The use of plants in the traditional treatment of diabetes patients: survey in southern Morocco

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Abstract

This study was conducted in public healthcare establishments in Guelmim city in south of Morocco to report medicinal plants used in folk medicine to treat diabetes. Three hundred sixty-two informants were interviewed through semi structured interviews. The inventory includes scientific, popular and common names of the plants, used parts and method of preparation. The survey shows that 24.6% of the patients use these plants. Twenty-seven medicinal plants belonging to seventeen families were inventoried and three species were cited for the first time in the treatment of diabetes in Morocco. *Olea europea* L., *Artemisia herba-alba* Asso and *Trigonella foenum-graecum* L. are the most plant species used to treat diabetes, and the two most cited families are Lamiaceae (5 species) and Apiaceae (4 species). Leaves represented the most utilized part of plants and decoction was the most cited mode of preparation of drugs. The present study highlights the wide variety of herbal remedies used to treat diabetes and the frequency of this use in diabetic patients.

Keywords: diabetes; ethnobotany; Guelmim city; medicinal plants; survey

Introduction

Diabetes is a serious chronic and metabolic disease that occurs when the pancreas does not produce enough insulin or when the body cannot effectively use the insulin it produces (WHO, 2016). The disease is characterized by elevated levels of blood glucose, which leads over time to serious damage to the heart, blood vessels, eyes, kidneys and nerves (WHO, 2016). According to Shaw *et al*. (2010), the world prevalence of diabetes among adults (aged 20–79 years) will increase to 7.7% by 2030, total number of people with diabetes is projected to rise from 285 million adults, in 2010 to 439 million adults by 2030, and number of adults with diabetes expected to increase 69% by 2030 in developing countries, compared to 20% for developed countries.

In Morocco, a country in the midst of a demographic, nutritional, social and epidemiological transition (Benjelloun, 2002), diabetes has significantly high frequency, with more than one and half million types 2 diabetics in 2010, and would reach 2.5 million by 2030 (Shaw *et al*., 2010). Despite the development of modern medicine, it is still difficult to achieve adequate glycaemic control in many diabetic patients due to the gradual decline in β cell function (Wallace and Matthews, 2000). All existing therapies for the treatment of diabetes, however, have limited efficacy and / or significant side effects (Moller, 2001; Rotenstein *et al*., 2012). The use of drugs and their side effects are of great concern, and most patients have perceived negative side effects of conventional medicine (Ithnain *et al*., 2020). In addition, there is also the need for chronic intake of a large number of drugs for diabetic complications (an average of four per day for each patient) (Enwere *et al*., 2006). Therefore, patients often resort to alternative treatments such as herbal remedies.

Traditional medicine based on the use of medicinal plants for the treatment of many diseases, including diabetes, continues to be used, and in recent years its popularity has only increased. All over the world, studies have shown that many diabetic patients use herbal medicine (Patel *et al*., 2012; Ezuruike and Prieto, 2014; Kamel *et al*., 2017; Hamza *et al*., 2019). Several pharmacological studies have also demonstrated the hypoglycaemic effect of plant extracts justifying their use in traditional medicine, this is for example the case of seeds of *Trigonella foenum-graecum* L. (Mowl *et al*., 2009) or leaves of *Phoenix dactylifera* (Mard *et al*., 2010).

Several studies have been carried out to describe the use of herbal medicine by people with diabetes in Morocco (Ziyyat *et al*., 1997; Jouad *et al*., 2001; Tahraoui *et al*., 2007; Katiri *et al*., 2017). So far, there is no data on the use of plants for the treatments of diabetes in the city of Guelmim. The Province of Guelmim is part of the Guelmim-Oued Noun Region and covers an area of 10,783 km², or 18% of the territory of the region. It is limited to the north by the Tiznit and Ifni Provinces, to the south by the Tan-Tan and Assa-Zag Provinces, to the east by the Tata and Assa-Zag Provinces and to the west by the Atlantic Ocean (figure 1). The Guelmim province constitutes a buffer zone between the Moroccan Sahara and the Souss plain. The proximity to the Atlantic Ocean mitigates the effect of Saharan continentality for the part close to the ocean.

Thus, the aim of this study was to identify the medicinal plants used to treat diabetes by people in public healthcare establishments in Guelmim city.

Materials and Methods

Presentation of the study area

This study was carried out in seven structures of primary health care establishments made up of seven urban health centers 1st level of the city of Guelmim (Figure 1).

Methodology

The study was conducted from February until June 2019 at health centers in Guelmim where 362 diabetic patients were interviewed. All registered diabetics more than age 18 and above and a minimum follow-up of three months at health centers, Guelmim, were eligible for the study.

