



Ethnopharmacological survey of aromatic and medicinal plants of the pharmacopoeia of northern Morocco

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Databases and Inventories

Abstract

Background: For centuries, Moroccan herbalists have been using traditional plant-based medicines; however, most of these traditional healers misuse their use because of the limited information about harmful side effects. The traditional healers prescribe recipes that do not comply with any quality standards.

Materials and methods: This study was designed and initiated in an effort to classify and shortlist the most reported medicinal plants used by traditional healers in the northern part of Morocco and identify their associated toxicities. Data from this work was obtained by collecting semi-interviews and direct questionnaires from local traditional healers and guided fieldtrips with herbalists.

Results: A total of 40 of the identified plant species belonged to 34 genera and 21 botanical families. The most represented were *Lamiaceae* (13 species) followed by *Asteraceae* (6 species) and *Cupressaceae* (3 species). The most frequently cited and used species were *Mentha pulegium* (22.5%) and *Rosmarinus officinalis* (15%). In addition, our survey revealed 11 recipes prepared from 40 species. Leaves were the most used parts with a percentage of 30.52% and the main preparation method was infusion (63%). It shows that these recipes are generally administered orally during seven, fifteen or even thirty days with an average of one to three cups a day. Some of these recipes are used to treat diseases of the digestive and nervous system. The local population, whose purchasing power is very low, uses the plants

harvested directly in the study area causing the disappearance of the most vulnerable species.

Conclusions: This study shows that traditional medicine is still used and constituted a very rich heritage in northern Morocco. Further investigation of the benefits and risks of these plants will be needed to guide ancestral knowledge during self-medication that causes negative effects on human health and will be needs planned exploitation.

Keywords: Medicinal plants; Aromatic plants; Pharmacopoeia; Ethnopharmacology; Morocco

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ملخص:

مقدمة: استخدم أخصائيو الأعشاب بالمغرب الأدوية النباتية التقليدية منذ قرون. ومع ذلك، فإن معظم هؤلاء المعالجين التقليديين يسيئون استخدامها بسبب معلوماتهم المحدودة حول الآثار الجانبية الضارة لها. إذ يصف هؤلاء المعالجون التقليديون وصفات لا تتوافق مع معايير الجودة.

المواد والأساليب: تم تصميم هذه الدراسة وبدنها في محاولة منا لتصنيف قائمة مختصرة بالنباتات الطبية الأكثر استعمالاً من طرف المعالجين التقليديين في الجزء الشمالي من المغرب، وتحديدًا التسمم المرتبط بها. وتم الحصول على البيانات من هذا العمل عن طريق مقابلات و جمع استبيانات مباشرة من المعالجين التقليديين المحليين والرحلات الميدانية الموجهة مع أخصائي الأعشاب.

النتائج: ينتمي 40 نوعاً من الأنواع النباتية حيث تضم حوالي 34 جنساً و 21 أسرة نباتية. فالعائلات الأكثر تمثيلية هي اللامية التي بها 13 نوعاً، تليها الفصيلة النجمية مع 6 أنواع و الفصيلة السروية (3 أنواع). أما الأنواع الأكثر استعمالاً هي النعناع الأوروبي مع تردد عالي جداً من الاستخدام (22.5 ٪)، تليها روزمارينوس أوفيسيناليس (15 ٪) من حيث الإيرادات. ويتم اعداد 11 وصفة من 40 نوعاً. والأجزاء الأكثر استعمالاً هي الأوراق (30.52 ٪). والطريقة الرئيسية للإعداد هي التسريب والإستخلاص (63 ٪). هذه الدراسة بينت كذلك أن أخذ هذه الوصفات عموماً يكون عن طريق الفم خلال سبعة أو خمسة عشر أو حتى ثلاثين يوماً مع متوسط واحد إلى ثلاثة أكواب في اليوم. وتستخدم بعض هذه الوصفات لعلاج أمراض الجهاز الهضمي والجهاز العصبي. ويستخدم السكان المحليون، الذين تتخفف قدرتهم الشرائية، النباتات التي يتم حصادها مباشرة في منطقة الدراسة مما يتسبب في اختفاء أكثر الأنواع ضعفاً.

الاستنتاجات: تظهر هذه الدراسة أن الطب التقليدي لا يزال يشكل تراثاً غنياً جداً في شمال المغرب. وستكون هناك حاجة إلى المزيد من التحقيق في فوائد هذه النباتات ومخاطرها لتوجيه معارف الأجداد أثناء التطبيق الذاتي الذي يسبب آثاراً سلبية على صحة الإنسان وسيكون من الضروري أن يكون الاستغلال المخطط له.

الكلمات الرئيسية: النباتات الطبية؛ النباتات العطرية؛ الأدوية؛ علم الأدوية العرقية؛ المغرب

Résumé

Introduction: Pendant des siècles, les tradipraticiens marocains utilisent des médicaments traditionnels à base de plantes; cependant, la plupart de ces tradipraticiens abusent de leur utilisation en raison de connaissances limitées sur les effets secondaires nocifs. Les guérisseurs traditionnels prescrivent parfois des recettes qui ne respectent aucune norme de qualité. Cette étude a été conçue et initiée dans le but de classer et de présélectionner les plantes médicinales les plus utilisées par les guérisseurs traditionnels dans la partie Nord du Maroc et d'identifier leurs toxicités associées.

Matériel et méthodes: Les données de cette recherche ont été obtenues en recueillant des semi-entrevues et des questionnaires directs auprès des tradipraticiens locaux.

Résultats: Au total, 40 espèces végétales identifiées appartenant à 34 genres et 21 familles botaniques. Les familles les plus représentées

étaient les *lamiaceae*, suivies des *Asteraceae* et des *Cupressaceae*. Les espèces les plus fréquemment citées et utilisées étaient: *Mentha pulegium* (22,5 %) et *Rosmarinus officinalis* (15%). De plus, notre enquête a révélé 11 recettes préparées à partir de 40 espèces. Les feuilles étaient la partie la plus utilisée avec un pourcentage de 30,92 %, et la principale méthode de préparation était l'infusion (90,90%). Notre recherche montre également que ces recettes sont généralement administrées oralement pendant sept, quinze ou même trente jours avec une à trois tasses par jour. La plupart de ces recettes sont utilisées pour traiter les maladies du système digestif ou nerveux. La population locale, dont le pouvoir d'achat est très faible, utilise les plantes récoltées directement dans la zone d'étude entraînant la disparition des espèces les plus vulnérables.

Conclusions: Notre étude a permis de recueillir 11 recettes médicales. Ces recettes ont été préparées avec plus de 40 espèces de plantes médicinales locales qui ont été identifiées sur différents sites de la région du nord du Maroc, largement connu pour leur espèce endémique et sa biodiversité biologique. Une enquête plus approfondie sera nécessaire pour consigner ces précieuses connaissances avant qu'elles ne disparaissent.

