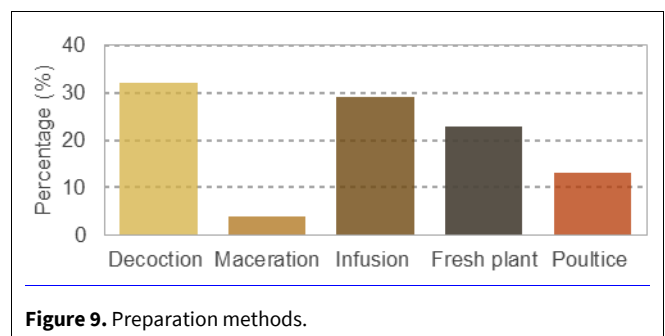


Figure 9. Preparation methods.

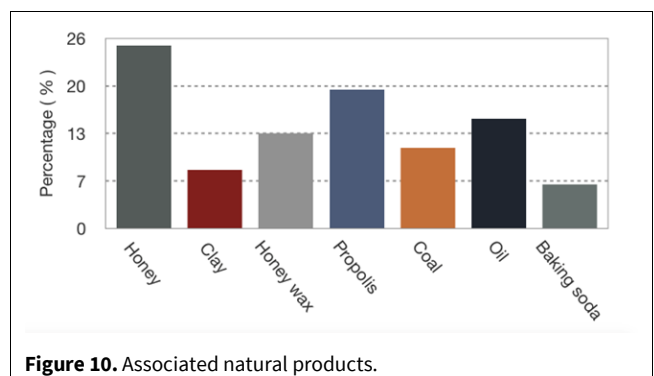
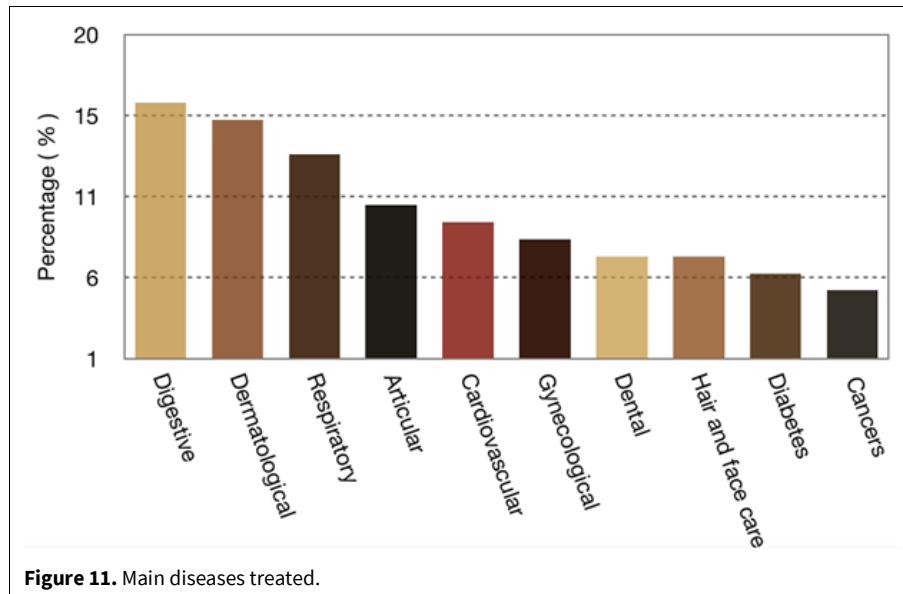


Figure 10. Associated natural products.



Treated diseases

The results of the studied region showed variability in the percentage of the various pathologies treated by the aromatic and medicinal plants. We noted that the digestive affections come first with a percentage of 16%, followed by the dermatological affections with 15%, then the respiratory, articular, cardiovascular, and gynecological diseases with respective percentages of 13, 10, 9, and 8%, respectively (Fig. 11). However, a study in the same region classified treatment of digestive disorders in the first place with a percentage (25%), followed by osteoarticular diseases (24%) and urogenital diseases (12%) (Achour et al., 2022). Another survey in the Fes-Meknes region demonstrated that cardiovascular disease, diabetes, and the common cold are the most treated diseases with medicinal plants combined with synthetic drugs (Saibari et al., 2021).

These plants are also frequently used for dental, hair, and skin care, with a percentage of 7%. The least treated diseases are diabetes 6% and cancers 4% (Fig. 11). These results almost match with those already obtained in the Pre-Rif of Morocco (El-Hilaly et al., 2003), in the North-East of Morocco (Alami et al., 2021), in the province of Laâyoune (El Yahyaoui et al., 2015), and the Gharb region (El-Assri et al., 2021).

Preparations remedies identified

Most herbalists were unwilling to cooperate and make their recipes public. Yet, we were able to identify some of these recipes in our study. The most cited recipes are represented with a preparation method, dosage, and duration of treatment, varying from three days to one month (Table 3). These results match those of Achour et al. (2022).