The data were collected through semi-structured interviews, and subsequently codified and categorized for proper statistical analysis. Interviews were carried according to a three-part questionnaire. The first part includes the profile of the interviewed diabetics (sex, age, family situation, level of study, professional activity and medical background). The second part contains diabetes-related characteristics (type of diabetes, diabetes treatment, medical follow-up), while the third part concerns plants and their uses (reasons for using medicinal plants, vernacular names, mode of preparation and administration and the duration of administration, part used, results of phytotherapy, effects of the drugs used).

Access to information on people with diabetes was obtained following an authorization from the regional health directorate of Guelmim. All participants were made aware that this study is for research

purposes and their participation was voluntary. The patient's consent was obtained before each interview with courteous information regarding the objectives and the nature of the work. The survey respondents have been identified by an anonymous study number corresponding to each of them and information on all participants is kept confidential.

At first, a list of vernacular names of medicinal plants used by this population was created. These plants were identified according to flora of Morocco (Fennane *et al.*, 2007; 2014). Scientific names of plant species were determined according to the Plant List (http://www.theplantlist.org).
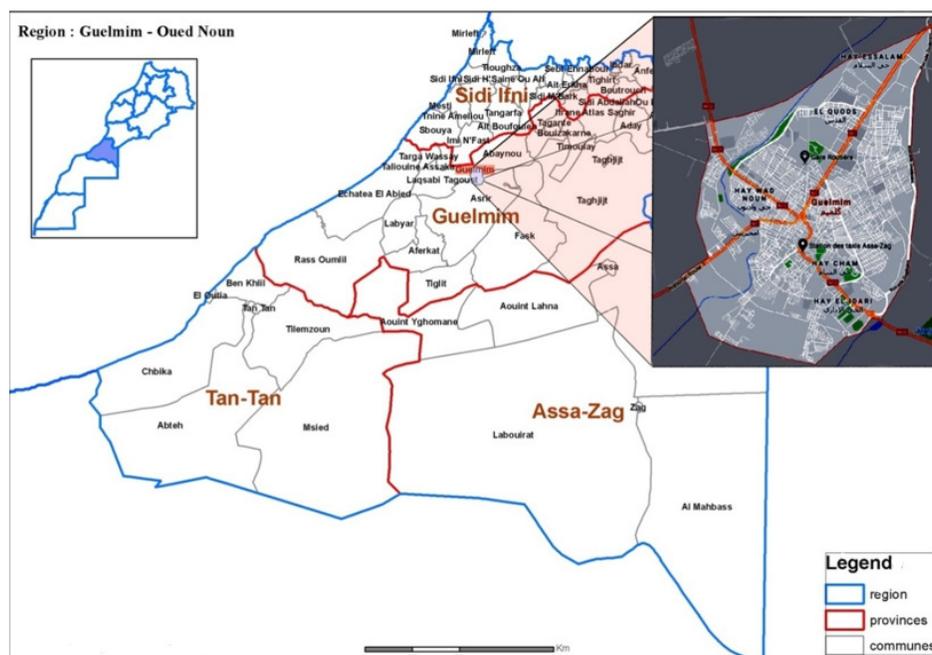

Figure 1. Map of Guelmim province and limit of the study area
Source: High Commission for planning - Regional Directorate of Guelmim

Data analysis

The data reported on the questionnaire were entered and listed on a Microsoft Excel database and Statistical Packages for Social Sciences (SPSS) version 24.0 and analysed to determine the proportions of different variables, the statistical significance was set at $p < 0.05$. Medicinal plants inventoried in this study were organized in alphabetical order by family. The data reported concerned family, scientific name, local name, part used, the utilized method, route of administration, and duration of treatment. These results were analysed using specific quantitative parameters.

In addition, ethnobotanical data was analysed using relative frequency of citation (RFC) to determine the well-known and most used species among diabetic patients. The relative frequency of citation (RFC) shows the local importance of each species and it's obtained by dividing the number of informants mentioning a useful species frequency of citation (FC) by the total number of informants in the survey (N) (Tardío and Pardo-de-Santayana, 2008). This index was calculated by the following formula: RFC = FC/N (0 < RFC < 1).

Results

Socio-demographic characteristics of respondents are shown in Table 1. During our survey, we interviewed 362 diabetic patients from which 60.22% were female and 67.4 were married. The diabetic patients were arbitrarily divided into four age groups: < 38 years, 38-52 years, 53-67 years and > 67 years. Average age is 52.54 ± 15.45 years, and about 80 percent are aged 38 and over. For the educational level, over half of the participants (59.67%) had never been to school and only 7.18% of patients had attended a higher education institution. Among the diabetic patients of the survey, 41.71% had type 1 diabetes, 56.63% had type 2 diabetes and 1.66% had gestational diabetes. They managed their disease in 53.31% with oral hypoglycaemic and in 38.95% with insulin.

