Ethnobotanical study of medicinal plants used to treat osteoarticular diseases in the Moroccan Rif, Morocco

[Estudio etnobotánico de plantas medicinales utilizadas para tratar enfermedades osteoarticulares en el Rif marroquí, Marruecos]

Noureddine Chaachouay*, Ouafae Benkhnigue, Mohamed Fadli, Rachida El Ayadi, Lahcen Zidane

Natural Resources and Biodiversity Laboratory, Department of Biology, Faculty of Sciences, Ibn Tofail University, B.P. 133 14000, Kenitra, Morocco.
*E-mail: noureddine.chaachouay@uit.ac.ma

Abstract

Context: Ethnobotanical studies are one of the important steps in bioprospecting and preserving traditional uses of medicinal plants.

Aims: To identify medicinal and aromatic plant used by the local people to treat osteoarticular diseases, together with the associated ethnomedicinal knowledge.

Methods: The ethnobotanical survey was conducted in the Moroccan Rif region (North of Morocco) for two periods from 2016 to 2018. In total, 520 local traditional herbalists and users of these plants were interviewed. Information was collected using semi-structured interviews and group discussion, analyzed and compared by quantitative ethnobotanical indices such as family importance value (FIV), relative frequency of citation (RFC), plant part value (PPV), fidelity level (FL) and informant consensus factor (ICF) were used to analyze the obtained data.

Results: The analysis of results identified 17 plant species distributed in 10 families with a dominance of the *Poaceae* (6 species). Concerning the diseases treated, rheumatism diseases have the highest ICF (0.98). The survey revealed that leaves were the most used part of the plants (PPV=0.37) and the majority preparation used was a decoction (40.9%).

Conclusions: The results of the present study showed the existence of indigenous ethnomedicinal knowledge of medicinal and aromatic plants in the Moroccan Rif to treat osteoarticular diseases. Further research on phytochemical, pharmacological and other biological activities should be considered to discover new drugs from these documented plants.

Keywords: Moroccan Rif; medicinal and aromatic plants; osteoarticular diseases.

Resumen

Contexto: Los estudios etnobotánicos son uno de los pasos importantes en la bio-prospección y preservación de los usos tradicionales de las plantas medicinales.

Objetivos: Identificar plantas medicinales y aromáticas utilizadas por la población local para tratar enfermedades osteoarticulares, junto con el conocimiento etnomedicinal asociado.

Métodos: El estudio etnobotánico se realizó en la región del Rif marroquí (norte de Marruecos) durante dos períodos, de 2016 a 2018. En total, se entrevistó a 520 herbolarios tradicionales locales y usuarios de estas plantas. La información se recopiló mediante entrevistas semiestructuradas y discusión grupal, se analizó y comparó mediante índices etnobotánicos cuantitativos como el valor de importancia familiar (FIV), la frecuencia relativa de citas (RFC), el valor de la parte de la planta (PPV), el nivel de fidelidad (FL) y el factor de consenso del informante (ICF) se utilizó para analizar los datos obtenidos.

Resultados: El análisis de los resultados identificó 17 especies de plantas distribuidas en 10 familias con un predominio de las *Poaceae* (6 especies). En cuanto a las enfermedades tratadas, las enfermedades de reumatismo tienen el ICF más alto (0,98). La encuesta reveló que las hojas eran la parte más utilizada de las plantas (VPP = 0,37) y la mayor parte de la preparación utilizada era una decocción (40,9%).

Conclusiones: Los resultados del presente estudio mostraron la existencia de conocimientos etnomedicinales indígenas de plantas medicinales y aromáticas en el Rif marroquí para tratar enfermedades osteoarticulares. Se deben considerar investigaciones adicionales sobre las actividades fitoquímicas, farmacológicas y otras actividades biológicas para descubrir nuevos fármacos a partir de estas plantas documentadas.

Palabras Clave: enfermedades osteoarticulares; plantas medicinales y aromáticas; Rif marroquí.

INTRODUCTION

Humans have always used medicinal and aromatic plants (MAPs) to treat themselves and fight against diseases. In all ancient civilizations and in all continents, one finds traces of this use. Thus, even today, despite the progress of pharmacology, the therapeutic use of plants is very present in some countries, especially in developing countries.

Morocco, by its biogeographical position, offers a very rich ecological and floristic diversity constituting a true plant genetic reserve, with about 4,500 species belonging to 940 genera and 135 families, the mountainous regions of Rif and Atlas being the most important areas for endemism (Matuhe, 2001). This biodiversity is characterized by a very marked endemism (Ghanmi et al., 2011) allows it to occupy a privileged place among the Mediterranean countries, which have a long medical tradition and traditional know-how based on medicinal and aromatic plants (Scherrer et al., 2005). Indeed, traditional medicine has always occupied an important place in the traditions of medication in Morocco and the Rif region is a concrete example.

The analysis of the Moroccan medicinal bibliography shows that the data on regional medicinal and aromatic plants are very fragmentary and dispersed. Because of the few thousand plant species, the medicinal species counted do not exceed the 600 species (Rejdali, 1996) or 14.28% of the total Moroccan flora. The heritage of the medicinal flora requires regular monitoring and evaluation in terms of quality and quantity.

Accordingly, this ethnobotanical study was conducted in the Moroccan Rif, which has a considerable lithological, structural, biological and floristic diversity, because of its relief, its topography and its geographical location. The purpose of the present investigation was to evaluate medicinal plants that grow in the study area with the aim to contribute to indigenous knowledge of MAPs

and to analyze the results concerning the existing relationships between medicinal species and osteoarticular diseases. Indeed, it is very important to transform this traditional knowledge into scientific knowledge in order to revalue it, to preserve it and use it rationally.

MATERIAL AND METHODS

Description of the study area

The present study was conducted in the Rif (northern Morocco) it is located on the Mediterranean coast, about 431 km at the north of Rabat, the administrative capital. The Rif is part of the region of Tangier-Tetouan-Al Hoceima, which is one of the twelve regions of Morocco established by the territorial division of 2015 (Bulletin officiel, 2015). This study area (between 34° to 36° N latitude and 4° to 6° E longitude) is limited to the north by the Strait of Gibraltar and the Mediterranean Sea, to the west by the Atlantic Ocean, to the south-west by the Rabat-Sale-Kenitra region, to the south-east by the Fez-Meknes region and to the east by the Eastern region. The region has two prefectures (Tangier-Asilah and M'Diq-Fnideq) and six provinces (Al Hoceima, Chefchaouen, Fahs-Anjra, Larache, Ouezzane and Tetouan) and the region's capital, Tangier-Asilah as shown in (Fig. 1).