Mots-clés: Plantes médicinales; Plantes aromatiques; Pharmacopoeia; Ethnopharmacologie

Background

For several millennia, Aromatic and Medicinal Plants (AMPs) have been used by man, in general, and by Moroccans in particular for the purposes of healing. All people have considered these plants as a part of their traditional medical heritage (Bekhechi 2009). In the history of medicine, plants represent a very important aspect. Hence, they enormously contributed to the evolution of modern medicine (Hussein 1991). Among 80% of the world's population, 4 billion people prefer healing with medicinal plants in which we actually find more than half of the medicines containing plants extract (Ghaemi 2007). This enables aromatic plants of being a huge potential for health, but which stay not really exploited (Makram 2015). The AMPs have a considerable asset due to the progressive discovery of the applications of their essential oils in health care as well as their use in other domains of economic interest. Their numerous uses have made them demanded more and more in international markets (Tchamdja 1995).

Nowadays, the users have become very worried about the undesirable secondary effects of medicines. For this reason, pharmaceutical

industries are becoming more and more interested in the usages of plants that tend to be less harmful (Larousse 2001). AMPs occupy not only a considerable place in cosmetic and food industries but also are important for pharmacological research and the elaboration of medicines; where the constituents of plants are directly used therapeutic agents and as basic materials for the synthesis of medicines, or as models for pharmacologically active compounds (Said-Hassane 2011). The effectiveness of medicines like antibiotics, considered the universal solution to dangerous infections decreases, due to increasing resistance of bacteria (Essawi & Srour 2000).

The enormous biodiversity that exists in Morocco, one of the Mediterranean countries known for its traditional expertise with medicinal plants (Scherrer *et al.* 2005) constitutes around 4.500 species and subspecies of vascular plants (Benkhniqne *et al.* 2011). However, according to Rejdali (1996), the number of medicinally used species doesn't exceed 600 species, and only 356 according to Hmamouchi and Agoumi (1993). This means that just between 8,69% and 14,28% of the Moroccan flora is considered to be medicinal plants (Benkhniqne *et al.* 2011).

In the north of Morocco, plants which are endemic, indigenous or introduced have been used at a large scale either as spices sold in local markets in cities and villages, or as remedies prescribed by traditional healers to treat different health problems or even taken directly by the people without any prescription. This allowed us to make a study that aims, particularly, at identifying the AMPs traditionally used by traditional healers in some areas between Chefchaouen and Tetouan. Preparation methods of different recipes, their mode of use and the duration of treatment has been studied.

Materials and Methods

Study area and survey

For a good realisation of this study, a bibliographical research was associated with the ethno-pharmacological investigation realised with traditional healers working in the selected areas in the north of Morocco.

This prospective study was done throughout the years 2014-2015. We investigated six sites in four

areas located between two cities in the north of Morocco: Chefchaouen and Tetouan. These areas were chosen because of their accessibility, and the very frequent usage of AMPs. The sites are Beni Ahmed Gharbia, Beni Ahmed Charkia, Mansoura, Bab Taza, Dardara, Chefchaouen, Benkerriche, Moulay Abdessalam, Sebt zinat and Tetouan (Figure 1). The information was collected from traditional healers located at Souks and homes. A total of fifty traditional healers aged between 30 and 70 (of which $\frac{3}{4}$ were men) were consulted. The investigation was conducted using open answer questionnaires. For better an understanding, the language used was local as it allowed smoothness and clarity in communication. The studied parameters are the sociodemographic status of traditional healers (age, gender, situation, level of education, residence and income), the ethnobotanic characteristics (usage forms, parts of the plant used, problems treated,...) and ethnopharmacological (usage modes, usage precautions,...). The tables below show the different information that was collected in a pre-established questionnaire (Annex 1).

Identification of medicinal plants

During this study, scientific identification of species was conducted by comparing two sets of samples. The first set was gathered and then verified by herbalists. The second are species which are kept in the herbarium of the Department of Botany of the Scientific Institute of Rabat. The plant identification was validated by comparison with reference to botanical descriptions (Fennane & Ibn Tattou, 2005; Fennane *et al.*, 2007; Valdes *et al.*, 2002) and on the website (www.theplantlist.org). Local names of listed species were checked with those recorded in the literature (Bellakhdar, 2017; Sijilmassi, 2011). The voucher specimens each sample were registered at the Scientific Institute of Rabat.

Statistical analysis

The ethnobotanical data was transferred in a database using the software SPSS (Statistical Package for Social Sciences, version 21.0). The quantitative variables were represented on the mean and standard deviation, and the qualitative variables were represented in frequencies and percentages. Moreover, we used the X² to know whether the quantitative variables have a significant difference.

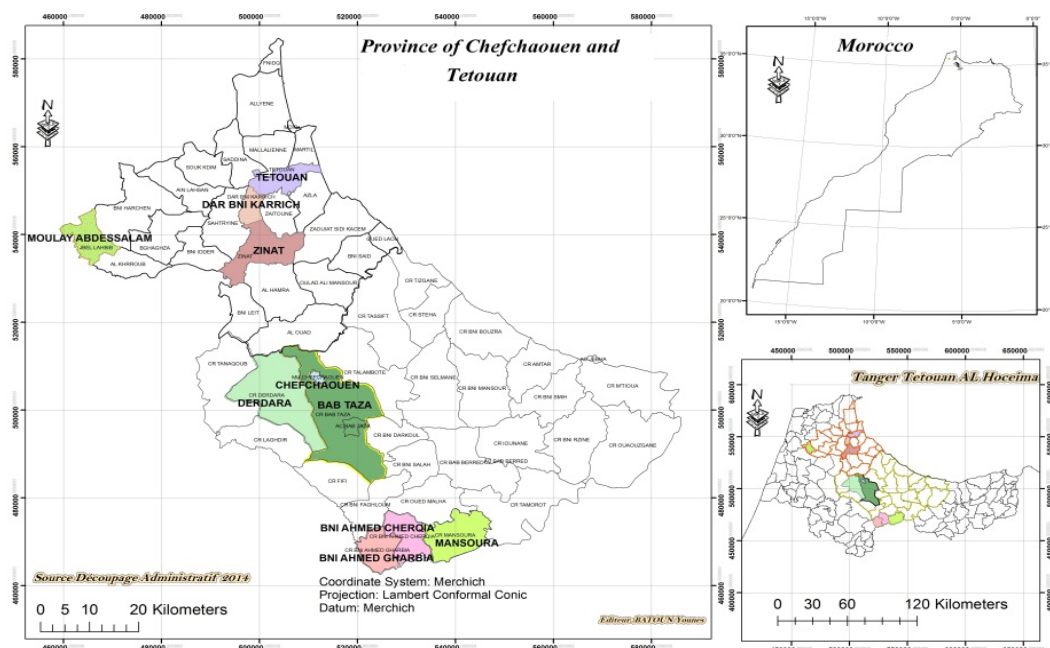


Figure 1. Rural and urban municipalities of Chefchaouen and Tetouan province

Results and discussion

Ethnobotanical data were collected and gathered in a database for treatment, analysis and visualisation. Among 70 interviewed healers, there are only 50 that have agreed to provide information.

