Medicinal plants used for diabetic problems in the Rif, Morocco

النباتات الطبية المستخدمة لداء السكري في الريف، المغرب

Noureddine Chaachouay, Ouafae Benkhnigue, Hamid El Ibaoui, Rachida El Ayadi, Lahcen Zidane

Research

Abstract

Background: since early times, the people of Morocco use medicinal plants as traditional medicine to treat diabetes. However, little studies have been made in the past to properly document and promote the traditional knowledge. This study was carried out in the Rif (North of Morocco), it aimed to identify medicinal plant used by the local people to treat diabetic problems, together with the associated ethnomedicinal knowledge.

Materials and Methods: The ethnomedical information collected was from 582 traditional healers using semi-structured interviews, free listing and focus group. Family use value (FUV), use value (UV), plant part value (PPV) and informant agreement ratio (IAR) were employed in data analysis. Medicinal plants were collected, identified and kept at the natural resources and biodiversity laboratory, Ibn Tofail University, Kenitra.

Results: During the present study 30 medicinal plant species belonging to 14 families has been documented. The most frequent ailments reported were type 1diabetes. The majority of the remedies were prepared from infusion. Leaves were the most frequently used plant part and *Rosmarinus officinalis* L. was the species most commonly prescribed by local herbalists.

Conclusions: The results of this study showed that people Arabs and Imazighen living in the Rif of Morocco are still dependent on medicinal plants. The documented medicinal plants can serve as a basis for further studies on the regions, medicinal plants knowledge and for future phytochemical and pharmacological studies.

Keywords: Rif; Ethnomedicinal; Medicinal plants; Diabetic problems.

Correspondence

Noureddine Chaachouay*, Ouafae Benkhnigue, Hamid El Ibaoui, Rachida El Ayadi, Lahcen Zidane

Natural Resources and Biodiversity Laboratory, Department of Biology, Faculty of Sciences, Ibn Tofail University, BP 133 14000, Kenitra, Morocco

*Corresponding author: our.chay@gmail.com
BP 106 Kenitra Road, Said Hajji, 11150 Sale, Morocco; Tel: +212677488621

Ethnobotany Research & Applications 18:21 (2019)

ملخص

مقدمة : منذ العصور المبكرة، يستخدم المجتمع المغربي النباتات الطبية كدواء تقليدي لعلاج مرض السكري. ومع ذلك، فقد أجريت دراسات قليلة في الماضي لتوثيق المعارف التقليدية وتعزيزها بشكل صحيح. أجريت هذه الدراسة في الريف (شمال المغرب) ، والتي تهدف إلى تحديد النباتات الطبية المستخدمة من قبل السكان المحليين لعلاج مشاكل مرض السكري ، وكذا توثيق المعرفة العرقية الطبية المرتبطة بها.

المواد والطرق: تم جمع المعلومات الإثنولوجية من 582 شخص من المعالجين التقليديين باستخدام مقابلات شبه منظمة محادثات جماعية. تم استخدام قيمة استخدام الأسرة (ق.ا.ا) ، قيمة الاستخدام (ق.ا)، قيمة جزء النبات (ق.ج.ن) ونسبة اتفاق المخبر (ن.ا.ا) في تحليل البيانات. تم جمع النباتات الطبية وتحديدها وحفظها في مختبر الموارد الطبيعية والتنوع البيولوجي ، جامعة ابن طفيل ، القنيطرة.

Published: 23 June 2019

http://dx.doi.org/10.32859/era.18.21.1-29

النتائج: خلال هذه الدراسة تم توثيق 30 نوعا من النباتات الطبية التي تنتمي إلى 14 عائلة. أكثر الأمراض التي تم الإبلاغ عنها هي النوع الأول من السكري. تم إعداد غالبية العلاجات من النقيع. أما الأوراق فهي الجزء الأكثر استخدامًا في النبات وكانت *روسمارينوس أوفيسيناليس* إل هي المسطرة الأكثر شيوعًا التي يصفها المعالجون بالأعشاب المحلية.
الاستنتاجات: أظهرت نتائج هذه الدراسة أن الناس العرب والأمازيغ الذين يعيشون في الريف المغربي لا يزالون يعتمدون على النباتات الطبية في علاج مشاكلهم الصحية. يمكن للنباتات الطبية الموثقة أن تكون بمثابة أساس لمزيد من الدراسات حول المناطق لمعرفة النباتات الطبية والدراسات الكيميائية النباتية والدوائية في المستقبل.
الكلمات المفاتيح: النباتات الطبية, مشاكل السكري, الريف المغربي, الطب الإثني.

Introduction

Diabetes mellitus is a metabolic disorder characterized by the presence of hyperglycemia due to defective insulin secretion, defective insulin action or both. The chronic hyperglycemia of diabetes is associated with relatively specific long-term microvascular complications affecting the eyes, kidneys and nerves, as well as an increased risk for cardiovascular disease (Goldenberg and Punthakee 2013).

Morocco is one of the 19 countries and territories of the international diabetes federation (IDF) Middle East and North Africa (MENA) region. 425 million people have diabetes in the world and more than 39 million people in the MENA Region; by 2045 this will rise to 67 million. There were 1.641.900 cases of diabetes in Morocco in 2017 (International Diabetes Federation 2019).

Nowadays, different treatments, such as insulin therapy, pharmacotherapy, and diet therapy, are available to control diabetes. The World Health Organization expert committee on diabetes has listed as one of its recommendations that traditional methods of treatment of diabetes should be further investigated (Committee 2009).

Currently, the main and effective treatment for diabetes is the use of insulin and hypoglycemic drugs, but these compounds also have many adverse side effects (Graham et al. 2007). Medicinal plants have a long history of usage and today, they are being extensively used for various diseases (Karami et al. 2017; Rabiei et al. 2016). There are several reasons for increasing the use of medicinal plants. Many plants from different parts of the world have been investigated for antidiabetic effects

The purpose of the present investigations was to evaluate MPs that grow in the study area with the aim to contribute to indigenous knowledge of MPs and to analyze the results concerning the existing relationships between medicinal species and diabetic problems. 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.

Materials 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 549512. 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 MPs for the treatment ailments due to expensive drugs Fig 2.

Methodology

Data collection tools and procedures

In order to gather information on MPs used for curing diabetic problems, an ethnobotanical survey was conducted from June 30^{h}, 2016 to June 1st, 2018. Semi-structured questionnaires were administered, and free listings were conducted, through face to face interviews and focus group. The inclusion criteria were people who are knowledgeable about plants used for diabetic problems, while the exclusion criteria were informants who are not living in the study area. Totally, 582 informants within aged 17 to 92 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

Published: 23 June 2019

http://dx.doi.org/10.32859/era.18.21.1-19

of language spoken by each case, in order to collect and document indigenous knowledge of plants usage against diabetic problems. 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 problems (Appendix A). The sample is made up of 311 females and 271 males from different socio-economic strata, chosen at random from the Rif's population. In this study, the sample is 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, we have divided our study area into sites (Sn), so we have 28 sites that correspond to the number of divisions in the study area (Fig. 3).

