

Ethnobotanical Survey of Medicinal Plants Used for the Treatment of Diabetes in the Tizi n' Test Region (Taroudant Province, Morocco)

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Abstract

In Morocco, diabetes mellitus is a major public health problem with over than 1.5 million cases in 2014. Medicinal plants are widely used by the Moroccan population to treat the illness. This study was carried out to identify the medicinal plants traditionally used in human therapy to treat diabetes in the Tizi n'Test region, and contribute to safeguarding knowledge and local expertise in traditional herbal medicine. A total of 280 interviews were conducted with traditional health practitioners and knowledgeable villagers. Data were collected by semi-structured and structured questionnaires. Indices on Fidelity Level (FL), Use Value (UV) and Relative Frequency of Citation (RFC) were calculated. The ethnobotanical survey has identified 39 species representing 24 families. The most encountered medicinal plant families were Asteraceae and Lamiaceae. The following plant species were showed the high significant FL, UV and RFC: *Artemisia herba-alba*, *Cistus creticus*, *Lavandula maroccana*, *Salvia lavandulifolia* and *Olea europaea*. Plant leaves were the most commonly used plant part, and decoction was the most common method of traditional drug preparation. Our study showed that medicinal plants continue to play an important role in the primary healthcare system for the local population of the Tizi n'Test region and represents a useful documentation, which can contribute to preserving knowledge on the use of medicinal plants for diabetes treatment and to explore the phytochemical and pharmacological potential of medicinal plant.

Keywords: Ethnobotanical survey; Medicinal plants; Traditional medicine; Tizi n'Test region; Morocco

Introduction

Diabetes mellitus is a chronic metabolic disorder of multiple etiologies characterized by hyperglycemia with disturbances of carbohydrate, fat and protein metabolism resulting from defects in insulin secretion, insulin action or both [1]. According to the International Diabetes Federation (IDF) there were 415 million people in the world with diabetes and this is projected to increase to 642 million by 2040 [2]. In Morocco, diabetes mellitus is one of the most common metabolic diseases, there were over 1.4 million cases of diabetes in 2013 [3]. Due to socio-economic and cultural factors, people in rural regions of developing countries exploit a variety of medicinal plants for the effective treatment of various diseases. According to WHO, about 80% of the world's population, essentially in developing countries, depends on medicinal plants to meet their primary healthcare needs [4]. In a survey in eastern Morocco, about 60% of non-insulin-dependent diabetics were found to resort to the use of medicinal plants to treat their disease [5,6]. Furthermore, the diabetes mellitus is one of the most common metabolic diseases in Morocco. Indeed, its prevalence ranges between 10% in rural areas and 13.3% in urban areas.

In Morocco, as much as 50% of the population resides in rural areas where access to modern health care facilities is lacking; furthermore, this access is more difficult if the medium is mountainous. Following these conditions, local people rely more heavily on traditional medicinal plants than on western drug. Morocco is known for its rich vegetation and plant biodiversity [7] and it is also one of the Mediterranean countries with a long medical tradition and ancestral knowhow of herbal medicine [8]. Traditional medicinal plants have several advantages, they are locally available and more easily accessible, there is no evidence of resistance to whole-plant extracts and are frequently considered being less toxic and free from side effects as western drug [9,10].

In several parts of the world, the knowledge of the use of medicinal plants and the procedures applied to their preparation is usually

transmitted from generation to generation by word of mouth rather than in writing, facing extinction if it is not recorded [11]. Also, factors such as migration, the rural exodus, expertise loss due to death of the elderly, acculturation, alteration of physical and biological environments, etc. are causing a rapid loss of traditional knowledge, which would make such studies primordial [12]. Therefore, in this study, we have done a survey of use of antidiabetic plants by Tizi n'test population, in order to contribute to the safeguarding of knowledge and local expertise and, on the other hand, to review the scientific data aiming at correlation between popular use and biological properties of medicinal plants.

Materials and Methods

Study area

The study was carried out in 7 rural communes (Tizi n'Test, Ouneine, Tafingoult, Sidi Ouaziz, Ida-Ougoummad, Tisrass and Ouzioua) who are situated in the southern Moroccan; province of Taroudant. The study area is located at about 90 km North East of Taroudant center. Geographically the area corresponds to the southern slope of the western High Atlas. The study site has 300-700

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mm mean annual rainfall. The Rainfall occurs mainly in autumn and winter. The snow, when it falls, can reach 1 m in high altitude and barely 5 cm in the plain. The average monthly temperatures range from 5.4°C in December and 24°C in July and August. Tizi n' Test region is characterized by a Mediterranean climate and semi-arid bioclimate, with altitudinal variations from 720-3000 masl (Figure 1). The Tizi n' Test region has characteristic vegetation dominated by shrubby and trees plant communities. The region is mountainous with fragile ecosystems where local biodiversity plays an important role in meeting the basic daily needs of the rural peoples inhabiting this region. Agricultural production is a main activity of the people; it is characterized by a moderately diversified production, followed by animal breeding and beekeeping.

Data collection

The ethnobotanical survey was carried out from January 2013 to October 2015, during which we conducted 280 interviews in different localities of the region. The data were collected through semi-structured and structured interviews with people having knowledge of traditional medicine and with traditional healers (called "Achab") living in major cities (Taroudant, Marrakech) around the region, but originally from the region of the study. The people interviewed were either born or had been living in the region for more than 16 years. During the interview, fresh plants, dried pressed plants or plant pictures, were shown to the informants to avoid misunderstandings concerning identification of the plants and to motivate informants to answer questions. The medicinal plants listed in this inventory were only included if they satisfied two criteria: the herbal remedies handed down from oral tradition and only those plant species that could be directly identified and/or collected by the person interviewed are cited in this paper. Interviews were designed to record information about the plants used to treat diabetes mellitus and their local names, methods of preparation, parts of the plant used, administration of medicines and the demographic characteristics of the participants in the study.

