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Original Article

Aromatic and medicinal plants in the Ifrane region (Morocco): Floristic diversity, with special emphasis on ethnobotanical and socioeconomic studies of six spontaneous plants

[Plantas aromáticas y medicinales en la región de Ifrane (Marruecos): diversidad florística, con especial énfasis en estudios etnobotánicos y socioeconómicos de seis plantas espontáneas]

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Abstract

Context: As part of a huge project to assess Aromatic and Medicinal Plants (AMP) in the Ifrane-region, we made a list of these AMP through a floristic study, then we carried out ethnobotanical and socio-economic studies of six AMP belonging to three different genera (*Lavandula* L., *Thymus* L. and *Crataegus* L.).

Aims: To investigate the AMP sector to enhance social and sustainable development of Ifrane region.

Methods: In order to explore the floristic diversity of aromatic and medicinal plants in the Ifrane region, six field surveys were conducted, while all relevant floristic and medicinal literature was consulted. The ethnobotanical and socioeconomic surveys were carried out using questionnaire forms and were conducted during six campaigns among informants.

Results: The inventory of spontaneous aromatic and medicinal flora in the study area highlighted the existence of 130 species belonging to 45 genera and 17 botanical families. The obtained results revealed that the exploitation in the spontaneous state of leaves and flowers, and the "decoction" method of preparation were the most frequently used ways to treat various diseases. The informants declared facing many problems such as high production costs, limited technical and financial means, processing and marketing difficulties, and lack of quality control and raw material traceability.

Conclusions: This study will be a database for the actors of the AMP sector in Ifrane. Thus, it will contribute to both social and sustainable developments of this sector in this region.

Keywords: aromatic and medicinal plant diversity; aromatic and medicinal plant valorization; local product; market study; sustainable development; traditional uses.

Resumen

Contexto: Como parte de un gran proyecto para evaluar las Plantas Aromáticas y Medicinales (AMP) en la región de Ifrane, hicimos una lista de estas AMP a través de un estudio florístico, luego llevamos a cabo estudios etnobotánicos y socioeconómicos de seis AMP pertenecientes a tres géneros diferentes (*Lavandula* L., *Thymus* L. y *Crataegus* L.).

Objetivos: Investigar el sector AMP para mejorar el desarrollo social y sostenible de la región de Ifrane.

Métodos: Con el fin de explorar la diversidad florística de plantas aromáticas y medicinales en la región de Ifrane, se realizaron seis estudios de campo, mientras que se consultó toda la literatura florística y medicinal relevante. Los relevamientos etnobotánicos y socioeconómicos se realizaron mediante formularios de cuestionarios, y se realizaron durante seis campañas entre informantes.

Resultados: El inventario de flora aromática y medicinal espontánea en el área de estudio destacó la existencia de 130 especies pertenecientes a 45 géneros y 17 familias botánicas. Los resultados obtenidos revelaron que el aprovechamiento en estado espontáneo de hojas y flores, y el método de preparación "decocción" fueron las formas más utilizadas para el tratamiento de diversas enfermedades. Los informantes declararon enfrentar muchos problemas, como altos costos de producción, medios técnicos y financieros limitados, dificultades de procesamiento y comercialización, y falta de control de calidad y trazabilidad de la materia prima.

Conclusiones: Este estudio será una base de datos para los actores del sector AMP en Ifrane. Por lo tanto, contribuirá al desarrollo social y sostenible de este sector en esta región.

Palabras Clave: diversidad de plantas medicinales y aromáticas; producto local; estudio de mercado; desarrollo sostenible; usos tradicionales; valorización de plantas medicinales y arométicas.

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INTRODUCTION

At the territory, the region or the country level, actors and decision-makers in agricultural and rural development often wonder about the existence of an agricultural heritage and the possibility of developing an agricultural product promotion strategy. These questions generally arise from the search for territorial development plans based on the enhancement of local resources with regard to geographical indications and on the interest of identifying quality products according to their origin to ensure their recognition and conservation.

Morocco (see map Fig. 1), with its cultural diversity, passed down from generation to generation and its great wealth of diversity floristic, which is reflected in a multitude of ecological ecosystems, is considered a showpiece among the north African countries rich in local products, many of which are endemic (MAPM, 2011). The promotion of local products, especially aromatic and medicinal plants (AMP), is a privileged goal of the Moroccan agricultural strategy and represents a promising alternative for local, viable and sustainable development, especially in peripheral and difficult areas (APDN, 2012). Although the exploitation of these natural resources (AMP) has a very old tradition (Bellakhdar, 1997), it has not seen much progress in the country (Neffati and Sghaier, 2014).

Moroccan wild flora comprises more than 41 ecosystems composed of more than 4200 wild species, including 600 species with aromatic or medicinal virtues, but only 80 species are currently exploited (Rhafouri et al., 2015). However, if Morocco's true potential for AMP is rich and diversified, the enhancement of this plant heritage is still far from sufficient. The real potential of the sector is far from being fully known to be assessed. On the other hand, the conservation of this heritage remains an ecological and economic stake, difficult to manage (Benjilali, 1997)

Due to its climate and geographical location in the Middle Atlas Mountains, the province of Ifrane represents one of phytogeographical sectors that exhibits a great AMP richness in Morocco (Fennane and Rejdali, 2016). The traditional uses of AMP in the region are numerous, but few people still practice its economic exploitation. It should also be noted that AMP production in this region is largely ensured by spontaneous plants, while the proportion of cultivated AMP remains very low. In addition, rudimentary operating systems and trading channels contributed to the disappearance of old knowledge and the deterioration in plant diversity, which led to a worsening of the situation.

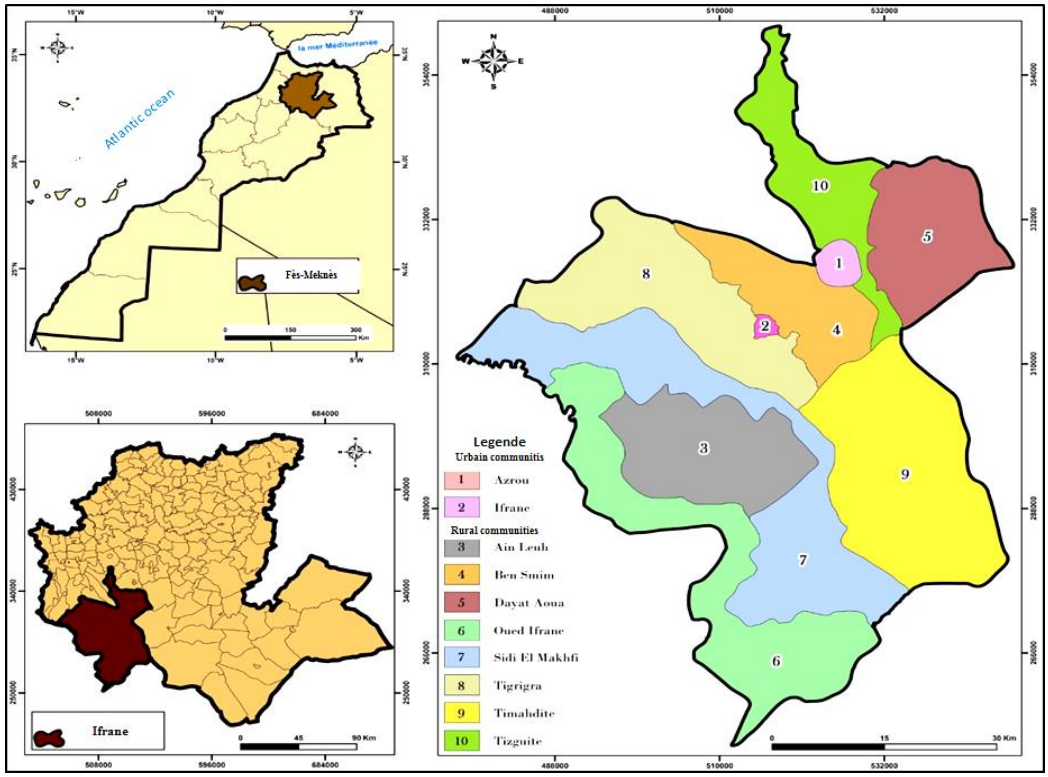

Figure1. Geographical location of the study area (province of Ifrane).

Several previous works have contributed to the enhancement of plant diversity in the Ifrane region. Indeed, the floristic study of the Ifrane valley (Watershed of the Oued Tizguit), carried out by Bachiri et al. (2015a), made it possible to establish an environmental diagnosis of the floristic heritage of the zone of the Oued Tizguit. An ethnobotanical study carried out by cooperatives and associations in the region of Meknès-Tafilalet (Morocco) (Fadil et al., 2014) aimed to identify the plants used and their uses in traditional medicine. Also, Rhafouri et al. (2015) published a relevant database on natural and cultural heritage and the sustainable management of natural resources in the region in their ethnobotanical study on plants of the Ifrane National Park. Referring to these studies, we affirm that regional data on medicinal plants are fragmented and scattered, while ancestral practices and practical knowledge of traditional medicine are threatened with disappearing. In this perspective, we are continuing our initiatives to consolidate previous work by creating harmonization and complementarity between the bibliographic, floristic, ethnobotany, and socio-economic aspects to develop a complete database on the AMP heritage and highlight the place of phytotherapy in the traditional health care system in the province of Ifrane.

As part of a large ongoing project viz., Valuation of Aromatic and Medicinal Plants sector for Social and Sustainable Development of Boulemane and Ifrane Regions that is conducted under the aegis of Wilaya of the Region of Meknes-Fez, the current study aims to: 1) create a comprehensive checklist of AMP for Ifrane region and 2) study ethnobotanical and socio-economic of the most commercialized and consumed local aromatic and medicinal plants with emphasis on six spontaneous plants belonging to three genera, namely *Lavandula* L. (lavender), *Thymus* L. (thyme) and *Crataegus* L. (hawthorn).

MATERIAL AND METHODS

Presentation of the study area

The province of Ifrane (Fig. 1) covers an area of 3573 km^2, with a population of 155.221 inhabitants, including 51.74% of urban inhabitants and 48.25% of rural inhabitants (HCP, 2007).

The population of Ifrane is made up of three large Tamazight speaking Amazigh tribes of Morocco: Bni Mguild, Bni M'tir and Ait Seghrouchen. The province is limited by the provinces of Sefrou and El Hajeb (North), by the province of Khenifra (South and West), and in the East by the province of Boulemane.

The forest area of the Province of Ifrane is of the order of 116 000 ha and is characterized by great ecological diversity with a predominance of *Cedrus atlantica* (42%) and *Quercus* (38%).

The livestock activity in the Ifrane area is of considerable importance due to its socioeconomic role as a main source of income. Rain-fed agriculture constitutes the second activity of the population of this region, while the cultivated area is subdivided into cereals (60%), fruit growing (5%) and market gardening (2%) (DPA, 2007).

Floristic studies of AMP in the Ifrane region

Field missions, sampling and identification

The botanical inventory was devoted to aromatic and medicinal flora, and it only concerned taxa (species or subspecies) that were spontaneous or naturalized. For that, six field missions were scheduled and carried out from the mid-September to the beginning of October 2016, from the mid-February to the beginning of March and from mid-April to the beginning of May 2017, in order to cover the entire phenological calendar of the flora present in the studied area, focusing on performing several passages per season and per level of vegetation, the surveys were distributed as follows: three missions in the wet season and three missions in the dry one. The adopted sampling method consisted of linear transects to cover all the plant species represented in the region. Surveys were accompanied by the recording of all ecological and phytosociological observations. The identification of the observed plants was carried out by the main floristic guides: Practical flora of Morocco (Fennane et al., 1999; 2007; 2014) and the flora of Algeria (Quézel and Santa, 1962; 1963). Nomenclature of plant taxa followed the Synonymic Index of the flora of North Africa (Dobignard and Chatelain, 2010; 2013), APG III (The Angiosperm Phylogeny Group, 2009) and APG IV (APG et al., 2016). The system of Raunkiaer (1934) was followed to assess the life-forms of plants. The determination of strictly endemic to Morocco or subendemic taxa that are common in neighboring countries was carried out with reference to the Chronological Inventory of Vascular Plants of Morocco (Fennane and Ibn Tattou, 2005; Ibn Tattou and Fennane, 2008), the Catalog of Endemic, Rare or Threatened Plants in Morocco (Fennane and Ibn Tattou 1998) and to the Catalog of Plants of Morocco (Jahandiez and Maire, 1931-1934; Emberger and Maire, 1941). Relevant floristic and medicinal literature, that may concern the study region, such as Bachiri et al. (2015a; Barbero et al. (1981); Benabid (2000); Benabid and Fennane (1994); Emberger and Maire (1941); Fadil et al. (2014); Fennane and Ibn Tattou (1998, 2005, 2012); Fennane and Rejdali (2016); Fennane et al. (1999, 2007, 2014); Rhafouri et al. (2015) ; Ibn Tattou and Fennane (2008);

Jahandiez and Maire (1931-1934); Lecompte (1986); Maire (1924); PDA (2007) were surveyed in order to inventory the AMP and to complete the current checklist of these plants in the Ifrane region.