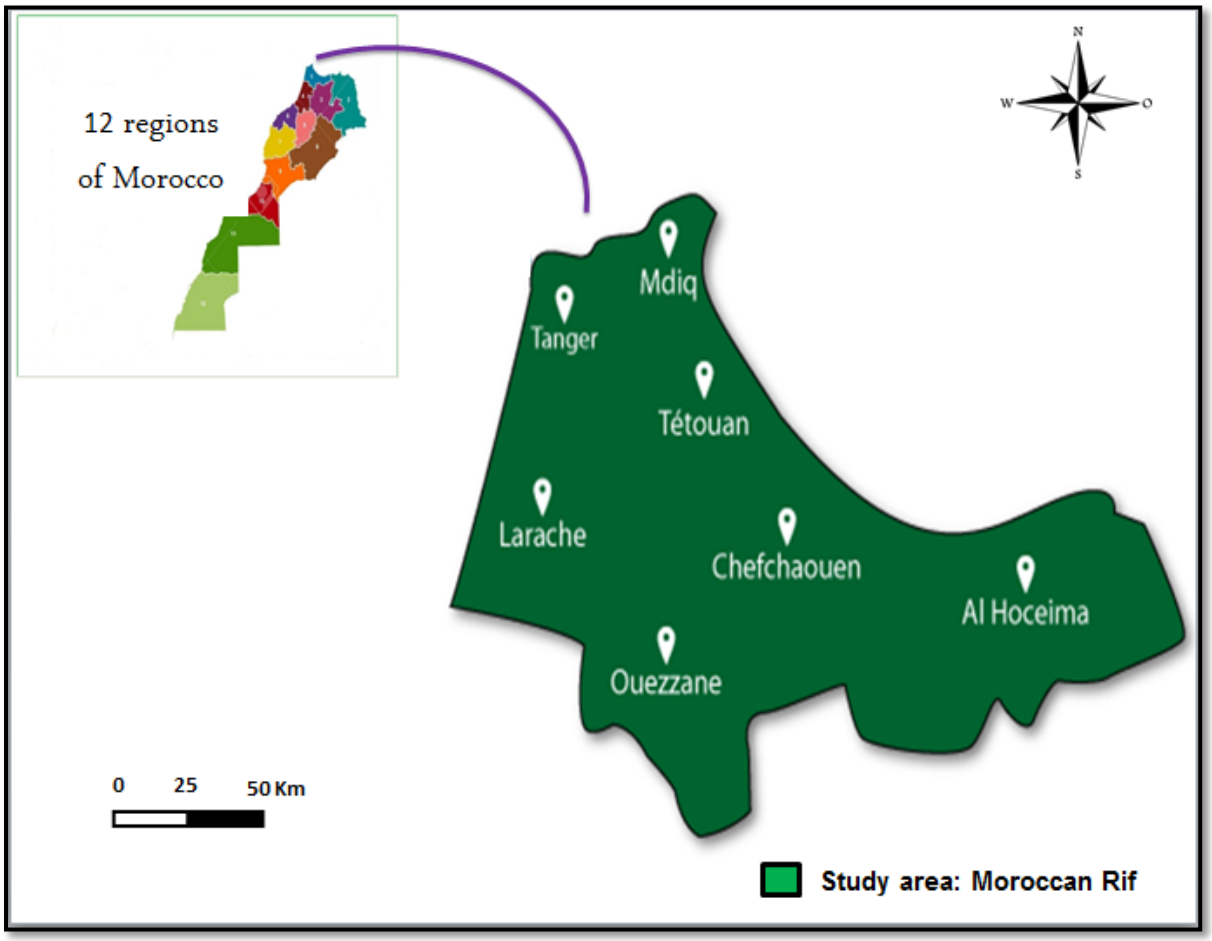

Fig. 1. Map of the study area

Plant species identification and preservation

Standard method was followed with record to collection of plant materials, drying, mounting, preparation and preservation of plant specimens (Jain 1964). MPs species in bi-plicate were collected prepared and identified. Plants with their correct nomenclature were arranged alphabetically by family name and vernacular name ethnomedicinal uses. The identification and nomenclature of the listed plants were based on the medicinal plants of 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), volumes I and II. They were later verified at resources and biodiversity laboratory, department of biology faculty of sciences, Ibn Tofail University Kenitra, Morocco. All the preserved specimens were deposited at the Herbarium of Ibn Tofail University.

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

Published: 23 June 2019

http://dx.doi.org/10.32859/era.18.21.1-19

ethnobotanical survey were analyzed using the Family Use Value (FUV), Use Value (UV), Use Report (UR), Plant Part Value (PPV), Fidelity Level (FL) and Informant Agreement Ratio (IAR). All statistical analyses were carried out with Statistical Package for Social Science (SPSS) version 21 and Microsoft Excel 2010.

Fig. 2. Landscape of the rural community Akchour

Family Use Value (FUV)

The FUV 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 FUV, we use the following formula: $\mathrm{FUV} = \frac{UVs}{\mathrm{N_S}}$. Where UVs = UV is the number of informants mentioning the family and Ns is the total number of species within each family (Sreekeesoon and Mahomoodally 2014).

Use value (UV)

The use value of species (UV), a quantitative method that demonstrates the relative importance of species known locally (Vitalini et al. 2013), was also calculated according to the following formula: $\mathrm{UV} = \frac{\sum U_i}{\mathrm{N}}$. Where U_i is the number of use reports mentioned by each informant (i) and N is the total number informants interviewed for a given plant species.

Plant Part Value (PPV)

Plant part value (PPV) was calculated using the following formula: $\mathrm{PPV} = \frac{\mathrm{RU_{Plant\ part}}}{\mathrm{RU}}$. Where RU is the number of uses reported of all parts of the plant and $\mathrm{RU_{plant\ part}}$ is the sum of uses reported per part of the plant. The part with the highest PPV is the most used by the respondents.

Informant Agreement Ratio (IAR)

The IAR for each use category in the four countries of investigation were calculated using the following formula (Heinrich et al. 1998): $\mathrm{IAR} = \frac{\mathrm{Nur-Nt}}{\mathrm{Nur-1}}$. Where IAR is the informant agreement ratio, $\mathrm{N_{ur}}$ is the number of mentions in each category and $\mathrm{N_t}$ is the number of taxa used in each category. The values for the factor range from 0 to 1.

Published: 23 June 2019

http://dx.doi.org/10.32859/era.18.21.1-19

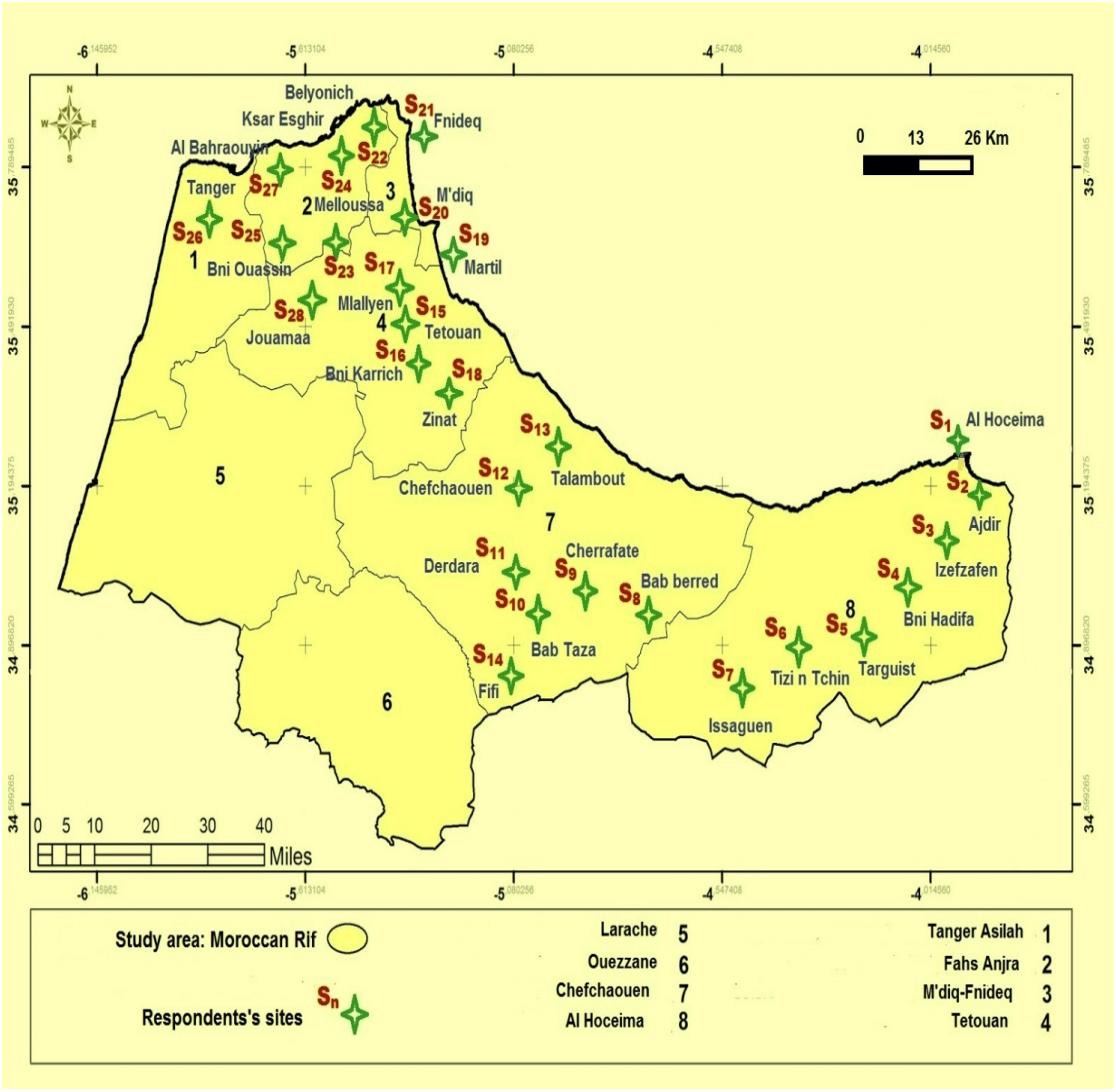

Fig. 3. Distribution of survey points at the study area level.