A medicinal property was accepted as valid only if it was mentioned by at least five independent interviewees. The interviews and the discussions were held in Berber (Tachelhit), the dialectal language of Tizi n' Test region. The collected plants were identifying by using "Flora of Morocco" [13-15] and voucher specimens of each plant were deposited in herbarium of the laboratory of Biotechnology and Valorization of the Natural Resources, Faculty of Sciences, Ibn Zohr University, and Agadir, Morocco.

Data analysis

The ethnobotanical data generated were analyzed using quantitative indices, namely: Fidelity Level (FL), Use Value (UV), and Relative Frequency of Citation (RFC). This helped to establish a consensus on which species are effective to cure diabetes, as well as the species' relative importance, and enabled us to understand the extent of the potential utilization of each species.

Fidelity Level

FL indicates the percentage of informants claiming the use of a certain plant species for the same major purpose. Fidelity level is calculated by the following formula:

$FL (\%) = N_p / N \times 100$, where N_p is the number of informants that claimed a use of a plant species to treat a particular disease and N is the number of informants that used plants as a medicine to treat any given disease [16].

Use Value (UV)

The UV was calculated by using the following formula: $UV = \sum U/n$; Where U is the number of use reports for a given plant species cited by each informant and n is the total number of informants interviewed for a given plant. The relative importance of plant species used in the traditional medicine can be determined by UV where most frequently cited plant species show a higher UV and plants with lesser citation show a lower UV [17].

Relative Frequency of Citation (RFC)

The RFC index was calculated on the basis of the following formula [18]: $RFC = FC/N$ ($0 < RFC < 1$).

Where FC is the number of informants who mentioned the use of the species and N is the total number of informants.

Results and Discussion

Demographic characteristics of interviewees

A total of 280 informants including traditional healers, herbalists and knowledgeable villagers participated in this study. 167 of respondents are women and 113 are men. 130 individuals depend on herbal medicine alone, 125 individuals use both herbal medicine and modern medicine and 25 people have recourse to modern medicine alone. Most of the local Tizi n' Test people were found to have some knowledge of diabetes mellitus based both on their ability to recognize a number of symptoms characteristic of the disease (such as excessive thirst, body weakness and frequent urination) and also on laboratory or hospital test results. The majority of people have opted for a traditional treatment because of its low cost and being accessible and affordable compared to modern medicine; that reflects the reality that local people have low incomes and therefore resort to traditional medicine that is cheap. Generally women had more knowledge of medicinal species by 65% against 35% for men. In contrast to men, women learn mainly from their mothers and grandmothers through routine observations. Similar findings were also reported in other parts of Morocco [5,19-21] and elsewhere in the world [22,23]. The study showed that the frequency of medicinal plant use increased with age. The people older than 50 years of age have a frequency of use of medicinal plants by 57%, followed by age categories (41 to 50), (31 to 40), (21 to 30) and finally the age of 20 with 18%, 13%, 8% and 4%, respectively. This indicates that ethno-medicinal knowledge is mainly held by the elderly; similar findings were observed in other studies [24,25].

Interestingly, the frequency of use of medicinal plants was inversely related to the level of education of the interviewed population; illiterate: 75%, primary education: 15%, secondary education: 9% and university education: 1%. The youngest respondents and people who studied up to the age of 20 or over were more inclined towards the modern medicines resulting in the loss of valuable herbal-based knowledge. Similar results were found in several studies [5,20,25-27].

Medicinal plants used by the population

The present ethnobotanical survey recorded information on 39 plant species, belonging to 24 families and 38 genera used to treat diabetes. These 39 plant species were cited by at least five separate informants (Table 1). The families with the most reported plant species were Asteraceae with 5 species (12.82%), Lamiaceae with four species (10.25%), Poaceae, Fabaceae and Rosaceae had three species each (7.69%); *Cistaceae* and *Apocynaceae* had two species each (5.13%), other families had 1 species each (2.56%) (Figure 2).