Table 1. Socio-demographic characteristics of respondents

Variable	N (%)	Non-users (273) N (%)	Users (89) N (%)	P-value
Age (Mean ± SD)	52.54 ± 15.45 years			
Age group (years)				
< 38	69 (19.06)	56 (20.52)	13 (14.60)	
38-52	104 (28.73)	83 (30.40)	21 (23.60)	0.218
53-67	132 (36.46)	93 (34.06)	39 (43.82)	
67 and above	57 (15.75)	41 (15.02)	16 (17.98)	
Sex				
Female	218 (60.22)	163 (59.71)	55 (61.80)	0.803
Male	144 (39.78)	110 (40.29)	34 (38.20)	
Marital status				
Single	67 (18.51)	52 (19.05)	15 (16.85)	
Married	244 (67.41)	180 (65.93)	64 (71.91)	0.651
Divorced	20 (5.52)	15 (5.49)	5 (5.62)	
Widowed	31 (8.56)	26 (9.53)	5 (5.62)	
Educational level				
Illiterate	216 (59.67)	158 (57.87)	58 (65.17)	
Primary	62 (17.13)	46 (16.85)	16 (17.98)	0.227
Secondary	58 (16.02)	50 (18.32)	8 (8.99)	
University	26 (7.18)	19 (6.96)	7 (7.86)	
Type of diabetes				
Gestational	6 (1.66)	4 (1.47)	2 (2.25)	
Type 1	151 (41.71)	108 (39.56)	43 (48.31)	0.219
Type 2	205 (56.63)	161 (58.97)	44 (49.44)	
Management of diabetes				
Oral hypoglycemic	193 (53.31)	153 (56.04)	40 (44.94)	
Insulin	141 (38.95)	102 (37.36)	39 (43.82)	0.095
Both	25 (6.91)	17 (6.23)	8 (8.99)	
Without	3 (0.83)	1 (0.37)	2 (2.25)	

In this study, 24.6% (55 women and 34 men) of the respondents used herbal medicine to treat their diabetes (Table 1) and 83% of these users consumed herbal and prescribed medicines concurrently (Figure 2). Response by the users showed that experience of others (54%) were the main sources of information on the use of herbal medicine (Figure 3).
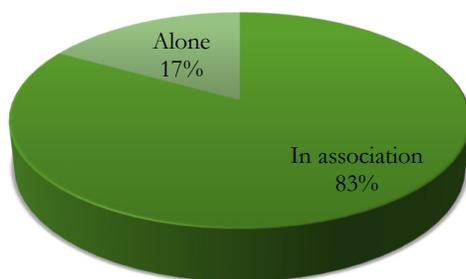
Figure 2. Consumption of plants in association or without allopathic treatment
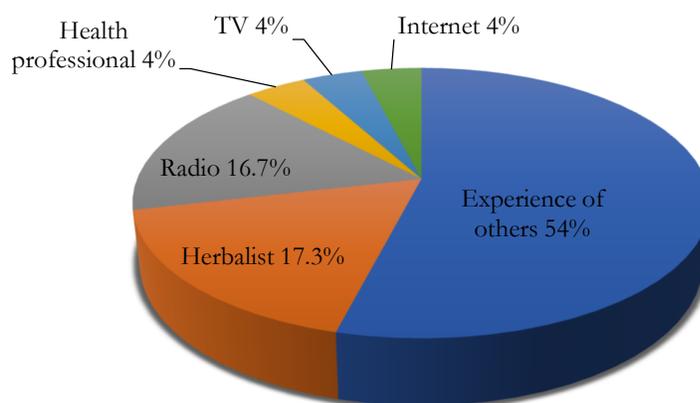

Figure 3. The percentage of information sources

In this study, twenty-seven plants species belonging to 17 families were identified (Figure 4, Table 4). The families with most antidiabetic plants included Lamiaceae (5 species) and Apiaceae (4 species) (Table 4). It was also found that *Olea europaea* L. (22.6%), *Artemisia herba-alba* Asso (16.7%) and *Trigonella foenum-graecum* L. (9.5%) were frequently used by diabetics (Figure 4). From the twenty-seven plant species inventoried, eight were used for diabetes type 1 only, ten plants were used for diabetes type 2 only, and nine plants were used both for type 1 and type 2 diabetes (Table 5). Furthermore, three plants were reported here for the first time as antidiabetic plants (*Saussurea costus* (Falc.) Lipsch., *Aquilaria malaccensis* Lam. and *Nardostachys jatamansi* (D. Don) DC.). The RFC of the encountered plant species varied from 0.21 to 0.01. The highest value of RFC ranked was for *Olea europaea* L. (0.21), followed by *Artemisia herba-alba* Asso (0.16), *Trigonella foenum-graecum* L. (0.09) and *Coriandrum sativum* L. (0.07) (Table 4).