Healers' sociodemographic status

The distribution of respondents in accordance to their gender is shown in table 1. In this later, it can be seen that males constitute 72% (n=36) of our survey, while females represent only 28% (n=14) with the gender ratio is in favour of males (gender ratio $\text{male/female}=2.57$). There is also a highly significant difference between the two genders ($p<0.05$).

The distribution of respondents in accordance to their age is shown in table 1. In this later, it can be seen that respondents between 30 and 50 years constitute a percentage of 54%, which is the majority compared to the other 46% that constitutes of respondents between 50 and 70 years. There is not a significant difference between the two modalities studied ($p<0.05$).

According to the results cited in Table 1, we found that the married traditional healers (76%, n=38) practice this craft more than the single ones (24%, n=12). This allows the married traditional healers to rely more on these plants to reduce the charges that come with doctors and medicines. There is also a highly significant difference between the two situations ($p<0.05$).

All the surveyed traditional healers are literate, 30% (n=15) have a higher educational level, 46% (n=23) had a secondary educational level, while 24% (n=12) have a primary educational level (Table 1). There is no significant difference between the three

levels of study. Indeed, most traditional healers depend on the traditional knowledge of medicinal virtues that was passed to them by their ancestors. This leads to the loss of traditional knowledge throughout the generations. Some traditional healers use books and some scientific publications or even reviews to verify the information. The interviewed healers were distributed over the ten selected regions of Morocco: Beni Ahmed Gharbia, Beni Ahmed Charkia, Mansoura, Bab Taza, Derdara, Chefchaouen, Benkerriche, Moulay Abdessalam, Sebte zinat and Tetouan (Table 1). Traditional healers that live in cities like Tetouan and Chefchaouen, are more educated and open in this particular field of study. Moreover, several respondents make a living mainly from their job as traditional healers. 62% (n=31) of healers made between 250-1500 MAD per month, 30% (n=15) made between 1500-5000 MAD, and 8% (n=4) of respondents made >5000 MAD per month with a highly significant difference between three income ($p<0.05$). Thus, most of these traditional healers do not have a decent income.

The medicinal plants used in the study area

The present study has shown a good diversity of plants identified and used in recipes in the north of Morocco, between the areas of Chefchaouen and Tetouan, which are presented in table 2. It shows that 40 species of plants divided into 34 genera and 21 botanical families were identified. The most represented family is that of *Lamiaceae* with 13 species, followed by that of *Asteraceae* with 6 species, as well as the family of *Cupressaceae* with 3 species. The species *Mentha Puleguim* (Figure 2) has a very high usage frequency (22.5%). It is followed by *Rosmarinus Officinalis* (15%), *Matricaria Chamomilla*, *Linum usitatissimum* and *Lippia Citriodora* (12.5%), then by *Centaurium erythrae*, *Mentha spicata*, *Origanum compactum*,

Salvia officinalis and *Laurus nobilis* (10%). These results show some similarities with the study of Rhattas et al. (2016), realized in the north of Morocco, in which the most represented families were the *Lamiaceae*, the *Cistaceae* and the *Asteraceae* that gathers the most used species *Cistus varius* and *Marrubium vulgare* (14.59%), followed by *Mentha pulegium* (12.46%) and *Matricaria chamomilla* (9.25%). Moreover, several works realized in other Moroccan regions also reported that *Lamiaceae* and *Asteraceae* are the most present families in the medicinal flora (Mehdioui and Kahoudji, 2007; Ouhaddou et al, 2014; Bouyahya et al., 2017; Eddouks et al. 2017; Salhi et al., 2019). According to Fennane and Ibn Tattou (2012), *Brassicaceae*, *Lamiaceae* and *Caryophyllaceae* are generally the richest families among species with approximately 200 species. Among these families, we find *Lamiaceae* which represent 40% and occupy the 6th place on the specific richness plan. The same authors have equally reported that *Asteraceae*, *Fabaceae* and *Poaceae* make 1329 species.

It should be noted that the AMPs shown in Table 2 are used much more by the people of Beni Ahmed Gharbia, Beni Ahmed Charkia, Mensoura and Moulay Abdessalam than by the people of Benkarriche and Bab Taza. It should be noted that women are especially more interested in using these AMPs. This accord with the results referred to Kahouadji (1995) and Hmamouchi (2001). Thus, the use of traditional plants, on one hand, depends on the social status of the people, which obliges them to avoid the exaggerated expenses of modern therapeutics. On the other hand, it depends on the geographical situation, and hence the accessibility privileges that it can offer to such people. Some ethno-botanic studies have shown that rural communities massively use AMPs, even more than urban and peri-urban communities, as in a study by Jeruto et al. (2008) in which was noted that 70% of

rural population commonly use traditional phytotherapy as a primary health need while only 30% rely on the modern health system. However, when the AMPs' resources are overused, it affects their renewal and regeneration which might turn out to be harmful (Mehdioui and Kahouadji 2007).

Table 1. Sociodemographic status of traditional healers

Characteristics	N=50
Age (mean years SD)*	57.46 ± 5.335
Gender (n,%)**	
Female	14 (28.0)
Male	36 (72.0)
Situation (n,%)**	
Single	12 (24.0)
Married	38 (76.0)
Level of study (n,%)**	
Illiterate	0 (00.0)
Primary	12 (24.0)
Secondary	23 (46.0)
University	15 (30.0)
Residence (n,%)**	
Beni Ahmed Gharbia	8 (16.0)
Beni Ahmed Charkia	5 (10.0)
Mansoura	2 (4.0)
Bab Taza	2 (4.0)
Derdara	4 (8.0)
Chefchaouen	10 (20.0)
Benkerriche	3 (6.0)
Moulay Abdessalam	2 (4.0)
Sebt zinat	3 (6.0)
Tetouan	11 (22.0)
Income/month (MAD) (n,%)**	
250-1500	31 (62.0)
1500-5000	15 (30.0)
>5000	4 (8.0)

*SD: Standard deviation;** (n, %): Effective (Percentage).