Ethnobotanical and socioeconomic studies

Pre-inquiry

A preliminary investigation has provided important information on the role of herbal medicine in traditional medicine in the Ifrane region. Thanks to this method, we were able to select the plants most used and traded locally according to the number of citations of the plant by the respondents. The pre-survey was intended for herbalists, cooperatives and specialists in the field of AMP, and we interviewed 50 people.

Surveys

Ethnobotanical and socio-economic surveys were carried out with 120 questionnaires (Annex 1) during six-month campaigns from October to December 2017 and from January to March 2018 with informants (traditional healers, herbalists and other actors or users of AMP).

We were mainly interested in the variability or the repetitiveness of information from one place to another. This is based on the value of the plant within the local pharmacopeia and the degree of communication between traditional healers and users. Thus, the knowledge of informants and their level of education were a variant to be considered because, in traditional medicine, the statements of an illiterate or an expert are intertwined. The surveys were carried out in the ten communes mentioned above (Fig. 1) and the type of sampling was simple random.

Statistical analysis

The collected data from the floristic study and ethnobotanical and socioeconomic surveys were dealt with by computer processing using SPSS statistical software version 23 (Statistical Package for the Social Sciences, IBM, New York, Unit-ed states). However, the data collected during the interviews with the informants were analyzed using various descriptive and quantitative statistical methods to test the hypothesis of the comparison of means between the groups of correspondents (ANOVA test and Student's test, has significance when ($p \leq 0.05$)). Also, the use-value of the species (UV), the Plant Part Value (PPV), the Informant Agreement Ratio (IAR) and the Relative Frequency of citation (RFC) were used in order to determine the importance of medicinal plant resources.

Use value (UV)

The calculation of the use-value of the three plants studied (UV) allowed us to determine the relative importance of these three known plants in the treatment of the disease. It was calculated according to the following equation [1].

$$UV = \Sigma Ui/N \quad [1]$$

Where Ui: number of uses cited by each informant for a given plant, and N: total number of informants (Vitalini et al., 2013).

Plant Part Value (PPV)

The plant part value (PPV) was calculated according to the equation [2].

$$VPP = RUplant\ part/RU \quad [2]$$

Where: RUplant part is the sum of reported uses per plant part and RU is the number of reported uses of all plant parts. The part with the highest VPP is the most used by respondents (Benkhnigue et al., 2022; Chaachouay et al., 2019).

Informant agreement ratio (IAR)

To calculate IAR we used the formula [3].

$$IAR = Nur - Nt\ /Nur - 1 \quad [3]$$

Where IAR is the informant agreement ratio, Nur is the number of mentions in each category and Nt is the number of taxa used in each category. The values of the factor are between 0 and 1 (Heinrich et al., 1998).

Relative Frequency of citation (RFC)

The Relative Frequency Citation is an index that is used to demonstrate the local importance of each plant species. It is calculated based on the frequency of citation divided by the total number of informants [4].

$$RFC = FC/N \quad [4]$$

Where FC is the number of informants related to the use of plant species and N indicates the total number of informants who participated in the study without using categories for consideration.

RESULTS AND DISCUSSION

Floristic analysis of Ifrane's AMP

Annex 2 gives an overview of the spontaneous Aromatic and Medicinal flora recorded in the Ifrane region. A total of 130 species belonging to 45 genera and 17 botanical families was recorded. From Table 1, it can be seen that aromatic and medicinal flora of the Ifrane region represents approximately 2.5% of the entire Moroccan aromatic and medicinal flora reported until today (Fennane and Rejdali, 2016).

Table 1. AMP richness of the Ifrane region.

Characteristics	Ifrane region	Morocco	%
Area	357 300 ha	71 500 000 ha	0.5
Family	17	155	11
Genus	47	981	05
Taxa (species and / or subspecies)	130	5350	2.5
Floristic richness (N / A)*	3.6×10^{-4}	0.00008	

*The flora richness of the region is defined as the total number of species (N) present per unit area (A); it is therefore expressed in taxa / A.

Table 2. Richness rates of species or subspecies per family.

Family	Richness of species/ or subspecies	Richness rates of species/ or subspecies (%)
Lamiaceae	96	73.84
Asteraceae	7	5.4
Salixaceae	4	3.1
Apiaceae	3	2.3
Fagaceae	3	2.3
Rosaceae	3	2.3
Oleaceae	2	1.5
Thymelaeaceae	2	1.5
Anacardiaceae	2	1.5
Cupressaceae	1	6.26
Malvaceae	1	
Papaveraceae	1	
Pinaceae	1	
Santalaceae	1	
Scrophulariaceae	1	
Taxaceae	1	
Urticaceae	1	

Specific diversity of families

According to the importance of the number of species, the richest family, with more than 50 species, was the *Lamiaceae*, with 96 taxa, 73.84% of the total richness of the region (Table 2). The *Asteraceae* and *Salixaceae* families were represented by seven taxa (5% of the total richness of the region) and 4 taxa (3% of the total richness of the region), respectively. The other three families: *Apiaceae*, *Fagaceae*, *Rosaceae* were represented by three taxa each, while the *Oleaceae*, *Thymelaeaceae*, *Anacardiaceae* families were represented by two taxa each. However, eight families viz., *Cupressaceae*, *Malvaceae*, *Papaveraceae*, *Pinaceae*, *Santalaceae*, *Scrophulariaceae*, *Taxaceae*, *Urticaceae* have only one taxon each.

Endemic taxa richness

Among the 130 species inventoried in the region of Ifrane, 32 taxa, which represented four families, were endemic (Annex 2). These, either endemic strict or sub-endemic taxa, which were shared with neighboring countries were distributed as follows: 22 taxa (17%) were strictly endemic to Morocco (E); seven taxa (5%) were endemic to Morocco and Algeria (EA); one taxon (1%) was common endemics between Morocco, Algeria and the Iberian Peninsula (Balearic Islands included) (EAI); two taxa (2%) were endemic to Morocco and the Iberian Peninsula (Balearic Islands included) (EI).

Life form spectrum

Concerning life-forms, the AMP flora of the Ifrane region is grouped into six forms. The most common life-forms were *Chamephytes* (42%) and *Hemicryptophytes* (32%), followed by *Therophytes* (12%), followed by *Phanerophytes* (11%), *Nanophanerophytes* (2%), and finally *Geophytes* (1%).

By comparing our results of floristic richness with those taken from the literature (bibliographic database)(Annex 3), it is known from the previous reports (Bachiri et al., 2015a; Barbero et al., 1981; Benabid, 2000; Benabid and Fennane, 1994; Emberger and Maire, 1941; Fadil et al., 2014; Fennane and Ibn Tattou, 1998; 2005; 2012; Fennane and Rejdali, 2016; Fennane et al., 1999; Ibn Tattou, 2001; Ibn Tattou and Fennane, 2008; Jahandiez and Maire, 1931-1934; Lecompte, 1986; Maire, 1924; PDA, 2007; Rhafouri et al., 2015) that floristic richness of AMP in this region was assessed at 121 species belonging to 50 families. However, with regard to specific abundance by family, previous data (Fig. 2 and Annex 3) showed that the four richest families were *Lamiaceae* (18 species), *Asteraceae* (11 species), *Apiaceae* (eight species) and *Ranunculaceae* (nine species). However, the remaining majority of families were represented only from one to four species.

Ethnobotanical study

Pre-surveys

Preliminary investigations with herbalists, cooperatives and specialists, before the authentic survey phase, made it possible to select three other plants mentioned: *Thymus*, *Lavandula* and *Crataegus* (Annex 4). Relative Citation Frequency (RFC) analysis showed that *Thymus zygis* and *Thymus willdenowii* were reported by 100% of respondents, followed by *Crataegus monogyna* (90%) and *Lavandula angustifolia* (85%). In addition, *Lavandula pedunculata* was used by 71% of informants.

Thus, these results show that *Thymus*, *Lavandula* and *Crataegus* were at the top of the list of species used by the local population in the ten municipalities. This shows the dependence of the respondents on their natural environment and also implies a mastery and a wealth of local popular knowledge in the multiple uses of medicinal plants in their forest ecosystem.

Socio-demographic features of the informant

In this part of the work, we have tried to cover all the municipalities of the province of Ifrane to have a representative sample that covers the entire population of the region. The results obtained after the treatment are shown in Table 3.

During the survey, 45% of the informants surveyed were illiterate and 40% had a primary school level, whereas those with university, secondary and college levels represented 5.0%, 7.2% and 2.5%, respectively (Table 3). There is consistency in the results obtained between the level of education and the profession, which is explained by the dominance of the rural environment that characterizes the Ifrane province. These results join those obtained by the High Commission for Planning (HCP), which noted in 2014 that 47.7% of the rural population was illiterate against 22.2% of the urban population (Boutayeb et al., 2020). The difference between education level and indigenous knowledge was significant ($p = 0.000$).

Furthermore, the ethnobotanical survey also made it possible to interview people of both sexes (men and women). Both men and women were interested in traditional medicine; both use plants in equal parts (50% *vs.* 50%). The test (Student's t-test) did not show any significant differences between gender ($p = 0.215$). Knowledge of APMs covers all age groups, and it can be seen that the use of AMP increased with age and the dominant age groups are: 40 and 49 years (30%). The difference between the age groups was significant ($p = 0.000$). This result is similar to those obtained from ethnobotanical studies previously carried out in the region of Ifrane by Rhafouri et al. (2015) and in other Moroccan regions (Benkhnigue et al., 2010; Mehdioui and Kahouadji, 2007). Indeed, with age, people acquire knowledge, learn to transfer traditional practices related to the use of AMP and acquire greater therapeutic confidence in natural plant substances, which justifies the static results obtained.

The frequency of use of these plant resources is linked to the family situation of the people questioned; 77.5% of families have limited financial resources, so they cannot access modern medicine. The difference between family status was statistically significant ($p = 0.000$).

Housewife were most closely related to traditional medicine, accounting for 27.5%, herbalists 15%, while collectors and healers represent the lowest percentage (5% each); however, other occupations make up 47.5% and were split between field workers, artisans and more. There was a significant difference between occupations ($p = 0.000$).

Study of target plants

Botanical classification

Due to their abundance in the region of Ifrane and widespread use by the population of the region based on the preliminary survey carried out, three taxa (viz., *Thymus* species, *Lavandula* species and *Crataegus* species) were selected. For each genus, two species were targeted. The taxonomy data for these plants are given in Table 4.

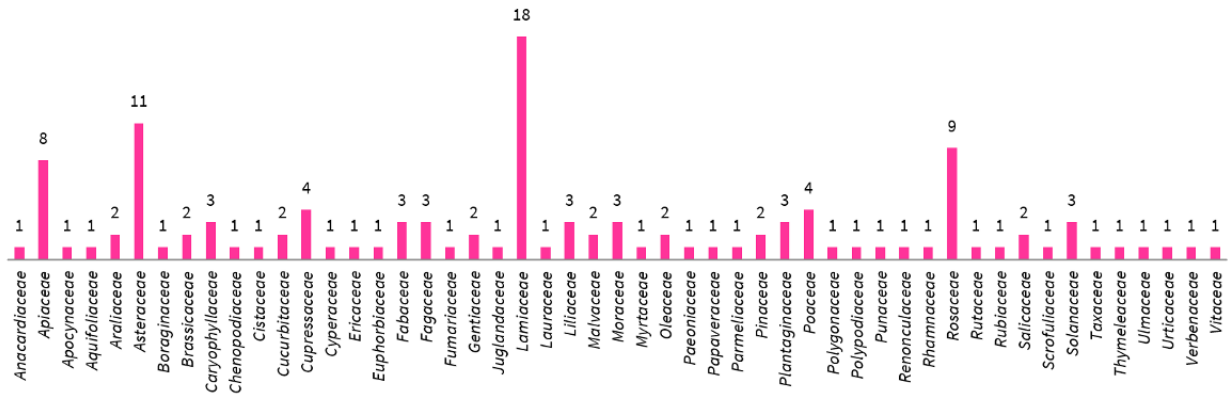

Figure 2. Family richness in species of AMP.

Table 3. Demographic profile of informants interviewed.

Variables	Category	Percentages (%)	P value
Gender	Female	50	0.215
	Male	50	
Age groups (years)	Between 20 and 29	17.5	0.00
	Between 30 and 39	25	
	Between 40 and 49	30	
	Between 50 and 60	20	
	>60	7.5	
Family situation	Single	10	0.00
	Married	77.5	
	Widower	10	
	Divorced	2.5	
Educational level	Primary	40	0.00
	Secondary	7.5	
	College	5	
	University	2.5	
	Illiterate	45	
Occupation	Herbalist	15	0.00
	Collector	5	
	Healer	5	
	Housewife	27.5	
	Other	47.5	

The majority of respondents revealed that target AMP employed in treating diseases were gathered from the field except for *Lavandula angustifolia* Mill., which was cultivated. Hereafter the target species will be named as follows, *Lavandula* species or *Lavandula* plants are used for *Lavandula* sp., *Thymus* species or *Thymus* plants will be used for *Thymus* sp. and *Crataegus* species or *Crataegus* plants are used for *Crataegus* sp.

