



## Ethnobotanical Survey of Antidiabetic Medicinal Plants Used by Patients Visiting Health Facilities in the SALÉ Region (Morocco)

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### Abstract

Herbal medicine (HM) is frequently used by diabetic patients in Morocco, although limited information exists about the specific plants used by diabetic patients in the SALÉ region. This study aims to collect a list of plant species used by diabetic patients as traditional remedies. This study is based on an ethnobotanical survey. It was carried out using questionnaires with a sample of 300 diabetic patients visiting the health centres in SALÉ. The results indicate that 93% of type 2 diabetic patients and 7% of type 1 diabetic patients use HM alongside modern medications. Patients justify their use of HM due to its easy accessibility (34.3%), greater efficacy (27.7%), and low cost (27%). The majority (60.3%) are unable to specify the dosage used, and 95.3% are unaware of the toxicity of the plants. This study identified 32 medicinal plant species from 18 botanical families, with the most commonly used plants being *Olea europea* L. (9.3%), *Coriandrum sativum* L. (7.7%), *Trigonella foenum-graecum* L. (7.3%), *Marrubium vulgare* L. (6%), *Lepidium sativum* L., *Lawsonia inermis* L., *Capparis spinosa* L. (5.7%), and *Artemisia absinthium* (5%). The most used plant parts are leaves (40%) and seeds (23.67%); with infusion and decoction being the preferred preparation methods for oral administration. The findings indicate that the SALÉ region has a wide range of HM knowledge for treating diabetes, which needs further scientific study. This knowledge can serve as a foundation for pharmacological studies to assess the antidiabetic effects of these plants.

**Keywords:** Ethnobotanical survey; Herbal medicine; Diabetes mellitus; The SALÉ region; Morocco

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## Introduction

Diabetes mellitus is a multifactorial metabolic disorder characterized by chronic hyperglycemia due to insufficient insulin secretion, insulin resistance, or a combination of these factors [1]. It is considered one of the most common diseases of the 21<sup>st</sup> century. This disease is increasing at an alarming rate worldwide. The anticipated prevalence of diabetes among people aged 20 to 79 years will increase to 12.2% (783.2 million people) in 2045 [2,3]. The prevalence of diabetes is significantly rising across the Middle East and North Africa regions. Recording the highest rate of increase in diabetic patients, with about 73 million diabetic patients aged 20-79 years in 2021; this number is expected to reach 135.7 million by 2045. Morocco is no exception, as it is estimated that there are more than 2.327 million diabetic adults aged 20-79, representing 9.7% of the adult population [4]. This prevalence represents a major public health problem. The disease is associated with the development of serious long-term complications, including cardiovascular disease, chronic kidney disease, and retinal damage [5]. Furthermore, the inaccessibility of some communities to health facilities limits medical management of diabetes and the fear that such drug treatments may be harmful to patients despite their apparent safety, as well as the high costs of these conventional treatments direct diabetics to herbal remedies [6]. These traditional therapies with unknown chemical compositions and pharmacological properties are increasingly being offered to diabetics. It is therefore essential for scientists to carry out ethnobotanical, phytochemical and pharmacological studies to validate the therapeutic virtues attributed to these preparations [7]. The practice of herbal healing is well-ingrained in Moroccan culture [8]. Many medicinal plants have been identified for the treatment of various illnesses, and Moroccan culture heavily incorporates ethnomedicine [7]. In modern society, based on this longstanding tradition, medicinal plants are still in use today and is crucial to maintaining current public health [9].

In Morocco, several studies have been conducted in different regions to describe the local pharmacopoeia [10-12]. Therefore, this work is a complement to the first work that our team carried out in the Ksar El Kebir city of Tangier-Tetouan-Al Hoceima region [13] to determine the plants recommended in traditional medicine of diabetes in this region. In addition, the present study was initiated to catalogue plants with therapeutic properties that are used to treat diabetes (especially type 2) in the SALÉ area. This survey also allowed us to investigate the specifics of diabetics and how they feel about using herbal remedies, as until now, no scientific survey has been carried out in this region, which is one of the regions of Morocco where knowledge of herbal medicine is highly developed.