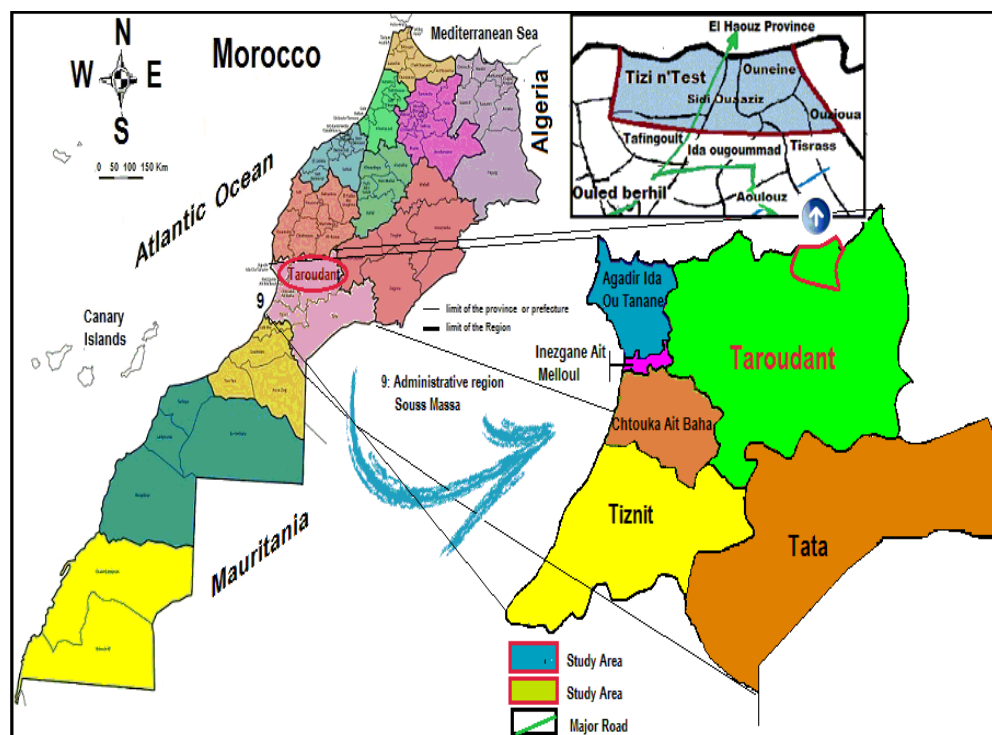


Figure 1: Location of the study area (Tizi n' Test region, North East of Taroudant).

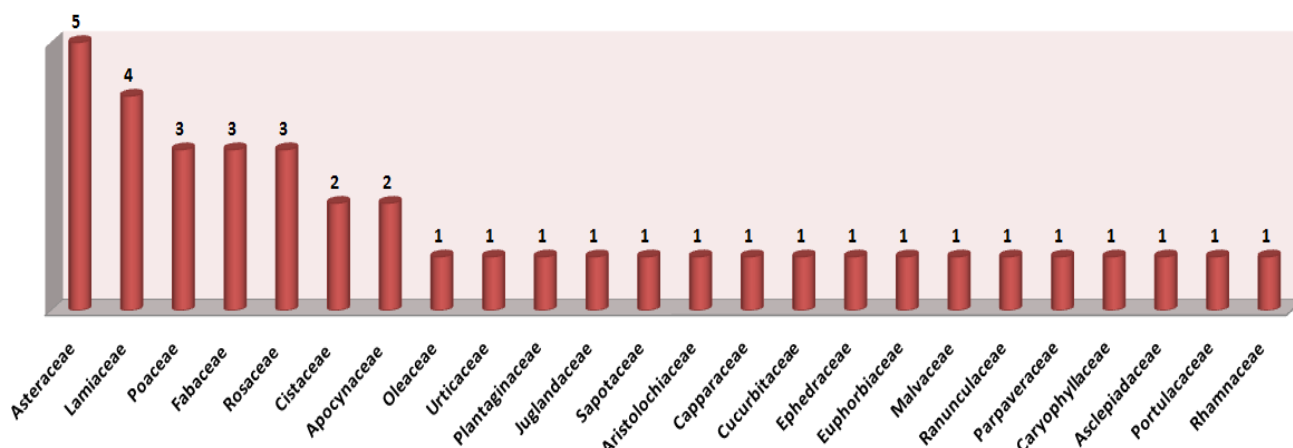


Figure 2: Number of medicinal species per botanical family.

The best two families which are well represented in the study area (Asteraceae and Lamiaceae), are also well distributed throughout Morocco, and also constitute the major groups of medicinal flora in most of other Mediterranean countries [22,28]. Asteraceae and Lamiaceae were also found among the predominant families in western Bengal in India [29]. Most of the families recorded are represented by single or two species which shows that medicinal plants used are not concentrated only in a few families and genera. This agrees with other ethnobotanical studies carried out in Morocco and in Mediterranean area [30-34].

The majority of medicinal plants (69.23%) recorded in this survey were wild species and many species (17.95%) are cultivated in the

Tizi n' Test region (Table 2). The large number of plant species used in the study area indicates a dependence on a great diversity of plant species to treat diabetes mellitus, and represents a good indicator of the profound knowledge on herbal plants held by the local people living in Tizi n' Test region.

The analysis of the biological forms of healing plants used to treat diabetes mellitus in the study area revealed that most of the species were herbs (30.77%), followed by shrubs (25.64%), subshrubs (15.39%), trees and hemicryptophytes (12.82 %) and geophytes (2.56%) (Figure 3). This agrees with another ethnobotanical study carried out in Morocco in which herbs were the most predominant growth form [24]. The most frequently mentioned medicinal plants to treat diabetes