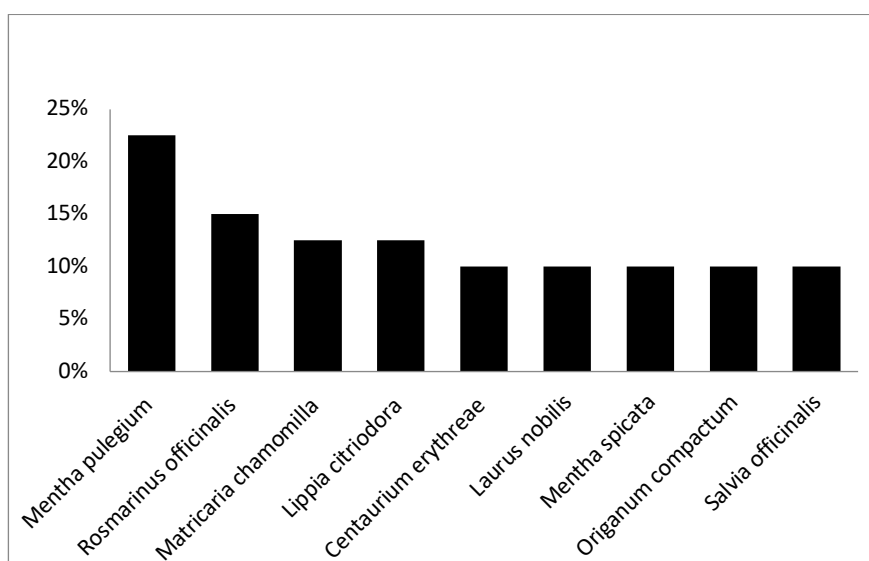


Figure 2. Distribution of the usage frequency of the most used medicinal plant species

Table 2. Identification and local names of plants identified according to their usage frequency

Family	Scientific name	Local name	Voucher number	Frequency
Anacardiaceae	<i>Pistacia lentiscus</i> L.	Drou	-	7,5
Apiaceae	<i>Ammi visnaga</i> (L.) Lam.	Khella	-	2,5
Asteraceae	<i>Achillea millefolium</i> L.	Lkayssoum	RAB107361	2,5
	<i>Arctium lappa</i> L.	Lkouk	-	2,5
	<i>Artemisia campestris</i> L.	Chih horrissi	-	5
	<i>Artemisia herba-alba</i> Asso	Chih	-	5
	<i>Matricaria chamomilla</i> L.	Lbabounej	RAB107328	12,5
	<i>Anthemis pedunculata</i> Desf.	Nouar eljenna	RAB107351	2,5
Campanulaceae	<i>Feeria angustifolia</i> (Schousb.) Buser	Laassif	RAB107358	2,5
Cannabaceae	<i>Cannabis sativa</i> L.	Lkif	-	2,5
Cupressaceae	<i>Juniperus phoenicea</i> L.	Larâar lhor	-	2,5
	<i>Juniperus thurifera</i> L.	Larâar lfawah	RAB107325	2,5
	<i>Tetraclinis articulata</i> (Vahl) Mast.	Laraar	RAB107366	2,5
Ericaceae	<i>Erica arborea</i> L.	Lekhlj	-	2,5
Convolvulaceae	<i>Convolvulus sepium</i> L.	Leleb	RAB107354	2,5
Gentianaceae	<i>Centaurium erythraea</i> Rafn	Kassat lhiya	RAB107357	10
Geraniaceae	<i>Pelargonium graveolens</i> L'Hér	Laatercha	RAB107368	2,5
Lamiaceae	<i>Lavandula angustifolia</i> Mill.	Lakhzama	RAB107349	5
	<i>Lavandula stoechas</i> L.	Lhalhal	RAB107323	5
	<i>Marrubium vulgare</i> L.	Meriw	RAB107322	2,5
	<i>Mentha pulegium</i> L.	Flayou	RAB107321	22,5
	<i>Satureja nepeta</i> (L.) Scheel	Nepta	RAB107355	2,5
	<i>Mentha spicata</i> L.	Naanae	-	10
	<i>Ocimum basilicum</i> L.	Lahbak	-	2,5
	<i>Origanum compactum</i> Benth.	Zaatar	RAB107352	10
	<i>Origanum majorana</i> L.	Mardadouch	RAB107365	7,5
	<i>Rosmarinus officinalis</i> L.	Lazir	RAB107371	15
	<i>Salvia officinalis</i> L.	Salmiya	RAB107330	10
	<i>Thymus vulgaris</i> L.	Ziitra	RAB107369	5
	<i>Vitex agnus-castus</i> L.	Lkharouae	RAB107319	2,5
Lauraceae	<i>Laurus nobilis</i> L.	Rand	RAB107318	10
Linaceae	<i>Linum usitatissimum</i> L.	Lkattan	-	2,5
Myrtaceae	<i>Eucalyptus globulus</i> Labill.	Lkallitou	RAB107370	5
	<i>Myrtus communis</i> L.	Rayhan	RAB107317	7,5
Pinaceae	<i>Pinus sylvestris</i> L.	Sanawbar	-	2,5
Poaceae	<i>Avena sativa</i> L.	Lkhartal	RAB107327	2,5
Ranunculaceae	<i>Nigella sativa</i> L.	Habba sawda	-	2,5
Rosaceae	<i>Rosa damascena</i> Herrm.	Al ward al baldi	RAB107364	2,5
Verbenaceae	<i>Lippia citriodora</i> (Palau) Kunth	Louiza	RAB107326	12,5
Zingiberaceae	<i>Alpinia galanga</i> (L.) Willd.	Khoulinjan	RAB107332	12,5

The medicinal plants and therapeutic treatments

The types of counted recipes of medicinal plants, their mode of preparation, the administered quantity, treatment duration, and the other medicines in which they are used, all are presented in Table 3. It shows that 11 types of medicinal recipes were inventoried. These preparations were obtained either from a mixture of four medicinal plants (recipe 11 with 4.44%), or from a mixture of five (recipe 9 with 5.56%), seven (recipe 6 and 7 with 7.78%), eight (recipe 1, 8 and 10 with 8.89%), nine (recipe 3 and 4 with 10%), ten (recipe 2 with 11.11%), and even fifteen medicinal plants (recipe 5 with 16.67%). These recipes were prepared from plants' leaves (38%), by infusion which constitutes

the most frequent mode of preparation (63%), by macerating (19%), by decoction (13%) in water (77%), or even taken with soup (6%). It shows that these recipes are generally administered orally during seven, fifteen or even thirty days with an average of one to three cups a day. As Table 3 shows, these medicinal plants are assigned to heal a lot of illnesses that could be chronic or temporary. Some of these recipes are used to treat several other illnesses, particularly those of the digestive and nervous system.