## Study Area Description

SALÉ is a city in Morocco's Northwest (34° 1' 54.476"

North 6° 46' 17.494 "West, at 34 m altitude) (GPS-longitude-latitude 2023). It has a surface area of 150.45 km<sup>2</sup>, and its proximity to the Atlantic and the Mediterranean, respectively 30 and 90 km, resulting in a Mediterranean climate with influences from the Atlantic. High temperatures characterize the summer season which is partly compensated for by the oceanic influence. SALÉ is among the most populated cities in Morocco, at the time of the 2019 census it had 1,074,734 inhabitants (census 2019) [14].

## Materials and Methods

### *Ethnobotanical survey*

Before going out into the field to conduct the ethnobotanical study properly, we wrote to the health authorities and obtained permission from the public health and local authorities, the questionnaires were optional, and the privacy of the patients was safeguarded by not collecting any of their personal data. The procedures followed were in accordance with the ethical standards of the competent Commission on Human Experimentation and with the principles of the declaration of Helsinki. Written informed consent was obtained from all participants and authorization from the ethics committee of the CED (Center for Doctoral Studies-FSK) of the Faculty of Sciences of Kenitra and the local Ethics Committee of the Ministry of Health in Rabat gave its approval to the ethnobotanical study which constitutes a component of our thesis work (protocol code 1059/1412 from 01/03/2019). Then, we proceeded to locate the various survey sites in the study area. Then surveys, based on direct questioning about the uses of antidiabetic plants, were conducted among patients visiting the health centers in the city of SALÉ. The medical collaboration made it possible to determine the precise pathology of each patient. Before the start of the interview, all patients interviewed were informed of the purpose of this study, and they all provided their cooperation voluntarily and without being compensated. To have an ethnobotanical inventory that varied from one area to another in the study area and was as complete as possible, the survey was carried out using a survey form or questionnaire to ensure a high degree of objectivity of the data obtained from our study.

This ethnobotanical survey was carried out in different areas of the city of SALÉ including the following health centers: Cheikh Lamfadel, Hay Salam I and II, Hay Rahma, Tabriquet, Laayayda I and II, Said Hajji, Sidi Moussa, Bab Lakhmiss, Pépinière, Bettana, My Ismail, Al Karia, Sala Al Jadida I and II (Figure 1).

Ethnobotanical information was obtained from 300 patients with diabetes mellitus who reported using or having used medicinal plants to treat their diabetes. Interviews served as the primary approach for gathering data, and questions were translated into the local tongue (Darija). The samples were identified and verified before the floristic list was created, and the botanical names of the plants were chosen in cooperation with the botany professors

(Faculty of Sciences, Ibn Tofail University in Kenitra) and Prof. Fekhaoui of the Scientific Institute of Rabat, following that of the Angiosperm Phylogeny Group's fourth revision of its angiosperm botanical classification [15] and the scientific names have been determined according to the world flora online (<http://www.worldfloraonline.org>) [16]. The mentioned plant species were acquired from local herbalists in SALÉ city, and typical specimens of each plant were deposited in the herbariums of the Kenitra Faculty of Sciences and the Scientific Institute in Rabat under voucher numbers from (HSIF-SKNR01/22) to (HSIFSKNR32/22). This information's given in table 2.

The following criteria were listed on the survey form:

- Patients' names along with information about their age, education level, weight, gender, diabetes type, degree of physical activity, socioeconomic status, length of illness, and current treatments.
- Source of supply of their traditional remedies (Pharmacist, 'Achab' (herbalist), other experience (insider) or 'fkih' (traditional healer)).
- Justifications offered for employing therapeutic herbs (more efficient, cheaper, or simple to acquire).
- Accuracy of doses (precise, not precise, not very precise, or sometimes precise).
- Their understanding of toxic plants.
- Recipes such as the vernacular name of the plant, the part used (leaves, fruits, flowers, root, seed, etc.), the quantity, and the effects observed.
- Preparation process, administration, length of treatment

and safety measures.