The most used organ parts in present study were leaves (33.7%), seeds (25.8%) and leafy stems (21.3%) (Figure 5). Diabetic patients used different preparation modes such as decoction, infusion or maceration (Figure 6). The most common mode of preparation was decoction (52%). Some plants were used in more than one method of preparation. The oral route of administration (100%) was the only used route by diabetic patients who participated in this survey. The duration of treatment varied considerably from one plant to another and for the same plant. The most common treatment duration was one week (48.31%) followed by one month (32.58%), and lifelong treatment (16.85%).

As a result of treatment, over sixty percent of the patients stated there is an improvement and 25.8% stated they were not (Table 2). Moreover, one or more side effects concurrent with use of medicinal plants were

observed in 17 patients (19%). Thirteen respondents presented gastrointestinal disorders (Gastritis, vomiting, constipation, diarrhea, Epigastralgia…) and three cases presented hypoglycaemia (Table 3).
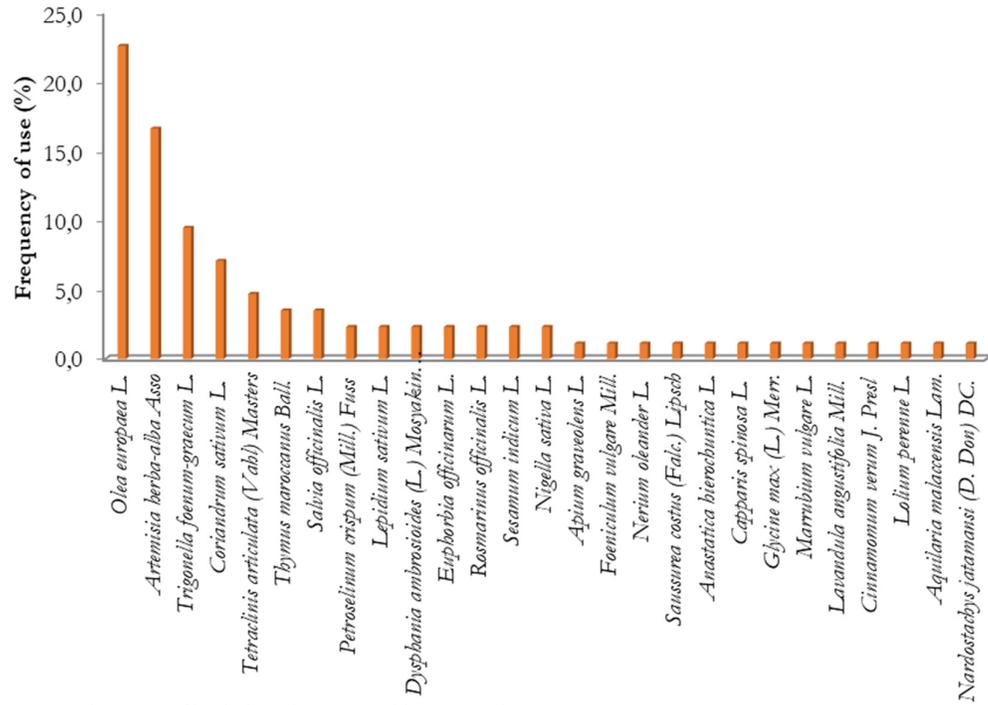

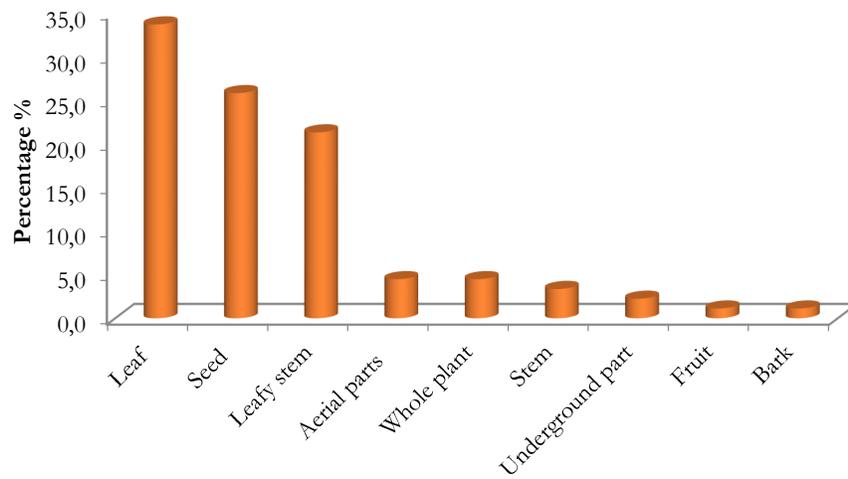**Figure 4.** Types of herbal medicines used by respondents