AMP operating status of target plants

The analysis of the results obtained (Fig. 3A) showed that the exploitation of the plants targeted as AMP in this study is 82.5%, 95%, and 100%, respectively for *Lavandula*, *Thymus* and *Crataegus* plants. These results join those given by Benkhnigue et al. (2022) and Rhafouri et al. (2015), which were underlined those wild medicinal plants in different regions Morocco are used more frequently than cultivated ones. On the other hand, Fig. 3B shows that the tar-

geted plants are mainly used after drying. Thus, the dried *Lavandula* species are used at 95% against only 5% in the fresh state, the dried *Thymus* plants at 75% against 25% in the fresh state and the dried *Crataegus* plants at 85% versus 15 % in the fresh state.

These results inquire about the importance of the drying phase of plants after harvest. Although the method of drying plants practiced by professionals remains traditional in the study region, it is one of the most essential operations in the production and marketing of aromatic and medicinal plants. In addition, it allows the conservation of the bioactive principles of plants, and it also contributes to their protection against possible depreciation or rotting as well as their storage for a long time.

Table 4. Systematic classification of six target species.

Order	Family	Genus	Species	Vernacular identity	Image
Lamiales	*Lamiaceae*	*Lavandula* L.	*Lavandula angustifolia* Mill. (naturalized)	French: Lavande vraie, lavande officinale and lavandin Arabic: Khôzama Berber: Amezzir	
Lamiales	*Lamiaceae*	*Lavandula* L.	*Lavandula pedunculata (*Mill.) Cav. (spontaneous)	French: Lavande pédunculée Arabic: Lhalhale Berber: Tamezirt	
Lamiales	*Lamiaceae*	*Thymus* L.	*Thymus zygis* L. (spontaneous)	French: Thym rouge Arabic: Zîtra Berber: Azoukeni	
Lamiales	*Lamiaceae*	*Thymus* L.	*Thymus wildenowii* Bois (spontaneous)	French: Thym rouge Arabic: Zîtra Berber: Azoukeni	
Rosales	*Rosaceae*	*Crataegus* L.	*Crataegus monogyna* Jacq. (spontaneous)	French: Aubépine Arabic: Zâarour Berber: Admam	
Rosales	*Rosaceae*	*Crataegus* L.	*Crataegus laciniata* Steven ex Besser (spontaneous)	French: Aubépine Arabic: Zâarour Berber: Admam	

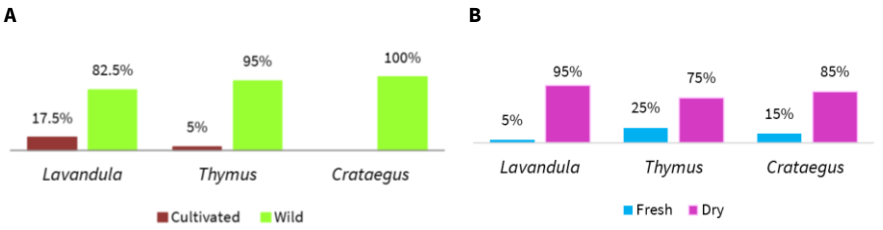

Figure 3. **(A)** Percentage of exploitation of target plants either spontaneous or cultivated states. **(B)** Proportion of use of target plants either dried or fresh.

Table 5. Different target plants' uses.

Plants	Percentages (%)					UV
	Therapeutic	Cosmetic	Others	Culinary	Ornamental	
Lavandula species	60	18	12	0	10	0.033
Thymus species	70	10	5	15	0	0.033
Crataegus species	90	5	5	0	0	0.025

Different areas of use of target plants and Use-Value (UV)

Data processing made it possible to obtain Table 5 relating to the uses of the various target plants in the Ifrane region. The analysis of the use-value index for the target plants, in our study area, showed that UV is ranged between 0.025 and 0.033; in the first row, we find *Lavandula* species and *Thymus* species with UV = 0.033, followed by *Crataegus* species with UV = 0.25. On the other hand, Table 5 showed that the therapeutic use of the target plants is prevailing over other uses such as cosmetics, culinary and ornamental purposes.

In the Ifrane region, the use of these target plants was very popular and had considerable local importance (Bachiri et al., 2015b). While the *Lavandula* plants were cultivated to decorate border gardens thanks to their pretty blue-purple flowers and their pleasant scent, they are largely used as aromatic for clothes closets, as cosmetic, and as medicinal plants in the treatment of diabetic diseases. As for the two target *Thymus* species in this work, they are mainly used as a condiment for flavoring various traditional dishes in the investigated region as well as in cosmetic and for animal feed; moreover, according to Djerroumi and Nacef (2004), these plants are also highly valued for their antimicrobial properties. However, in the study region, *Crataegus* plants have rarely been used in cosmetics or other fields, but have occupied a prominent place in traditional medicine and are used as sedatives of the sympathetic nervous system and leaves are used as anti-diarrhea. Recently, thanks to their therapeutic secrets, the *Crataegus* species have become more interested in specialists around the world (Kashyap et al., 2012; Khan and Abourashed, 2010; Rigelsky et al., 2002; Yuan et al., 2011).

Used parts of the three target plants and plant part value (PPV)

Referring to Table 6 and based on the PPV value of plant parts, it can be noted that the leaves and flowers are the organs most used for medicinal purposes in the study area; viz., 85% (PPV = 0.85) of *Thymus* plants, 70% (PPV = 0.7) of *Lavandula* species, and 40% (PPV = 0.4) of *Crataegus* plants. However, for single use of the flowers, *Lavandula* plants had a rate of 26%, while *Thymus* species had a low rate (2%) (PPV = 0.2), and no sole use was recorded for *Crataegus* species. For the use of leaves alone, *Crataegus* comes first at 37% (PPV = 0.37), followed by *Thymus* at 15% (PPV = 0.15). Then *Lavandula* at only 4% (PPV = 0.4). Nevertheless, for the fruit, that of the *Crataegus* plants is the only one widely used with 23% (PPV = 0.23) of respondents in the study region, and it is naturally served when it is mature.

We emphasize here owing to the existence of active ingredients with different concentrations in different parts of the plant (leaves, flowers, fruits) depending on the species used. According to our field survey, there has been an indiscriminate collection of medicinal plants, especially herbaceous plants, with their underground parts. This anarchic harvesting method has certainly impacted the floristic diversity of the region and may even ultimately contribute to the disappearance of these species in their natural state. Therefore, there is a need to educate and raise awareness among the local population about ways to conserve as well as the importance of native plants in the sustainable development of the region (Fennane and Rejdali, 2016).

Table 6. Used parts of the three target plants according to the respondents in the study area.

Used parts	Plant	Percentage (%)	PPV
Flowers and leaves	*Lavandula*	70	0.7
	Thymus	85	0.85
	Crataegus	40	0.4
Flowers	*Lavandula*	26	0.26
	Thymus	2	0.02
	Crataegus	0	0
Leaves	*Lavandula*	4	0.04
	Thymus	15	0.15
	Crataegus	37	0.37
Fruits	*Lavandula*	0	0
	Thymus	0	0
	Crataegus	23	0.23

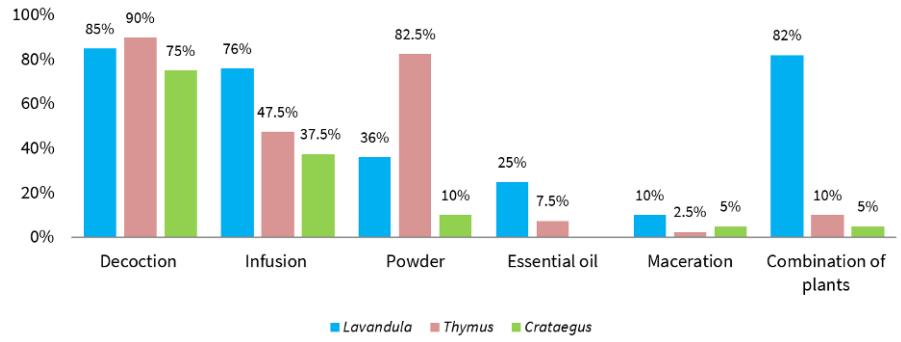

Figure 4. Different methods of preparation of extracts and associations of target plants in therapeutic recipes.

Method of preparation of target AMP

Five methods used to prepare the traditional medicinal plant, from target AMP, were identified during our surveys in the Ifrane region, namely decoction, infusion, maceration, essential oils (EO), and powder (Fig. 4). Thus, the most common one used by indigenous people is the decoction method (viz., *Thymus* species at 90%, *Lavandula* species at 85% and *Crataegus* species at 75%). These results are congruent with other works carried out in different regions of the central Atlas and prove that the decoction is the most required mode (Daoudi et al., 2015; Hachi et al., 2016; Ibijbijen et al., 2016; Najem et al., 2020).

Next comes the infusion method, which is represented by large percentages for the three target plants *Lavandula* (75%), *Thymus* (47,5%) and *Crataegus* (37,3%); regardless of the plant used, the liquid resulting from this method is referred to as ATAI by the local population. According to Baba Aïssa (2011), this form of preparation ensures optimal diffusion of volatile substances viz., essences, resins, essential oils. Also, its large use can be explained, however, because it is commonly used in the preparation of numerous folk recipes (Bachar et al., 2021; Benkhnigue et al., 2022) and allows to decrease the toxic effect of some recipes (Baba Aïssa, 2011; Chaachouay et al., 2019; 2022; El Khomsi et al., 2022).

As for the powder method, which is also common in the region, *Thymus* species are dominant at 82.5%, followed by *Lavandula* species at 36% and *Crataegus* species at 10%. The prepared plants in powder form are used for internal care (swallowed with water or mixed with honey or absorbed through the oral mucosa) or for external care serve as a base for compresses and can be mixed with ointments. These uses are also largely reported in various ethnobotanical studies carried out in Morocco (Belhaj et al., 2021; Bellakhdar, 1997; El-Ghazouani et al., 2021) and elsewhere (Chevallier, 2001; Kumar et al., 2012; Fasola et al., 2014).

Concerning the use of essential oils (EOs) in the region, we have revealed that *Lavandula* species oils

have been used at 25% and those of *Thymus* species at 7.5%; however, no EO product was found for *Crataegus* species (Fig. 4). These high rates of use of essential oils of *Lavandul*a and *Thymus* species for both therapeutic and culinary purposes in the region can be due to two main factors: 1) the spontaneous spread and the abundance of these plants in the study area (Fennane et al., 2007), and 2) the spread of the culture to create cooperatives among the local population thanks to regional stakeholder institutions as well as to the facilities offered by the country's forests and water administration in recent years (APDN, 2012).

Finally, the extraction method by maceration comes last among the methods used in the study region according to the people questioned [*Lavandula* species (10%), *Crataegus* species (5%) and *Thymus* species (2.5%)].

The present study made it possible to identify a certain number of folk recipes containing each of the plants examined in combination with others to treat certain diseases in the region. Thus, in descending order of rate use in traditional recipes, we found *Lavandula* species at 82%, *Crataegus* species at 10% and *Thymus* species at 5%. As examples of preparations that are used by the local population, we mention the association of *Lavandula* species with *Rosa* × *damascena* Herrm. (family *Rosaceae*), *Lawsonia inermis* L. (family *Lythraceae*) and *Chamaemelum* sp. (family *Asteraceae*) for the treatment of hair loss; all plants are reduced to powder and made with slightly lukewarm water. For *Crataegus* species, the *Crataegus* powder is blended with honey to treat cardiovascular disease and hypertension or mix it with henna in hair care. Concerning *Thymus* plants, they are added to tea as perfumed or used after infusion but without precise the quantity of plant infused (handful, bunch) to remedy various diseases such as colds, rheumatism, and pneumonia.

Dosage, administration routes and duration of use of target AMP

In the present study, we point out that there is a lack of precision on the dose used per plant for medicinal purposes. According to a high number of respondents, the dose is usually prescribed either by the handful or by the pinch. This agrees with the findings in previous works (El-Assri et al., 2021; Benkhnigue et al., 2022). According to the results shown in Table 7, the handful is the most used dose with a higher percentage ranging between 85 to 87.5%. However, the pinch dose displayed lower proportions varying between 10 to 15%.