Results and discussion

Socio-demographic features of the informants

In total, 582 respondents belonging to 2 ethnic groups (311 men and 271 women with a sex ratio female/male of 1.15) were randomly selected at the Rif's area. Comparative data of the sampling composition can be observed in the Table 1.

In this study, both sexes are affected by traditional phytotherapy. The ethnic groups with the highest numbers are the Arabs 313 (53.8). The gender distribution among Imazighen showed that 51.6% of the respondents were males and 55.6% were females, among the Arabs, 48.4% were males and 44.4% were females. In both groups, women have a greater knowledge on the plant species. The result of independent sample t test indicated that there is a significant knowledge difference between male and female informants for Arabs (χ^2 = 0.34, df = 1, P = 0.514) and not significantly for Imazighen (χ^2 = 9.058, df = 1, P = 0.004). 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).

In our study, the informants involved in the present study were 17–92 years old. From the total informants, (50.7%) were in the age range of 40–60 (57.6% Arabs and 42.4% Imazighen), while 23% of the informants were more than 60 years old (51.5 per cent of whom are Arabs), 22.8% were in the age range of 20–40 years old (49.6 per cent of whom are Imazighen) and informants with an age less than 20 come in last position with a rate of 3.5% (including 65% Imazighen and 35% Arabs) Table 1. In both

Published: 23 June 2019

http://dx.doi.org/10.32859/era.18.21.1-19

ethnolinguistic group, 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 is a loss of information on MPs, which can be explained by the mistrust of certain young people, who tend disinterest on this herbal medicine due 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).

Altogether, in the two human groups analyzed, fieldwork overall generated more ethnobotanical information, of the total informants, most informants (313) were Arabs (including 233 married, 46 divorced, 63 widowers and 5 singles), 269 of them were Imazighen (including 192 married, 51 divorced, 17 widowers and 9 singles), because the married informants 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 diabetic diseases by Imazighen and Arabs 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, more than half of the informants (70.8%) were illiterate including 200 Imazighen and 212 Arabs, and (21.3%) of the informants had been primary school (57.3% per cent of whom are Arabs), (7.2%) of the informants had been secondary school (71.4 per cent of whom are Arabs). Nevertheless, informants with a university level education use little medicinal plants (0.7%). Thus, the difference between educational level and indigenous knowledge for both groups was significant (P = 0.000). We can therefore see that the use of MPs decreases as the level of study increases. This result is similar to the findings reported by (Bouzid et al. 2017; El Hafian et al. 2014; El Hilah et al. 2015; Lahsissene et al. 2009).

In our study, 46.3% of the interviewees had a low socio-economic level (55.5 per cent of whom are Arabs), (36.1%) were unemployed including 48.6% Imazighen and 51.4% Arabs, (16%) with average level (53.8 per cent of whom are Arabs), and only 1.6% with higher level (55.6 per cent of whom are Arabs). In both ethnolinguistic groups, 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. We can therefore see 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).

Medicinal plant richness

In total, we registered 30 plant species belonging to 14 botanical families were used to treat diabetic problems by two cultural groups from the study region. However, the number of medicinal plants used as traditional medicines varies between two ethnolinguistic groups Imazighen and Arabs. The Imazighen use 23 species in their home therapies, while Arabs reported 21 plants as medicinally useful. These plants are presented in alphabetical order. For each plant listed, we give the scientific name, the family, the local name, the part used, the method of preparation adopted by the local population, as well as the data of UR, UV and FUV are shown in Table 2.

Table 1. Comparative table with socioeconomic characteristics of the study area

Variables	Imazighen groups		Arab groups		Total	Percentages (%)	P-values
	Number	%	Number	%			
Gender							0.514 .0004
Female	173	55.6	138	44.4	311	53.4	
Male	140	51.6	131	48.4	271	46.6	
Age groups							0.000
< 20 years	13	65	7	35	20	3.5	
20-40	66	49.6	67	51.4	133	22.8	
40-60	125	42.4	170	57.6	295	50.7	
> 60 years	65	48.5	69	51.5	134	23	

Published: 23 June 2019

http://dx.doi.org/10.32859/era.18.21.1-19

Family situation							0.000
Married	192	45	233	55	425	73.6	
Divorced	51	52.6	46	47.4	97	16.6	
Widower	17	37	29	63	46	8	
Single	9	64.3	5	35.7	14	2.3	
Educational level							0.000
Illiterate	200	48.54	212	51.46	412	70.8	
Primary	53	42.7	71	57.3	124	21.3	
Secondary	12	28.6	30	71.4	42	7.2	
University	3	75	1	25	4	0.7	
Income/month							0.000
Unemployed	102	48.6	107	51.4	210	36.1	
250 - 1500 MAD	120	45.5	150	55.5	270	46.3	
1500 - 5000 MAD	43	46.2	50	53.8	93	16	
> 5000 MAD	4	44.4	5	55.6	9	1.6	

Similarity and diversity of medicinal plants

In order to estimate species diversity and similarity, we considered the number of medicinal uses assigned to each medicinal plant. By analysing species similarity between the two ethno-sociolinguistic groups, we observed that the coefficient of similarity of the plants species documented in the study area was shared between the two groups (Imazighen and Arabs) is 63.6%. The longest lists of plant species used were found on Imazighen (23 plant species). The shortest lists were found on Arabs (21 plant species), as mentioned in Fig. 4. Using chi-square analysis, the number of mentions for medicinal plants used similar significantly between our interviewees Imazighen and Arabs (χ^2 = 203.48 df = 1, p value = 0.763). We conclude, therefore, that species diversity is the highest for the Imazighen group.

In both ethnosociolinguistic groups, the most representative families, in terms of number of species, were Asteraceae (6 species each) followed by Fabaceae and Moraceae (4 species each) and Lamiaceae (03 species), while other families were represented by two or single species (Fig. 5). Based on the FUV index, the 5 most cited families are Lamiaceae (FUV = 0.177), Cupressaceae (FUV = 0.136), Rosaceae (FUV = 0.130), Linaceae (FUV = 0.112) and Moraceae (FUV = 0.083). This high proportion could be explained by the high representation of these families in the Rif's flora because of the ecological factors that favour the development and adaptation of the majority of their species. This partially coincides with the findings in other territories with similar characteristics (Bonet 2001; Eddouks et al. 2002; Ghourri et al. 2012; Jouad et al. 2001; Tahraoui et al. 2007).

MAPs and their UV values

The importance of MPs was assayed by use values (UV) that were ranged between 0.002 for the less used species and 0.170 for the most used species for each cultural group (Fig. 6). 23 species achieved use value (UV) for Imazighen people (with values between 0.002 and 0.170) the most important being: *Rosmarinus officinalis* L. (UV = 0.170), *Salvia officinalis* L. (UV = 0.101), *Calendula arvensis* M.Bieb. (UV = 0.096), *Ficus abelii* Miq. (UV = 0.086), *Juniperus phoenicea* L. (UV = 0.081) and *Malus domestica* Borkh. (UV = 0.074). 21 species resulted to be characteristic for Arabs with the highest UV values being: *Rosmarinus officinalis* L. (UV = 0.155), *Salvia officinalis* L. (UV = 0.103), *Ficus abelii* Miq. (UV = 0.091), *Calendula arvensis* M.Bieb. (UV = 0.069), *Morus alba* L. (UV = 0.065). It was noticed that MPs exhibiting higher UV (*Rosmarinus officinalis* L., *Salvia officinalis* L., *Calendula arvensis* M.Bieb. and *Ficus abelii* Miq. were found frequently in both ethnosociolinguistic groups Imazighen and Arabs and practiced in herbal therapies with higher uses than other plants. Those medicinal plant species with low UV are also very important and should not be ignored as failing to declare them to upcoming generations could raise the threat of slowly vanishing of the knowledge. Medicinal plant species having high UV must be further assessed for phytochemical and pharmaceutical analysis to identify their active constituents for any drug extraction (Vitalini et al. 2013).