Families and plant species	Vernacular name	Voucher	Used parts	Preparation	Mode of administration	UV	FL	RFC	Literature references
Apocynaceae <i>Caralluma europaea</i> (Guss.) N.E.Br.ssp. <i>maroccana</i> (Hooker f.) Maire.	Aknariy nouzrou/ Oukan	TSO3	Aerial parts	Decoction	Oral	1.28	38.46	0.7	[84]
<i>Nerium oleander</i> L.	Allili/Dafla	TIZ19	Leaf	Decoction	shower bath	1.6	40.48	0.6	[5,6,20,21,24,33,38,53,54,84-86].
Aristolochiaceae <i>Aristolochia baetica</i> L.	Tiswik nigrane / barztame	TIZ21	Root	Powder mixed with honey	Oral	0.96	34.09	0.16	No reference
Asclepiadaceae <i>Periploca laevigata</i> Ait.	Asellif/Lhelab	TAF3	Leaf	Decoction	Oral	0.15	29.41	0.12	[87]
Asteraceae <i>Artemisia herba alba</i> Asso	Izri/Chih	TIZ28	Leafy stem	Infusion/ Tisane	Oral	2.24	77.53	0.99	[5,19,20,33,38,42,51-59,84-86]
<i>Cladanthus scariosus</i> (Ball) Oberpr. & Vogt	Arzgi/irzgi	TIZ32	Flower	Decoction	Oral	0.19	48.15	0.1	No reference
<i>Echinops spinosus</i> L.	Taskra	TIZ35	Root	Decoction	Oral	1.25	21.43	0.15	[6,24,39,84]
<i>Inula viscosa</i> Ait	Tinirine/ Terrhla	TIZ36	Leaf	Decoction	Oral	1.05	37.57	0.62	[21,38,54,84,86]
<i>Scolymus hispanicus</i> L.	Taggdut/ L'gernina	TIZ40	Root	Decoction	Oral	0.21	45	0.14	[6,84]
Capparaceae <i>Capparis spinosa</i> L.	Tayilult/Lkebar	TIZ50	Fruit	Decoction	Oral	2.03	48.46	0.93	[5,6,19,38,54,72,84,87]
Caryophyllaceae <i>Paronychia argentea</i> Lam	Tahidourt n'imksaoum	TON14	Leafy stem	infusion	Oral	0.15	29.03	0.11	No reference
Cistaceae <i>Cistus creticus</i> L.	Ahnako/ Irgel	TIZ56	Leaf	Decoction	Oral	2.05	76.36	0.98	[39]
<i>Cistus Laurifolius</i> L.	Hmiko/ Irgel	TIZ54	Leaf	Decoction	Oral	1.21	39.44	0.64	[63,73,84]
Cucurbitaceae <i>Citrullus colocynthis</i> (L.) Schrader	Aferziz/Lhedja	TSO9	Seed	Decoction	Oral	0.19	22.22	0.06	[5,20,24,33,38,39,42,54,64-66,84,86,87]
Ephedraceae <i>Ephedra fragilis</i> desf	Amater	TIZ64	Leafy stem	Decoction	Oral	1.5	34.27	0.64	No reference
Euphorbiaceae <i>Euphorbia resinifera</i> Berg	Zaqoum	TSO12	Leafy stem	Decoction	Oral	0.11	47.61	0.08	[24]
Fabaceae <i>Glycine max</i> (L.) Merr.	Soja	TIZ69	Seed	powder	Oral	0.46	36.84	0.34	[6,19,24,33]
<i>Lupinus angustifolius</i> L.	Ibaoun dokok	TIZ71	Leaf	Infusion	Oral	0.06	33.33	0.03	[6,84]
<i>Trigonella foenum graecum</i> L.	Tifidas/Lhalba	TAF13	Seed	Decoction	Oral	1.99	49.43	0.62	[5,6,19-21,24,33,38,39,42,45,48-50,52,54,62,84,86]
Juglandaceae <i>Juglans regia</i> L.	Siwak/Grgaa	TIZ78	Leaf	Decoction	Oral	2.01	47.01	0.9	[5,6,60,84,86]
Lamiaceae <i>Ajuga iva</i> (L.) Schreb	Timnra niznkad/ chendgoura	TIZ80	Leafy stem	Decoction	Oral	0.94	36.11	0.64	[5,6,24,33,53,54,70,71,84,86,87]
<i>Lavandula maroccana</i> Murbeck	Iguiz	TON17	Aerial parts	Decoction	Oral	2.21	65.19	0.96	[24,39]
<i>Salvia lavandulifolia</i> Vahl.	Salmiya Tabeldit	TON20	Leaf	Infusion	Oral	2.22	59.32	0.96	[61]
<i>Teucrium polium</i> L.	Tiwrar nizane/Touga nozbar	TIZ88	Aerial parts	Tisane	Oral	1.99	48.3	0.95	[6,39,45,74]
Malvaceae <i>Hibiscus sabdariffa</i> L.	Lkarkadi	TSO21	Leaf	Tisane	Oral	0.06	25	0.03	[63,84]
Oleaceae <i>Olea europaea</i> L.	Zaytoun	TIZ94	Leaf	Decoction	Oral	1.71	51.31	0.95	[5,20,21,24,33,38,39,52,54,62,63,84-86]
Papaveraceae <i>Papaver rhoeas</i> L.	Gawche / Belaamen	TIZ96	Seed	Decoction	Oral	1.98	46.45	0.75	[45,86]
Plantaginaceae <i>Globularia alypum</i> L.	Tasselgha/Ain lerneb	TON23	Leaf	Decoction	Oral	1.46	39.33	0.64	[6,24,38,39,53,54,84,86,87]
Poaceae <i>Avena sterilis</i> L.	Waskone/ Khortal	TON27	Seed	powder	Oral	0.93	39.39	0.59	No reference
<i>Lolium perenne</i> L.	Ezéwane	TON29	Seed	Decoction	Oral	1.01	40.24	0.59	No reference
<i>Zea mays</i> L.	Asngar/Lkbal	TIZ102	Seed	Decoction	Oral	1.15	33.79	0.52	[76,86]

Portulacaceae <i>Portulaca oleracea</i> L.	Errajla /Tafrita	TIZ104	Leafy stem	Decoction	Oral	0.19	31.25	0.11	[6,84,87]
Ranunculaceae <i>Nigella Sativa</i> L.	Sanouj/Haba sawda	TSO25	Seed	Powder with Honey	Oral	1.58	45.4	0.54	[6,54,67,68,84,86]
Rhamnaceae <i>Ziziphus lotus</i> (L.) Lam	Azougar/Sedr- Nbeg	TIZ108	Root	Infusion	Oral	1.97	35.2	0.64	[6,21,24,33,54,75,84,86]
Rosaceae <i>Malus communis</i> L.	Etefah	TIZ110	Fruit	Juice	Oral	1.03	29	0.36	[85]
<i>Prunus dulcis</i> (Miller) D.A.Webb	Loz irzagen/loz Mor	TIZ114	Leaf	Decoction	Oral	1.1	37.02	0.65	[6,20,33,38,84,86]
<i>Rubus ulmifolius</i> (Schott).	Tanajelt	TIZ117	Leaf	Decoction	Oral	1.22	41.08	0.66	[86]
Sapotaceae <i>Argania spinosa</i> (L) Skeels	Argan	TAF19	Leaf	Decoction	Oral	1.2	34.38	0.57	[24,39,47,69,84]
Urticaceae <i>Urtica dioica</i> L.	Tlamtz/Lhryaga	TIZ126	Leaf and Seed	Decoction	Oral	1.98	49.25	0.95	[5,6,38,45,54,84,87]

*: Endemic species of Morocco, **: Endemic species of Morocco, Algeria and the Iberian Peninsula. FL%: Fidelity Level; UV: Use Value; RFC: Relative Frequency of Citation

Table 1: Plants used against diabetes in Tizi n'Test region.