According to the 2014 national census report (HCP, 2018), the total area of study area is about 11,570 km² with an average population density of 222.2/km², and the human population is 3,549,512. The study area has Mediterranean climate with maximum temperature beyond 45°C during summer (July-August) and below 0°C during winter (December-January) and annual rainfall is about 1000 mm. In the area, economy of the local people is very much dependent on subsistence agriculture, livestock and to a lesser extent, from forest resources for their livelihood. Inhabitants of the region use variety of MAPs for the treatment ailments due to expensive drugs.
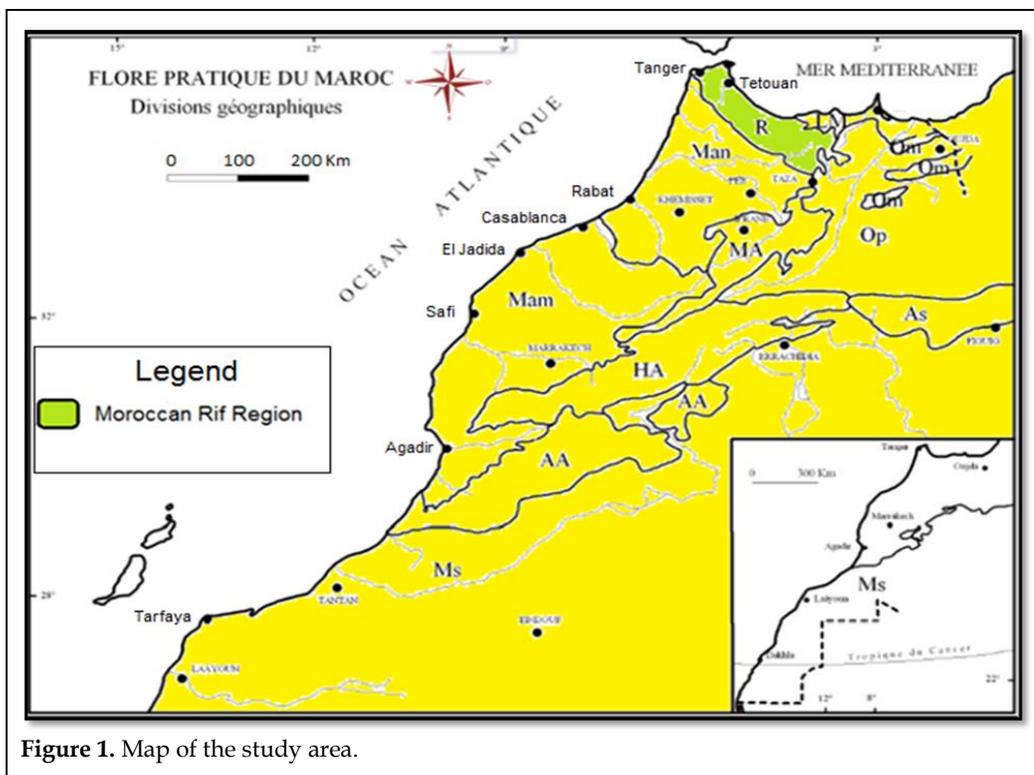
Figure 1. Map of the study area.

Methodology

Data collection

In order to gather information on MAPs used for curing osteoarticular disorders, an ethnobotanical survey was conducted from June 30th, 2016 to June 1st, 2018. Semi-structured questionnaires were administered and open-ended interviews were conducted, through face to face interviews and focus group. The inclusion criteria were people who are knowledgeable about plants used for osteoarticular problems, while the exclusion criteria were informants who are not living in the study area. Totally, 520 informants within aged 18 to 79 were randomly selected for interviews (pharmacists, herbalists, practitioners and therapists) in the study area (hospitals, pharmacies, houses, mosques, and weekly markets). Who have been informed about the objective of this study, after obtaining their trust and were regularly interviewed in Amazigh or Arabic dialects depending on the variety of language spoken by each case, in order to collect and document indigenous knowledge of plants usage against osteoarticular diseases. They are people reputedly experienced

and serious. The questionnaire used consists of two parts: the first part deals with the demographic characteristic of the informants and the second one focuses on the plants used in the treatment of the diseases (Appendix 1). The sample was made up of 265 females and 255 males from different socio-economic strata, chosen at random from the Rif's population. In this study, the sample was developed using a stratified random sampling method (Godron, 1971) to conduct various surveys from a site to another in the study area. According to this sampling method, the study area has been divided into (Sn) sites, so there are 28 sites that correspond to the number of sections in the study area (Fig. 2).

Plant species collection and identification

Each plant used by informants was placed in the Herbarium or in a plastic bag with a label indicating its vernacular name. They were photographed and subsequently sampled for identification at the biodiversity and resource laboratory, department of biology faculty of sciences, Ibn Tofail University Kenitra, Morocco, using the following botanical works: the medicinal plants of
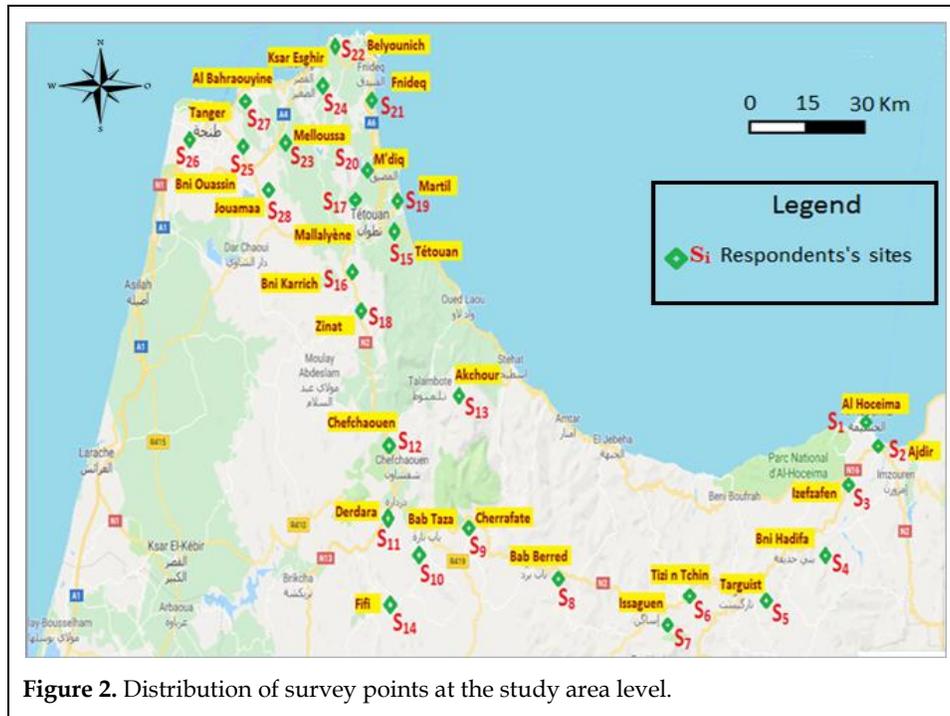
Figure 2. Distribution of survey points at the study area level.

the Morocco (Sijelmassi, 1993), practical flora of Morocco (Fennane et al.,1999) and catalogs of vascular plants of Northern Morocco, including identification keys (Valdés, 2002).

Ethics statement and consent

Letters of consent were taken from department of biology, Ibn Tofail University and an agreement with the local authorities of Chefchaouen, Al Hoceima, Tetouan and Tangier. All data collections were done with special care on the base of the cultural view of the local sites in the study area. Informants were also informed that the objectives of the research were not for commercial purposes but for academic reasons. Participants provided verbal informed consent to participate in this study. They were free to withdraw their information at any point of time. Finally, informants were accepted the idea and they have clearly agreed to have their names and personal data to be published.