- The results of their herbal medicine (good, average, or variable).
- Finally, patients are asked about their attitude towards herbal medicine and the medicines used.

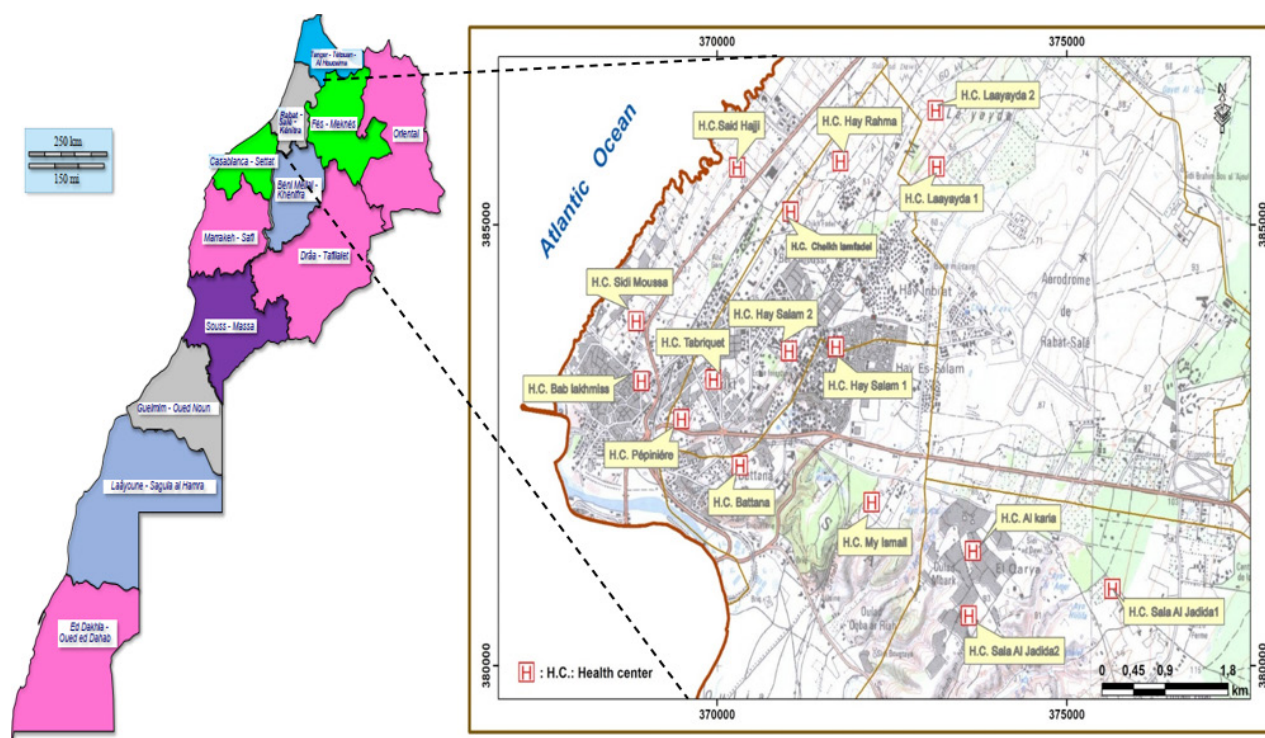
### Data analysis

The responses to the questionnaire were recorded in a Microsoft Excel database, and IBM SPSS statistics version 21 was used to analyze the data to determine the proportions of the various variables. This information was analyzed using the relative frequency of citation (RFC) calculation, which reflects the regularity of a species' distribution within the community;  $RFC = (n/N) \times 100$  ( $0 < RFC < 1$ ), where:  $n$  = number of people who cited the species,  $N$  = total number of respondents, RFC: Relative Frequency of citation [17].