CONCLUSION

The surveys conducted allowed for an inventory of medicinal species and the collection of as much information as possible about local traditional therapeutic uses. These results can be considered a source of information for scientific research in phytochemistry and pharmacology. The ethnobotanical study showed that the Fes-Meknes region has a diversified and rich flora of medicinal plants, which enabled us to highlight the important place of traditional phytotherapy among the region's local population. The information acquired from the questionnaires helped us to identify 57 species belonging to 24 families used in phytotherapy, with a clear dominance of the *Lamiaceae* family (12 species). Most of the medicinal species of the region are used in treating digestive, dermatological, and respiratory diseases, with decoction as a dominant method of preparation.

CONFLICT OF INTEREST

The authors declare no conflicts of interest.

Table 3. Some used recipes to treat many diseases in the Fes-Meknes region.

Diseases	Recipe	Preparation methods	Dosage	Treatment duration
Eczema	<i>Thymus vulgaris</i> L. + <i>Matricaria chamomilla</i> L. + <i>Trigonella foenum- graecum</i> L. + Honey wax	Bland all plants with honey	A scoop on the part to be treated	Four weeks
Asthma	(1) <i>Allium sativum</i> L. + <i>Foeniculum vulgare</i> Mill. + oil (2) <i>Marrubium vulgare</i> L.+ <i>Papaver rhoeas</i> L. <i>Thymus vulgaris</i> L. + Honey	Maceration	A spoonful of the mixture in the evening	Three weeks
Digestive disorder	(1) <i>Foeniculum vulgare</i> Mill. + <i>Ammodaucus leucotrichus</i> Coss. + <i>Coriandrum sativum</i> L. + Propolis (2) <i>Rosmarinus officinalis</i> L.+ <i>Thymus vulgaris</i> L. + <i>Aloysia triphylla</i> (L'Hér.) Britton	Infusion	One glass once a day	One week
Cancer	(1) <i>Allium cepa</i> L.+ <i>Quercus suber</i> L.+ <i>Urtica dioica</i> L. + Honey (2) <i>Artemisia absinthium</i> L. + <i>Marrubium vulgare</i> L. + <i>Trigonella foenum- graecum</i> L. + Honey	Bland all plants with honey	One tablespoon every morning	Until healing
Fever	(1) <i>Brassica rapa</i> L.+ <i>Origanum majorana</i> L. (2) <i>Salvia officinalis</i> L.	(1) Fumigation (2) Cataplasm on head	(1) A pinch one a day (2) Scoop of cataplasm twice a day	3 days
Diabetes	<i>Allium cepa</i> L.+ <i>Citrus × aurantium</i> L.+ <i>Ocimum basilicum</i> L.	Decoction of leaves	One glass/day	1 month
Burns	<i>Dittrichia viscosa</i> (L.) Greuter + <i>Urtica dioica</i> L. + Honey wax	Cataplasm	Three times per day	Until healing

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AUTHOR CONTRIBUTION:

Contribution	Tlemcani S	Lahkimi A	Eloutassi N	Bendaoud A	Hmamou A	Bekkari H
Concepts or ideas	x	x	x			x
Design	x		x		x	
Definition of intellectual content	x					
Literature search	x					
Experimental studies	x					
Data acquisition	x			x		
Data analysis	x			x		
Statistical analysis	x			x		
Manuscript preparation	x					
Manuscript editing	x					
Manuscript review	x	x	x	x	x	x

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Annex 1. Survey used in the present study.

I-Personal questions:

- Age:
- Gender: Men. Women
- Study level: Illiterate Primary college High school University
- Profession:

II-Questions in herbal medicine

-What plants are abundant in the area ?

Name of plant (Arabic, French)	Name of plant (Arabic, French)

- Type of plant: Spontaneous Cultivated
- State of plants: Fresh Dry
- If dried, what is the method of drying?
- Harvest technique: Manual Mechanical
- Harvesting period of the plants:
 - All the year Autumn Winter Spring Summer
- Parts of the plant used:
 - Whole plant Leaves Stem Seeds Flowers Roots
- Preparation methods
 - Decoction Maceration Infusion Fresh plant Poultice
- Areas of use of plants: Cosmetic Therapeutic Aromatic Other
- Cause of use of plants: Availability Efficiency Low cost Other
- Frequency of use of plant:
- Have you ever consulted a doctor and followed a treatment?.....
- Who would you go to see first if you get sick and why?.....
- Where did you acquire your knowledge of herbal medicine?.....
- Do you have plants available at home (useful for herbal medicine)?.....
- (take samples) (take photos)
- Are they local plants or not?.....
- If yes, where exactly are these plants in the region?.....
- Operational mode of use

Plant and Part used	Disease	Preparation and quantity	Method of administration and Number of times/day	Contraindications (children, pregnant women, interactions, etc.)

- Have you already followed cases of healing? Yes No
- If yes, which ones?.....
- How long did it take?

III-Questions on remedies

-Do you combine several plants in herbal medicine?

Association of plants: (name of plants)	Diseases	Preparation and quantity	Method of administration and Number of times/day	Contraindications (children, pregnant women, interactions, etc.)
Association 1:				
Association 2:				
Association 3:				

- Do you combine other natural products with herbal medicine? Yes No

Natural product	Benefits	Contraindication or side effects

-What do you think are the benefits of these natural products?