Regarding the modes of administration applied in the study area, four modes have been specified, namely, the oral route, massage, brushing and rinsing. Numerous studies have reported that these different preparation methods for administering folk remedies are the most common methods used among local communities in Morocco (Ajjoun et al., 2021; Benkhaira et al., 2021a; 2021b; Benkhnigue et al., 2010; Chaachouay et al., 2019; Katiri et al., 2017). As shown in Table 7, the oral route was the most common method for the three target AMP (97.5% for *Thymus* species to 100% for *Lavandula* and *Crataegus* species), followed by massage (dermal route) (77.5% for *Lavandula* species and 10% for *Thymus* species), brushing (25% for *Lavandula* species, 15% for *Thymus* species and 5% for *Crataegus* species) and rinsing methods (15% for *Crataegus* species and *Lavandula* and *Thymus* species each recorded a rate of 12.5%).

The duration of use of herbal preparations varied depending on the illness to be treated and as well as the plant species used and patient age. Overall, it was claimed to be for a day, a week or a month (Table 7). However, concerning the number of administrations per day, regardless of the age group (children, adults, older adults), all investigators (100%) recommend using the target AMP preparations once a day up to recovery.

Health disorders treated by target AMP and informant agreement ratio (IAR)

The ethnobotanical surveys carried out with informants made it possible to determine a certain number of chronic diseases treated with the target plants. Thus, nine illnesses were specified (Table 8). The obtained results revealed that *Crataegus* species were used by 97.5% of the local population in the treatment of cardiovascular diseases, by 10% in the treatment of neurological diseases (cases of insomnia) and by 7.5% in the treatment of buco-dentary diseases. Conversely, *Thymus* species were indicated for five illnesses; they recorded 30% of users in the treatment of genitourinary, 22.5% of users in the treatment of dermatological skin care, 22.5% of users in the digestive treatment issues, 20 % of users in the treatment of buco-dentary and 2.5% of users in the treatment of respiratory. However, the *Lavandula* species, in the study region, were commonly used to remedy seven treatments; records indicated that the digestive diseases was above the rank with 33% of users, then respiratory with 30% of users, followed by neurological with 15% of users, genitourinary with 12.5% of users, dermatological with 5% of users and metabolic and osteoarticular with 4% of users each.

In this study, the informant agreement ratio (IAR) values were calculated for the nine diseases to determine the disease prevalence level in the study area. The range of IAR values was 0.94-1% (Table 8). Cardiovascular and osteoarticular disease represented

the highest IAR (1%), followed by digestive and genitourinary disorders each recording an IAR of 0.98 and respiratory disorders with IAR (0.87), then dermatological diseases, buco-dentary diseases and neurological diseases each having score an IAV of 0.96 and the least value of IAV (0.94) was recorded for metabolic disorders.

The higher reported IAR values suggest, first of all, the good knowledge of the local population about the nine different diseases and an acquaintance on the target plants used against these categories of sicknesses. On the other hand, it may indicate that indigenous people have a strong dependence on traditional medicine and the well exchanged among members of the community. In the studied region, their herbal knowledge was associated with the treatment of said diseases.

The large medicinal uses noted of the plants targeted in our study region to treat these chronic diseases can be related to their wider distribution and abundance in the local flora area (Fennane and Ibn Tattou, 2005; Fennane et al., 2007) as well as the ease of their preparing as remedies. In fact, it is revealed from the literature that ethnobotanical or ethnomedical studies conducted in different parts of Morocco have shown that the species of *Crataegus*, *Thymus* and *Lavandula* were among other medicinal plants recommended for treating large categories of weakness (Belkhdaer, 1997) in addition to their richness in bioactive ingredients (Zaidi, 1991; Amarti et al., 2011; Ait Ouakrouch, 2015; Bachiri et al., 2015b).

Table 7. Dosage, mode of administration and period of use of target AMP.

Variables	Category		Administration times/day (T/D)	Percentege (%)		
				Lavandula	***Thymus***	***Crataegus***
Dosage	Handle			87.5	85	85
	Pinch			12.5	15	10
Daily frequency	Child (1-14 years)		1T/D	100	100	100
			2T/D	0	0	0
			3T/D	0	0	0
	Adult (15-64 years)		1T/D	95	87.5	82.5
			2T/D	5	7.5	12.5
			3T/D	0	5	5
	Old (> 65 years)		1T/D	100	100	100
			2T/D	0	0	0
			3T/D	0	0	0
Method of administration	Oral	Yes		100	97.5	100
		No		0	2.5	0
	Massage	Yes		77.5	10	0
		No		22.5	90	0
	Brushing	Yes		25	15	5
		No		75	85	95
	Rinsing	Yes		12.5	12.5	15
		No		87.5	87.5	85
Duration of use	One day			82.5	92.5	2
	One week			5	2.5	3
	One month			5	2.5	5
	Not determined			7.5	2.5	90

Table 8. Diseases treated by target AMP and their IAR values.

Disease	Percentage (%)					
	Lavandula	***Thymus***	***Crataegus***	**Nt**	**Nur**	**IAR**
Cardiovascular	0	0	97.5	1	117	1
Neurological	15	0	10	2	30	0.96
Buco-dentary	0	20	7.5	2	33	0.96
Digestive	33	22.5	0	2	67	0.98
Dermatological	5	22.5	0	2	33	0.96
Metabolic	4	12.5	0	2	20	0.94
Respiratory	30	2.5	0	2	39	0.97
Genitourinary	12.5	30	0	2	51	0.98
Osteoarticular	4	0	0	1	5	1

IAR: informant agreement ratio; Nur: Number of mentions in each category; Nt: Number of taxa used in each category

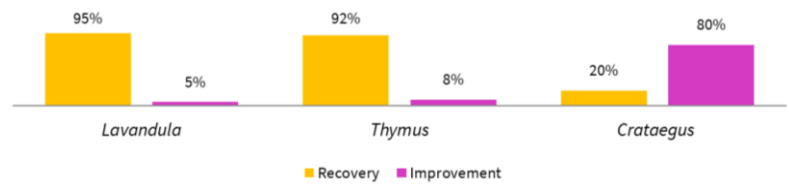

Figure 5. The efficiency of herbal remedies.

Evaluation of the effectiveness of herbal remedies of the target plants

Based on answers from informants during field surveys, most of them confirmed that improvement was the most common result after treatment with *Crataegus* species (80%); however, as regards *Thymus* species and *Lavandula* species, the improvement reached 8% and 5%, respectively (Fig. 5). Nevertheless, in terms of recovery and as indicated in Fig. 5, the treatment by *Thymus* plants and *Lavandula* plants recorded the highest with 92 and 95%, respectively, followed by *Crataegus* species scored 20%. In this retrieval case, most of the patients surveyed were satisfied with the relief of their symptoms in the second week of treatment, relapse was rare, and no side effects or toxicity were observed.

Socioeconomic study

Marketing aspect

Socially, medicinal plants are a treasure of information for those who have decided to approach their daily ailments differently, turning their backs on the chemical arsenal of modern medicine. This practice can be an alternative for improving the standard of living of the rural population. In this perspective, the AMP sector remains a promising sector in creating income-generating activities to improve natural plant resources in the commercial and pharmacological aspects.

Informant's profile and AMP place of marketing

The study revealed that most respondents were AMP consumers representing 75%, while only 15% work as traders in this field, and 10% were processors of AMP (Table 9). The three plants marketing places identified during this survey were national, regional, and local markets beside fairs and shops (Table 9).

The obtained data revealed that *Thymus*, *Lavandula* and *Crataegus* were marketed at the local market level (100%), while *Thymus* was marketed at the regional market level (93%), and *Lavandula* is marketed at the national market level (15%). *Lavandula* and *Thymus* were also sold in shops (100%) and at local and national trade fairs. It is worth mentioning that *Lavandula* was more marketed than *Thymus* at both local (*Lavandula*: 100% and *Thymus*: 50%) and national (*Lavandula*: 10% and *Thymus*: 6%) markets. As for *Crataegus*, despite its effective therapeutic virtues, it was not yet marketed in salons and shops or national and regional markets but was instead recognized at the local level.

For the national market and fairs, access to sales is not always easy for traders, processors, and cooperatives operating in the AMP sector. We observed that these cooperatives encounter several constraints in

Table 9. Distribution of informants according to profile and AMP place of marketing.

Variable	Category	Percentage (%)	Percentage (%)		
Informant profile	Consumer	75			
	Processor	10			
	Trader	15			
			Lavandula	***Thymus***	***Crataegus***
AMP place of marketing	Local market		100	100	100
	Regional market		93	12.5	87.5
	National market		62.5	15	17.5
	Shop		100	100	94.5
	Local trade show		100	50	92.5
	National trade show		10	6	0

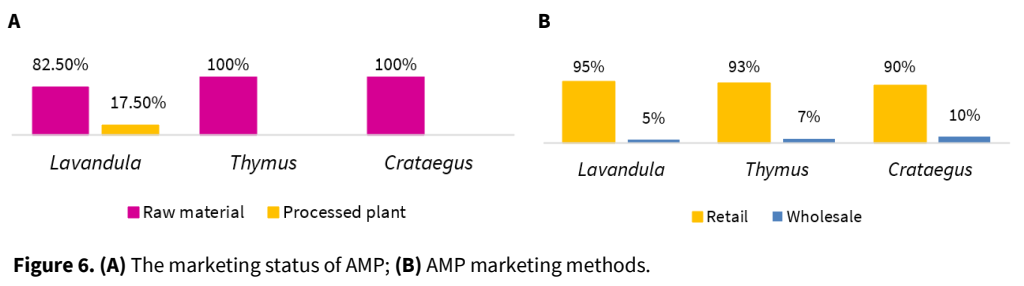

Figure 6. (A) The marketing status of AMP; **(B)** AMP marketing methods.

marketing their products in AMP, such as a lack of technical and financial resources and assistance in this field. Indeed, most cooperatives do not have points of sale at the national level (Diani, 2015). They can only market their products at national or local fairs cause of additional costs, especially since this possibility of exposure was not generalized and concerns only a limited number of cooperatives.

According to the survey results, access to the international market is difficult to meet the international market's needs. It is essential to improve the quality and regularity of raw material supply. It is also necessary to develop the capacities of the actors who must work within cooperatives to acquire and exploit processing and primary production units (drying, threshing). Furthermore, for the main exported species, it would be wise to establish an exploitation plan of AMP resources at the national level, then a regular supply to the market, and ensure conservation and sustainable management of natural resources (HCEFLCD-PNUD, 2014).

Marketed AMP status and their marketing methods

According to our investigations, *Thymus, Lavandula* and *Crataegus* were marketed in the raw state as dry matter (Fig 6A), and the retail mode was the most dominant (Fig 6B). However, local communities did not derive enough profit compared to the real value of these plants because they were sold as raw materials due to processing and marketing difficulties.

Several efforts have been made to improve the AMP sector in Morocco, such as the High Commission for Water, Forests and the Fight Against Desertification (HCWFFAD), which in 2009 developed a national strategy for developing the AMP sector. The main objective of this strategy is to prepare the sector to transition from a supplier sector of unprocessed raw materials to a true industrial sector offering a range of products with high added value intended for the national and international markets (Mehdioui and Kahouadji, 2007).

The quantity of the three plants sold in retail greatly exceeded their wholesale (Fig 6B). There were generally two AMP marketing modes in Morocco: Bulk Trading (wholesale), which is often done through a trader, and direct sales to consumers (retail sale), which remains a source of low added value (HCEFLCD, 2008).

The development of prices along the marketing chains

Table 10 gathers the data on the development of prices according to marketing methods. Retail prices for *Thymus*, *Lavandula*, and *Crataegus* vary between 25-70, 40-100, 15-50 (in DH/kg), while wholesale prices vary between DH/Q: 500- 700, 400-600 and 320-500.

Table 10. The development of prices along the marketing chains.

Crataegus				*Thymus*				*Lavandula*			
Retail cost DH/kg		**Wholesale cost DH/Q**		**Retail cost DH/kg**		**Wholesale cost DH/Q**		**Retail cost DH/kg**		**Wholesale cost DH/Q**	
15	2.5	500	20	25	2.5	500	60	40	5	400	10
20	15	450	15	30	12.5	600	14	50	17.5	500	15
25	2.5	320	1	35	5	700	23	60	10	600	50
30	40	350	49	40	25	650	3	70	5	450	25
35	7.5	400	10	45	7.5			75	5		
40	17.5	370	5	50	17.5	Total	100	80	25	Total	100
45	5	Total	100	60	5			100	32.5		
50	7.5			65	5			Total	100		
37	2.5			70	5						
Total	100	Average: 398.33 DH		Total	100	Average cost: 612.5 DH		Average: 67.85 DH (7.144 USD)		Average: 487.5 DH (51.32 USD)	
Average: 29.7 DH (3.13 USD)				Average cost: 46.6 DH (4.91 USD)							

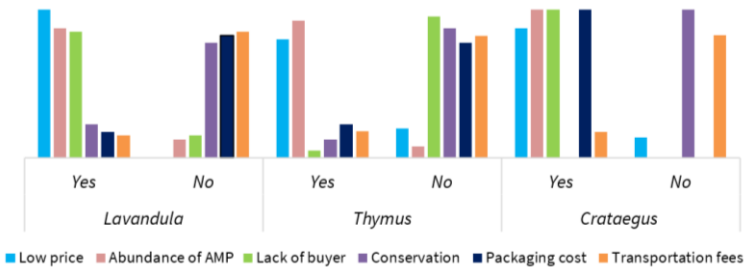

Figure 7. The marketing constraints.