Data analysis

A descriptive and quantitative statistical method was used to analyze the socio-demographic data of the informants (ANOVA One-way and independent samples T-test, p-values of 0.05 or less were considered significant). The results of the ethnobotanical survey were analyzed using the Family Importance Value (FIV), Relative Frequency of Citation (RFC), Plant Part Value (PPV), Fidelity Level (FL) and Informant Consensus Factor (ICF). All statistical analyses were carried out with Statistical Package for Social Science (SPSS) version 21 and Microsoft Excel 2010.

Family Importance Value (FIV)

The FIV identify the significance of plants families. It is as an index of cultural importance, which can be applied in ethnobotany to calculate a value of biological plant taxon. To calculate FIV, using the following formula [1].

$$FIV = \frac{FC_{family}}{N_S} \qquad [1]$$

Where FC_{family} = RFC is the number of informants mentioning the family and Ns = Total number of species within each family [1] (Sreekeesoon and Mahomoodally, 2014).

Frequency (FC) and Relative Frequency of Citation (RFC)

Relative frequency of citation (RFC) is obtained by dividing frequency citation (FC) by total number of informants in the survey (N). The value of RFC for species of medicinal plants is based on the citing percentage of informants for every species. RFC was calculated by using the following formula [2] (Tardío and Pardo-de-Santayana, 2008) with (0 < RFC < 1 .

$$\text{RFC} = \frac{FC}{N} \tag{2}$$

Plant Part Value (PPV)

Plant part value (PPV) was calculated using the following formula [3].

$$\text{PPV} = \frac{\text{RU}_{\text{Plant part}}}{\text{RU}} \times 100 \tag{3}$$

Where RU is the number of uses reported of all parts of the plant and RU$_{\text{plant part}}$ is the sum of uses reported per part of the plant. The part with the highest PPV is the most used by the respondents.

Fidelity Level (FL)

Fidelity level (FL) was the percentage of informants who mentioned the uses of certain plant species to treat a particular ailment in the study area. The FL index was calculated using the formula [4] (Friedman et al., 1986).

$$\text{FL (\%)} = \frac{\text{Np}}{N} \times 100 \tag{4}$$

Where Np is the number of informants that claim a use of a plant species to treat a particular disease, and N is the number of informants that use the plants as a medicine to treat any given disease.

Informant Consensus Factor (ICF)

Informant consensus factor [5] was derived in order to seek an agreement between the informants on the reported cures for each group of diseases (Heinrich et al., 1998).

$$\text{ICF} = \frac{\text{Nur} - \text{Nt}}{\text{Nur} - 1} \tag{5}$$

Where Nur is the number of use-reports in each disease category and Nt is number of species used.

RESULTS AND DISCUSSION

Socio-demographic features of the informants

In total, 520 local informants including 265 females and 255 males (with a sex ratio female/male of 1.04) were interviewed (Table 1). In the Moroccan Rif, both sexes are affected by traditional herbal medicines. However, women have a greater knowledge on the plant species and their use with a predominance of 50.9% against a percentage of 49.1% among men though the test (independent sample t test) did not show a significant difference (p=0.275) between male and female informants on the number of medicinal plant species they listed and associated uses reported. This predominance of females can be explained by the vigilance of women for the balance of the disease, and their attachment to all that is traditional; indeed, it is women who give sustenance and healthcare to their families in case of an illness. These results confirm the results of other ethnobotanical work carried out at national scale (Jouad et al., 2001; Salhi et al., 2010; Tahraoui et al., 2007; Ziyyat et al., 1997).

At the level of the study area, the majority of respondents were with the age range between 40 and 60 (43.6%) followed by informants who were between 20 and 40 years (27%), informants who were more than 60 years (19.4%). Finally, informants with an age less than 20 come in last position (10%). Significant differences (p=0.000) were obtained by ANOVA One-way between age groups and indigenous knowledge. The highest age respondents provide more reliable information because they hold much of the ancestral knowledge that is part of the oral tradition. So, there was a loss of information on MAPs, which can be explained by the mistrust of certain young people, who tend disinterest on this herbal medicine due

Table 1. Sociodemographic details of the informants in the Moroccan Rif area.

Variables	Categories	Number of informants N = 520	Percentages (%)	P-values
Gender	Female	265	50.9	.0275
	Male	255	49.1	
Age groups	< 18 years	52	10	0.000
	20-40	140	27	
	40-60	227	43.6	
	> 60 years	101	19.4	
Family situation	Married	357	68.7	0.000
	Divorced	77	14.8	
	Widower	36	7	
	Single	50	9.5	
Educational level	Illiterate	304	58.4	0.000
	Primary	159	30.6	
	Secondary	51	9.8	
	University	6	1.2	
Income/month	Unemployed	214	41.2	0.000
	250 - 1500 DH	189	36.3	
	1500 - 5000 DH	99	19	
	> 5000 DH	18	3.5	

DH: Dirhams

to the influence of modernization and exotic culture influence. At present, the traditional medical knowledge transmitted from generation to generation is in danger, because transmission between old people and younger generation is not always assured (Anyinam, 1995). These values confirm the results obtained in other regions of Morocco (Aribi, 2013; Benlamdini et al., 2014; El Hafian et al., 2014).

The analysis of the collected data shows that, MAPs are much more used by married (68.7%) than by divorced (14.8%), knowing that singles have a percentage of 9.5% and only 7% for widowers, because the married people can avoid or minimize the material charges required by the doctor and the pharmacist. The difference between family status and indigenous knowledge for the treatment of osteoarticular diseases was statistically significant (p=0.000). Those findings coincide with those of similar study conducted by (El Hilah et al., 2015) in the central plateau of Morocco.

Regarding the level of education, 42% of the respondents are illiterate, followed by the categories of primary and secondary with percentages respectively 30.6% and 9.8%. Nevertheless, people with a university level education use little medicinal plants with a percentage of 1.2%. Thus, the difference between educational level and indigenous knowledge was significant (p=0.000). Therefore, it can be seen that the use of MAPs decreases as the level of study increases. This result is similar to the findings reported by (Bouzid et al., 2017; El Hilah et al., 2015; Lahsissene et al., 2009).

In this study, (41.2%) were unemployed, 36.3% of the interviewees had a low socio-economic level, (19%) with average level, and only 3.5% with higher level. The difference between income/month and indigenous knowledge was significant (p=0.000). The high cost of modern medical treatments and their side effects are among the main reasons why respondents used herbal medicine. It can be seen that the use of plants increases with the increase in monthly income of these informants. These results are similar to those obtained in Moyen Moulouya of Morocco by Douiri et al. (2007).

Floristic analysis

Medicinal plant species of the study area

A total of 17 medicinal plant species belonging to 10 botanical families, including 9 from dicotyledons and 1 from monocotyledons were used to treat osteoarticular diseases in the study area. These plants are presented in alphabetical order. For each plant listed .The scientific name, family, local name, the part used, and the method of preparation adopted by the local population are given, as well as the data of FIV, RFC and FL are shown in Table 2.