Species	Type of plants	Habit	Species	Type of plants	Habit
1- <i>Ajuga iva</i> (L.) Schreb.	Spontaneous	Hemicryptophyte	21- <i>Lolium perenne</i> L.	Cultivated	Hemicryptophyte
2- <i>Argania spinosa</i> (L.) Skeels.	Spontaneous	Tree	22- <i>Lupinus angustifolius</i> L.	Spontaneous	Herb
3- <i>Aristolochia baetica</i> L.	Spontaneous	Shrub	23- <i>Malus communis</i> L.	Cultivated	Tree
4- <i>Artemisia herba alba</i> .	Spontaneous	Shrub	24- <i>Nerium oleander</i> L.	Spontaneous	Subshrub
5- <i>Avena sterilis</i> L.	Spontaneous	Herb	25- <i>Nigella Sativa</i> L.	Imported	Herb
6- <i>Capparis spinosa</i> L.	Spontaneous	Shrub	26- <i>Olea europaea</i> L.	Cultivated	Tree
7- <i>Caralluma europaea</i> (Guss.) N.E.Br. ssp. maroccana (Hooker f.) Maire.	Spontaneous	Herb	27- <i>Papaver rhoeas</i> L.	Spontaneous	Herb
8- <i>Cistus creticus</i> L.	Spontaneous	Shrub	28- <i>Paronychia argentea</i> Lamk.	Spontaneous	Hemicryptophyte
9- <i>Cistus Laurifolius</i> L.	Spontaneous	Shrub	29- <i>Periploca laevigata</i> Ait.	Spontaneous	Shrub
10- <i>Citrullus colocynthis</i> (L.) Schrader	Imported	Geophyte	30- <i>Portulaca oleracea</i> L.	Spontaneous	Herb
11- <i>Cladanthus scariosus</i> Ball.	Spontaneous	Herb	31- <i>Prunus dulcis</i> (Miller) D.A.Webb.	Cultivated	Tree
12- <i>Echinops spinosus</i> L.	Spontaneous	Hemicryptophyte	32- <i>Rubus ulmifolius</i> (chott).	Spontaneous	Shrub
13- <i>Ephedra fragilis</i> desf.	Spontaneous	Subshrub	33- <i>Salvia lavandulifolia</i> Vahl.	Spontaneous	Shrub
14- <i>Euphorbia resinifera</i> Berg.	Imported	Subshrub	34- <i>Scolymus hispanicus</i> L.	Spontaneous	Hemicryptophyte
15- <i>Globularia alypum</i> L.	Spontaneous	Shrub	35- <i>Teucrium polium</i> L.	Spontaneous	Subshrub
16- <i>Glycine max</i> (L.) Merr.	Imported	Herb	36- <i>Trigonella foenum graecum</i> L.	Cultivated	Herb
17- <i>Hibiscus sabdariffa</i> L.	Imported	Subshrub	37- <i>Urtica dioica</i> L.	Spontaneous	Herb
18- <i>Inula viscosa</i> Ait.	Spontaneous	Herb	38- <i>Zea mays</i> L .	Cultivated	Herb
19- <i>Juglans regia</i> L.	Cultivated	Tree	39- <i>Ziziphus lotus</i> (L.)Lam.	Spontaneous	Subshrub
20- <i>Lavandula maroccana</i> Murbeck L.	Spontaneous	Shrub	-	-	-

Table 2: Type of plants and habit.

are *Artemisia herba-alba*, *Cistus creticus*, *Lavandula maroccana*, *Salvia lavandulifolia*, *Olea europaea* and *Urtica dioica* (Figure 4).

In the Tzi n'Test region, like most regions of Morocco as well as in other countries, a conflict may be established between plant use and resources conservation [35,36]. Some species suffer a high collection pressure with medicinal purposes. These factors combined with an increasing population pressure may lead to further reduction in natural habitats of the medicinal plants. Furthermore, during collection of plants, users tend to uproot the whole plant instead of collecting only the desired parts. This method of collection may seriously compromise the sustainability of medicinal species.

Plant parts used, their preparation and administration

Leaves were the most frequently used plant parts (37.5%), followed by seeds (22.5%), leafy stem (15%), roots (10%), aerial parts (7%), fruits (5%) and flowers (3%) (Figure 5). The use of leaves to treat diseases is based on the fact that leaves are the main photosynthetic organs and constitute the parts relatively most easily accessible and available throughout the year [37]. The results of this study showed that aerial plant parts play an important role in herbal medicine preparation in Tzi n'Test region, agreeing with the results of studies in Morocco [24,38,39] and in other countries [25,26,40-42]. Most preparations were drawn from single plant, but their mixtures were also commonly