Based on the statements of respondents, the sale of AMP generally and the three selected plants, especially by wholesale, remains very low because they were sold mainly in retail.

The marketing of AMP wholesale takes place through traders, who ensure quality control, cleaning, sorting, and packaging of the finished product. These traders offer low prices, which inhibit this type of sale and encourage traders to move towards direct sales to users and consumers (retail sales) (Jacob, 2017).

We found that the selling prices of AMP were generally influenced by the factors determining their quality, which include: (i) the origin of the product, (ii) the climate, (iii) the components of the harvested plant, (iv) the concentration of bioactive substances, and (v) the produced quantities. Economic factors also determine prices based on (i) supply and demand, (ii) the previously harvested stocks available to traders, manufacturers and final users. Certification can also influence prices (Jacob, 2017).

AMP marketing constraints

According to our results, all respondents admited that they face many difficulties that hamper the development of the AMP sector. These results are presented in Fig. 7. The constraints were abundance and availability of AMP in points of sale at very low prices but without any packaging in terms of hygiene and food safety (conservation, transport, packaging), in addition to the scarcity of buyers and the multiplication of the number of sellers (cooperatives, and collectors, among others). It should also be noted that the relatively high cost or the non-availability of packaging, in addition to the lack of precise practical knowledge concerning good agricultural and production practices from the harvest of the plant material to the finished product, were among the most frequent constraints in the plant marketing circuit (Fig. 7) and consequently this hampers the development of the sector.

Marketing constraints include, among other things, the lack of both a market information system and an adequate regulatory framework, the pre-eminence of the informal sector, the low purchase price, and the weak organizational capacity of the actors (Awono et al., 2013; Betti, 2007).

Evolution of sales revenues

The seasonal harvest of spontaneous plants with high added value allowed families in rural and urban areas to benefit from them. Sales revenues may vary depending on the seller's skill, marketing season, organ, or plant weight.

The results in Table 11 show that the sales revenues for the three plants were average for both periods of abundance and scarcity of the plant. Vermeulen et al. (2011) explained that the prices of non-timber forest products depend on supply and demand, which are influenced by the seasonality of the products.

As for the AMP marketing circuit, local populations are the most disadvantaged because they do not benefit from their marketing. The possibilities for improving the income from the sale of AMP are quite diverse, complex and must cover several aspects: technical, environmental and human resources. Of course, improving the living conditions of local populations is essential, but could only be achieved through the implementation of a program to strengthen the technical, organizational and commercial capacities of AMP actors, and also by the use of a set of tools (awareness workshops, harvesting, processing, and production, among others) to ensure both the safeguard of plant biodiversity, the empowerment of stakeholders, and the sustainability of economic activity around these plant resources. Monitoring, granting of financial assistance, and finding outlets are necessary. It is also essential to strengthen certification and labeling systems to give the AMP sector its best possibilities for development in the region.

Valuation aspect or value chain (local product)

At the level of the Ifrane region, the organization of the value chain of medicinal plants was developing through four axes: markets, consumers, natural resources and added values axes (Fig 8).

It was possible to identify the main constraints by studying the activities of each actor and the relationships between them within a value chain.

Table 11. Sales revenues according to abundance and shortage periods.

AMP	Percentage of answers (%)					
	Abundance period			Shortage period		
	Low revenues	Average revenues	Important revenues	Low revenues	Average revenues	Important revenues
Lavandula	10	68	22	8	61	31
Thymus	11	67.5	21.5	7.5	87.5	5
Crataegus	12.5	77.5	10	0	87.5	12.5

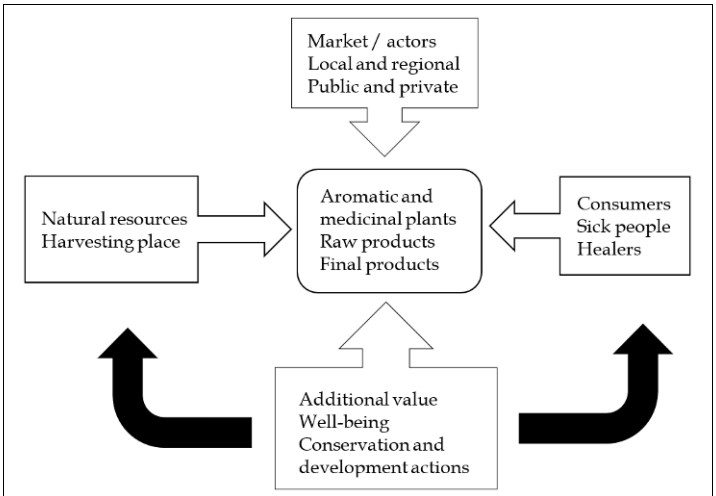

Figure 8. Value chain of aromatic and medicinal plants.

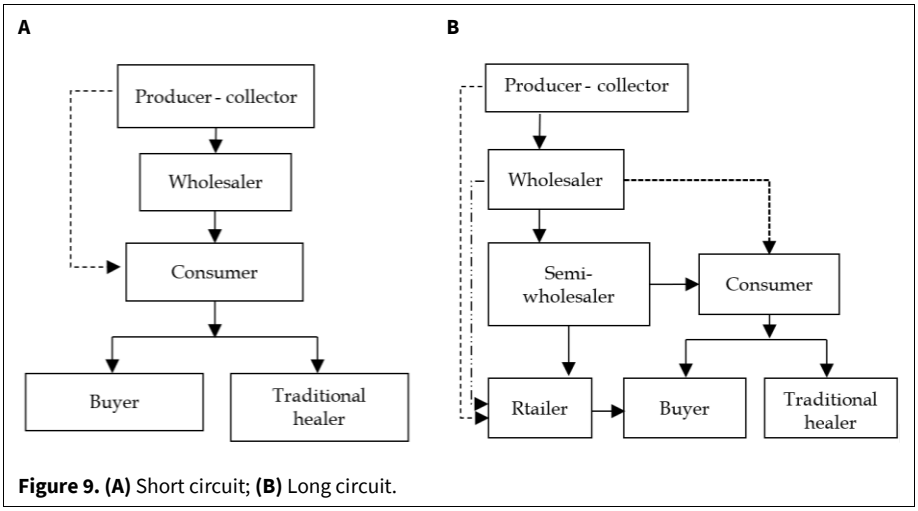

Figure 9. (A) Short circuit; **(B)** Long circuit.

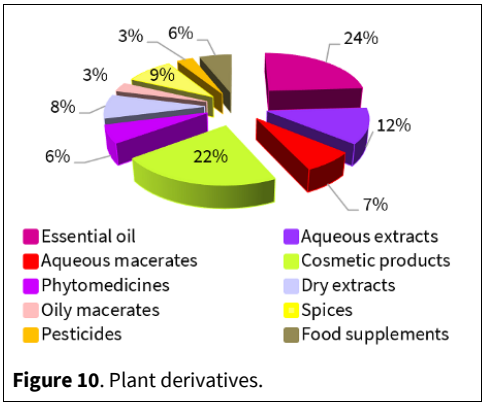

Figure 10. Plant derivatives.

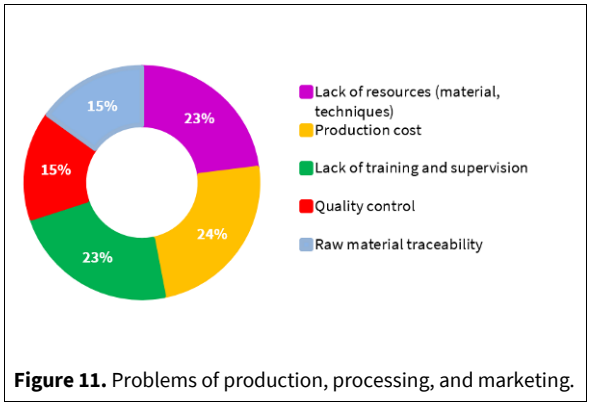

Figure 11. Problems of production, processing, and marketing.

AMP marketing chain

The medicinal plants' sector in the province of Ifrane was distinguished by two marketing chains, the short and the long circuits. The first circuit puts the producer-collector in direct contact with consumers or via wholesalers. The second concerns the relationships between the producer-collector, the wholesaler, semi-wholesaler, retailer and the consumer (Fig. 9).

Constraints of the value chain

A study of the value chain constraints is necessary to give the AMP sector its best possibilities for development.

Existing plant derivatives

The study of the AMP market in Ifrane helped us identify a wide range of products that derive from plants, which were EOs, cosmetic products, and aqueous extracts with 21.93, 24.56% and 12%, respectively (Fig. 10). In addition to these derivatives, we found the spices (9%), characterized by *Thymus*, whose aspect of culinary use was well known. There were also dry extracts (8%), aqueous macerates (7%), food supplements and phytomedicines (6%), and finally, phytosanitary products and oily macerates (3%). On the local market, the production of dry AMP was still traditional, and there was more and more competition from these products.

In the province of Ifrane, we were able to identify two types of products: those manufactured by cooperatives with modest resources and techniques at a reasonable price, and those of imports, which are much more expensive, but better presented and with packaging that is more reassuring as to the quality of the product. Generally, the marketing of these derivatives at the regional level remains rudimentary compared to the sale of the raw plants at the local and national market level, although the processed products have high added value. To improve the production and processing of AMP, partnerships must be developed between the local population, operators and industrialists in the sector. Indeed, the on-site installation of production and processing systems for harvested products could contribute to the development of production areas.

At the level of the Kingdom, exported products are mainly dominated by bulk plants, but aromatic extracts and EOs from AMP in Morocco are globally increasing significantly. A study conducted by the

Sahara and Sahel Observatory (SSO) declared that the *Thymus* EO was among the products exported from Morocco (it belongs to the group NDEO to Europe, the USA, Canada and the rest of the world (Neffati and Sghaier, 2014).

Processing and extraction methods and techniques

During this study, we diagnosed the problems encountered by the AMP processing sector in Ifrane. We thus identified the lack of the required resources (technical and material) (23%), the high production cost (24%), the lack of supervision and training (23%), the need for quality standards for AMP and derivatives (15%), as well as the lack of traceability of the raw material (15%) (Fig. 11).

The production of dry plants remains mostly traditional (100%), using the drying in the sun or the shade. For essential oils, almost all Moroccan distillers use vapor-hydrodistillation using mobile stills over an open fire. The technologies used remain artisanal, and the management of the distillation sites is inefficient. These technologies have the advantage of being inexpensive and technically easy to use, but they suffer from many weaknesses: the risk of overheating, the distillation time is too long, and it is a painful process, which harms the quality of the obtained products.

To develop a higher value-added industry in the region, several obstacles should be overcome. At the upstream level, the main obstacles concern the poor quality of the raw material and the lack of traceability. At the level of industrial production, the difficulties of access to financing for actors, the lack of technical expertise, the lack of analytical laboratories, the difficulties of access to commercial outlets, and a weak innovation dynamic block the development of this market.

Scientific collaboration and practical knowledge

For some time, applied science specialists were interested and impressed by the indigenous knowledge of those who practice Moroccan pharmacopeia. This practical knowledge can provide relevant information and valuable tools for scientific research. In addition, people in close contact with the plant can come to a more profound knowledge of its benefits.

In this study area, we noted a weak scientific collaboration between the marketing actors, the universities, the research centers and laboratories. That is to say, 100% of the respondents declared the absence of this important component (Table 12), yet the role of scientific research is indisputable. The establishment of the National Agency for Research and Development of Aromatic and Medicinal Plants for Morocco fits very well with this aim (Soro and Dédianhoua, 2015). Scientists can greatly contribute to the development of the sector. So, it needs a commitment and collaboration of all concerned actors to ensure that researchers' investigations are devoted to real and clearly defined problems in the sector (Neffati and Sghaier, 2014).

This collaboration should deepen the axes of research, for example, in studying current distillation methods and suggesting alternative solutions that can improve the quality and yields of essential oils.

The practices showed that the local population used specific theoretical and practical knowledge in phytotherapy (90%) (Table 12). The exchange value was on plants and types of diseases and the effectiveness of the treatment.

On the other hand, the transmission of this important practical knowledge was low (7%) (Table 12), which loss would be irreparable for humanity if no effort is made for its faithful and urgent transcription. The traditional therapeutic knowledge was transmitted from generation to generation among rural populations. It is an oral family heritage that is particularly prevalent among elderly and illiterate women. The preservation of this ancestral heritage in the process of erosion is more than essential.

Therefore, it is logical for a scientist to study practical knowledge to compare it with scientific data drawn from experience and observation. There will always be a disagreement between AMP users and scientists about some aspects of the natural world, but there is already a considerable degree of epistemological agreement, or it can be easily achieved.