The most botanical family of medicinal plant species, used to treat osteoarticular diseases based on the number of species and FIV index, was *Poaceae* the leading family with 6 species (FIV 0.072), followed by Asteraceae (03 species with FIV 0.154), while other families were represented by one species only (Fig. 3). This high proportion of *Poaceae* could be explained by the high representation of this family in the Rif's flora because of the ecological factors that favor the development and adaptation of the majority of the species of this family. This representation has also been observed, with some differences, in other ethnomedicinal surveys conducted in other regions of the country (Jouad et al., 2001; Eddouks et al., 2002; Tahraoui et al., 2007).

RFC and FL plant species

To evaluate the relative importance of reported medicinal plants relative frequency of citation (RFC) were calculated based on the informants' citations for specific under study plant, its value ranged from 0.015 to 0.28. Results of this study depicted that *Nerium oleander* L. exhibited the higher RFC (0.28), followed by the *Oryza sativa* L. (RFC = 0.194), *Onopordum acanthium* L. (RFC = 0.175) and *Anacyclus pyrethrum* (L.) Lag. (RFC = 0.156). The least RFC was exhibited by the *Poa annua* L. (RFC = 0.015) and this increasing trend was found as follow: *Agrostis reuteri* Boiss. (RFC = 0.027) and *Bromus squarrosus* L. (RFC = 0.03). These species had the highest RFC index, because these plants were mentioned by a large number of informants and RFC directly depends on the number of informants mentioning the use of a specific plant. Those medicinal plant species having high RFC must be further assessed for phytochemical and pharmaceutical analysis to identify their active constituents for any drug extraction (Vitalini et al., 2013).

The fidelity value FL is an important means to see for which ailment a particular species is more effective, in the present study, the FL of plant species varied between 75 and 100%. The calculation results showed that all have more than 75% (Table 2). Of the results, twelve medicinal plants scored the highest FL values (100%) were used in the treatment of rheumatism, osteoporosis and arthrosis by the interviewees. The MAPs with high fidelity level are considered as having better healing potential in Moroccan Rif region and possess more natural products (tannins, flavonoids and alkaloids).

The fidelity value FL is an important means to see for which ailment a particular species is more effective, in the present study, the FL of plant species varied between 75 and 100%. The calculation results showed that all have more than 75% (Table 2). Of the results, twelve medicinal plants scored the highest FL values (100%) were used in the treatment of rheumatism, osteoporosis and arthrosis by the interviewees. The MAPs with high fidelity level are considered as having better healing potential in Moroccan Rif region and possess more natural products (tannins, flavonoids and alkaloids).
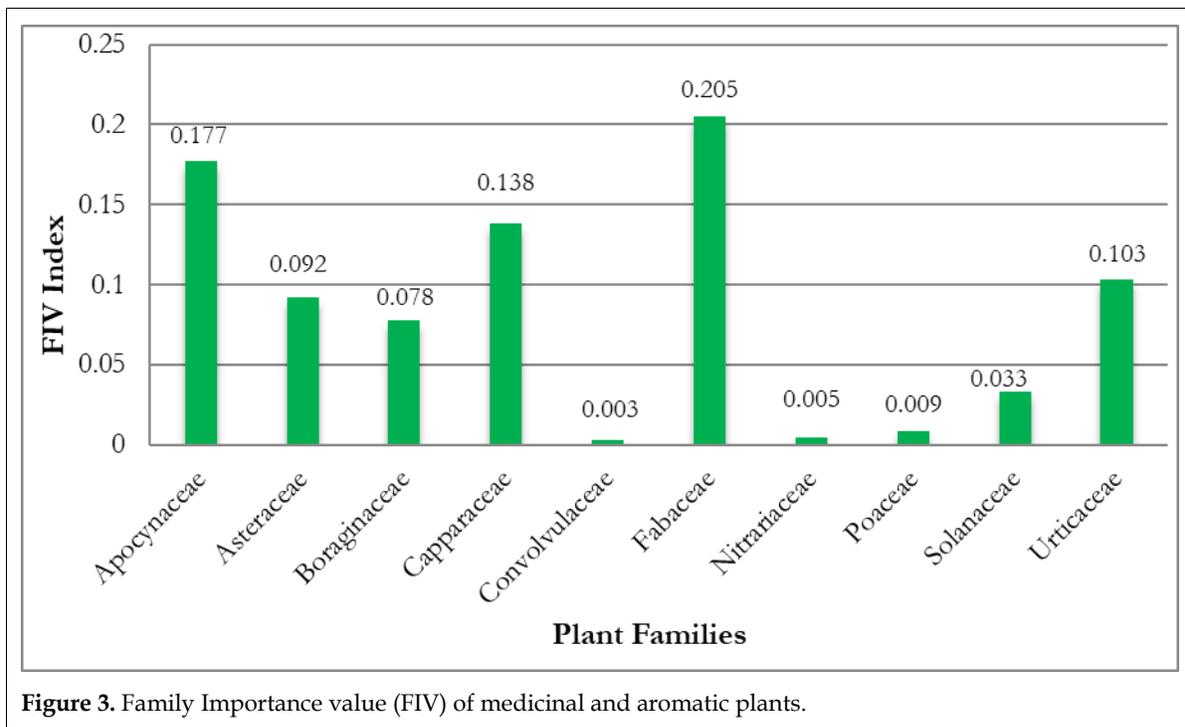
Figure 3. Family Importance value (FIV) of medicinal and aromatic plants.

Ethnobotanical and pharmacological aspect

Parts of the plant used to treat osteoarticular problems

People of the Moroccan Rif harvest different plant parts for the preparation of traditional remedies (e.g., seed, root, flower and leaf). Based on the plant part value PPV index (PPV: is the sum of uses reported per part of the plant divided by the number of uses reported of all parts of the plant), leaf was reported as the dominant plant part for osteoarticular remedy preparation in the study area (PPV 0.37), followed by seed (PPV 0.344), flower (PPV 0.2) and root (PPV 0.086) respectively (Fig. 4). The preference of leaves was due to its easy availability, easy harvesting and simplicity in remedy preparation. In addition, the leaves are the seat of the photosynthesis and sometimes the storage of the secondary metabolites responsible for biological properties of the plant. Similar findings indicated leaf as a major dominant plant part in Morocco (Daoudi et al., 2016; Douiri et al., 2007; Hachi et al., 2015) or in Africa (Asase et al., 2010; Asnake et al., 2016; Mukungu et al., 2016; Nouri, 2016) for herbal medicine preparation.

Method of preparation and route of administration

In order to facilitate the administration of the active principles of the plant, several modes of preparation are employed to know the decoction, the infusion, cataplasm, maceration, fumigation and cooked (Fig. 5). In the study area, decoction remains the most dominant mode of preparation (40.9%), followed by infusion (26.7%), cataplasm (19.8%) and cooked (12.6%). The percentage of the other modes of preparation grouped (fumigation, maceration) is 0%. The frequent use of the decoction can be explained by the fact that the decoction makes it possible to collect the most active ingredients and attenuates or cancels out the toxic effect of certain recipes. Ethnobotanical research surveys conducted elsewhere in Morocco showed the majority of the interviewees prepared the remedy by decoction (Salhi et al., 2010; El Hilah et al., 2015; Slimani et al., 2016). This confirms that there is a perpetual exchange of information on the use of medicinal and aromatic plants between the people of Morocco. Decoction mentioned as the major method of preparation at the continental level

(Okello et al., 2010; Stangeland et al., 2011; Yetein et al., 2013).