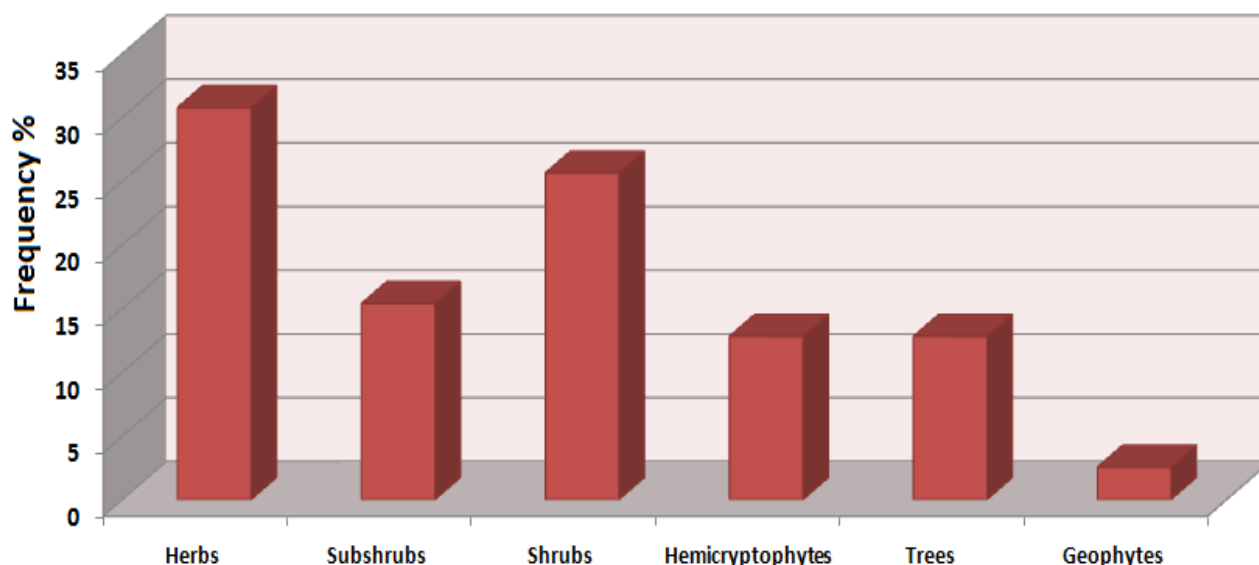


Figure 3: Growth forms (habits) of the reported medicinal plant species used for the treatment of diabetes in the Tizi n' Test region.

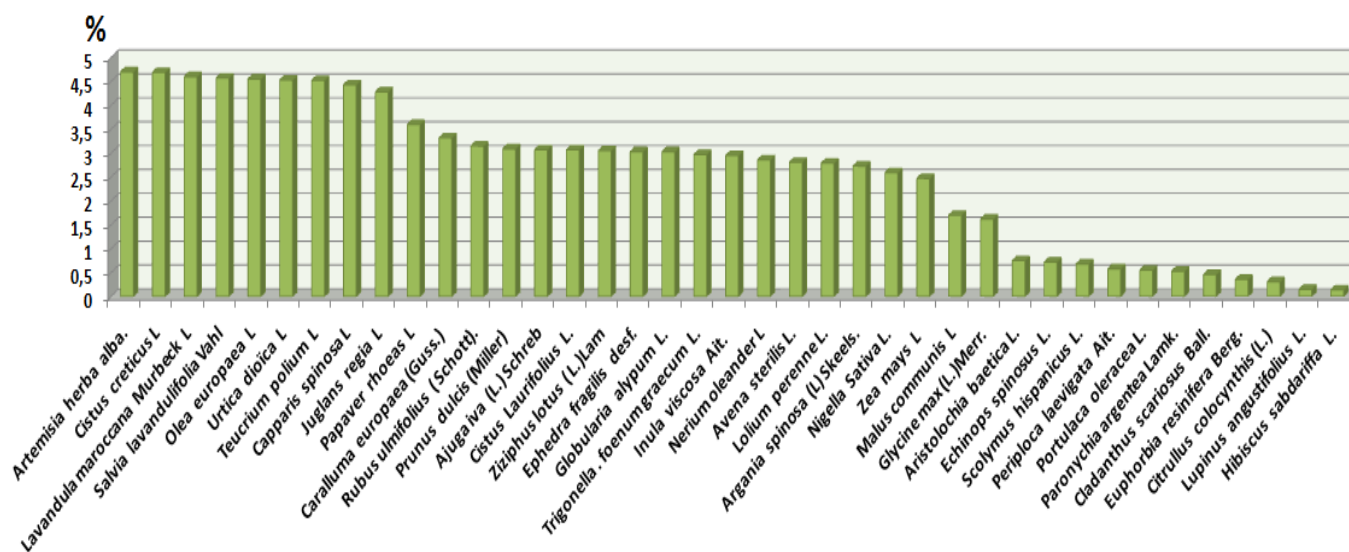


Figure 4: Use frequency of the popular medicinal plants to treat diabetes in the Tizi n' Test region (Taroudant Province).

used. Some remedies contain varying combinations of plant organs. The use of more than one plant species to prepare a remedy to treat diabetes mellitus is attributed to the additive or synergistic effects that they could have [43].

Most preparations are made with water as a solvent. Various plant parts were also mixed with oil, honey, milk or tea for enhancing their acceptability and medicinal properties (for example, powder of *Nigella sativa* mixed with honey). The decoction and infusion were generally the method of choice, accounting for 68.29 and 12.19% respectively, followed by powder preparation (9.76%) (Figure 6). It was also observed that some plants were used in more than one form of preparation. Other less common ways of preparation included juice and tisane. Decoction and infusion were also the most used herbal preparations

in other regions of Morocco and worldwide [5,20,21,26,33,41,44-46]. The great majority of the remedies were taken orally. Decoctions and infusions are usually drunk as teas.

Ethnobotanical indices

FL, UV and RFC values of each species are calculated from the available information. FL indicates the informants choice for a potential plant species to treat a given disease; UV determined most frequently used plant species, whereas RFC determined the most popular medicinal plants accepted by the majority of the informants for treating diabetes. FL, UV and RFC values of collected plants for the selected study area ranges between 21.43% and 77.53%, 0.06 and 2.24, 0.03 and 0.99 respectively (Table 1).