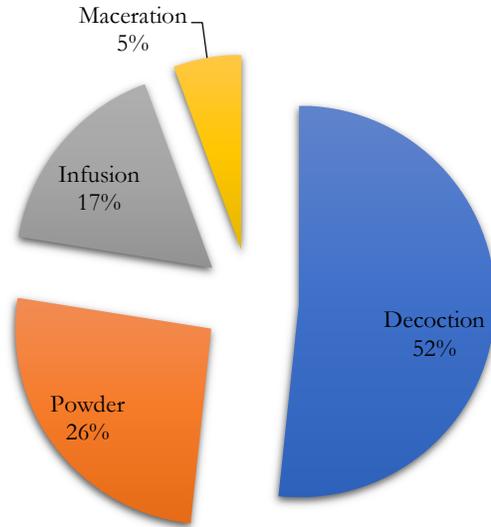**Figure 5.** Percentage of organ parts used for therapy of diabetes

Figure 6. Percentage of preparation methods of plants

Table 2. Treatment result

Variable	Characteristics	Number of patients	Percentage %
Treatment result	Improvement	54	60.7
	No improvement	23	25.8
	Appearance of complications	12	13.5

Table 3. Types of side effects

Variable	Characteristics	Number of patients	Percentage %
Types of side effects	Gastritis	5	27.8
	Hypoglycaemia	3	16.7
	Epigastralgia	2	11.1
	Vomiting	2	11.1
	Constipation	1	5.6
	Diarrhea	1	5.6
	Dyspepsia	1	5.6
	Dizziness	1	5.6
	Arterial hypertension	1	5.6
	Nausea	1	5.6

Table 4. Ethnobotanical remedies for the treatment of diabetes

Family	Plant species	Vernacular name	Part used	Using method	Route of administration	Duration of treatment	Frequency of citation	Relative frequency of citation
Apiaceae	*Coriandrum sativum* L.	Kazbor	Seed	Powder	Orally	Lifelong	6	0.07
Apiaceae	*Apium graveolens* L.	Krafess	Leaf	Infusion	Orally	One month	1	0.01
Apiaceae	*Petroselinum crispum* (Mill.) Fuss	Maadnouss	Leafy stem	Infusion	Orally	One month	2	0.02
Apiaceae	*Foeniculum vulgare* Mill.	Nafaa	Seed	Decoction	Orally	One week	1	0.01
Apocynaceae	*Nerium oleander* L.	Defla	Leaf	Decoction	Orally	One month	1	0.01
Asteraceae	*Artemisia herba-alba* Asso	Chih	Aerial parts, leafy stem and whole plant	Decoction	Orally	One day, one week or one month	14	0.16
Asteraceae	*Saussurea costus* (Falc.) Lipsch.	Qist hindi	Stem	Powder	Orally	Lifelong	1	0.01
Brassicaceae	*Lepidium sativum* L.	Hab rachad	Seed	Powder	Orally	One month	2	0.02
Brassicaceae	*Anastatica hierochuntica* L.	Chajarat Maryem/lkemcha	Whole plant	Infusion	Orally	One month	1	0.01
Capparaceae	*Capparis spinosa* L.	Kabar	Fruit	Decoction	Orally	One month	1	0.01
Chenopodiaceae	*Dysphania ambrosioides* (L.) Mosyakin & Clemants	Mkhinza	Leaf	Infusion	Orally	One week or one month	2	0.02
Cupressaceae	*Tetraclinis articulata* (Vahl) Masters	Arar	Leaf	Maceration	Orally	One day or one month	4	0.04
Euphorbiaceae	*Euphorbia officinarum* L.	Daghmouss	Stem and leaf	Decoction	Orally	One week	2	0.02
Fabaceae	*Trigonella foenum-graecum* L.	Helba	Seed	Powder	Orally	One week, one month or lifelong	8	0.09
Fabaceae	*Glycine max* (L.) Merr.	Soja	Seed	Maceration	Orally	One month	1	0.01
Lamiaceae	*Rosmarinus officinalis* L.	Azir	Aerial parts	Decoction	Orally	One week	2	0.02
Lamiaceae	*Thymus maroccanus* Ball.	Azoukni	Leaf	Decoction	Orally	One week	3	0.03
Lamiaceae	*Marrubium vulgare* L.	Lmerrout	Leaf	Powder	Orally	One month	1	0.01
Lamiaceae	*Lavandula angustifolia* Mill.	Khouzama	Whole plant	Infusion	Orally	One week	1	0.01
Lamiaceae	*Salvia officinalis* L.	Salmiya	Leaf	Infusion	Orally	One week	3	0.03
Lauraceae	*Cinnamomum verum* J. Presl	Karfa	Bark	Decoction	Orally	One week	1	0.01
Oleaceae	*Olea europaea* L.	Zitoun	Leaf and leafy stem	Decoction	Orally	One week, one month or lifelong	19	0.21
Pedaliaceae	*Sesamum indicum* L.	Jenjelan	Seed	Powder and infusion	Orally	One month or lifelong	2	0.02
Poaceae	*Lolium perenne* L.	Zeouan	Seed	Decoction	Orally	One month	1	0.01
Ranunculaceae	*Nigella sativa* L.	Sanouj	Seed	Infusion and decoction	Orally	One week	2	0.02
Thymeleaceae	*Aquilaria malaccensis* Lam.	Tigherst	Stem	Infusion	Orally	One week	1	0.01
Valerianaceae	*Nardostachys jatamansi* (D. Don) DC.	Senbel	Underground part	Infusion	Orally	Lifelong	1	0.01