Route of administration also varies depends on the disease and materials used. In general, most of the prepared recipes are orally prescribed (81%) followed by massage (10%), swabbing (6.7%), rinsing (3.8%) and other modes of administration (2%). The predominance of oral administration may be explained by a high incidence of internal ailments in the region (Polat and Satıl, 2012). On the other hand, it's thought that oral route is the most acceptable for the patient. The predominance of oral administration of the different medicinal plants in Moroccan Rif is in total agreement with most of the carried out ethnobotanical studies in Africa (Benarba et al., 2014; El Hafian et al., 2014; Chermat and Gharzouli, 2015).

Table 2. List of medicinal and aromatic plants actives on the osteoarticular diseases in the Moroccan Rif region.

Family and scientific name	Vernacular name	Part used	Mode of preparation	Medicinal uses	FL %	FC	RFC	FIV
Apocynaceae								0.280
Nerium oleander L.	Defla, Alili	Leaf	Decoction	RH, OS, AR	95.2	146	0.280	
Asteraceae								0.154
Anacyclus pyrethrum (L.) Lag.	Tiguentest,	Root	Infusion	RH	100	81	0.156	
Calendula eckerleinii Ohle.	Jemra	Flower	Cataplasm	RH	100	67	0.130	
Onopordum acanthium L.	Chok Lhmir	Leaf	Decoction	RH	100	91	0.175	
Boraginaceae								0.050
Anchusa arvensis (L.) M.Bieb.	Lsan Etthawr	Flower	Infusion	RH	100	26	0.050	
Capparaceae								0.140
Capparis spinosa L.	Kebbar, Taglulut	Seed	Infusion	RH	100	73	0.140	
Convolvulaceae								0.069
Convolvulus althaeoides L.	Lablab El hokol	Flower	Decoction	OS	100	63	0.069	
Fabaceae								0.048
Pisum sativum L.	Jelbana	Seed	Cataplasm	OS	100	25	0.048	
Nitrariaceae								0.102
Peganum harmala L.	El Harmel	Seed	Cataplasm	RH	100	53	0.102	
Poaceae								0.072
Oryza sativa L.	Rûz	Seed	Cooked	RH, AR	94	101	0.194	
Pennisetum glaucum (L.) R.Br.	Illân	Seed	Infusion	RH	100	70	0.135	
Agrostis reuteri Boiss.	Ziwan Khachabi	Flower	Decoction	OS, AR	85.7	14	0.027	
Setaria verticillata (L.) P.Beauv.	Dayl Eddib	Flower	Cooked	RH	100	17	0.033	
Poa annua L.	Kabaa Howli	Leaf	Decoction	OS	100	08	0.015	
Bromus squarrosus L.	Amlsikh,	Leaf	Decoction	OS, AR	0.75	16	0.030	
Solanaceae								0.086
Withania frutescens (L.) Pauquy.	Ali Amlal, Tayrta	Leaf	Decoction	RH, AR	88.9	45	0.086	
Urticaceae								0.079
Urtica dioica L.	Hriga	Leaf	Cataplasm	OS	100	41	0.079	

RH: Rheumatism, OS: Osteoporosis, AR: Arthrosis. FIV=Family importancee value; FC= No. of informants; RFC=Relative frequency of citation, FL = Fidelity level. The scientific names were proposed according to The Plant List (http://www.theplantlist.org/).
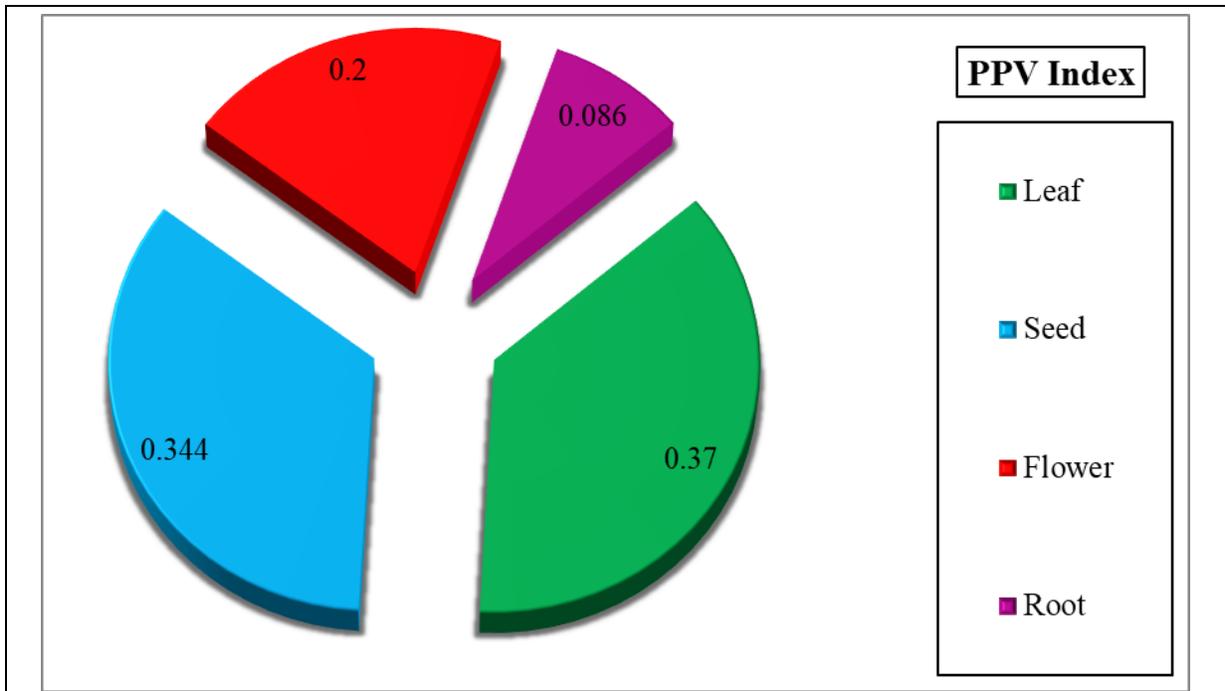
Figure 4. Plant part used in the treatment of osteoarticular diseases in the study area.

PPV: is the sum of uses reported per part of the plant divided by the number of uses reported of all parts of the plant.
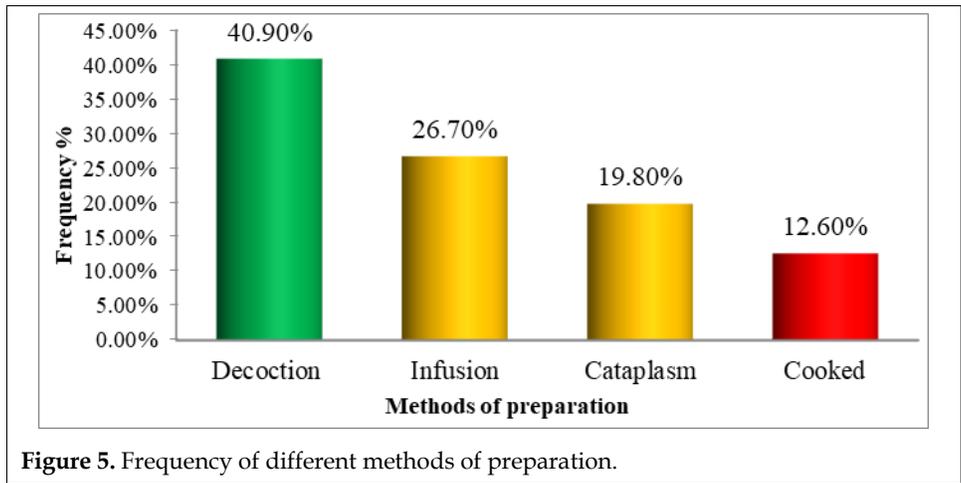
Figure 5. Frequency of different methods of preparation.