Threat of natural resources and sustainable development

AMP are increasingly in demand nationally and internationally with the establishment of specialized industrial units in Morocco. Hence, we are currently witnessing overexploitation, which threatens our plant biodiversity in AMP, particularly certain endemic species such as *Thymus*. Natural resources in AMP in the province of Ifrane were threatened (95%) (Table 13) due to ignorance of the consequences of acts (65%), excessive confidence in nature's capacity for renewal (14%), lack of good citizenship (13%) and other concerns that were believed to be more important than protecting the environment (eating, heating) (10%) (Table 13). Respondents believe that documentaries for the general public (43%), training for professionals (35%), and intervention in schools by personalities from the scientific world (32%) were the most effective ways of raising public awareness of the threat to the region's plant heritage (Table 13).

Table 12. Scientific collaboration and practical knowledge.

Variables	Yes/No	Percentage %
Collaboration with Universities, Research Center and Laboratory	Yes	0
	No	100
Use of theoretical and practical knowledge	Yes	90
	No	10
Transmission of practical knowledge	Yes	7
	No	93

Table 13. Threat of natural resources and sustainable development.

Variables	Category	Percentage%
Threats to local resources	Yes	95
	No	5
Causes of threats to natural resources	Educational interventions in schools by scientists	23
	Professional training	35
	Documentary films	43
Public awareness method	Ignorance of the consequences of acts	65
	Excessive confidence in nature's capacity of renewal	12.5
	Lack of good citizenship	12.5
	Other concerns more important than saving the environment (i.e., food, heat)	10

This drastic environmental situation resulting from unsustainable exploitation is even more worrying for local communities dependent on collecting these species in spontaneous environments.

According to the United Nations program, the vast majority of aromatic and medicinal plants used in Morocco come from wild picking (UNDP, 2011). The species are overexploited at the time of flowering and often uprooted without worrying about their regeneration. Pickers in the wild are generally paid according to the harvested quantity; thus, the main objective is to collect the maximum possible quantity. This unsustainable form of harvesting exposes several species, especially those in high demand, to a real threat of genetic erosion and, in some cases, increases the risk of their extinction. Field visits by experts have confirmed the reduction of several species that were once abundant.

To mitigate the extinction of AMP and improve the success of sustainable development, research in this field should be conducted and deepened in terms of:

- Study and cartography of all the aspects of AMP and their development, which must take into account their multi-use characteristics, aiming at sustainable exploitation without creating conflict situations with users.
- The involvement of research organizations to initiate studies on the management and sustainable use of AMP, in particular, the study of the natural and artificial regeneration of species, and the implementation for the benefit of managers of technical models (natural sowing, cuttings, plant breeding method, soil preparation, and species management, among others).
- Study of exploitation methods to improve current practices which are detrimental to the viability of the species.
- Regulation, organization, encouragement and animation of the sector.

Local products

The geographical location made the Ifrane province an area with a rich plant diversity. This natural wealth explains the diversity of AMP and their specificity and can make the suitable region terrain for the development of PAM terroirs and also for the improvement of traditional practical knowledge. The development of local products in Ifrane offers a promising path for local, viable and sustainable development, especially for the three plants *Thymus*, *Lavandula* and *Crataegus*.

Table 14. Types of products intended for consumption and cost of local product.

Variables	Category	Percentage (%)
Types of products intended for consumption	Local products	92
	High consumption products	8
Cost of local product	Yes	90
	No	10

Local products have been the subject of several previous studies (Zindy, 2017; Lapoule, 2007; Giraud, 2005; Rastoin, 2004; Scheffer, 2002; Burt, 2000; Dunne and Narasimhan, 1999) on consumer perceptions and attitudes towards local products. To convey an essential vision to the economic actors responsible for organizing care. From this perspective, our survey is keen to examine a number of points about consumer attitudes and preferences towards these products.

Consumption and purchase cost of local products (LP)

The obtained data showed that consumers' preferences for local products were very frequent (92%) against 8% for mass consumption products (Table 14). Moreover, the respondents declare that they were ready to pay a high price to purchase these products (90%) (Table 14). Consumers often perceive local products as traditional, artisanal and better products (Tregear et al., 1998; Aurier et al., 2004).

The huge demand for LP was mainly due to the emergence of a consumer market that demands quality. These consumers perceive the health risks of food, hence this passion for this type of product as natural, high quality and free from manufactured materials.

Jekanowski et al. (2000) argued that buying decisions depend on perceived quality rather than price. The authors refer to irrelevant (packaging, places of sale, product price, information on the label) and intrinsic (additive, organic, composition, taste, and freshness, among others) factors of the product.

Aurier et al. (2004) found that products sold directly from smallholders or sold in raw packaging at farmers' markets are often rated positively.

Expectations to develop and promote local products

The promotion and development of local products depend on several factors of specialized training aimed at promoting these products for sustainable management. All respondents expressed their need for AMP development and product training to ensure their region's rational and sustainable plant resources.

These studies have enabled us to select plants (*Thymus*, *Lavandula* and *Crataegus*), which perfectly embody the three dimensions of sustainable development: economic, social and ecological. In this context, initiatives and measures should be updated to promote these plants and integrate them into development as local plants by establishing effective national strategies.

The dysfunctions mentioned above in the value chain may reflect the enormous specific training needs linked to the AMP sector to strengthen the capacities of actors in the processes of management, organization, production and marketing. Thus, a theoretical and practical educational program must be designed and delivered for the benefit of these actors for the mastery of production techniques, from harvest to processing and evaluation. In addition, members of a higher education level can benefit from management and marketing courses to support and maintain their social structure. This training must be harmonized in favor of a long-term sustainable exploitation of the species, which presents a promising added value for the province of Ifrane and Morocco as a whole. We also underline the need for a project to support the economic emancipation of economically disadvantaged categories through the development of income-generating poles (the evaluation of aromatic and medicinal plants) to encourage entrepreneurship, re-qualification, and increase their access to the supports offered. Through state-provided programs, to increase competitive power and build a balanced and inclusive society.

Training professionals with a complete and concise vision of technological, economic, and regulatory aspects relating to so-called "local" AMP products is the main objective of this study, which is part of the promotion of future projects aimed at the development of the Fez-Meknes region.

CONCLUSION

The comprehensive inventory of spontaneous AMP in the Ifrane region has enabled us to provide an up-to-date checklist of taxa exclusive to this region. Indeed, 130 species belonging to 45 genera 17 botanical families have been identified, representing 2.5% of the total recognized Moroccan aromatic and medicinal flora. The most represented family is that of the Lamiaceae (with 96 taxa, 73.84% of the total wealth of

the region) and which is known for its many aromatic species among the botanical families.

On the other hand, both ethnobotanical studies and the AMP diversity emphasize the importance of medicinal and aromatic plants in the daily lives of indigenous peoples and villages and among traditional practitioners in the study region.

These studies made it possible to select plants (*Thymus*, *Lavandula* and *Crataegus*), which perfectly represent the three dimensions of sustainable development: economic, social and ecological. From this perspective, initiatives and measures should be updated to add value to these plants and integrate them in sustainable development, such as local plants, by establishing effective national strategies.

The positive attitude of the local population to these three AMP (ethnobotanical study and commercial aspect) favors their evaluation, their labeling and also provides positive effects on the economic, social and ecological sphere of the study region. In addition, there are still specific uses linked to each locality (practical knowledge); this reflects the originality and diversity of therapeutic traditions and their immanence among the local population. These results provide important information for economic actors responsible for promoting local products to improve and improve the value chain of this sector to offer a high-quality product at an affordable price for the consumer, locally, nationally and internationally. In addition, this sector needs to be driven by "key players" who are endowed with effective financial, human and practical technical, commercial and managerial skills necessary to create and maintain a competitive advantage in an increasingly globalized and rapidly expanding international market.

CONFLICT OF INTEREST

The authors declare no conflicts of interest.

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Contribution	Radi F	Khamar H	Remok F	Amine S	Drioiche A	Aoudry S	Zekri N	Bouzoubaa A	Zair T
Concepts or ideas	x	x							x
Design	x	x							x
Definition of intellectual content	x	x							x
Literature search	x							x	x
Experimental studies	x	x							x
Data acquisition	x	x	x	x		x	x	x	x
Data analysis	x	x			x	x			x
Statistical analysis	x	x		x					
Manuscript preparation	x		x		x		x		x
Manuscript editing	x								
Manuscript review	x	x	x	x	x	x	x	x	x

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Annex 1. Questionnaire: Ethnobotanical survey.
Use of *Lavandula, Thymus, Crataegus* in Morocco

1. Name: ……..
2. Code: …… Date: ……
3. Region: ……..... Commune: ……..

I. Population information

1. Gender: □Male □Female
2. Age group: □< 20 □20-29 □30-39 □40-49 □50-60 □> 60
3. Family situation: □Single □Married □Widower □Divorced
4. Profession: □Herborist □Housewife □Farmer □Collector □Researcher □Healer □ Other
5. Level of education: □Illiterate □Primary □Secondary □High school □College
6. Residential area: ……..
7. Plant Information
   - Use of AMP by the informant: □Yes □No
   - Use of genres: □Lavander □Crataegus □Thymus

Family:……..
Genus: ……..
Species: ……...
Arabic: ……
French: ……
Amazigh:……

8. Type: □Cultivated □Wild
9. Use: □Therapeutic □Cosmetic □Ornamental □Feed □Culinary □Other
10. Used part: □Leaves □Roots □Stems □Flowers □Fruit □Bark □Resin □Seeds
11. State of the plant: □Fresh □Dry
12. Preparation mode: □Infusion □Decoction □Maceration □Essential oil □Powder
13. Possible associations (recipe): Used dose: □Pinch □Handful
14. Administration mode: □Oral □Massage □Rinsing □Brushing
15. Dosage:
    - Children □1 time/day □2 times/day □3 times/day
    - Adults □1 time/day □2 times/day □3 times/day
    - The elderly people □1 time/day □2 times/day □3 times/day
16. Use duration: □A day □A week □A month □Until recovery
17. Diseases treated:
    □Dermatological conditions □Respiratory ailments □Neurological disorders
    □Cardiovascular disorders □Genitourinary disorders □Oral disorders
    □Osteoarticular disorders □Metabolic disorders □Ophthalmic disorders
    □Disorders of the digestive tract □Gland disorders □Other:……..
18. Results: □Recovery □Improvement □Ineffective

II. Commercial aspect

1. Relationship between the informant and the plant: □Producer □Processor □Trader □Consumer □Other: ……
2. Place of marketing: □Local market □Regional market □National market □International market □Exhibition □Shop
   □Website □Other:……..
3. Sales mode and cost:
   □Wholesale □Cost: □Dh/ □Retail: □Cost: □Dh/
4. Marketing constraints:
   □Low price □Transportation fees □Packaging cost □Conservation constraint □Abundance of AMP in the market
   □Lack of buyers □Others: ……..

5. Sales revenues according to periods:

Abundance: □Low □Average □Important

Shortage: □Low □Average □Important

6. Most marketed state of the plant: □Row □Processed

III. Valuation aspect (value chain / local product)

1. Plant derivatives (local product or not*):

□Essential oils □Dry extracts □Aqueous extracts □Oily macerates □Aqueous macerates □Spices □Cosmetic products □Pesticides □Fertilizers □Food supplements

2. Problems related to the production, processing, marketing and consumption methods of these products (AMP and its derivatives or local product)

□Lack of technical and material resources □Production cost □Quality control □Lack of training and supervision □Raw material traceability □Others:……

3. Extraction and processing methods: □Traditional □Modern

4. Use of local theoretical and practical knowledge: □Yes □No

5. Do training sessions exist to transmit local practical knowledge? □Yes □No

6. When you have the choice, you prefer to consume: □Local products □Mass consumption products

7. Be prepared to pay more to buy a local product rather than its mass consumption equivalent: □Yes □No

8. Collaboration with universities, research centers and laboratories: □ Yes □ No

9. If yes, which ones:

What are their activities or area of intervention: □Quality control □Compliance testing □New product creation

□ Others (specify) ……

IV. Sustainable development

1. Local resources are threatened: □ Yes □No

2. If no, why?

□ Excessive confidence in nature's capacity for renewal

□ Lack of good citizenship □ Ignorance of the consequences of acts

□ Other concerns that are more important than protecting the environment (Ex: feeding the cattle, warming).

3. The appropriate cultural methods aiming to raise the general public awareness of fighting against the degradation or disappearance of AMP species:

□Intervention in schools by personalities from the scientific world □Professional training □Documentary for the general public □Others ……..

V. Expectations to develop and promote local products

1. Need for training in the field of AMP valuation: □Yes □ No

2. Need for training in the field of sustainable use of AMP: □Yes □ No

VI. Other observations

……
……
……
……
……
……
……
……

Annex 2. List of AMP of Ifrane region.