Table 5. Plants used by patients according to their type 1 or type 2 diabetes diseases

Plants	Type 1 diabetes	Type 2 diabetes
Anastatica hierochuntica L.	-	+
Apium graveolens L.	-	+
Aquilaria malaccensis Lam.	-	+
Artemisia herba-alba Asso	+	+
Capparis spinosa L.	-	+
Dysphania ambrosioides (L.) Mosyakin & Clemants	+	+
Cinnamomum verum J. Presl	-	+
Coriandrum sativum L.	+	+
Euphorbia officinarum L.	+	+
Foeniculum vulgare Mill.	+	-
Glycine max (L.) Merr.	-	+
Lavandula angustifolia Mill.	+	-
Lepidium sativum L.	+	+
Lolium perenne L.	+	-
Marrubium vulgare L.	+	-
Nardostachys jatamansi (D. Don) DC.	+	-
Nerium oleander L.	+	-
Nigella sativa L.	-	+
Olea europaea L.	+	+
Petroselinum crispum (Mill.) Fuss.	-	+
Rosmarinus officinalis L.	+	-
Salvia officinalis L.	+	-
Saussurea costus (Falc.) Lipsch	-	+
Sesamum indicum L.	-	+
Tetraclinis articulata (Vahl) Masters	+	+
Thymus maroccanus Ball.	+	+
Trigonella foenum-graecum L.	+	+

+: used; -: not used

Discussion

Our survey was conducted at health centers in Guelmim City and included 362 diabetic patients. Results revealed that patients with diabetes frequently use medicinal plants to control the disease. Indeed, 24.6% of the respondents used herbal medicine to treat their diabetes and 83% consumed medicinal plants in association with pharmaceutical drugs. This was in accordance with several studies, which reported the interest of diabetic patients in medicinal plants to treat their diabetes in Morocco (Eddouks *et al.*, 2002; Tahraoui *et al.*, 2007; Skalli *et al.*, 2019 ; Alami *et al.*, 2015; Laadim *et al.*, 2017 ; Barkaoui *et al.*, 2017; Katiri *et al.*, 2017; Mrabti *et al.*, 2019; Chetoui *et al.*, 2021) and in other countries (Bell *et al.*, 2006; Otoom *et al.*, 2006; Inanç *et al.*, 2007; Khalaf and Whitford, 2010; Ali-Shtayeh *et al.*, 2012; Ching *et al.*, 2013; Kamel *et al.*, 2017; Mekuria *et al.*, 2018).

Sociodemographic data indicated that more than 80% of diabetic patients who used medicinal plants are aged 38 years and above. Our results are in line with the previous studies conducted in other regions of Morocco (Jouad *et al.*, 2001; Skalli *et al.*, 2019; Barkaoui *et al.*, 2017). According to Skalli *et al.* (2019), older diabetic patients have acquired valuable experience during their life as users of medicinal plants or have learned from the experiences of others.

The distribution by sex showed that women (61.8%) used herbal medicine more often than men, although this is not statistically significant (p= 0.05). In comparison with other Moroccan regions, the more frequent users of plants were women with the respective percentages of 81% (Skalli *et al.*, 2019), 74.5% (Chetoui *et al.*, 2021) and 58.5% (Alami *et al.*, 2015). Similar findings were also reported in elsewhere in the world (Ogbera *et al.*, 2010; Amaeze *et al.*, 2018).

This study showed that illiterate diabetic patients seem to be the more frequent users (59.67 %) of plants for diabetes. This is consistent with findings in other studies (Chetoui *et al.*, 2021; Laadim *et al.*, 2017; Alami *et al.*, 2015; Kpodar *et al.*, 2015; Kadir *et al.*, 2012; Jouad *et al.*, 2001). Contrary, Kumar *et al.* (2006) in India, Kamel *et al.* (2017) in Saudi Arabia and Amaeze *et al.* (2018) in Nigeria indicated that the educational level positively influenced herbal medicine use.

The current study emphasized that the rate of herbal medicine use was high among participants managing their disease with oral hypoglycemic (44.9%) and among those using insulin (43.8%). Previous studies conducted in the Beni Mellal-Khenifra region (Chetoui *et al.*, 2021) and Oriental Morocco (Alami *et al.*, 2015) showed that the rate of herbal medicine use was high among patients taking oral medications alone or treated by both oral hypoglycaemic agents and insulin injection. Patients use herbal medicine to reduce their daily insulin dose (Chetoui *et al.*, 2021) or to potentiate the anti-diabetic activity of the allopathic treatment and thus contribute to the management of their disease (Alami *et al.*, 2015).