Condition of preparations

The majority of the remedies (58.3%) in the study area were prepared from fresh parts of medicinal plants followed by dried form (40.2%) and (1.5%) prepared either from dry or fresh plant parts. The study conducted by (Abdurhman, 2010) indicated that 86% of preparations were in fresh form and (Getahun, 1976) reported that most of (64%) medicinal plants were used in fresh form and 36% in dried from. The dependency of Moroc-

can Rif people on fresh materials is mostly due to the effectiveness of fresh medicinal plants in treatment as the contents are not lost before use compared to the dried forms.

Source of knowledge about medicinal plants

In this ethnobotanical survey, 80.5% of the population acquired knowledge about medicinal use of plants as remedy for osteoarticular diseases through others' experiences. This reflects the rela-

tive transmission of traditional practices from a generation to the next one. 12% practice herbal medicine according to herbalists' advices, (6.5%) of respondents their information is reflected from pharmacist and only 1% had built this knowledge by reading books about traditional Arab medicine, by watching television programs or by their own experience with a large number of medicinal plants in their surroundings. The environment and others' experience remain therefore the most effective means to transmit knowledge about medicinal purposes of plants (Fig. 6).

Treated ailments and informant consensus factor (ICF)

The informant consensus factor (ICF) depends upon the availability of plants within the study area to treat diseases. In the present study, the ICF values ranged from 0.76 to 0.98 per uses categories. A total of 17 species were identified to treat osteoarticular diseases. The informant consensus factors have been calculated for each category (Table 3). The highest ICF (0.98) value was obtained for diseases related to rheumatism and the least one (ICF = 0.76) was associated with arthrosis. The ICF results of the study proved that diseases that were frequent in the Moroccan Rif area have the higher informant consensus factor (values between

0.76 and 0.98). This high ICF values indicated reasonable reliability of informants on the use of medicinal plant species (Lin et al., 2002). The informant consensus values also indicated that the people share the knowledge of the most important medicinal plant species to treat the most frequently encountered diseases in the study area. Therefore, species with high ICF are to be prioritized for further on pharmacological and phytochemical studies.

Limitations of the study

This study was limited to a part of Morocco (Moroccan Rif region). The same study in various parts of Morocco is suggested.

CONCLUSIONS

The ethnobotanical survey revealed that, the study area has a great biodiversity with a variety of medicinal and aromatic plants and still needs more explorations. This rich floral indicates the high potential of traditional knowledge to serve for the development of natural product-derivate as affordable medicines. These plants still play a crucial role of people in Moroccan Rif, but medicinal plants used to treat osteoarticular diseases in this region lacks ethno-medicinal evidence.

Figure 6. Traditional knowledge acquisition modes.
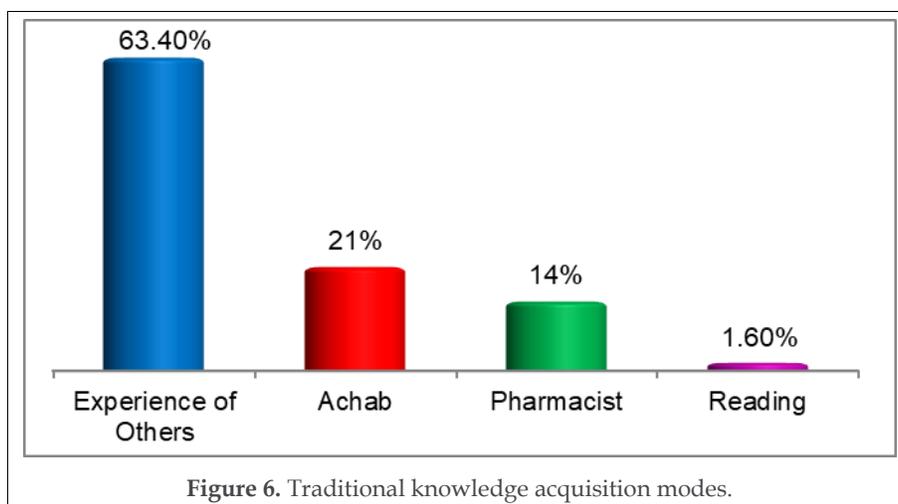
Table 3. ICF values by categories for treating osteoarticular diseases.

Categories	List of plant species used and number of citations	Total number of		ICF
		Species	Use citations	
Rheumatism (RH)	*Nerium oleander* L. (139), *Anacyclus pyrethrum* (L.) Lag. (81), *Calendula eckerleinii* Ohle. (67), *Onopordum acanthium* L. (91), *Anchusa arvensis* (L.) M.Bieb. (26), *Capparis spinosa* L. (73), *Peganum harmala* L. (53), *Oryza sativa* L. (95), *Pennisetum glaucum* (L.) R.Br. (70), *Setaria verticillata* (L.) P.Beauv. (17), *Withania frutescens* (L.) Pauquy. (40).	10	752	0.98
Osteoporosis (OS)	*Convolvulus althaeoides* L. (63), *Nerium oleander* L. (1), *Pisum sativum* L. (25), *Poa annua* L. (8), *Urtica dioica* L. (41), *Bromus squarrosus* L. (12), *Agrostis reuteri* Boiss. (12).	7	162	0.95
Arthrosis (AR)	*Withania frutescens* (L.) Pauquy. (5), *Nerium oleander* L. (6), *Oryza sativa* L. (6), *Bromus squarrosus* L. (2), *Agrostis reuteri* Boiss. (2).	5	21	0.76

On the basis of results of the present study, higher use value, preference ranking scores, and fidelity level values of the recorded medicinal plant species would empower the future pharmaceutical and phytochemical studies and conservation practices. In this connection, attention should be drawn to the conservations of traditional medicinal plants and associated indigenous knowledge in the Moroccan Rif area to sustain them in the future.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

Availability of data and materials

All data collected and analyzed in this paper are included within the article and attached in the form of 'Appendices' as additional files. Medicinal and aromatic plant specimens are deposited in Ibn Tofail University, Kenitra, Morocco.

REFERENCES

Abdurhman N (2010) Ethnobotanical study of medicinal plants used by local people in Ofla Wereda, Southern Zone of Tigray Region Ethiopia. Addis Ababa University: MSc Thesis.

Anyinam C (1995) Ecology and ethnomedicine. Exploring links between current environmental crisis and indigenous medical practices. pp. 4, 321-329.

Aribi I (2013) Etude ethnobotanique de plantes médicinales de la région du Jijel: Étude anatomique, phytochimique, et recherche d'activités biologiques de deux espèces.