Published: 23 June 2019

http://dx.doi.org/10.32859/era.18.21.1-19

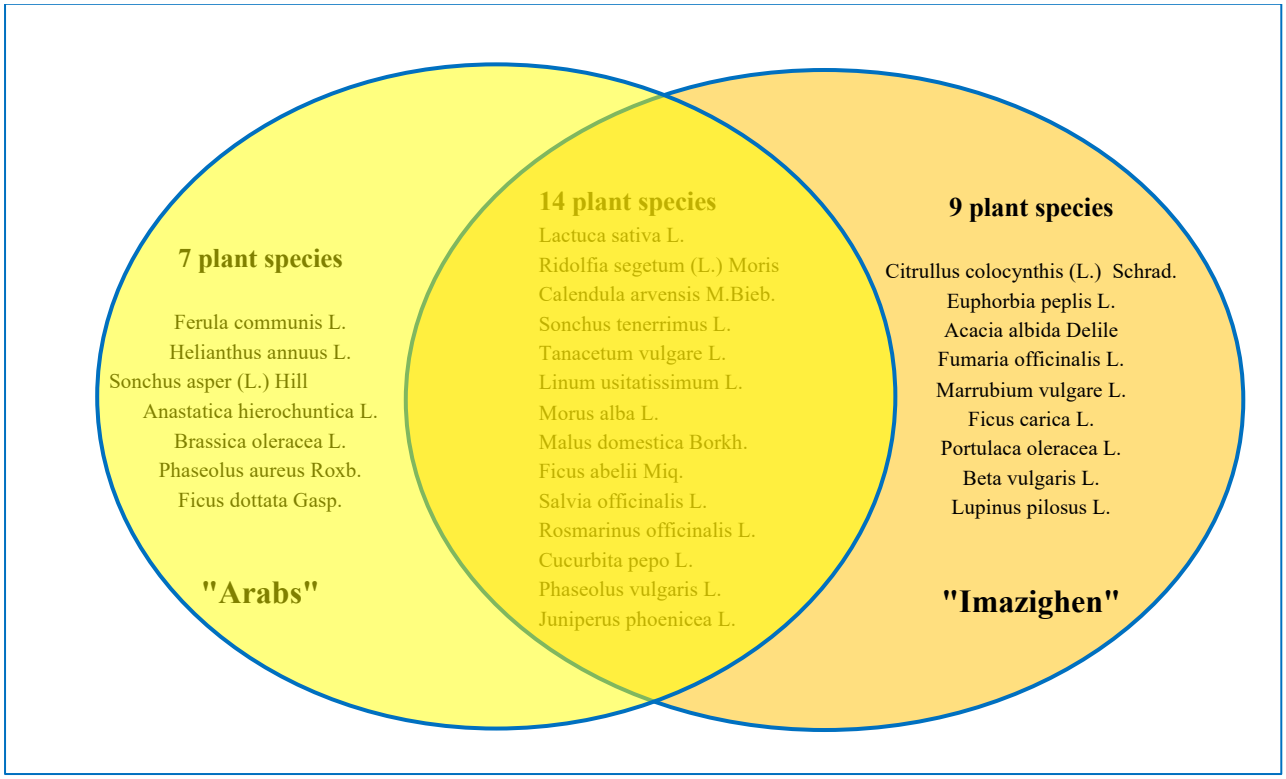

Fig. 4. medicinal plant species registered among the Imazighen and Arabs.

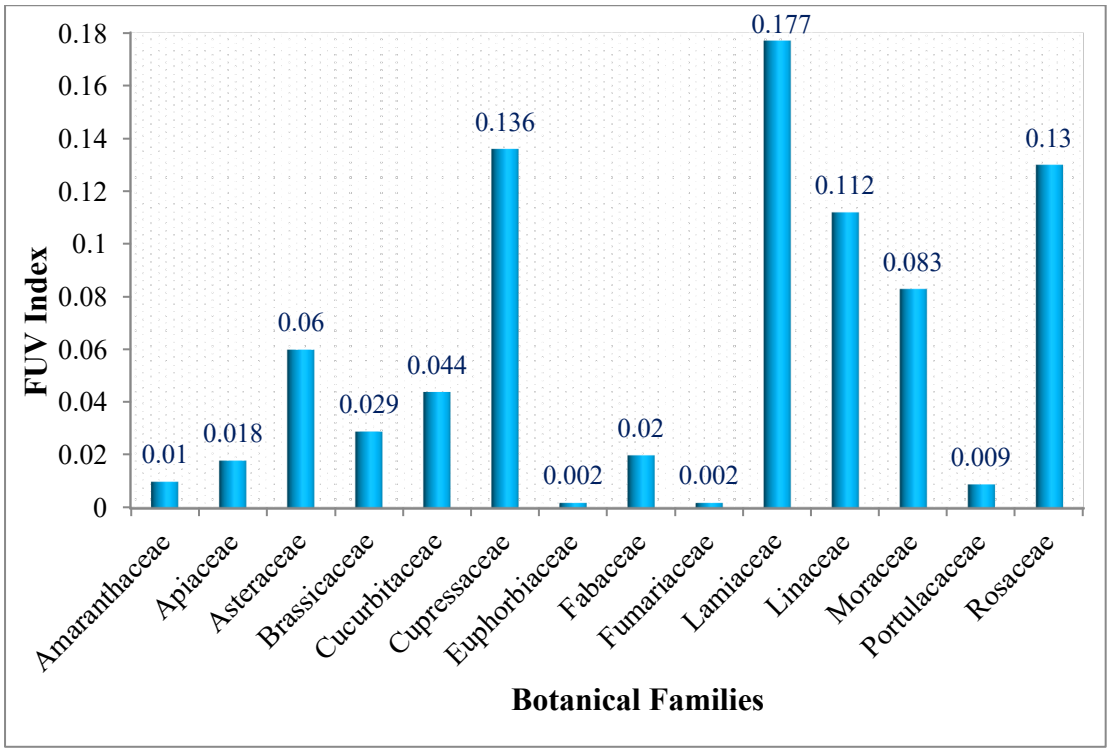

Fig. 5. Family use value (FUV) of MAPs.

Published: 23 June 2019
http://dx.doi.org/10.32859/era.18.21.1-19

Table 2. List of MPs used to cure diabetic problems in the Rif region, Morocco.

Scientific names of species and families	Local name	Voucher specimen number	Parts used	Preparation	Medicinal uses	Ethnolinguistic groups	UR	UV	FUV
Amaranthaceae									0.01
Beta vulgaris L.	لباربة	289	Seed	Infusion	TD 1	Imazighen	06	0.01	
Apiaceae									0.018
Ferula communis L.	لكلخة	287	Leaf	Decoction	TD 2	Arabs	04	0.007	
Ridolfia segetum (L.) Moris.	سليلو	270	Leaf	Cooked	TD 1	Imazighen, Arabs	17	0.029	
Asteraceae									0.060
Lactuca sativa L.	لخس	277	Leaf	Infusion	GDM	Imazighen, Arabs	22	0.038	
Calendula arvensis M.Bieb.	جمرة, أزويول	286	Whole plant	Infusion	TD 1, TD 2	Imazighen, Arabs	96	0.165	
Helianthus annuus L.	عباد الشمس	288	Seed	Infusion	TD 1	Arabs	21	0.036	
Sonchus tenerrimus L.	ثيفاف	269	Leaf	Decoction	TD 2	Imazighen, Arabs	25	0.043	
Sonchus asper (L.) Hill.	ثيفاف	285	Whole plant	Decoction	TD 2	Arabs	01	0.002	
Tanacetum vulgare L.	لبلسم	278	Leaf	Infusion	TD 1	Imazighen, Arabs	42	0.072	
Brassicaceae									0.029
Anastatica hierochuntica L.	شجرة كف مريم	268	Root	Decoction	GDM	Arabs	25	0.043	
Brassica oleracea L.	قرنبيط	276	Leaf	Other	GDM	Arabs	09	0.015	
Cucurbitaceae									0.112
Cucurbita pepo L.	كرعة خضراء	266	Fruit	Cooked	TD 1, TD 2	Imazighen, Arabs	43	0.074	
Citrullus colocynthis (L.) Schrad.	لحدج, تافرزيزت	279	Seed	Infusion	GDM	Imazighen	09	0.015	
Cupressaceae									0.136
Juniperus phoenicea L.	عرعار فينيقي	267	Leaf	Decoction	TD 1	Imazighen, Arabs	79	0.136	
Euphorbiaceae									0.002
Euphorbia peplis L.	لاعية, حليبة	290	Whole plant	Other	GDM	Imazighen	01	0.002	