This study also found that 83% of the respondents consumed herbal and prescribed medicines concurrently; same comportment has been reported amongst diabetic patients in other studies. Thus, Alami *et al.* (2015) showed in oriental Morocco a significant result of using herbal medicine alongside allopathic treatment among patients treated by both oral hypoglycaemic agents and insulin injection. In Rabat, Skalli *et al.* (2019) reported that 53.6% of the patients' used plants in combination with their conventional treatment. Amaeze *et al.* (2018) in Nigeria indicated that 35.4% of the respondent's consumed herbal in addition with prescribed medicines. According to Suroowan *et al.* (2021), herbal and conventional medicine combination is a potentially dangerous practice leading to perilous Herbal drug interactions and toxicity. In addition, Chelghoum *et al.* (2021) revealed, through several clinical trials, that the anti-diabetic plants had a synergistic effect with oral anti-diabetic agents, which can increase the hypoglycemia of diabetics.

The most used plant families in this study were Lamiaceae, Apiaceae and Asteraceae. This has been confirmed by other studies conducted in different areas of Morocco (Chetoui *et al.*, 2021; Idm'hand *et al.*, 2020; Skalli *et al.*, 2019; Laadim *et al.*, 2017; Katiri *et al.*, 2017; Barkaoui *et al.*, 2017) where diabetic patients mostly use plants belonging to these three families. The richness of Morocco flora by species belonging to these families might explain this wide use. In this study, 27 species were identified and most of them have been validated experimentally in previous research for their hypoglycemic activity (Guex *et al.*, 2019; Boudjelal *et al.*, 2015; Al-Khazraji *et al.*, 1993).

Olea europea L., *Artemisia herba-alba* Asso and *Trigonella foenum-graecum* L. were the most cited herbals. This is consistent with similar studies (Chetoui *et al.*, 2021; Chelghoum *et al.*, 2021; Skalli *et al.*, 2019; Laadim *et al.*, 2017; Telli *et al.*, 2016; Alami *et al.*, 2015; Jouad *et al.*, 2001), in which the most frequent species used were *Trigonella foenum-graecum* L., *Artemisia herba-alba* Asso and *Olea europaea* L.

The antidiabetic effect of *Trigonella foenum-graecum* L., *Artemisia herba-alba* Asso and *Olea europaea* L. have been well documented and reported in both animal and human models (Acar-Tek and Ağagündüz,

2020; Hadi *et al.*, 2020; Al-Attar and Alsalmi, 2019; Geberemeskel *et al.*, 2019; Jiang *et al.*, 2018; Boudjelal *et al.*, 2015; Subramanian and Prasath, 2014; Al-Khazraji *et al.*, 1993).

The comparison with previously literature conducted in different regions of Morocco showed that *Saussurea costus* (Falc.) Lipsch., *Aquilaria malaccensis* Lam. and *Nardostachys grandiflora* were mentioned for the first time in Morocco as hypoglycemic plants. These three plants are known for their medicinal uses and are used in many countries for the treatment of various ailments. *Saussurea costus* (Falc.) Lipsch. is recommended for rheumatism, abdominal pain, anorexia, nausea (Choi *et al.*, 2012) for colds and join paint (Rani and Rana, 2014) for asthma, inflammatory diseases, ulcers and stomach problems (Pandey *et al.*, 2007). *Aquilaria malaccensis* Lam. is commonly used in traditional medicine to relive pain, fever, rheumatism, asthma (Ibrahim *et al.*, 2011), cancer (Bouhaous *et al.*, 2022) and thyroid disorders (Taïbi *et al.*, 2021).

Nardostachys jatamansi (D. Don) DC. has been reported to have many therapeutic activities like antifungal, antimicrobial, antioxidant, hepatoprotective and cardio protective properties. It is used in the treatment of insomnia and CNS disorders. The vasodilator, bronchodilator, spasmolytic and platelet aggregation inhibition activities of the plant have also been reported (Sahu *et al.*, 2016).

However, despite their therapeutic effects and their wide use as antidiabetic, some of the cited plant species (table 4) are toxic and still used in the treatment of diabetes in Guelmim city. The main toxic plants whose toxicity has been proven by several scientific research is *Euphorbia officinarum* L. (Idm'hand *et al.*, 2020; Daoubi *et al.*, 2007), *Nerium oleander* L. (Idm'hand *et al.*, 2020; Al-Yahya *et al.*, 2000), *Artemisia herba-alba* Asso (Idm'hand *et al.*, 2020; Almasad *et al.*, 2007), *Nigella sativa* L. (Idm'hand *et al.*, 2020; Zaoui *et al.*, 2002), *Foeniculum vulgare* Mill. (Al-Hizab *et al.*, 2018), *Trigonella foenum-graecum* L. (Ouzir *et al.*, 2016; Al-Ashban *et al.*, 2010), *Salvia officinalis* L. (Lima *et al.*, 2007) and *Lolium perenne* L. (Rocheleau *et al.*, 2008). According to Idm'hand *et al.* (2020) and Skalli *et al.* (2019), toxicity of plants may be related to a variety of causes including, contamination, adulteration, misidentification and incorrect dosing or use of species. Although fortunately, as reported by diabetic patients in our survey and in previous studies (Skalli *et al.*, 2019; Barkaoui *et al.*, 2017; Katiri *et al.*, 2017; Tahraoui *et al.*, 2007), it seems that diabetic patients are aware of toxicity of these plants and they are very careful when using it.