Asase A, Akwetey GA, Achel DG (2010) Ethnopharmacological use of herbal remedies for the treatment of malaria in the Dangme West District of Ghana. J Ethnopharmacol 129(3): 367–376.

Asnake S, Teklehaymanot T, Hymete A, Erko B, Giday M (2016) Survey of medicinal plants used to treat malaria by Sidama People of Boricha District, Sidama Zone, South Region of Ethiopia. Evid Based Complement Alternat Med 2016: Article ID 9690164.

Benarba B, Meddah B, Tir Touil A (2014) Response of bone resorption markers to *Aristolochia longa* intake by Algerian breast cancer postmenopausal women. Adv Pharmacol Sci 2014: Article ID 820589.

Benlamdini N, Elhafian M, Rochdi A, Zidane L (2014) Étude floristique et ethnobotanique de la flore médicinale du Haut Atlas oriental (Haute Moulouya). J Appl Biosc 78(1): 6771–6787.

Bouzid A, Chadli R, Bouzid K (2017) Étude ethnobotanique de la plante médicinale Arbutus unedo L. dans la région de Sidi Bel Abbés en Algérie occidentale. Phytothérapie 15(6): 373–378.

Bulletin officiel (2015) Bulletin officiel, Décret n° 2-15-40 du 1er joumada I 1436 (20 février 2015).

Chermat S, Gharzouli R (2015) Ethnobotanical study of medicinal flora in the North East of Algeria-An empirical knowledge in Djebel Zdimm (Setif). J Mater Sci Eng 5: 50–59.

Daoudi A, Bammou M, Zarkani S, Slimani I, Ibijbijen J, Nassiri L (2016) Étude ethnobotanique de la flore médicinale dans la commune rurale d'Aguelmouss province de Khénifra (Maroc). Phytothérapie 14(4): 220–228.

Douiri E, El Hassani M, Bammi J, Badoc A, Douira A (2007) Plantes vasculaires de la Moyenne Moulouya (Maroc oriental). Bull Soc Linn Bordeaux 142: 409–438.

Eddouks M, Maghrani M, Lemhadri A, Ouahidi ML, Jouad H (2002) Ethnopharmacological survey of medicinal plants used for the treatment of diabetes mellitus, hypertension and cardiac diseases in the south-east region of Morocco (Tafilalet). J Ethnopharmacol 82(2–3): 97–103.

El Hafian M, Benlandini N, Elyacoubi H, Zidane L, Rochdi A (2014) Étude floristique et ethnobotanique des plantes médicinales utilisées au niveau de la préfecture d'Agadir-Ida-Outanane (Maroc). J Appl Biosc 81(1): 7198–7213.

El Hilah FBA, Dahmani J, Belahbib N, Zidane L (2015) Étude ethnobotanique des plantes médicinales utilisées dans le traitement des infections du système respiratoire dans le plateau central marocain. J Anim Plant Sci 25(2): 3886–3897.

Fennane M, Tattou MI, Mathez J, Quézel P (1999) Flore pratique du Maroc: Manuel de détermination des plantes vasculaires. *Pteridophyta, Gymnospermae, Angiospermae* (*Lauraceae-Neuradaceae*). Institut Scientifique.

Friedman J, Yaniv Z, Dafni A, Palewitch D (1986) A preliminary classification of the healing potential of medicinal plants, based on a rational analysis of an ethnopharmacological field survey among Bedouins in the Negev Desert, Israel. J Ethnopharmacol 16(2–3): 275–287.

Getahun A (1976) *S*ome common medicinal and poisonous plants used in Ethiopian folk medicine. Amare Getahun.

Ghanmi M, Satrani B, Aberchane M, Ismaili MR, Aafi A, El Abid A (2011) Plantes Aromatiques et Médicinales du Maroc, les milles et une vertu. p. 130 p.

Godron M (1971) Essai sur une approche probabiliste de l'écologie des végétaux. Thèse de Doctorat,. p. 247 p.

Hachi M, Hachi T, Belahbib N, Dahmani J, Zidane L (2015) Contribution à l'etude floristique et ethnobotanique de la flore médicinale utilisée au niveau de la ville de khenifra (Maroc). Int J Innov Appl Studies 11(3): 754–770.

HCP (2018) Haut-commissariat au plan, Monograpie de la région Tanger Tétouan Al Hoceima, Direction Régionale de Tanger-Tétouan-Al Hoceima.

Heinrich M, Ankli A, Frei B, Weimann C, Sticher O (1998) Medicinal plants in Mexico: Healers' consensus and cultural importance. Soc Sci Med 47(11): 1859–1871.

Jouad H, Haloui M, Rhiouani H, El Hilaly J, Eddouks M (2001) Ethnobotanical survey of medicinal plants used for the treatment of diabetes, cardiac and renal diseases in the North centre region of Morocco (Fez–Boulemane). J Ethnopharmacol 77(2–3): 175–182.

Lahsissene H, Kahouadji A, Hseini S (2009) Catalogue des plantes medicinales utilisees dans la region de Zaër (Maroc Occidental). Lejeunia, Revue de Botanique.

Lin J, Puckree T, Mvelase TP (2002) Anti-diarrhoeal evaluation of some medicinal plants used by Zulu traditional healers. J Ethnopharmacol 79(1): 53–56.

Matuhe (2001) Rapport sur l'Etat de L'Environnement du Maroc. MATUHE/DE. Rabat ‒ Maroc.

Mukungu N, Abuga K, Okalebo F, Ingwela R, Mwangi J (2016) Medicinal plants used for management of malaria among the Luhya community of Kakamega East sub-County, Kenya. J Ethnopharmacol 194: 98–107.

Nouri J (2016) Étude floristique et ethnobotanique des plantes médicinales au nord-ouest de la Tunisie: Cas de la communauté d'Ouled Sedra. J Adv Res Sci Technol 3(1): 281–291.

Okello SV, Nyunja RO, Netondo GW, Onyango JC (2010) Ethnobotanical study of medicinal plants used by Sabaots of Mt. Elgon Kenya. Afr J Tradit Complement Altern Med 7(1): 1–10.

Polat R, Satıl F (2012) An ethnobotanical survey of medicinal plants in Edremit Gulf (Balıkesir–Turkey). J Ethnopharmacol 139(2): 626–641.

Rejdali M (1996) La flore du Maroc: État actuel et perspectives de conservation. Diversité biologique et valorisation des plantes médicinales. pp. 17–22.

Salhi S, Fadli M, Zidane L, Douira A (2010) Etudes floristique et ethnobotanique des plantes médicinales de la ville de Kénitra (Maroc). Lazaroa 31: 133–146.

Scherrer AM, Motti R, Weckerle CS (2005) Traditional plant use in the areas of Monte Vesole and Ascea, Cilento National Park (Campania, Southern Italy). pp. 129–143.

Sijelmassi A (1993) Les plantes médicinales du Maroc, 3ème édition Fennec. Casablanca, Moroc.

Slimani I, Najem M, Belaidi R, Bachiri L, Bouiamrine EH, Nassiri L, Ibijbijen J (2016) Étude ethnobotanique des plantes médicinales utilisées dans la région de Zerhoun-Maroc-[Ethnobotanical Survey of medicinal plants used in Zerhoun region-Morocco-]. Int J Innov Appl Studies 15(4): 846–863.