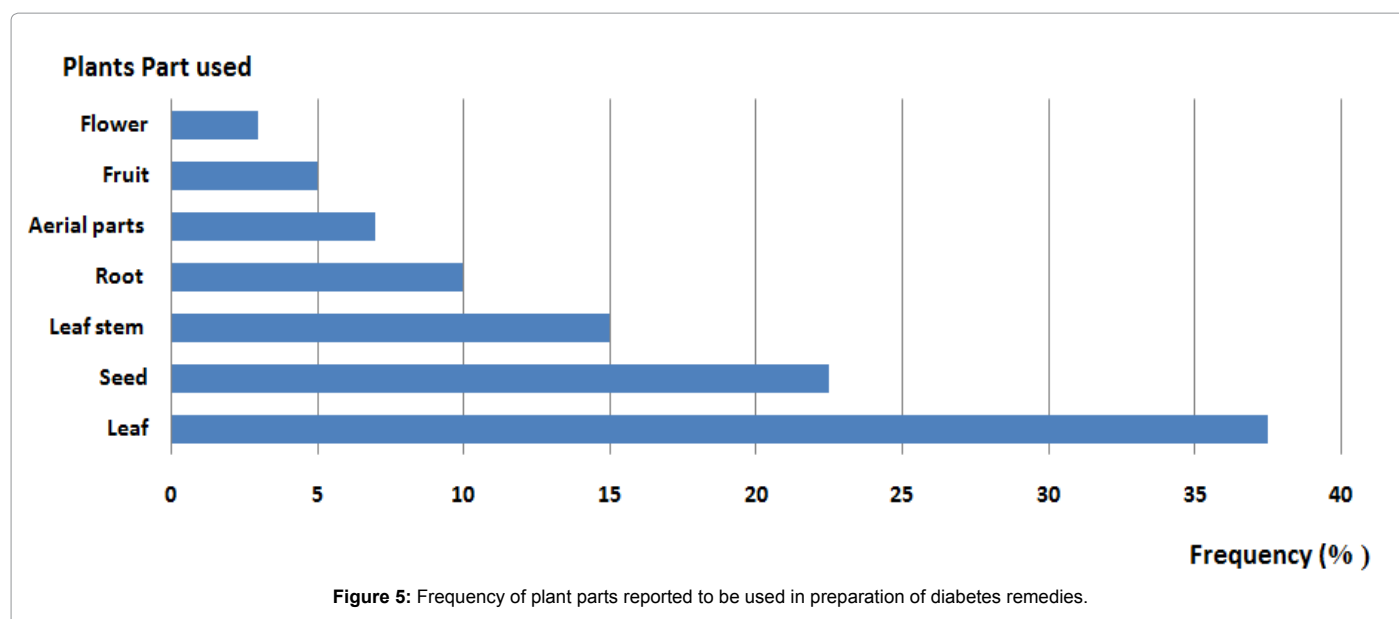


Figure 5: Frequency of plant parts reported to be used in preparation of diabetes remedies.

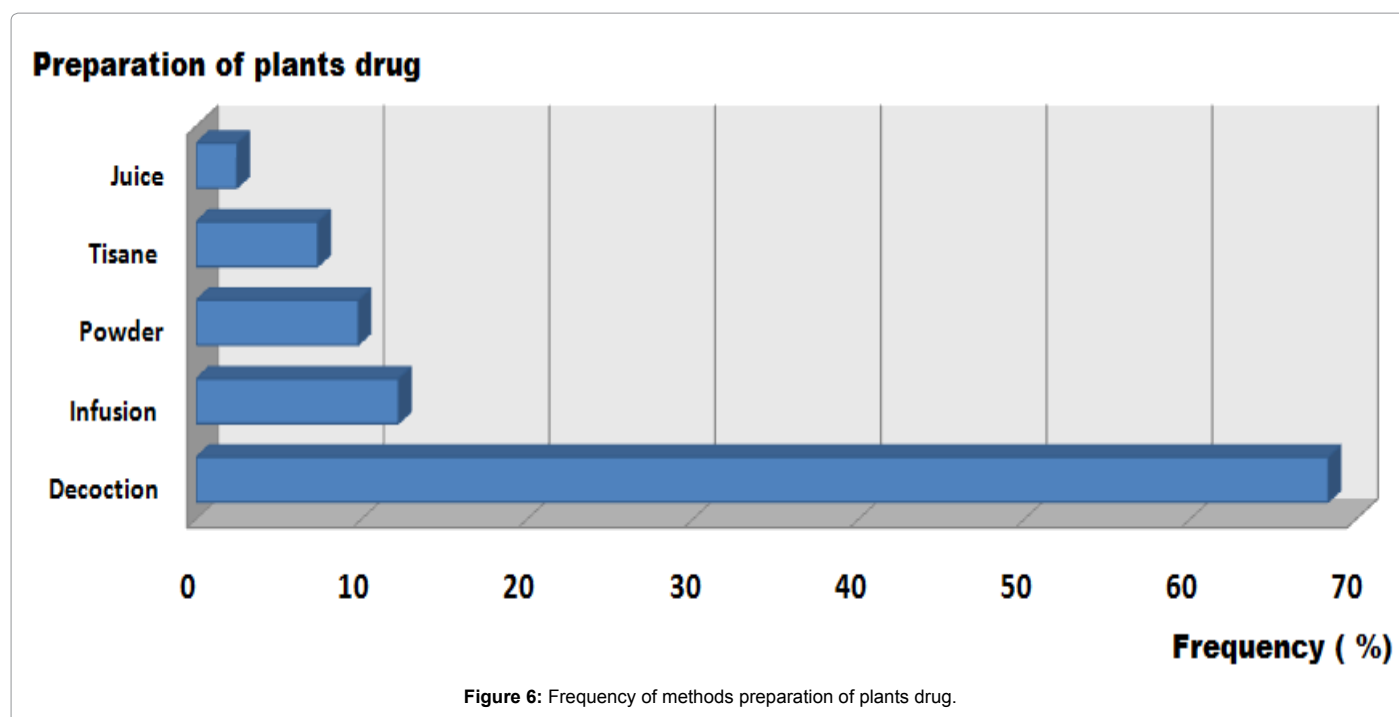


Figure 6: Frequency of methods preparation of plants drug.