Botanical family	Taxon (species et subspecies)	Vernacular name		Biological type	Endemic
		French	Arabic/Tamazight		
Anacardiaceae	*Pistacia atlantica* Desf	Pistachier de l'Atlas	Lebtem	Phan	
	Pistacia terebinthus L.	Pistachier térébinthe	Drô	Phan	
Apiaceae	*Bupleurum mesatlanticum* Litard. & Maire	Buplèvre épineux	CHdida	Hem	E
	Ferula communis L.	Férule	Lboubal	Géo	
	Pimpinella villosa Schousboe.	Anis vert	Habbet hlawa	Hem	
Asteraceae	*Anacyclus pyrethrum* (L.) Lag.	Pyrèthre d'Afrique	Tigendast	Hem	
	Artemisia ifranensis J. Didier	Armoise	*šši*ḥ	Cham	E
	Artemisia mesatlantica Maire	Armoise	*šuaya*	Cham	E
	Artemisia negrei Ouyahya	Armoise	*šši*ḥ	Cham	E
	Artemisia herba-alba Asso	Armoise	*šiḥa* et *alâla*	Cham	
	Silybum marianum (L.) Gaertn.	Chardon Marie	Chouk Lahmar Tawra	Ther	
	Taraxacum atlanticum Pomel	Pissenlit	Ûdjem	Hem	EA
Cupressaceae	*Juniperus oxycedrus* L.	Genévrier oxycèdre	Tâqqa	Phan	
Fagaceae	*Quercus ilex* L.	Chêne faux-houx	Korrich	Phan	
	Quercus rotundifolia Lam.	Chêne-vert	Tassaft	Phan	
	Quercus faginea Lam.	Chêne zen	Tacht	Phan	
Lamiaceae	*Ajuga chamaepitys* (L.) Schreb.	Bugle petit-pin	Chantgoura	Ther	
	Ajuga chamaepitys subsp. *chamaepitys*	Ive	Tof Telba	Ther	
	Ajuga iva (L.) Schreber subsp. *pseudoiva* (DC.) Briq.	Ivette, Bugle	Chandgour	Hem	
	Ballota hirsuta Benth.	Ballote hirsute	-	Cham	
	Ballota inermis (Emb. & Maire) Ouyahya	Ballote inerme	-	Cham	
	Cleonia lusitanica (L.) L.	Brunelle du Portugal	-	Ther	
	Lamium amplexicaule L.	Lamier embrassant	Üdnïn l-fâr	Ther	
	Lamium flexuosum Ten.	Lamier flexueux	-	Hem	
	Lamium mauritanicum Gand. ex Batt.	Lamier	Ragma	Ther	
	Lavandula pedunculata subsp. *atlántica* (Braun-Blanq.) Romo	Lavande pédonculée	Lhalhal	Cham	
	Marrubium ayardii Maire	-	-	Cham	
	Marrubium multibracteatum Humbert & Maire	-	-	Cham	
	Marrubium vulgare L.	Marrube blanc	Meriwte	Cham	
	Marrubuim echinatum Ball	-	-	Hem	E
	Melissa officinalis L.	Melisse	Mlilsa	Cham	
	Mentha gattefossei Maire	Menthe de Gatefossé	Fliyyo dîal jbel	Hem	E
	Mentha longifolia (L.) L.	Menthe sylvestre	Habaq el-baḥr /ḥabaq el-mā'	Hem	
	Mentha pulegium L.	Menthe pouliot	Fliyyou	Hem	
	Mentha spicata L.	Menthe marocaine	Likama/naânaâ	Hem	
	Mentha suaveolens Ehrh.	Menthe odorante	Marseta/ timersit	Hem	
	Mentha suaveolens Ehrh. Subsp. *suaveolens*	Menthe odorante	Marseta/ timersit	Hem	
	Nepeta amethystina Desf. ex Poir.	Népète	Gouzeia	Hem	

Annex 2. List of AMP of Ifrane region (continued...)

Botanical family	Taxon (species et subspecies)	Vernacular name		Biological type	Endemic
		French	Arabic/Tamazight		
Lamiaceae	*Nepeta amethystina* subsp. *laciniata* (Willk.) Ubera & Valdés	-	-	Hem	EI
	Nepeta atlantica Ball	Menthe desmontagnes	Manta	Hem	
	Nepeta granatensis Boiss.	Nepeta de granate	qestân ou qestâl	Hem	
	Nepeta hispanica Boiss. & Reut.	-	-	Hem	EI
	Nepeta hispanica subsp. *statice* Maire	-	-	Hem	E
	Nepeta tuberosa L. subsp. *reticulata* (Desf.) Maire	Herbe à chat tubéreux		Hem	EAI
	Origanum elongatum (Bonnet) Emb. & Maire	Origon	Zaâtar/Zwi	Cham	E
	Origanum majorana L.	Origan marjolaine	Merdadouch	Hem	
	Phlomis bovei De Noé subsp. *maroccana* Maire	Sauges de Jérusalem rose	-	Cham	E
	Phlomis crinita Cav.	-	-	Hem	
	Phlomis crinita subsp. *mauritanica* (Munby) Murb.			Hem	
	Phlomis herba-venti L.	Herbe au vent	Djeda	Hem	
	Phlomis herba-venti L. subsp. *herba-venti*	Herbe au vent	-	Hem	
	Pitardia nepetoides Batt. ex Pit.	-	-	Cham	E
	Prunella laciniata (L.) L.	Brunelle laciniée	-	Hem	
	Prunella vulgaris L.	Brunelle commune	-	Hem	
	Salvia argentea L.	Sauge argentée	Ferrache en neda	Hem	
	Salvia argentea L. subsp. *patula* (Desf.) Maire	Sauge argentée	-	Hem	
	Salvia barrelieri Etl.	-	-	Hem	
	Salvia barrelieri Etl. subsp. *barrelieri*	-	-	Hem	
	Salvia lavandulifolia subsp. Mesatlantica (Maire) Rosua & Blanca *(Salvia aucheri* var. *Mesatlantica* Maire)	-	-	Cham	
	Salvia lavandulifolia Vahl	Sauge à feuilles de lavande	-	Cham	
	Salvia phlomoides Asso	-	-	Hem	
	Salvia phlomoides Asso subsp. *africana* (Maire) Greuter & Burdet	-	-	Hem	
	Salvia verbenaca L.	Sauge verveine	Khiyyata	Hem	
	Salvia viridis (L.) Soják	Sauge verte	-	Ther	
	Satureja alpina (L.) Scheele	Calament des Alpes	Fliyyou dial berr	Ther	
	Satureja alpina subsp. *meridionalis* (Nyman) Greuter & Burdet	Calament des Alpes	Fliyyou dial berr	Ther	
	Satureja atlantica (Ball) Maire	-	-	Cham	E
	Satureja baborensis (Batt.) Briq.	Sariette	-	Cham	EA
	Satureja briquetii Maire	Sariette	-	Cham	EA
	Satureja filiformis Desf.	-	-	Cham	
	Satureja graeca L.	-	-	Cham	
	Satureja graeca L. subsp. *graeca*	-	-	Cham	

Annex 2. List of AMP of Ifrane region (continued...)

Botanical family	Taxon (species and subspecies)	Vernacular name		Biological type	Endemic
		French	Arabic/Tamazight		
Lamiaceae	*Satureja graeca* L. subsp. *micrantha* (Brot.) Greuter & Burdet	-	-	Cham	
	Satureja hochreutineri Briq.	-	-	Cham	
	Satureja nepeta (L.) Scheele	Calament glanduleux	-	Cham	
	Satureja rotundifolia (Pers.) Briq.	-	-	Ther	
	Satureja vulgaris Fritsch	Sariette commune	Za'tar diâl wad	Cham	
	Satureja vulgaris subsp. *Arundana* (Boiss.) Greuter & Burdet	-	-	Cham	
	Scutellaria orientalis subsp. *demnatensis* Batt	Crâne à fleur jaune	-	Cham	E
	Sideritis hirsuta L.	Crapaudine velue	-	Cham	
	Sideritis incana L.	-	-	Cham	
	Sideritis incana subsp. *incana*	-	-	Cham	
	Sideritis incana subsp. subsp. *altiatlantica* (Font Quer) Fennane	-	-	Cham	
	Sideritis jahandiezii Font Quer	-	-	Cham	E
	Sideritis romana L.	Crapaudine romaine, Thé de campagne	-	Ther	
	Sideritis villosa Coss. & Ball	-	-	Hem	E
	Stachys arenaria subsp. *divaricatidens* H. lindb. fil	-	-	Cham	
	Stachys arenaria Vahl	-	-	Cham	
	Stachys arenaria Vahl subsp. *divaricatidens* H. lindb. fil.	-	-	Cham	E
	Stachys circinata L'Hér.	-	-	Hem	
	Stachys circinata L'Hér. subsp. *circinata*	-	-	Hem	
	Stachys mouretii Batt. & Pit	-	-	Hem	E
	Stachys saxicola Coss. & Balansa	-	-	Hem	EA
	Stachys saxicola Cosson subsp. *saxicola*	-	-	Hem	E
	Stachys saxicola subsp. *villosissima* (Ball) Maire	-	-	Hem	E
	Teucrium chamaedrys L.	Germandrée en capitule, pouliot de montagne	Ja'da	Cham	
	Teucrium decipiens Cosson & Balansa	-	Ja'da	Ther	E
	Teucrium demnatense Coss. ex Batt	-	Ja'da	Cham	E
	Teucrium fruticans L.	Germandrée arbustive	Ja'da	Cham	
	Teucrium joannis (Sauvage & Vindt) El Oualidi, T.Navarro & A.Martin	-	Ja'da	Cham	
	Teucrium musimonum Humbert ex Maire	Germandrée en capitule, pouliot de montagne	Ja'da	Cham	
	Thymus algeriensis Boiss. & Reut.	Thym	Z'îtra/äzzukni	Cham	
	Thymus atlanticus (Ball) Pau	Thym	Z'îtra/äzzukni	Cham	E
	Thymus maroccanus subsp. *maroccanus*	Thym	Z'îtra/äzzukni	Cham	
	Thymus munbyanus subsp. *coloratus* (Boiss. & Reuter) Greuter & Burdet	Thym	Z'îtra/äzzukni	Cham	

Annex 2. List of AMP of Ifrane region (continued...)

Botanical family	Taxon (species and subspecies)	Vernacular name		Biological type	Endemic
		French	Arabic/Tamazight		
Lamiaceae	*Thymus munbyanus* Boiss. & Reut.	Thym	Z'îtra/äzzukni	Cham	
	Thymus munbyanus subsp. *munbyanus*	Thym	Z'îtra/äzzukni	Cham	
	Thymus satureioides Cosson	Thym	Z'îtra/äzzukni	Cham	
	Thymus satureioides Cosson subsp. *satureioides*	Thym	Z'îtra/äzzukni	Cham	E
	Thymus willdenowii Boiss	Thym	Z'îtra/äzzukni	Cham	
	Thymus zygis L.	Thym rouge	Z'îtra/äzzukni	Cham	EA
	Thymus zygis L. subsp. *gracilis* (Boiss.) R. Morales	Thym rouge	Z'îtra/äzzukni	Cham	EA
Malvaceae	*Malva parviflora* L.	Mauve	Al Bekoula	Ther	
Oleaceae	*Fraxinus angustifolia* Vahl	Frêne	Islen	Phan	
	Olea europaea L.	Olivier	Zaytûn berrî / Zebbûj	Phan	
Papaveraceae	*Papaver rhoeas* L.	Coquelicot	Belaâman	Ther	
Pinaceae	*Cedrus atlantica* (Endl.) Manetti ex Carrière	Cèdre d'Atlas	Arz/Îddil	Phan	EA
Rosaceae	*Crataegus monogyna* Jaq.	Aubepine	Zaarour/Admam	Nph	
	Crataegus laciniata Steven ex Besser	Aubepine	Zaarour/Admam	Nph	
	Rosa canina L.	l'églantier commun	Tabgha	Nph	
Salixaceae	*Populus nigra* L.	Peuplier noir	Sefsaf	Phan	
	Populus alba L.	Peuplier blanc	Sefsaf	Phan	
	Salix alba L.	Saule	Aaoud Lma	Phan	
	Salix pedicellata Desf.	Saule	Mmû-swâlef/ämmas	Phan	
Santalaceae	*Viscum cruciatum* Sieber ex Boiss.	Gui	Henna diâl-âdâm /Taborzizte	Cham	
Scrophulariaceae	*Vrebascum sinautaum* L.	Bouillon blanc	Aberdoud / Izem	Hem	
Taxaceae	*Taxus baccata* L.	If	Boulehrouz, Igné	Phan	
Thymelaeaceous	*Daphne laureola* L.	Garou	Alzaz	Cham	
	Thymelaea tartonraira (L.) All.	Passerine Tartonraire	Bûftîla/Belganbû	Cham	
Urticaceae	*Urtica urens* L.	Ortie romaine	L-hurrîga/Tikzinin	Ther	

Ther: therophytes; Cham: chamephytes; Phan: phanerophytes; Hem: hemicryptophytes; Géo: geophytes; Nph: nanophanerophytes; EA: Endemic to Morocco and Algeria; E: Endemic; EAI: Algeria and the Iberian Peninsula; EI: endemic to Morocco and the Iberian Peninsula. The correct spelling of scientific names was made according to: http://www.theplantlist.org/

Annex 3. List of plants in the Ifrane region (bibliographic database).