## Results

### Description of the diabetic population

The survey's diabetic participants ranged in age from 26 to 86 years. Regarding educational level, most of them are illiterate. The population studied in this investigation ranges in weight from 46 kg to 120 kg and more than half of the participants weighed more than 70 kg. Feedback from diabetics who were asked about the type of diabetes they suffered from allowed us to identify that most of them suffered from type 2 diabetes and some of whom do not know the type of diabetes they suffer from but deter-



**Figure 1.** Location map of the ethnobotanical survey sites

mined by the prescriptions and medications used by these patients. Most of them do not engage in regular physical exercise. In this study, there were no diabetics from a higher socioeconomic class, and the period of the disease varies greatly (Table 1).

Regarding the treatment currently used by the patients surveyed, we found that the majority of patients use oral hypoglycemic drugs to reduce high blood sugar; while others use insulin therapy. Knowledge of other diabetics is the main source of traditional medicine for our population. In addition, about one-third of the study population uses or has used herbal remedies to treat diabetes, considering these remedies easy to obtain and low cost and believing them to be more effective than modern drugs. However, they use medicinal plants in inaccurate doses; while some use accurate doses of traditional medicine, but most of them do not know anything about poisonous plants (Table 1).

### *The recipe as a traditional remedy*

#### *Medicinal plants used in the treatment of diabetes*

The ethnopharmacological information supported the variety of medicinal plants employed for treating hyperglycemia in the SALÉ territory. Table 2 illustrates a summary of plants by family and details about each plant (scientific name, vernacular name, part used, method of preparation, and their relative frequency of citation (RFC).

Ethnopharmacological data obtained from diabetic patients led to the identification of 32 plants used in the traditional treatment of diabetes mellitus, belonging to 19 different families. The most represented family was Lamiaceae with nine species, followed by Apiaceae with three species. Lythraceae, Amaryllidaceae, Myrtaceae each had two species, while the other families were represented by only one plant species. Among the identified plants, *Olea europaea* L. had the highest relative frequency of citation (RFC) at 9.3%, followed by *Coriandrum sativum* L. (RFC: 7.7%), and *Trigonella foenum-graecum* L. (RFC: 7.3%). Other commonly cited plants include *Marrubium vulgare* L., *Lepidium sativum* L., *Lawsonia inermis* L., *Capparis spinosa* L. and *Artemisia absinthium* L. (RFC: 5% to 5.7%) (Table 2, Figure 2).

#### *Parts of the plants used*

For the parts of the plants used for the preparation of antidiabetic recipes in the SALÉ region, the results indicate that leaves were used in the majority (40%), followed by seeds (23.67%), fruits (9.33%), whole plants (8.33%), bulbs and flowers (5.67%), peels (3%), barks (2.67%) and rackets (1.67%) (Figure 3).

#### *Preparation techniques*

To facilitate the administration of drugs, several preparation techniques are used. So, our survey showed that infusion was the main mode of preparation of medicinal

plants used in the treatment of diabetes followed by decoction, crude form, juice, maceration and powder (Figure 4).

#### *Route of administration*

The oral route is the only route of administration of antidiabetic medicinal plants.

#### *Attitude towards therapy and medication*

According to the diabetics involved in this study, the results of the therapy are not uniform; thus, some patients think that the therapy has a good result (6.33%), others say that the result of the therapy is variable (28%) and environ half (55.67%) of the patients find the therapy have an average result (Figure 5). Regarding the attitude towards medication, all diabetics involved in the study are satisfied with the use of medication for the treatment of diabetes mellitus.

### **Discussion**

The ethnobotanical survey was conducted in the health centers of the SALÉ city, on a sample of 300 diabetic patients, mostly elderly, most of whom were women (Table 1). Older individuals were considered more reliable sources of information due to their possession of ancestral knowledge passed down orally, although this knowledge transmission is currently at risk [18]. A similar study revealed that over 80% of diabetic patients using medicinal plants were aged 38 years and older [19]. Additionally, another study indicated that the age group most affected by diabetes falls between 50 and 60 years [13]. These findings align with national data and are consistent with other studies conducted in various regions of Morocco, which have reported that the majority of diabetic patients with a preference for medicinal plants tend to be illiterate or have a primary school level education and belong to lower socioeconomic backgrounds [13,19-21].