Published: 23 June 2019

http://dx.doi.org/10.32859/era.18.21.1-19

Fabaceae									0.020
Lupinus pilosus L.	رجل الدجاجة	275	Seed	Infusion	TD 2	Imazighen	07	0.012	
Acacia albida Delile.	شوك الطلح	284	Root	Decoction	GDM	Imazighen	02	0.003	
Phaseolus aureus Roxb.	صوجا	261	Seed	Decoction	GDM	Arabs	02	0.003	
Phaseolus vulgaris L.	لوبيا, فاصوليا	271	Seed	Cooked	TD 1, TD 2	Imazighen, Arabs	36	0.062	
Fumariaceae									0.002
Fumaria officinalis L.	حشيشة الصبيان	283	Root	Decoction	TD 1	Imazighen	01	0.002	
Lamiaceae									0.177
Marrubium vulgare L.	مريوت حارة, إفزي	274	Leaf	Infusion	GDM	Imazighen	01	0.002	
Salvia officinalis L.	سالمية	265	Leaf	Infusion	TD 1, TD 2	Imazighen, Arabs	119	0.205	
Rosmarinus officinalis L.	أزير, إكليل الجبل	282	Leaf	Infusion	TD 1, TD 2	Imazighen, Arabs	189	0.325	
Euphorbiaceae									0.002
Euphorbia peplis L.	لاعية, حليبة	290	Whole plant	Other	GDM	Imazighen	01	0.002	
Fabaceae									0.020
Lupinus pilosus L.	رجل الدجاجة	275	Seed	Infusion	TD 2	Imazighen	07	0.012	
Acacia albida Delile.	شوك الطلح	284	Root	Decoction	GDM	Imazighen	02	0.003	
Phaseolus aureus Roxb.	صوجا	261	Seed	Decoction	GDM	Arabs	02	0.003	
Phaseolus vulgaris L.	لوبيا, فاصوليا	271	Seed	Cooked	TD 1, TD 2	Imazighen, Arabs	36	0.062	
Fumariaceae									0.002
Fumaria officinalis L.	حشيشة الصبيان	283	Root	Decoction	TD 1	Imazighen	01	0.002	
Lamiaceae									0.177
Marrubium vulgare L.	مريوت حارة, إفزي	274	Leaf	Infusion	GDM	Imazighen	01	0.002	
Salvia officinalis L.	سالمية	265	Leaf	Infusion	TD 1, TD 2	Imazighen, Arabs	119	0.205	
Rosmarinus officinalis L.	أزير, إكليل الجبل	282	Leaf	Infusion	TD 1, TD 2	Imazighen, Arabs	189	0.325	
Linaceae									0.112
Linum usitatissimum L.	زريعة الكتان	264	Seed	Cooked	TD 1, TD 2	Imazighen, Arabs	65	0.112	

Published: 23 June 2019

http://dx.doi.org/10.32859/era.18.21.1-19

Moraceae									0.083
Ficus carica L.	كرموس, شريحة	280	Leaf	Infusion	TD 1	Imazighen	10	0.0172	
Ficus abelii Miq.	كرموس, شريحة	273	Leaf	Decoction	TD 2	Imazighen, Arabs	103	0.177	
Ficus dottata Gasp.	كرموس, شريحة	262	Fruit	Other	GDM	Arabs	11	0.019	
Morus alba L.	توت	263	Leaf	Infusion	TD 1, TD 2	Imazighen, Arabs	68	0.117	
Portulacaceae									0.009
Portulaca oleracea L.	رجلة, تسمامين	272	Leaf	Cooked	TD 1	Imazighen	05	0.009	
Rosaceae									0.130
Malus domestica Borkh.	تفاح	281	Fruit	Other	TD 1	Imazighen, Arabs	76	0.130	

TD 1: Type 1 diabetes; TD 2: Type 2 diabetes; GDM : Gestational diabetes mellitus.

Table 3. IAR values by categories for treating diabetic problems.

Ethno sociolinguistic groups	Ailment Category	No. of use reports	% of use reports	No. of Species	% of all species	IAR
Imazighen	Type 1 diabetes (TD 1)	312	52.35	13	43.33	0.958
	Type 2 diabetes (TD 2)	206	34.56	10	33.33	0.951
	Gestational diabetes mellitus (GDM)	78	13.09	5	16.67	0.936
Arabs	Type 1 diabetes (TD 1)	304	53.52	13	43.33	0.957
	Type 2 diabetes (TD 2)	198	34.86	11	36.67	0.944
	Gestational diabetes mellitus (GDM)	66	11.62	4	13.33	0.939