Family	Scientific name	Vernacular name	
		French	Arab/Tamazight
Anacardiaceae	*Pistacia atlantica* Desf.	Pistachier de l'Atlas	Lebtem
Apiaceae	*Ammi visnaga* L.Lam	Khella	Bechnikha
	Carum carvi L.	Carv	Karwiya
	Coriandrum sativum L.	Coriandre	Kezbour
	Ferula communis L.	Férule	Lboubal
	Pimpinella anisum L.	Anis vert	Habbet hlawa
	Helosciadium nodiflorum (L.) Koch	Carvi	Tilgdamine =Ziyata
	Petroselinum sativum Hoffm	Persil	Ma'adnûs
	Thapsia garganica L.	Thapsi	Bounefaa
Apocynaceae	*Vinca major* L.	Pervenche	Tamnayt nachal Louaya
Aquifoliaceae	*Ilex aquifolium* L.	Houx commun	Âbdlisser
Araliaceae	*Hedera helix* L.	Lierre grimpant	Louwaya
	Muscari comosum (L.) Mill.	Muscari à toupet	Bsyla
Asteraceae	*Anacyclus pyrethrum* L. Lag.	Pyrèthre d'Afrique	Tigendast
	Anthemis nobilis L.	Camomille romaine	Babunj
	Artemesia absinthium L.	Absinthe	Chiba
	Arctium lappa L.	Bardane	Ouden lfil
	Calendula officinalis L.	Souci	Louerd Lahmer
	Cynara scolymus L.	Artichau	Al Kherchouf
	Cynara humilis L.	Artichaut nain	Timta
	Inula viscosa (L.) Aiton	inule Visqueuse	Terehla
	Scolymus hispanicus L.	Scolyme d'Espagne	Al Guernina
	Silybum marianum (L.) Gaertn.	Chardon Marie	Chouk Lahmar Tawra
	Taraxacum obovatum (Willd.) DC.	Pissenlit	Ûdjem
Boraginaceae	*Borago officinalis* L.	Bourache	Ils Iziar, Lsan lebgar, Lsantour
Brassicaceae	*Capsella bursa-pastoris* (L.) Medik.	Bourse à pasteur	Akrab Nemeksaouen
	Nasturtium officinale R.Br.	Cresson de fontaine	Guernounche
Caryophyllaceae	*Corrigiola telephiifolia* Pourr.	*Corrigiole à feuilles de téléphium*	Sarghîna / tawserghint
	Saponaria vaccaria L.	Saponaire	Tighighecht
	Silene vulgaris (Moench) Garcke	Silène vulgaire	Tighîghecht
Chenopodiaceae	*Chenopodium ambrosoides* L.	vermifuge -Ansérine	Mkhinza
Cistaceae	*Cistus salviifolius* L.	Ciste	Touzalt, Irguel
Cucurbitaceae	*Bryonia dioica* Jacq.	Bryone dioïque	Adéle Nouchéne, Dalia Lbida
	Cucurbita sp.	Citrouille	Garaa Hamra
Cupressaceae	*Cupressus sempervirens* L.	Cyprés	Tayda, Assipé
	Juniperus oxycedrus L.	Genévrier oxycèdre	Tâqqa
	Juniperus thurifera var. africana Maire	Genévrier thurifère	Tawalt
	Tetraclinis articulata (Vahl) Mast	Thuya de berberie	Alaaraar
Cyperaceae	*Cyperus longus* L.	Souchet Odorant	Tghda Nwaman
Ericaceae	*Arbutus unedo* L.	*Arbousier*	*Sasno, Bakheno*
Euphorbiaceae	*Euphorbia nicaeensis* All	Euphorbe	Tanugha, Molbin

Annex 3. List of plants in the Ifrane region (bibliographic database) (continued...)

Family	Scientific name	Vernacular name	
		French	Arab/Tamazight
Fabaceae	*Medicago sativa* L.	Luzerne	Lfessa
	Melilotus officinalis (L.) Pall.	Melilot	Tazmort
	Trigonella foenum-graecum L.	Trigonnelle	Lhelba
Fagaceae	*Castanea sativa* Mill	Châtaigner	Belout n'ssara
	Quercus faginea Lam	Chêne zen	Tacht
	Quercus rotundifolia Lam	Chêne-vert	Tassaft
Fumariaceae	*Fumaria officinalis* L.	Fumeterre	Ahchlaf Nesli
Gentiaceae	*Centaurium spicatum* (L.) Fritsch	Petite centaurée	Kesat Haya
	Pelargonium Sp.	Géranium	Laatercha
Juglandaceae	*Juglans regia* L.	Noyer	Gargaa
Lamiaceae	*Ajuga iva* (L.) Schreb.	Ivette, Bugle	Tof Telba, Chandgour
	Lavandula stoechas L.	Lavande	Al Helhal
	Lavandula angustifolia Mill.	Lavande officinale, lavande vraie	Elkhzama lfassia / Amezzir
	Lavandula pedunculata (Mill).Cav	Lavande pédonculée, lavande papillon	Al Helhal
	Melissa officinalis L.	Melisse	Mlilsa
	Mentha suaveolens Ehr.	Menthe à feuilles rondes	Marseta
	Mentha pulegium L.	Menthe pouliot	Fliyyo dîal lma
	Mentha gattefossei Maire	Menthe de Gatefossé	Fliyyo dîal jbe
	Mentha piperita L.	Menthe Poivré	Naânaâ Al Aabdi
	Mentha spicata L.	Menthe	Naânaâ
	Marrubium vulgare L.	Marrube blanc	Meriwte
	Ocimum basilicum L.	Basilic	Lehbeq
	Origanum compactum Benth.	Origan	Za'tar
	Salvia officinalis L.	Sauge	Salmia
	Satureja alpina (L.) Scheele	Calament des Alpes	Fliyyo dial berr
	Thymus algeriensis Boiss. & Reut.	Thym	Z'îtra
	Thymus zygis L.	Thym rouge	Z'îtra
	Thymus willdenowii Boiss	Thym	Azoukani/ Zaatar
	Vitex agnus castus L.	Gattilier	Angarf
Lauraceae	*Laurus nobilis* L.	Laurier noble	Asa sidna Moussa
Liliaceae	*Allium cepa* L.	Oignon	L-besla
	Asphodelus ramosus L.	Asphodèle rameux	Berwâg
	Ruscus aculeatus L.	Petit houx	Bû-chûka
Malvaceae	*Althaea rosea (*L.) Cav.	*Guimauve*	*Tabensserte*
	Malva parviflora L.	Mauve	Al Bekoula
Moraceae	*Ficus carica* L.	Figuier	Ikorane, Alkermousse
	Morus alba L.	Murier blanc	Atoute Lebied
	Morus nigra L.	Murier noir	Atoute Lekhel
Myrtaceae	*Eucalyptus Sp*	Eucalyptus	Al Kalitous
Oleaceae	*Fraxinus Sp*	Frêne	Imtse
	Olea europaea L.	Oléastre	Azitoune, Jebouje
Paeoniaceae	*Paeonia corallina* var. *maroccana* Pau & Font Quer ex Maire	Pivoine mâle	Habersis
Papaveraceae	*Papaver rhoeas* L.	Coquelicot	Belaâman

Annex 3. List of plants in the Ifrane region (bibliographic database) (continued...)

Family	Scientific name	Vernacular name	
		French	Arab/Tamazight
Parmeliaceae	*Evernia furfuracea* (L.) W.Mann - GBIF *Or Evernia prunastri* (L.) Ach.	Mousse de cèdre	Tamert numghar
Pinaceae	*Cedrus atlantica* (Endl.) Manetti ex Carrière	Cèdre d'Atlas	Îddil
	Pinus halepensis Mill	Pin d'alep	Tayda
Plantaginaceae	*Plantago coronopus* L.	Plantain corne de cerf	Tamzourte ntikhsi
	Plantago major L.	Plantain	Plantain
	Plantago lanceolata L.	Plantain	Plantain
Poaceae	*Avena sativa* L.	Avoine	Al Khortal
	Triticum sp.	Blé	Lekmeh
	Hordeum vulgare L.	Orge	Chaaire
	Zea mays L.	Maïs	Dra
Polygonaceae	*Rumex acetosa* L.	Rumex	Tassemoumt, Lhemida
Polypodiaceae	*Adiantum capillu-veneris* L.	Capillaire	Kezbour Lakhla
Punaceae	*Punica granatum* L.	Grenadier	Romane
Renonculaceae	*Ranunculus bullatus* L.	Ranunculus	Weden Lhelouf
Rhamnaceae	*Zizyphus lotus* L.	Jujubier	Nbeg, Cedra
Rosaceae	*Rosa canina* L.	l'églantier commun	Tabgha
	Crataegus laciniata Steven ex Besser	Aubépine d'Orient	Admame
	Crataegus monogyna Jacq.	Aubepine monogyne	Zaarour/Admame
	Malus communis Lam	Pomme	Tefah
	Prunus amygdalus var. amara (DC.) Focke	Amandier	Louz
	Prunus cerasus L.	Cerise	Hab Lemlouk
	Prunus domestica L.	Prunes	Berkouk
	Pyrus communis L.	Poivrier	Bouaaouida
	Prunus persica (L.) Batsch	Pêche	Al Khoukh
Rutaceae	*Ruta chalepensis* L.	Rue d'Alep	Iwrmi
Rubiaceae	*Rubia peregrina* L.	Garence	Taroubia Al Foua
Salicaceae	*Salix alba* L.	Saule	Aaoud Lma
	Populus alba L.	Peuplier blanc	Sefsaf
	Populus nigra L.	Peuplier noir	Sefsaf
Scrofuliaceae	*Verbascum sinuatum* L.	Bouillon blanc	Aberdoud Izem
Solanaceae	*Atropa belladonna* L.	Belladone	bib Laydour
	Datura stramonium L.	Datura	Tabourzegt, Chdek Jmel
	Hyoscyamus albus L.	Jusquiame Blanche	Guenguitt, Sekrane
Taxaceae	*Taxus baccata* L.	If	Boulehrouz, Igné
Thymeleaceae	*Daphne gnidium* L.	Garou	Alzaz
Ulmaceae	*Celtis australis* L.	Micocoulier	Teghzaze
Urticaceae	*Urtica dioica* L.	Ortie	Heriga, Tesergmaz
Verbenaceae	*Lippia citriodora* (Palau) Kunth	Verveine odorante	Lwisa
Vitaceae	*Vitis vinifera* L.	Vigne	Adel asmom

The correct spelling of scientific names was made according to: http://www.theplantlist.org/

Annex 4. Main potential wild AMP in the Ifrane region.

Species	Vernacular name	Berber or Arabic name	RFC
*Anacyclus pyrethrum (*L.)Lag.	African pyrethrum	Tigendast	10%
Anthemis nobilis L.	Roman chamomile	babounj	8%
*Cedrus atlantic*a (Endl.) Manetti ex Carrière	Atlas cedar	Larz-Iddil	26%
Crataegus monogyna Jacq.	Crataegus	Zaarour-admâm	90%
Ferula communis L.	False fennel,	Bûbal	2%
Genista quadriflora Munby	Four-flowered genet	Chdida	30%
Juniperus oxycedrus L.	Juniper oxyhedron	Tâqqa	3%
Juniperus thurifera L.	Thuriferous juniper	tawalt	7%
Lavandula angustifolia Mill.	True lavender	Lakhzama	85%
Lavandula pedunculata (Mill.) Cav	Pedunculate lavender	Lhalhal	71%
Marrubium vulgare L.	White horehound	Meriwte	18%
Mentha pulegium L.	Pennyroyal	Fliyou	32%
Mentha rotundifolia (L.) Huds.	Round leaf mint	Marsita	40%
Papaver rhoeas L.	Poppy	Balaaman	6%
Pistacia atlantica Desf.	Atlas Pistachio	Lebtem	38%
Populus nigra L.	Black poplar	safsaf	6%
Quercus faginea Lam.	Zen oak	tacht	11%
Quercus rotundifolia Lam.	Holm oak	Tasaft	10%
Ranunculus aquatilis L.	Branched asphodel	Berwague	2%
Rosa canina L.	Common rose hips	Tabgha	1%
Silybum marianum (L.) Gaertn.	Milk thistle	Chûka el-hmîr	4%
Sinapis arvensis L.	Field mustard	Bahmmou	5%
Taxus baccata L.	Yew	Dakhs	1%
Thymus zygis L.	Thym	Zaîtra	100%
Thymus willdenowii Bois.	Thym	Zaîtra	100%
Verbascum thapsus L.	Mullein Bouillon-blanc	Slah nder	1%

RFC: Relative Frequency Citation. The correct spelling of scientific names was made according to: http://www.theplantlist.org/