The rise of high-calorie diets, sedentary lifestyles, and urbanization have established obesity as a significant risk factor for type 2 diabetes mellitus and/or metabolic syndrome [22]. In this study, more than half of the participants weighed more than 70 kg; while similar surveys reported the most common weight range as being between 60 and 80 kg [23], and another showed that the average weight is 67 kg [24]. When collecting responses from diabetics about the type of diabetes they have, we found that most of the population surveyed had type 2 diabetes. On the other hand, similar studies have shown that among the diabetic patients in the survey, 72.58% had type 1 diabetes and 27.42% had type 2 diabetes in the town of Sidi Slimane (northwestern Morocco)[23], 41.71% had type 1 diabetes and 56.63% had type 2 diabetes in Guelmim city in south of Morocco [19]. The distribution of women exceeds that of men in the population studied, which is consistent with other studies in different Moroccan regions, where women were predominantly represented [19,21,23-25].



**Table 1.** Sociodemographic profiles and information on the diabetic patients interviewed

Variables	Category	Number	Percentage (%)
Age (Years)	< 40	54	18,00
	40 – 59	130	43,30
	60 – 79	88	29,30
	80+	28	09,30
	U	14	04,60
Study level	SQ	39	13,00
	SC	69	23,00
	P	84	28,00
	I	94	31,30
	< 50	14	03,20
Weight	50 – 59	27	06,30
	60 – 69	133	30,80
	70 – 79	142	32,90
	80+	116	26,90
	I	21	07,00
Type of diabetes	II	279	93,00
	F	160	53,30
Gender	M	140	46,70
	No	215	71,70
Physical activity	Yes	85	28,30
	Low	226	75,30
Socio-economic level	Medium	74	24,70
	High	0	00,00
	< 1 year	21	07,00
Duration of illness	2 - 6 years	92	30,70
	7 - 11 years	80	26,70
Treatment currently used	12 - 16 years	12	04,00
	17 - 21 years	68	22,70
	> 21 years	27	09,00
	insulin therapy	17	05,70
	(11%)		
	Insulatard (Biogenetic human insulin)	11	03,70
	Actrapid (Biogenetic human insulin)	5	01,70
	Mixtard (Biogenetic human insulin)	61	20,30
	Diamicron (Gliclazid)	31	10,30
	Geprid (Glimepiride)	9	03,00
Source of supply of traditional remedies	Oral antidiabetics (89%)	137	45,70
	Ado (Metformine)	5	01,70
	Acol (Metformine)	24	08,00
	Stagid (Metformine)	163	54,30
	Experiences of others	104	34,70
	Herbalist	20	06,70
Reasons for using medicinal plants	Fkih	13	04,30
	Pharmacist	103	34,30
	Easy acquisition	81	27,00
	Less expensive	83	27,70
Accuracy of doses	More efficient	33	11,00
	Others	181	60,30
	not precise	77	25,70
Knowledge of poisonous plants	inaccurate or sometimes precis	42	14,00
	Precise	286	95,30
	No	14	04,70
	Yes		

Note: U: University; SQ: Qualifying secondary; SC: College secondary; P: primary; I: illiteracy; I: Type 1 diabetes; II: Type 2 diabetes; F: Female; M: Male; Nr.: number; %: percentage.