Published: 23 June 2019

http://dx.doi.org/10.32859/era.18.21.1-19

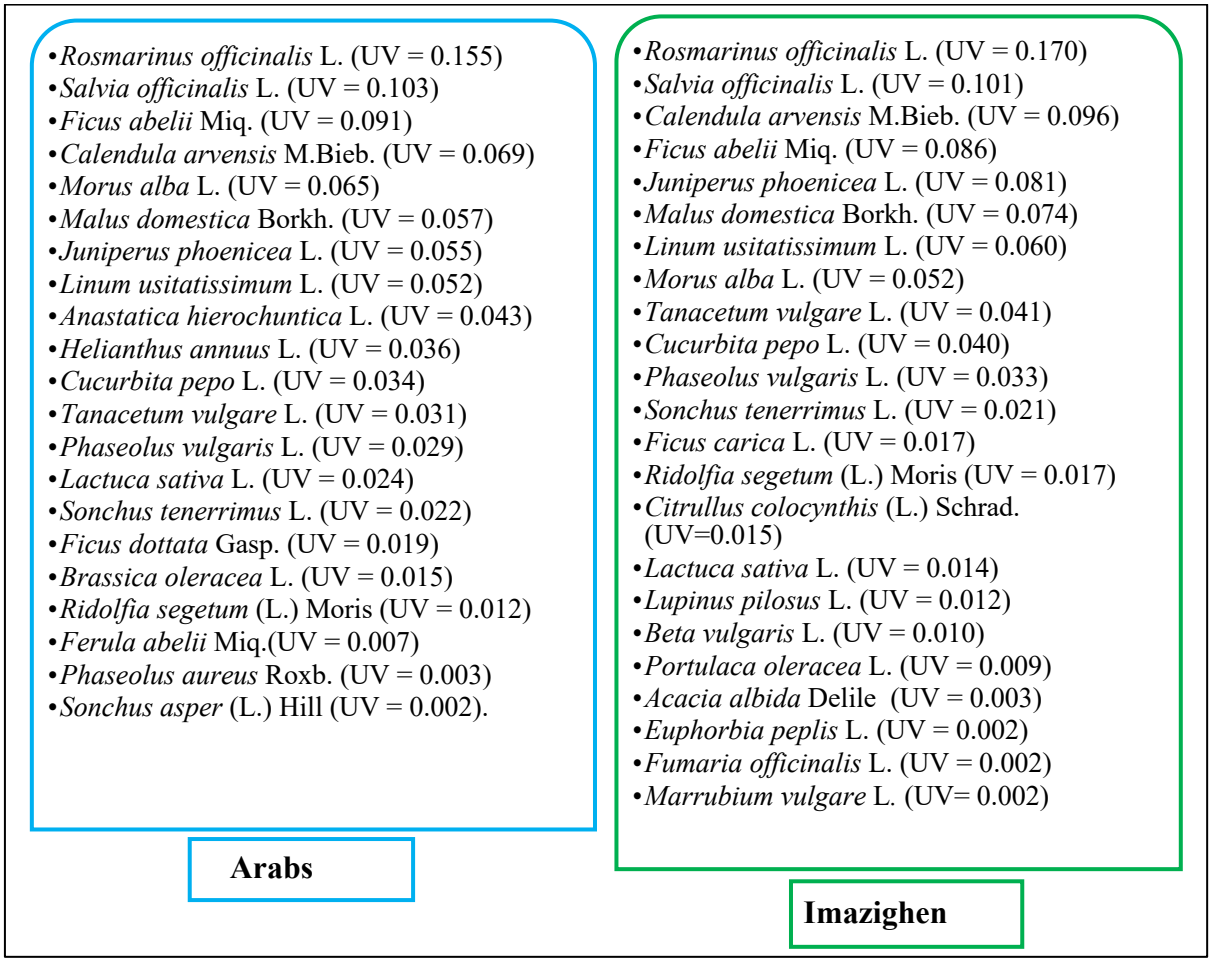

Fig. 6. UV of plant species by each ethnolinguistic group.

Similarity of illnesses and their IAR values

Informant agreement ratio (IAR) depends upon the availability of plants within the study area to treat diseases. The authors reported a total of 1 164 reports of different diseases categorized into 3 groups. In the present study, the IAR values ranged from 0.936 to 0.958 per uses categories. For both ethnolinguistic groups, the category with the highest degree of agreement from informants was type 1 diabetes related disorders. The ranking followed with type 2 diabetes problems and gestational diabetes mellitus (GDM), the number of use categories per plant species did not differ between Imazighen and Arabs.(Kruskal-Wallis $\chi 2 = 5.68$, df = 3, p = 0.13) shown in Table 3. The IAR results of the study proved that diseases that were frequent in both groups have the higher informant agreement ratio (values between 0.936 and 0.958). According to conclusions of (Albuquerque 2002), the highest IARs in the above reported categories represent the common occurrence of reported diseases in the study area and that were treated by specific plants. The informant agreement values also indicated the maximal networking of indigenous people Imazighen and Arabs in the sharing of their knowledge on medicinal practices and this is usually the case with traditional healers to treat the most frequently encountered diseases in the study area. Therefore, species with high IAR are to be prioritized for further on pharmacological and phytochemical studies.

Parts of the MPs used

In traditional medicine, different parts of plants identified particularly the leaves, flowers, roots, the fruit or even whole plant are exploited by the local population. Based on the plant part value PPV index, leaf was reported as the dominant plant part for diabetic remedy preparation by two ethnolinguistic groups Imazighen (PPV=0.0.548) and Arabs (PPV=0.0.452), PPV values of the other plant parts were varied by ethnolinguistic group (Fig. 7). This indicates that the local healers Arabs and Imazighen

Published: 23 June 2019

http://dx.doi.org/10.32859/era.18.21.1-19

count on a very well-developed knowledge about the properties of different plant parts. 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.

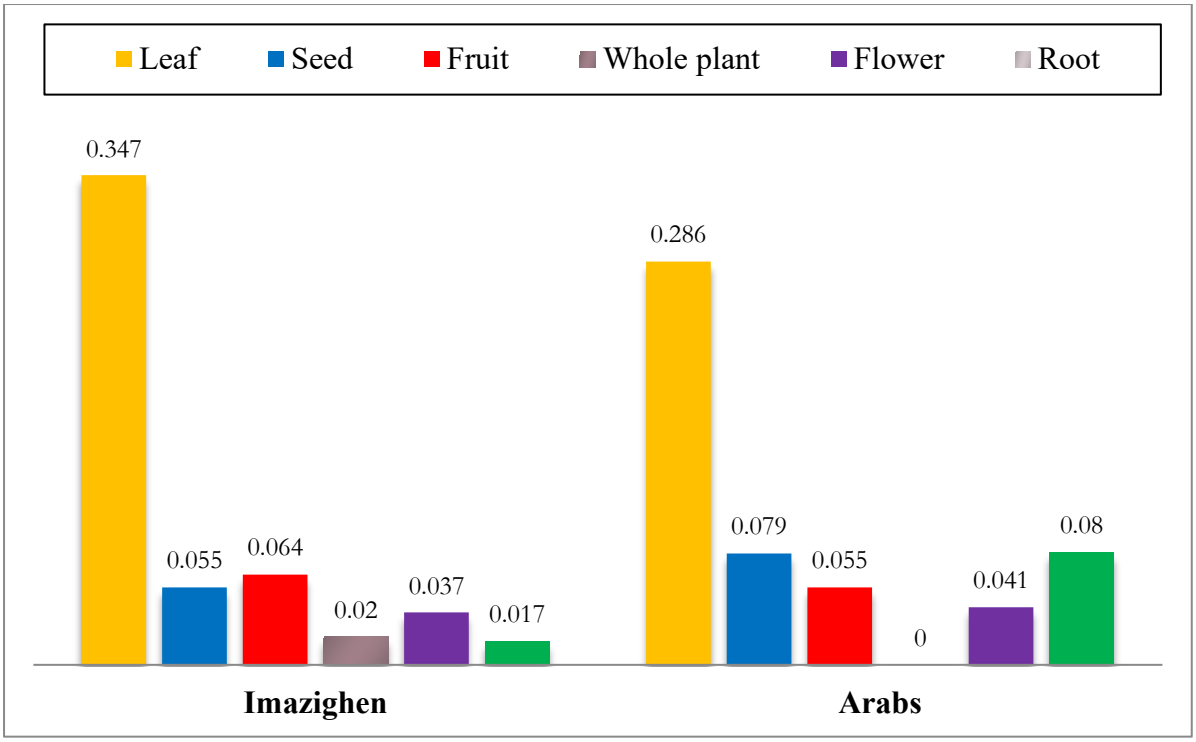

Fig. 7. Plant part used in the treatment of diabetic problems in the study area.

Methods of remedy preparations

In order to facilitate the administration of the active principles of the plant, several modes of preparation are employed to know decoction, infusion, cataplasm, maceration, fumigation and cooked (Fig. 8). In the study area, information about the preparation of each plant has been included in Table 2. For Imazighen the majorities of remedies were prepared from infusion (27.46%), followed by decoction (14.56%), cooked (7%) and other methods of preparation (5.2%). For Arabs, the primary methods of preparation of remedies were infusion (26.54%), cooked (8.26%) and decoction (7.44%), the percentage of the other methods of preparation grouped (fumigation, maceration, cataplasm, raw) does not exceed 3.64%. In the present study, the majority of informants Imazighen and Arabs indicated that powder is easily prepared and there is very less chance of contamination as compared to maceration or fumigation. The frequent use of the infusion by our informants can be explained by the fact that the infusion 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 infusion (El Hilah et al. 2015; Salhi et al. 2010; Slimani et al. 2016). This confirms that there is a perpetual exchange of information on the use of medicinal plants between the people of Morocco.

Routes of administration

In our ethnobotanical survey, the respondent's reports showed that most of the informants Imazighen in the study area administered traditional plant medicines through oral (40.2%) followed by massage (3.6%), other modes of administration (2.9%) and swabbing (1.7%). For Arabs, the most common one was orally that accounted for (41.1%) followed by massage (6%), swabbing (6%), other modes of administration (1.9%) rinsing (1%) and swabbing (0.8%). The predominance of oral administration may be explained by a high incidence of internal ailments in the region (Polat and Satıl

Published: 23 June 2019

http://dx.doi.org/10.32859/era.18.21.1-19

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 MPs in the Rif is in total agreement with most of the carried out ethnobotanical studies in Africa (Benarba et al. 2014; Chermat and Gharzouli 2015; El Hafian et al. 2014).