From the results in Table 2, it is shown that *Mentha Pulegium* has a very high usage frequency (22.5%), this high frequency is explained by the fact that this

species is used by traditional healers in almost all medicinal recipes. According to existing literature, it appears that *Mentha puleguim* protects against urinary and digestive microbial infections (Bouyahya et al., 2017; Bishr et al., 2018), and against colopathy in Portugal (Novais et al., 2004). It is also used to heal Hematomas, wounds and swellings in Italy (Tuttolomondo et al., 2014). Moreover, this plant is well known as a remedy for respiratory tract diseases in Algeria (Boudjelal et al., 2013; Benarba, 2015). It is considered beneficial for health (Sivropoulou et al. 1995; Pardini and Lucheroni 1996) and it is also considered as one of the plants that are frequently used in the Mediterranean region (Quezel and Santa 1963; Marrotti et al. 1994). In addition to its medicinal uses, *Mentha puleguim* is widely used in pharmaceutical and cosmetic industries (Bishr et al., 2018).

This species is followed by *Rosmarinus officinalis* (15%) which spontaneously distributed in the Mediterranean basin (Perot, 1943; Guinochet, 1973). This plant is used for its different pharmacological and therapeutic properties. Many studies have shown that the components of rosemary inhibit the initiation and promotion phases of cancerogenesis (Offord et al. 1995). It is to be equally noted that this species has an antibacterial ability, antimutagenic, antioxidant and chemopreventive (Ibanez et al. 2000; Pérez et al. 2007; Wang et al. 2008), anti-inflammatory and anti-metastasis (Cheung and Tai 2007), anti-spasmodic, diuretic, hepatoprotective and relieving respiratory disorders (Lemonica et al. 1996; Souza et al. 2008). This plant is respectively followed by *Matricaria chamomilla*, *Lippia citriodora* and *Alpinia galanga* (12.5%).

Concerning *Matricaria chamomilla*, it is used as an antineuralgic, febrifuge, antispastic of digestive organs, emmenagogue, hypo-allergenic and bactericidal. For external usage, *Matricaria chamomilla* is an anti-inflammatory, and it is used for skin care and mucous. It is prescribed against inflammations of mouth, ears, eyes and against cutaneous affections. Its essential oil is used as an antirheumatic agent (Bruno and Herz 1988; Richter 1933).

Lippia citriodora is traditionally used in Morocco for its muscle relaxant properties, sedatives, antipyretic, anti-asthmatic and antispasmodic, in case of digestive troubles, measles and headache (Pascual et al., 2001; Mojab and Yamouhamadi 2002; Manenzhe 2004), this species also works against respiratory disease (Benarba, 2015). Moreover, it is used to reduce nervousness and helps with sleeping especially with infants (Makram 2015).

According to Pascual et al. (2001), this plant is used as a flavouring agent in certain culinary preparations.

Alpinia galanga is generally used to improve appetite, taste and, voice and it is widely known in stomachic, aphrodisiac, diuretic, rheumatic pain, diabetes, and heart diseases. Furthermore, this plant is prescribed against bronchitis and diseases of the kidney (Chudiwali et al., 2010). It also used for the treatment of pyogenic diseases, ringworm, venereal diseases, abdominal discomfort (Kose et al., 2015). Recent chemical and pharmacological studies on the properties of the galanga rhizomes have shown that this latter has three chemical groups of important constituents which are flavonoids, glycosides and diarylheptanoids (Eumkeb et al., 2010).

Table 3 and Figures (3 and 4) demonstrated the number of recipes in each treated disease, while the different recipes of medicinal plants used by traditional healers in the studied areas are shown in Fig. 4a. In the same time, organs of the plants used, their mode of preparation, and their usage aspects were shown in (Fig. 4 (b, c, d, e and f)) respectively. According to traditional healers, these recipes were made from the most available plants in their areas. This allows traditional healers to have many options when it comes to the plants that they can use in their recipes. Traditional healers think they get better results when they combine plants. However, several studies have shown that there might be unwanted interactions between the components of the many species of plants that are used in preparing a remedy for diseases (Bussmann and Sharon, 2006; Ouhaddou et al., 2014).

The previous data shows that the most used parts of the plants in recipes are leaves with 30,92%. According to Zheng and Xing (2009); El Yahyaoui et al. (2015); Salhi et al. (2019), leaves were the most frequently used part of plants (47.3%). Also, this organ is the most used part in treating several diseases and dermatological wounds (Adetutu et al., 2011; Bhat et al.; 2013; Ouhaddou et al., 2015 and Salhi et al., 2019). In addition, Bigendako-Polygenis and Lejoly (1990) found many chemical components that are synthesized by plants, in the form of secondary metabolites biologically active in this organ. The harvest ease justifies the high rate of leaves, however, a huge part of it can be granted to the sun which when exposed to the organs get their virtues and benefications (El Rhaffari and Zaid, 2000). An explanation of such case would be by photosynthesis phenomenon which prefers the biosynthesis and the storage of metabolites (Simbo, 2010; Ouhaddou et al., 2014). Moreover, and in a descending order, the other plant parts that are used are flower (18%), flower and leaf (14%), twigs (6%), seed (4%), leaf and fruit (4%), stem and leaf (4%), fruit (2%), twigs and fruit (2%), leaf, flower and stem (2%), whole plant (1%), sap and leaf (1%), leaf, bud and sap (1%), flower, seed and leaf (1%).

Table 3. List of plant species used in different recipes, modes of preparation, parts used and posology.