Sreekeesoon DP, Mahomoodally MF (2014) Ethnopharmacological analysis of medicinal plants and animals used in the treatment and management of pain in Mauritius. J Ethnopharmacol 157: 181–200.

Stangeland T, Alele PE, Katuura E, Lye KA (2011) Plants used to treat malaria in Nyakayojo sub-county, western Uganda. J Ethnopharmacol 137(1): 154–166.

Tahraoui A, El-Hilaly J, Israili ZH, Lyoussi B (2007) Ethnopharmacological survey of plants used in the traditional treatment of hypertension and diabetes in south-eastern Morocco (Errachidia province). J Ethnopharmacol 110(1): 105–117.

Tardío J, Pardo-de-Santayana M (2008) Cultural importance indices: A comparative analysis based on the useful wild plants of Southern Cantabria (Northern Spain). Econ Bot 62(1): 24–39.

Valdés B (2002) Catalogue des plantes vasculaires du Nord du Maroc, incluant des clés d'identification (Vol. 1). Editorial CSIC-CSIC Press.

Vitalini S, Iriti M, Puricelli C, Ciuchi D, Segale A, Fico G (2013) Traditional knowledge on medicinal and food plants used in Val San Giacomo (Sondrio, Italy)—An alpine ethnobotanical study. J Ethnopharmacol 145(2): 517–529.

Yetein MH, Houessou LG, Lougbégnon TO, Teka O, Tente B (2013) Ethnobotanical study of medicinal plants used for the treatment of malaria in plateau of Allada, Benin (West Africa). J Ethnopharmacol 146(1): 154–163.

Ziyyat A, Legssyer A, Mekhfi H, Dassouli A, Serrhrouchni M, Benjelloun W (1997) Phytotherapy of hypertension and diabetes in oriental Morocco. J Ethnopharmacol 58(1): 45–54.

_____

AUTHOR CONTRIBUTION:

Contribution	Chaachouay N	Benkhnigue O	Fadli M	El Ayadi R	Zidane L
Concepts or ideas	x			x	
Design		x			x
Definition of intellectual content					x
Literature search	x			x	
Experimental studies	x		x		
Data acquisition			x		x
Data analysis	x				
Statistical analysis	x				
Manuscript preparation		x			x
Manuscript editing	x	x			
Manuscript review	x	x	x	x	x

Appendix 1. Questionnaire sheets: Medicinal plants and herbal medicine.

Date...
Region ………….………………………………………………...…………….……………………
Commune..
Survey number...

Age	Al Hoceima	Chefchaouen	Tetouan	Tanger	Total
≤20					
20-40					
40-60					
≥60					
Job	Al Hoceima	Chefchaouen	Tetouan	Tanger	Total
Sex	Al Hoceima	Chefchaouen	Tetouan	Tanger	Total
Male					
Female					
Family situation	Al Hoceima	Chefchaouen	Tetouan	Tanger	Total
Single					
Divorced					
Widower					
Married					
Level of study	Al Hoceima	Chefchaouen	Tetouan	Tanger	Total
Illiterate					
Primary					
Secondary					
University					
Locality	Al Hoceima	Chefchaouen	Tetouan	Tanger	Total
Nomadic					
Town					
Village					
City					
Income / month (MAD)	Al Hoceima	Chefchaouen	Tetouan	Tanger	Total
Unemployed					
250 - 1500 DH					
1500 - 5000					
≥5000					
When you feel sick, you address:	Al Hoceima	Chefchaouen	Tetouan	Tanger	Total
Traditional medicine					
Modern medicine					
Traditional medicine and Modern medicine					
To traditional medicine, why?	Al Hoceima	Chefchaouen	Tetouan	Tanger	Total
Effective					
Cheapest					
Acquisition					
Ineffective medication					
Plant Type	Al Hoceima	Chefchaouen	Tetouan	Tanger	Total
Spontaneous					
Cultivated					
Introduced					
Use of the plant	Al Hoceima	Chefchaouen	Tetouan	Tanger	Total
Therapeutic					
Cosmetic					
Other					
Harvesting technique	Al Hoceima	Chefchaouen	Tetouan	Tanger	Total
Manual					
Mechanical					

Appendix 1. Questionnaire sheets: Medicinal plants and herbal medicine (continued...)

Harvest Time	Al Hoceima	Chefchaouen	Tetouan	Tanger	Total
Summer					
Fall					
Winter					
Spring					
Any year					
If desiccated, drying method	**Al Hoceima**	**Chefchaouen**	**Tetouan**	**Tanger**	**Total**
Sun exposure					
In the Shade					
Use of the plant	**Al Hoceima**	**Chefchaouen**	**Tetouan**	**Tanger**	**Total**
Fresh					
Desiccated					
After treatment					
Used part	**Al Hoceima**	**Chefchaouen**	**Tetouan**	**Tanger**	**Total**
Fruit					
Stem					
Whole plant					
Seed					
Rhizome					
Other combination					
Root					
Bark					
Leaf					
Flower					
Bulb					
Form of employment	**Al Hoceima**	**Chefchaouen**	**Tetouan**	**Tanger**	**Total**
Tisane					
Powder					
Essential oil					
Oily oil					
Tincture					
Method of preparation	**Al Hoceima**	**Chefchaouen**	**Tetouan**	**Tanger**	**Total**
Decoction					
Infusion					
Cataplasm					
Raw					
Cooked					
Others					
Dose used	**Al Hoceima**	**Chefchaouen**	**Tetouan**	**Tanger**	**Total**
Pinch					
Handle					
Spoonful					
Administration mode	**Al Hoceima**	**Chefchaouen**	**Tetouan**	**Tanger**	**Total**
Oral					
Massage					
Rinse					
Swabbing					
Others					
Dosage for children	**Al Hoceima**	**Chefchaouen**	**Tetouan**	**Tanger**	**Total**
1time/day					
2time/day					
3time/day					
Other					
Dosage for adults	**Al Hoceima**	**Chefchaouen**	**Tetouan**	**Tanger**	**Total**
1time/day					
2time/day					
3time/day					
Other					

Appendix 1. Questionnaire sheets: Medicinal plants and herbal medicine (continued...)

Dosage for older people	Al Hoceima	Chefchaouen	Tetouan	Tanger	Total
1time/day					
2time/day					
3time/day					
Other					
Length of Use	**Al Hoceima**	**Chefchaouen**	**Tetouan**	**Tanger**	**Total**
One day					
A week					
One month					
Until healing					
Conservation method	**Al Hoceima**	**Chefchaouen**	**Tetouan**	**Tanger**	**Total**
Sheltered from the light					
Exposed to light					
Other					
Diagnosis By	**Al Hoceima**	**Chefchaouen**	**Tetouan**	**Tanger**	**Total**
Himself					
Doctor					
Herbalist					
Other					
Results	**Al Hoceima**	**Chefchaouen**	**Tetouan**	**Tanger**	**Total**
Healing					
Improvement					
Ineffective					
Side effects	**Al Hoceima**	**Chefchaouen**	**Tetouan**	**Tanger**	**Total**
No					
Yes					
Toxicity	**Al Hoceima**	**Chefchaouen**	**Tetouan**	**Tanger**	**Total**
No					
Yes					