Source of knowledge about medicinal plants

In our ethnobotanical survey, 71.5% of the population acquired knowledge about medicinal use of plants as remedy for diabetic diseases through others' experiences including 33.2% of informants Imazighen and 40% of informants Arabs. This reflects the relative transmission of traditional practices from a generation to the next one. 9.5% of respondents Arabs and 8.5% of respondents Imazighen practice herbal medicine according to herbalists' advices, (12%) of respondents their information is reflected from pharmacist (4.1% Imazighen and 2.9% Arabs) and 1.8% of the respondents (including 1% Imazighen and 0.8% Arabs) 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 MPs in their surroundings. The environment and others' experience remain therefore the most effective means to transmit knowledge about medicinal purposes of plants (Fig. 9).

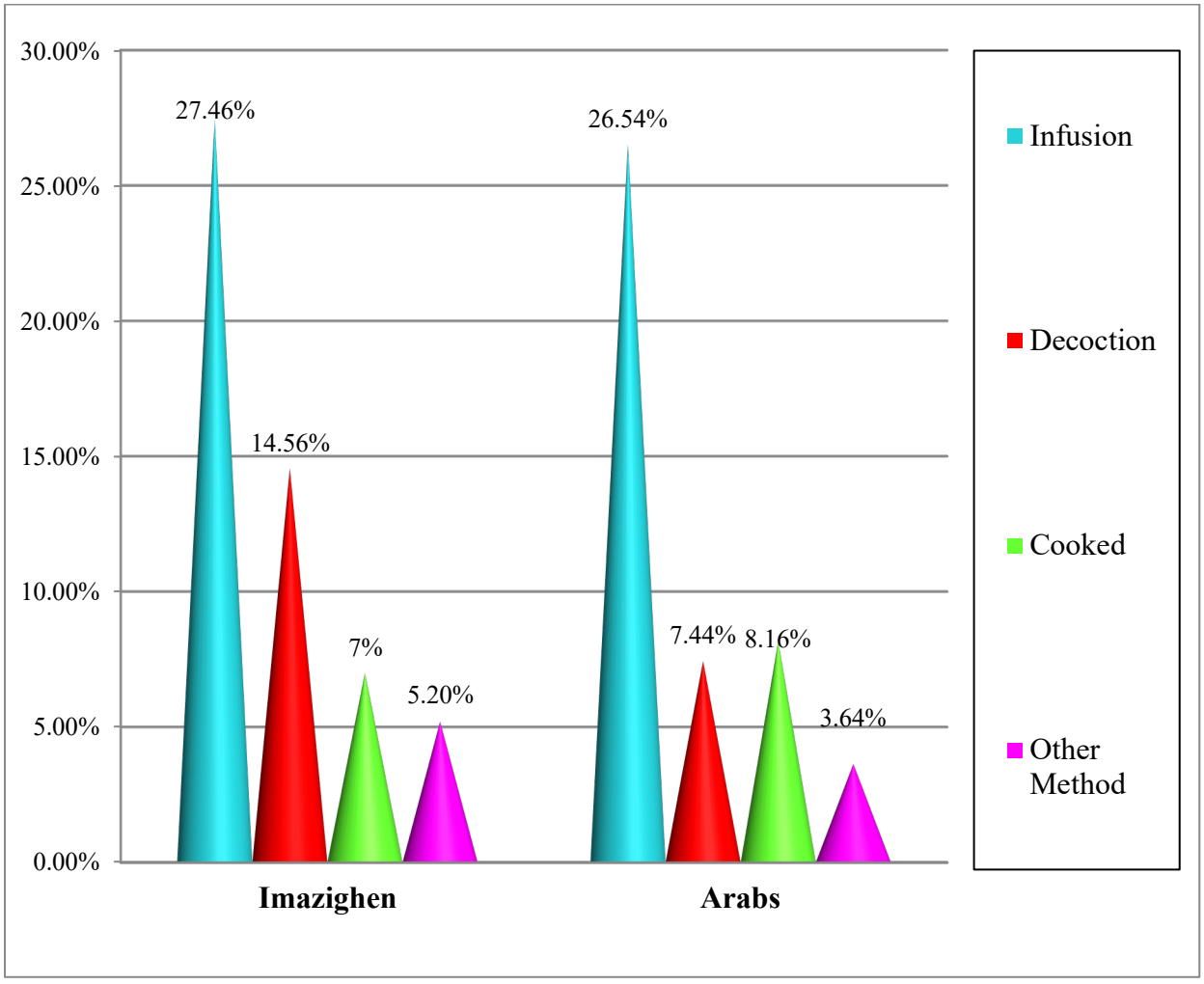

Fig. 8. Frequency of different methods of preparation.

Published: 23 June 2019

http://dx.doi.org/10.32859/era.18.21.1-19

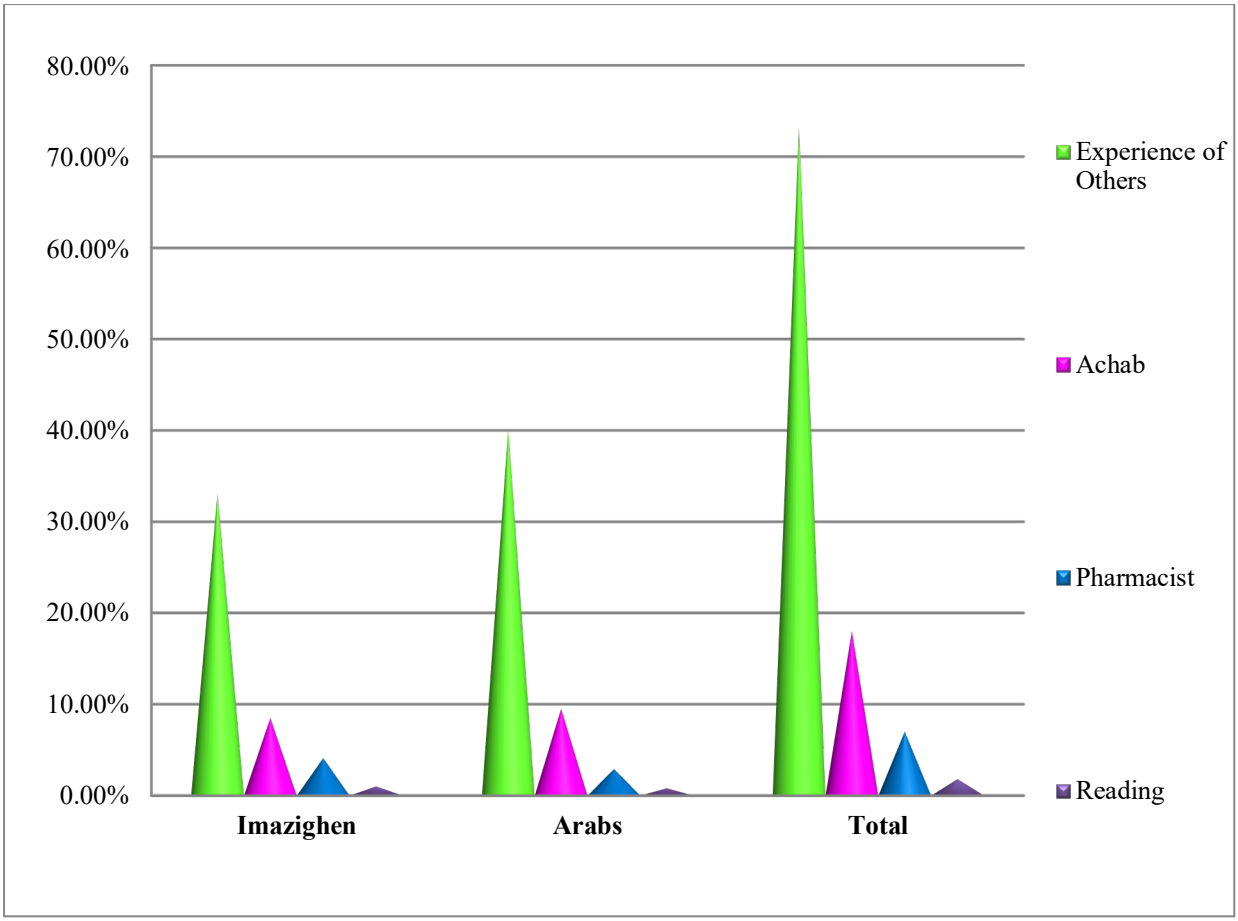

Fig. 9. Traditional knowledge acquisition modes.