Recipe N°	Species	Part used	Solvent	Mode of preparation	Administration time	Treatment period	Diseases treated and uses
1	<i>Origanum compactum</i>	Fl	Water	I	3S/3Ts x day	3-4 d	Dyspepsia
	<i>Mentha pulegium</i>	Le	Tea				Genitourinary spasms
	<i>Myrtus communis</i>	Le+Fr	Drink				Colopathy
	<i>Pistacia lentiscus</i>	Tw					Dysmenorrhea
	<i>Matricaria chamomilla</i>	Fl					Bile colic
	<i>Salvia officinalis</i>	Le					Flatulence and intestinal gas
	<i>Lippia citriodora</i>	St+Le					
2	<i>Rosmarinus officinalis</i>	Sa+Le			1Ts/S x day	7 d	Microbial infections
	<i>Origanum compactum</i>	Fl+Le	Tea	I/So			Intestinal worms
	<i>Mentha pulegium</i>	Le	Drink				Headaches
	<i>Myrtus communis</i>	Le+Fr					Dyspepsia
	<i>Lippia citriodora</i>	St+Le					Abdominal pain
	<i>Lavandula officinalis</i>	Le					Febrile State
	<i>Pelargonium graveolens</i>	Fl					Cold and flu
	<i>Mentha spicata</i>	Le					Toothache
	<i>Origanum majorana</i>	Fl					
	<i>Rosmarinus officinalis</i>	Fl+Le					
	<i>Alpinia officinarum</i>	Tw					
3	<i>Marrubium vulgare</i>	Le	Water	D/I	3Ts x day	7-15 d	Bronchitis
	<i>Centaurium erythraea</i>	Fl					Rhinitis
	<i>Artemisia campestris</i>	Fl+Le					Immunodeficiency
	<i>Lavandula stoechas</i>	Fl					Diabetes
	<i>Pistacia lentiscus</i>	Tw					Cough
	<i>Salvia officinalis</i>	Le					Sore throat
	<i>Convolvulus sepium</i>	Se					
	<i>Nigella sativa</i>	Se					
4	<i>Mentha pulegium</i>	Le			3Ts/3S x day	30 d	
	<i>Lavandula stoechas</i>	Fl	Water	I			Colopathy
	<i>Rosmarinus officinalis</i>	Fl+Le					Stress
	<i>Mentha spicata</i>	Fl					Urinary and cutaneous infections
	<i>Matricaria chamomilla</i>	Fl					Constipation
	<i>Avena sativa</i>	WP					Obesity
	<i>Linum usitatissimum</i>	Se					
	<i>Foeniculum vulgare</i>	Fr					
5	<i>Cassia angustifolia</i>	Le			1/2 Ts x week	30-60 d	
	<i>Laurus nobilis</i>	Le					Stress
	<i>Cannabis sativa</i>	Le	Water / Olive oil	M / I			Skin Infections
	<i>Rosmarinus officinalis</i>	Fl+Le					Alopecia
	<i>Tetraclinis articulata</i>	Le					Toothache
	<i>Juniperus phoenicea</i>	Tw+Fr					Dermatological diseases
	<i>Juniperus thurifera</i>	Le+Fr					
	<i>Origanum compactum</i>	Fl+Le					
	<i>Myrtus communis</i>	Le+Fr					
	<i>Pistacia lentiscus</i>	Tw					
	<i>Matricaria chamomilla</i>	Fl					
	<i>Salvia officinalis</i>	Le					
	<i>Lippia citriodora</i>	St+Le					
	<i>Rosa damascena</i>	Fl					
<i>Nardostachys jatamansi</i>	Tw						
6	<i>Linum usitatissimum</i>	Se			3Ts x day	7-15 d	Cystitis
	<i>Mentha pulegium</i>	Le	Water	I / D			Rheumatism
	<i>Thymus vulgaris</i>	Fl+Le					Urinary tract infections
	<i>Mentha spicata</i>	Le					Sleep disturbances
	<i>Anthemis pedunculata</i>	Le+Fl+S					
	<i>Feeria angustifolia</i>	t					
	<i>Pinus sylvestris</i>	Le+B+S a Le					

7	<i>Mentha pulegium</i>	Le	Water	I	3S/3Ts x day	7-15 d	Bronchitis				
	<i>Centaurium erythraea</i>	Fl					Rhinitis				
	<i>Salvia officinalis</i>	Le					Muscular inflammation				
	<i>Eucalyptus globulus</i>	Le					Gynecological Problems				
	<i>Arctium lappa</i>	Tw+Fr					Sleep disturbances				
	<i>Origanum compactum</i>	Fl+Le					Allergies				
	<i>Laurus nobilis</i>	Le					Diarrhea				
8	<i>Matricaria chamomilla</i>	Fl	Water	I	3Ts/S x day	30 d	Bronchitis				
	<i>Thymus vulgaris</i>	Le					Digestive Colic				
	<i>Mentha pulegium</i>	Le					Digestive Spasms				
	<i>Eucalyptus globulus</i>	Le					Inflammation of the buccopharyngeal area				
	<i>Origanum majorana</i>	Fl					Asthma				
	<i>Ocimum basilicum</i>	Le									
	<i>Inula viscosa</i>	Le+Fl+S									
	<i>Laurus nobilis</i>	t									
9	<i>Rosmarinus officinalis</i>	Fl+Le	Water	I/M	3Ts x day	30 d	Hepatitis				
	<i>Fumaria officinalis</i>	Fl+Le					Intestinal gases				
	<i>Centaurium erythraea</i>	Le					Diabetes				
	<i>Mentha pulegium</i>	Le									
	<i>Mentha spicata</i>	Le									
10	<i>Rosmarinus officinalis</i>	Fl+Le	Water	I	3Ts x day	30-60 d	Intestinal gases				
	<i>Artemisia herba-alba</i>	St+Le					Dyspepsia				
	<i>Artemisia campestris</i>	Fl+Le					Gastrointestinal disturbances				
	<i>Origanum compactum</i>	Le					Diuretic				
	<i>Centaurium erythraea</i>	Fl									
	<i>Ocimum basilicum</i>	Le									
	<i>Matricaria chamomilla</i>	Fl									
	<i>Lippia citriodora</i>	Le									
	<i>Vitex agnus-castus</i>	Fl+Se+L					Water	M	3Ts x day	30 d	Dysmenorrhia
	<i>Mentha pulegium</i>	e									Hypermenorrhia
<i>Achillea millefolium</i>	Le	Mastalgia									
11	<i>Lippia citriodora</i>	Fl+Le					Lower abdominal pain				
		Le									

Le: Leaf; Fl: Flower; St: Stem; Fr: Fruit; WP: Whole Plant; Se: Seed; B: Bud; Sa: Sap; Tw: Twigs; I: Infusion; So: Soup; D: Decoction; M: Maceration.

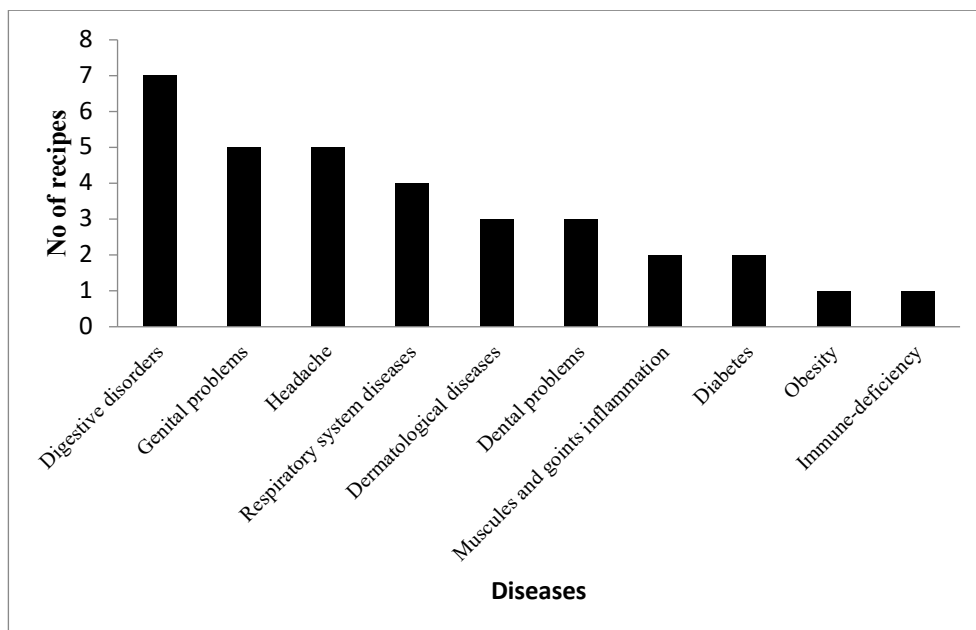


Figure 3. Number of recipes in predominant diseases

In this inquiry, the most widespread modes of preparation (Fig. 4d) are classified as follows: infusion, maceration, decoction and soup, 63%, 19%, 13% and 6% respectively. For a better usage of a plant, we should choose that one which preserves all the properties in a way that is permitting extraction and assimilation of active principles (Dextreit 1984).