**Table 2.** Antidiabetic medicinal plants used by the population of the SALÉ city

N°	Family Name	Specie name (Voucher number)	Local name	Part Used	Mode of Preparation	RFC (%)
1		<i>Marrubium vulgare</i> L. (HSIFSKNR01/22)	Marriwta	Leaves	Decoction	6,0
2		<i>Ajuga iva</i> L. (HSIFSKNR02/22)	Chand-goura	Whole plant	Decoction	3,7
3	Lamiaceae	<i>Lavandula multifida</i> L. (HSIFSKNR03/22)	Lhalhal	Flowers	Infusion	2,3
4		<i>Origanum syriacum</i> L. (HSIFSKNR04/22)	Zaater	Leaves	Infusion, raw	2,3
5		<i>Lavandula angustifolia</i> Mill. (HSIFSKNR05/22)	Lakhza-ma	Whole plant	Infusion	2,0
6		<i>Mentha spicata</i> L. (HSIFSKNR06/22)	Naanaa	Leaves	Infusion	,3
7	Apiaceae	<i>Salvia officinalis</i> L. (HSIFSKNR07/22)	Salmiya	Leaves	Decoction	1,3
8		<i>Rosmarinus officinalis</i> L. (HSIFSKNR08/22)	Azir	Leaves	Decoction	1,0
9		<i>Mentha pulegium</i> L. (HSIFSKNR09/22)	Fliou	Leaves	Decoction	2,0
10		<i>Coriandrum sativum</i> L. (HSIFSKNR10/22)	Kezbour	Seeds	Decoction, infusion	7,7
11		<i>Petroselinum crispum</i> Mill. (HSIFSKNR11/22)	Maad-nouss	Leaves	Infusion	1,7
12		<i>Pimpinella anisum</i> L. (HSIFSKNR12/22)	Hbbat hlawa	Seeds	Decoction	1,0
13	Lythraceae	<i>Punica granatum</i> L. (HSIFSKNR14/22)	Romman	Peels	Infusion!	3,0
14		<i>Lawsonia inermis</i> L. (HSIFSKNR15/22)	Lhanna	Leaves	Infusion	5,7
15	Amaryllidaceae	<i>Allium sativum</i> L. (HSIFSKNR16/22)	Touma	Bulbs	Raw	4,3
16		<i>Allium cepa</i> L. (HSIFSKNR17/22)	Lbasla	Bulbs	Juice, raw	1,3
17	Myrtaceae	<i>Eucalyptus globulus</i> L. (HSIFSKNR18/22)	Kalitouss	Leaves	Decoction	3,0
18		<i>Myrtus communis</i> L. (HSIFSKNR19/22)	Arrayhan	Leaves	Infusion	1,3
19	Ranunculaceae	<i>Nigella sativa</i> L. (HSIFSKNR20/22)	Sanouj	Seeds	Infusion, powder	1,7
20	Cactaceae	<i>Opuntia ficus indica</i> L. (HSIFSKNR 20/22)	Lhandiya	Rackets	Decoction	1,7
21	Lauraceae	<i>Laurus cinnamomum</i> L. (HSIFSKNR21/22)	Lkarfa	Barks	Decoction	2,7
22	Oleaceae	<i>Olea europea</i> L. (HSIFSKNR22/22)	Zaitoun	Leaves	Decoction, raw	9,3
23	Asteraceae	<i>Artemisia absinthium</i> L. (HSIFSKNR23/22)	Chiba	Leaves	Infusion	5,0
24	Fagaceae	<i>Quercus</i> L. (HSIFSKNR24/22)	Ballout	Fruit	Juice, raw	4,0
25	Capparaceae	<i>Capparis spinosa</i> L. (HSIFSKNR25/22)	Lkabbar	flowers	Infusion	5,7
26	Fabaceae	<i>Trigonella foenum-graecum</i> L. (HSIFSKNR26/22)	Lhalba	Seeds	Decoction, powder	7,3
27	Schisandraceae	<i>Illicium verum</i> Hook. (HSIFSKNR27/22)	Badiana	Fruit	Decoction	4,3
28	Cucurbitaceae	<i>Cucurbita pepo</i> L. (HSIFSKNR28/22)	Garaa	Fruit	Juice, cooked	0,7
29	Geraniaceae	<i>Geranium robertianum</i> L. (HSIFSKNR29/22)	Laattercha	Leaves	Decoction	0,7
30	Urticaceae	<i>Urtica dioica</i> L. (HSIFSKNR30/22)	Lharriga	Leaves	Decoction	0,7
31	Nitrariaceae	<i>Peganum harmala</i> L. (HSIFSKNR31/22)	Lharmal	Seeds	Infusion	0,3
32	Brassicaceae	<i>Lepidium sativum</i> L. (HSIFSKNR32/22)	Habb Rchad	Seeds	Infusion, decoction	5,7