Conclusion

Our study revealed that the local traditional healers of Rif, northern Morocco are rich in ethnomedicinal knowledge and majority of people rely on plant based remedies for common diabetic problems. The survey also revealed that all the traditional healers have strong faith on ethnomedicines although they were less conscious about the documentation and preservation of medicinal plants and ethnomedicinal folklore. Based on the results of this study, higher use value, informant agreement ratio scores 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.

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.

Declarations

Authors' contributions

NC: Carried out field research in Rif, compiled the literature sources, data analysis, and interpretation and wrote the manuscript. **OB:** Helped in data and made a substantial contribution to data analysis. **HE:** Performed data analysis and drafted the manuscript. **RE:** Realization and manuscript evaluation. **LZ:** Designed the research and identification of plant species. All authors read and approved the final manuscript.

Ethics statement and consent to participate

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

Published: 23 June 2019

http://dx.doi.org/10.32859/era.18.21.1-19

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.

Funding
This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Conflicts of interest
We certify that there is no conflict of interest with any financial organization regarding the manuscript.

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.

Literature cited

Albuquerque UP. 2002. Uso e conservação de plantas e animais medicinais no estado de Pernambuco (Nordeste do Brasil): Um estudo de caso. Interciencia, 27(6).

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. Journal of Ethnopharmacology, 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. Evidence-Based Complementary and Alternative Medicine, 2016.

Benarba B, Meddah B, Tir Touil A. 2014. Response of bone resorption markers to Aristolochia longa intake by Algerian breast cancer postmenopausal women. Advances in Pharmacological Sciences, 2014.

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

Bonet M. 2001. Estudi etnobotànic del Montseny (Ph. D. thesis). Universitat de Barcelona.

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, 50–9.

Committee IE. 2009. International Expert Committee report on the role of the A1C assay in the diagnosis of diabetes. Diabetes Care, 32(7), 1327–1334.

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). Journal of Ethnopharmacology, 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). Journal of Applied Biosciences, 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. Journal of Animal &Plant Sciences, 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.

Ghourri M, Zidane L, Rochdi A, Fadli M, Douira A. 2012. Etude floristique et ethnobotanique des plantes médicinales de la ville d'El Ouatia (Maroc Saharien). Kastamonu Üniversitesi Orman Fakültesi Dergisi, 12(2), 218–235.

Published: 23 June 2019

http://dx.doi.org/10.32859/era.18.21.1-19

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

Goldenberg R, Punthakee Z. 2013. Definition, classification and diagnosis of diabetes, prediabetes and metabolic syndrome. Canadian Journal of Diabetes, 37, S8–S11.

Graham JE, Stoebner-May DG, Ostir GV, Al Snih S, Peek MK, Markides K, Ottenbacher KJ. 2007. Health related quality of life in older Mexican Americans with diabetes: A cross-sectional study. Health and Quality of Life Outcomes, 5(1), 39.

Hachi M, Hachi T, Belahbib N, Dahmani J, Zidane L. 2015. 'Contribution à l'étude floristique et ethnobotanique de la flore médicinale utilisée au niveau de la ville de khenifra (Maroc)'. International Journal of Innovation and Applied Studies, 11(3), 754.

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. Social Science & Medicine, 47(11), 1859–1871.

International Diabetes Federation. (2019). https://www.idf.org/our-network/regions-members/middle-east-and-north-africa/members/37-jordan.html.

Jain SK. 1964. The role of botanist in folklore research. Folklore, 5(4), 145–150.

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). Journal of Ethnopharmacology, 77(2–3), 175–182.

Karami S, Roayaei M, Hamzavi H, Bahmani M, Hassanzad-Azar H, Leila M, Rafieian-Kopaei M. 2017. Isolation and identification of probiotic Lactobacillus from local dairy and evaluating their antagonistic effect on pathogens. International Journal of Pharmaceutical Investigation, 7(3), 137.

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

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. Journal of Ethnopharmacology, 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. Journal of Advanced Research in Science and Technology, 3(1), 281–291.

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

Rabiei Z, Gholami M, Rafieian-Kopaei M. 2016. Antidepressant effects of Mentha pulegium in mice. Bangladesh Journal of Pharmacology, 11(3), 711–715.

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.

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-]. International Journal of Innovation and Applied Studies, 15(4), 846.

Sreekeesoon DP, Mahomoodally MF. 2014. Ethnopharmacological analysis of medicinal plants and animals used in the treatment and management of pain in Mauritius. Journal of Ethnopharmacology, 157, 181–200.

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). Journal of Ethnopharmacology, 110(1), 105–117.

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. Journal of Ethnopharmacology, 145(2), 517–529.

Ziyyat A, Legssyer A, Mekhfi H, Dassouli A, Serhrouchni M, Benjelloun W. 1997. Phytotherapy of hypertension and diabetes in oriental Morocco. Journal of Ethnopharmacology, 58(1), 45–54.

Published: 23 June 2019

http://dx.doi.org/10.32859/era.18.21.1-19

Appendix A

Questionnaire sheets: Medicinal plants and herbal medicine

Date.....

Region .....

Commune.....

Survey number.....

Informant:

Profession: .....

Sex: Male ☐ Female ☐

Age: { ≤ 20} ☐ {20 - 40} ☐ {40 - 60} ☐ { ≥ 60 ☐

Family situation: Single ☐ Divorced ☐ Widower ☐ Married ☐

Level of study: Illiterate ☐ Primary ☐ Secondary ☐ University ☐

Locality: Nomadic ☐ Town ☐ Village ☐ City ☐

Income / month (MAD): Unemployed ☐ {250 - 1500} ☐ {1500 - 5000} ☐ { ≥ 5000} ☐

Therapeutic practices :

When you feel sick, you address:

To traditional medicine, why?

Effective ☐ Cheapest ☐ Acquisition ☐ Ineffective medication ☐

To modern medicine, why? Effective ☐ More precise ☐ Toxicity of plants ☐

If it is two that it is the first: Traditional medicine ☐ Modern medicine ☐

Vegetal material:

Vernacular name:.....

Scientific Name: .....

Plant Type: Spontaneous ☐ Cultivated ☐ Introduced ☐

Use of the plant: Therapeutic ☐ Cosmetic ☐ Other ☐

Harvesting technique: Manual ☐ Mechanical ☐

Harvest Time: Summer ☐ Fall ☐ Winter ☐ Spring ☐ Any year ☐

Drug preparation: Plant alone ☐ Possible association (of plants) ☐

If association of plants, quote the recipe:.....

Use of the plant: Fresh ☐ Desiccated ☐ After treatment ☐

If desiccated, drying method: Sun exposure ☐ In the Shade ☐

Published: 23 June 2019

http://dx.doi.org/10.32859/era.18.21.1-19

Used part: Stem ☐ Flower ☐ Fruit ☐ Seed ☐ Bark ☐ Bulb ☐
Root ☐ Rhizome ☐ Leaf ☐ Whole plant ☐ Other combination ☐
Form of employment: Tisane ☐ Powder ☐ Essential oil ☐ Oily oil ☐ Tincture ☐

Method of preparation: Infusion ☐ Decoction ☐ Cataplasm ☐ Raw ☐ cooked ☐ Other ☐
Dose used: Pinch ☐ Handle ☐ Spoonful ☐
Precise Dose: Quantity in g / glass: …….. Quantity in g / liter: ……... Other: .....
Administration mode: Oral ☐ Massage ☐ Rinse ☐ Swabbing ☐ Other ☐
Dosage: number of doses per day:
For children: 1time / day ☐ 2time / day ☐ 3time / day ☐ Other ☐
For adults: 1time / day ☐ 2time / day ☐ 3time / day ☐ Other ☐

For older people: 1time / day ☐ 2time / day ☐ 3time / day ☐ Other ☐

Length of Use: One Day ☐ A Week ☐ One month ☐ Until healing ☐

Conservation method: Sheltered from the light ☐ Exposed to light ☐ Other ☐
Expiration date:…… ……..……

Use :

Diagnosis By: Himself ☐ Doctor ☐ Herbalist ☐ Other ☐
Results: Healing ☐ Improvement ☐ Ineffective ☐
Side effect: ..... Toxicity: ..... Caution of use: .....

Published: 23 June 2019
http://dx.doi.org/10.32859/era.18.21.1-19