Relative RFC values obtained from the reported species indicate the degree of indigenous knowledge shared by local people regarding the use of medicinal plants for the treatment of diabetes. The plants having the highest RFC are, in fact, predominantly used and commonly known by the local people. These may prove important for linking and evaluating research for future drug discovery and sustainable use of medicinal plants for the treatment of diabetes.

In our study, plant leaves were the most used plant part by the patients. This could be explained by the availability of leaves as the main photosynthetic organs throughout the year (Yetein *et al.*, 2013) and their richness in therapeutic substances (Skalli *et al.*, 2019; Yetein *et al.*, 2013). The preference for leaves may be linked also to the fact that use of leaves is less damaging to the plant species compared to the use of entire plant or other parts (Zheng and Xing, 2009). This predominance of plant leaves had also been recorded in several studies (Chetoui *et al.*, 2021; Skalli *et al.*, 2019; Barkaoui *et al.*, 2017; Katiri *et al.*, 2017; Gnagne *et al.*, 2017; Kadir *et al.*, 2012), which confirmed the effectiveness and importance of the use of this plant part worldwide.

Regarding the plants noted in our survey, the most common method of preparation used by the patients is decoction. The dominance of this mode of preparation has also been reported by other studies (Chetoui *et al.*, 2021; Barkaoui *et al.*, 2017; Eddouks *et al.*, 2017; Katiri *et al.*, 2017; Gnagne *et al.*, 2017; Hachi *et al.*, 2016; Orch *et al.*, 2015). These results were in disagreement with other works performed in Rabat (Skalli *et al.*, 2019), which showed that the infusion is the most requested mode. The use of decoction to treat diseases might be explained by the fact that the decoction allows collecting the most active substances and reduces or cancels the toxic effect of certain recipes (Salhi *et al.*, 2010).

The plants were mostly consumed by oral way which might be due to easy administration of this mode (Skalli *et al*., 2019) or can be explained by the fact that this pathology is linked to deep organs. This is consistent with the results of others studies (Skalli *et al*., 2019; Gnagne *et al*., 2017). The duration of treatment varied considerably from one day to lifelong treatment. Skalli *et al*., (2019) have also noted this variation. Lifelong use of plants with conventional treatment testifies patient trust in herbal medicine (Skalli *et al*., 2019). Additionally, Jouad *et al*. (2001) reported that patients did not take into account the accumulation of certain constituents in the body after prolonged use of plants, which could cause serious side effects.

Conclusions

This study is the first one on the use of medicinal plants in diabetic patients in the city of Guelmim (Morocco). The findings of the present investigation indicated a low utilization of herbal medicine to treat diabetes in comparison of others areas in Morocco. Over a three quarter of the diabetic patients used herbal medicine alongside allopathic treatment, thus increasing the potential for herb–drug interactions and consequently, therapy failure. The present study highlights the wide variety of herbal remedies used to treat diabetes and the frequency of this use in diabetic patients. In addition, and to our knowledge, three plants (*Saussurea costus* (Falc.) Lipsch., *Aquilaria malaccensis* Lam. and *Nardostachys jatamansi* (D. Don) DC.) were reported for the first time to treat diabetes in Morocco and more of five plants were used in the traditional treatment of diabetes has been proven toxic by several scientific research. Consequently, these results on the medicinal plants used in Guelmim constitute a database for future studies to experimentally assess the potential of these plants. Despite the therapeutic effects of Medicinal plants, they should be used with great caution, since they may have a toxicity risk.

Authors' Contributions

Rachida El Boullani: Conceptualization, Investigation, Writing - Original Draft; Mohamed Barkaoui: Investigation, Writing; Khalid Lagram: Formal analysis; Aissam El Finti: Formal analysis; Nadia Kamel: Investigation, Writing; Abdelhamid El Mousadik: Review & Editing; Mohammed Amine Serghini: Review & Editing; Fouad Msanda: Conceptualization, Methodology, Writing - Review, Supervision. All authors read and approved the final manuscript.

Ethical approval (for researches involving animals or humans)

Before conducting interviews, prior informed consent was obtained from all participants. No further ethics approval was required.

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Conflict of Interests

The authors declare that there are no conflicts of interest related to this article.

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