To determine culturally important medicinal species in the Tizi n' Test region, FL of plants has been calculated based on use reports which have been cited by five or more informants for being used against diabetes mellitus. Of the 39 inventoried species five plants were identified with FL greater than 50%: *Artemisia herba-alba*, *Cistus creticus*, *Lavandula maroccana*, *Olea europaea* and *Salvia lavandulifolia* (Table 1). Additionally, according to the calculation made on the basis of the UV, *A. herba-alba*, *Cistus creticus*, *Lavandula maroccana*, *Capparis spinosa*, *Juglans regia* and *Salvia lavandulifolia*, showed the highest use value (UV>2) (Table 1). The most frequently used plants to treat diabetes with high RFC (>0.5) include *A. herb-alba*, *Capparis spinosa*, *Cistus creticus*, *Lavandula maroccana*, *Juglans regia*, *Salvia lavandulifolia*, *Olea europaea*, *Teucrium polium*, *Urtica dioica*, etc. In

the obtained results, *Artemisia herba alba*, *Cistus creticus*, *Lavandula maroccana*, *Salvia lavandulifolia*, *Olea europaea* and *Capparis spinosa* shows high values of UV and also possess high RFC. The utilization rates of these plants are higher than for any other plants, indicating the value of these plants to the community of Tizi n' Test region as a medicinal resource.

Additionally, FL indices were high for *Trigonella foenum graecum* (49.43%), *Euphorbia resinifera* (47.61%) and *Urtica dioica* (49.25%) (Table 1).

Our results are similar to those reported in Morocco in other studies [5,19,20,33,47] where *Lavandula* spp., *Artemisia herba alba* and *Trigonella foenum graecum* are also used to treat diabetes mellitus.

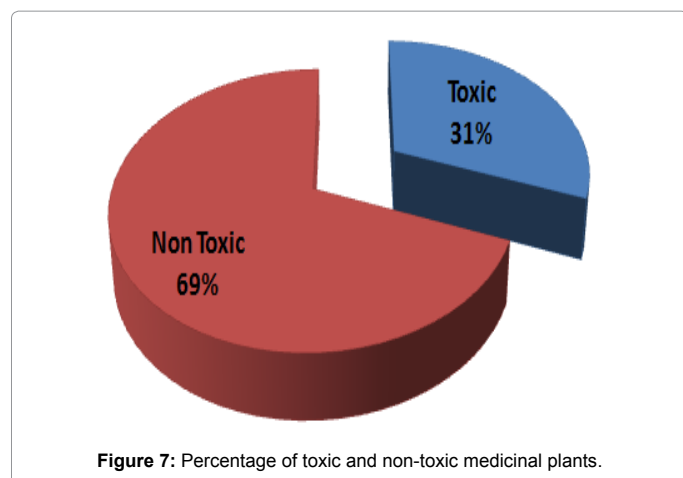


Figure 7: Percentage of toxic and non-toxic medicinal plants.

Recently, *Artemisia herba-alba* and *Trigonella foenum graecum* are also documented as the most frequently used species to treat diabetes in Southeastern Algeria [42].

Most of the plants listed in Table 1 have been validated experimentally through *in vitro* and *in vivo* research for their hypoglycemic activity and support their traditional use in diabetes mellitus control. These species include *Trigonella foenum-graecum* [48-50], *Artemisia herba-alba* [51-69], *Juglans regia* [60], *Lavandula maroccana* [24,39], *Salvia lavandulifolia* [61], *Olea europaea* [21,24,38,39,52,54,62,63], *Citrullus colocynthis* [64-66], *Nigella* [67,68], *Argania spinosa* [47,69], *Ajuga iva* [70,71], *Capparis spinosa* [72], *Cistus laurifolius* [73], *Teucrium polium* [74], *Ziziphus lotus* [75], *Zea mays* [76] and *Hibiscus sabdariffa* [63]. To the best of our knowledge, *Cistus creticus* and *Cladanthus scariosus* are mentioned for the first time for treating diabetes.

Harmful effects of medicinal plants

Through this survey and according to bibliographical data, 31% of the plants used to treat diabetes in the Tizi n'Test region are toxic (Figure 7). Although fortunately, most of the local Tizi n'Test people recognize these toxic plants and are very careful when using it. The main toxic plants in the Tizi n'Test region are *Nerium oleander* [77,78], *Aristolochia baetica* [78], *Citrullus colocynthis* [64,78,79], *Lupinus angustifolius* [80], *Teucrium polium* [78,81], *Nigella sativa* [78,82], *Papaver rhoeas* [83], *Lolium perenne* [78], which are still used in the treatment of diabetes diseases.

Conclusion

Our study showed that medicinal plants continue to play an important role in the primary healthcare system for the local population of the tizi n'Test region, Taroudant Province, southern Morocco. Most people in the region have little economic means to access Western medicine, and still have belief in the efficacy of herbal medicine to treat diabetes. Current study represents a useful documentation, which can contribute to preserving knowledge on the use of medicinal plants in this region. Moreover, protective measures are necessary for the conservation and preservation of the natural herbal resources, to avoid their overexploitation.

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