In other regions of Morocco, infusion, decoction and powder were the main traditional drug forms used while treating cases such as oral treatment, burnt skin, and digestive system disorders (El-Hilalya et al., 2003; Tahraoui et al., 2007; Mehdioui and Kahoudji, 2007; Abouri et al., 2012; Ouhaddou et al., 2014; Boukhraz et al., 2015). As shown in figure 4c, the most common solvent used for preparations is water (77%), followed by tea drinks (15%), and then olive oil (8%). According to traditional healers, several people prefer to take recipes with water to improve the acceptability of several oral drugs, and those people must use medicinal plants with the precise doses by each treatment period (Fig.4e and 4f).

In cases where the remedy has an unbearable taste, informants have reported the use of some additives to enhance the acceptability of many oral drugs such as juice and milk to reduce the bitterness of the preparation (Bouyahya et al., 2017).

The marketing of medicinal species

According to traditional healers, many people buy medicinal and aromatic plants with a price of which is less than 20 MAD/kg (Fig. 5). However, species that cost more than 40 MAD/kg, and which are imported from other Moroccan regions like *Nigella sativa* and *Avena sativa* or from other countries like *Zingiber officinale*, are less demanded by the people. Similarity in the medicinal species marketing was obtained by Mehdioui and Kahoudji (2007) in their ethnopharmacological studies of medicinal plants used in Imi n'Tlit region (province of Essaouira), Morocco.

The results of our survey have shown that the most demanded recipes by consumers are the ones used for digestive system disorders, genital tract, respiratory system problems and hair loss. This means that people largely use medicinal plants which are known by their phytotherapeutic, antispasmodic and antiarrheal effects.

Throughout ethnobotanical surveys in many other studies, it was found that medicinal plants are mostly used for gastro-intestinal disorders (Merzouki et al., 2000; El-Hilaly et al., 2003; Benitez et al., 2010; Mati and De Boer, 2011). Accordingly, experimental studies have proven that many alleged therapeutic manifestations in folk-medicine are valid. For instance, the present survey includes several plants that are reported useful in renal

diseases. However, these plants have been shown to have a diuretic effect in experimental studies: *Centaurium erythraea* and *Rosmarinus officinalis* (Haloui et al., 2000). On the other hand, some of the species reported in the current study are also used as preservatives for foodstuffs like *Myrtus communis* for meat, while *Mentha pulegium*, *Origanum compactum*, *Laurus nobilis* and *Thymus vulgaris* for milk, honey and olive (Elharas et al., 2013; El-Hilalya et al., 2003; Bouyahya et al., 2017).

Conclusions

The results of the ethnobotanic study were used to identify and make an inventory of the most used medicinal plants in the studied region. The same investigations allowed gathering 11 medical recipes that are prepared using more than 40 local medicinal plant species. These species were identified at different sites in the north region of Morocco, which is widely known for its endemic species and biological biodiversity.

The craft is practiced more by men and married couples than by women and singles. Throughout the analysis of the findings, it was noticed that leave are the most used part in a plant (30.52%), 63% for infusion as the most used method of preparation. Digestive disorders are the most cited diseases which explain the use of plants such as *Mentha pulegium* that is known by the following effects: antispasmodic, stomachic, respiratory tract diseases, analgesic and antiseptic. Secondary graduate and university graduate traditional healers who live in Chefchaouen, Tetouan, or in nearby villages are more experienced as they have been practicing for a long period of time. Their competence when it comes to the use and properties of medicinal plants is generally acquired and followed by long experience. This indicates that these traditional healers are always learning, and thus, it is fair to state that with such accumulated experience throughout the years, their advancement is certain.

The relatively high price of plants, specifically those imported from other regions of the country, pushes the common people and traditional healers to depend only on the plants located in their territory, especially in the areas of Beni Ahmed Gharbia, Beni Ahmed Charkia, Mensoura, and Moulay Abdessalam. In the locals' opinion, the collection method and the excessive use of vegetal resources, due to their availability in the natural environment, is unproblematic. This abuse of the vegetal biodiversity by the common population can potentially induce the degradation of this regional feature. The concerned region is widely known for its cultural and spontaneous species as well as its biological biodiversity. However, further investigation is necessary to record this valuable knowledge before its disappearing.

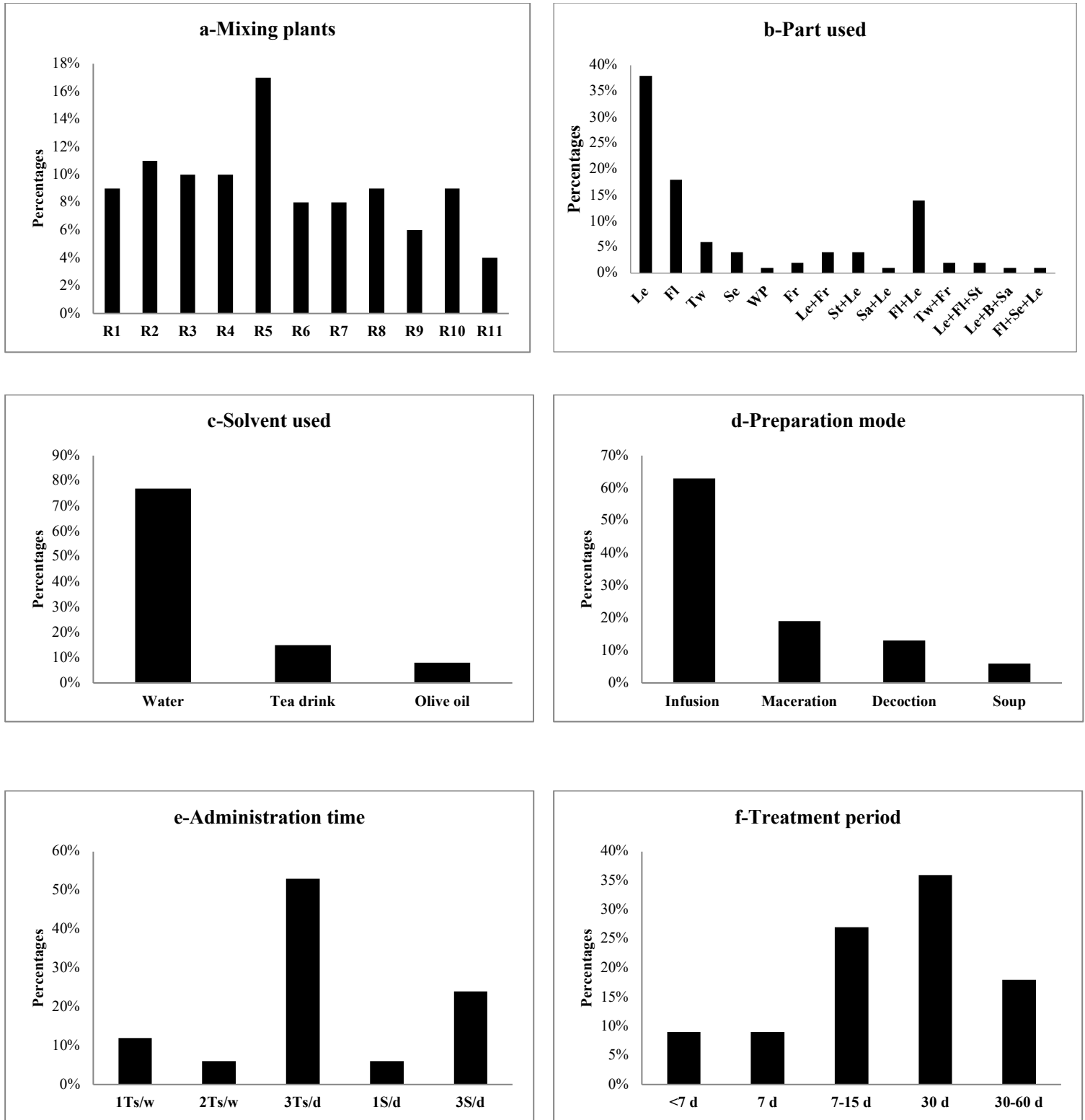


Fig. 4. Recipes used in case of (a) Mixing plants, (b) Part used, (c) Solvent used, (d) Preparation mode, (e) Administration time and (f) Treatment period. R: Recipe, d: day, w: week, Ts: Tea spoonful, S: Spoon, F: Leaf; Fl: Flower; St: Stem; Fr: Fruit; WP: Whole Plant; Se: Seed; B: Bud; Sa: Sap; Tw: Twigs; I: Infusion; So: Soup; D: Decoction; M: Maceration.

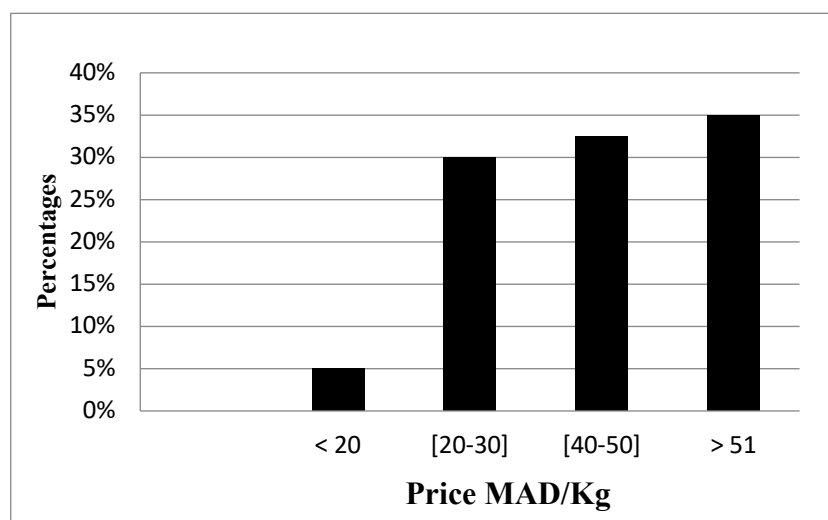


Figure 5. Distribution of medicinal plants recipes depending on their prices

Declarations:

List of abbreviations: Not applicable.

Ethics approval and consent to participate: The purpose of the study was explained to the community members interviewed. Auditors and interviewees were not asked to sign a particular consent form as the questionnaire was anonymous.

Consent for publication: Not applicable.

Availability of data and materials: The data was not deposited in public repositories.

Competing interests: The authors do not have any competing interests.

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Authors' contributions: All PhD students have done fieldwork, data analysis and drafted the manuscript. The university teams and the Forest Research Center in Rabat team, participated in the configuration of the research project, supervised the work and improved the manuscript. All authors have read, reviewed and approved the final manuscript.

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Informant details

Ages	<input type="text"/>			
Gender	Male <input type="checkbox"/>	Female <input type="checkbox"/>		
Family situation	Married <input type="checkbox"/>	Single <input type="checkbox"/>	Widowed <input type="checkbox"/>	Divorced <input type="checkbox"/>
Education Level	Illiterate <input type="checkbox"/>	Intermediate <input type="checkbox"/>	Middle <input type="checkbox"/>	Graduation <input type="checkbox"/>
Income/month (MAD)	250-1500 <input type="checkbox"/>	1500-5000 <input type="checkbox"/>	>5000 <input type="checkbox"/>	

Plant material

Medicinal species	Vernacular name <input type="text"/>	Scientific name <input type="text"/>							
Plant type	Spontaneous <input type="checkbox"/>	Cultivated <input type="checkbox"/>							
Part used	Leaves <input type="checkbox"/>	Flower <input type="checkbox"/>	Fruit <input type="checkbox"/>	Stem <input type="checkbox"/>	Seed <input type="checkbox"/>	Whole plant <input type="checkbox"/>	Bub <input type="checkbox"/>	Sap <input type="checkbox"/>	Branches <input type="checkbox"/>

Therapeutic use

Preparation mode	Infusion <input type="checkbox"/>	Soup <input type="checkbox"/>	Decoction <input type="checkbox"/>	Maceration <input type="checkbox"/>
Solvent used	<input type="text"/>			
Treated diseases	<input type="text"/>			
Treatment periode (days)	<input type="text"/>			
Administration time	<input type="text"/>			

Commercialisation of species

Price (MAD/Kg)	<10 <input type="checkbox"/>	[20-30] <input type="checkbox"/>	[40-50] <input type="checkbox"/>	> 50 <input type="checkbox"/>
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