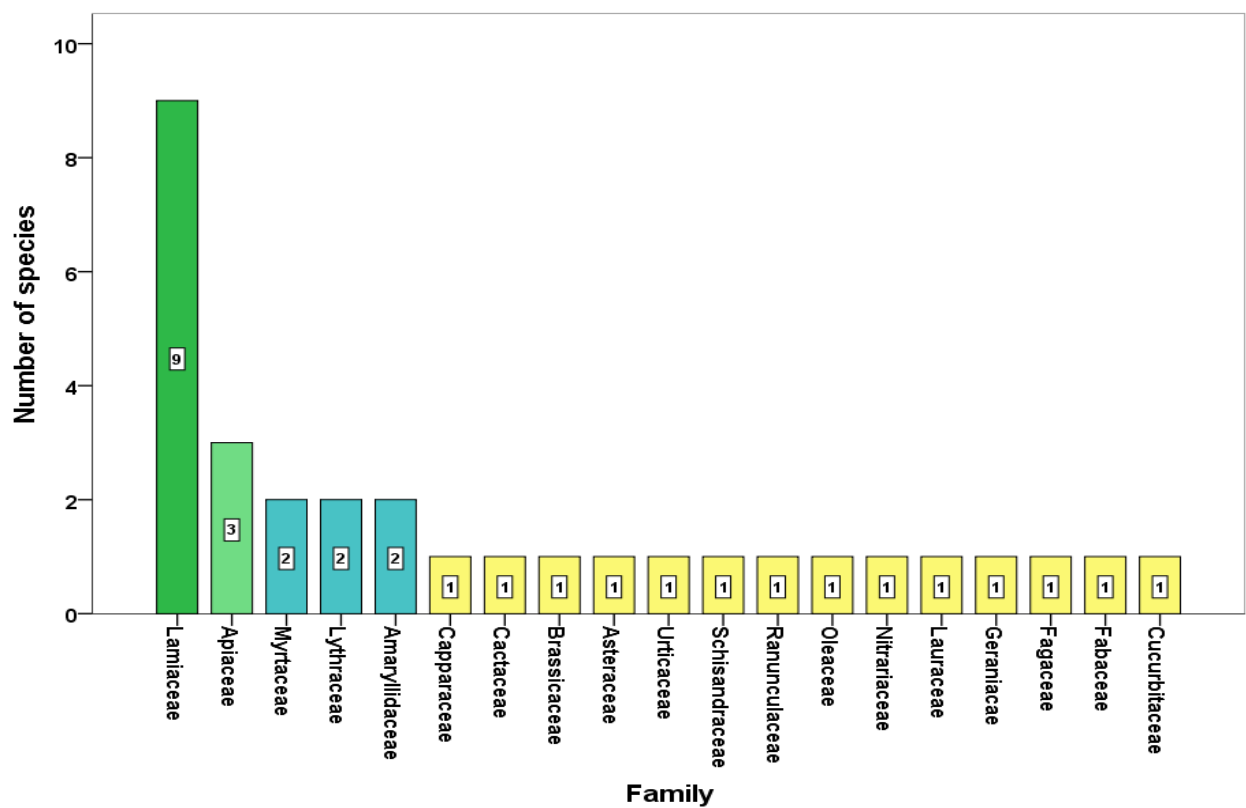


Figure 2. The number of species in each family of medicinal plants reported by diabetic patients in the SALÉ region

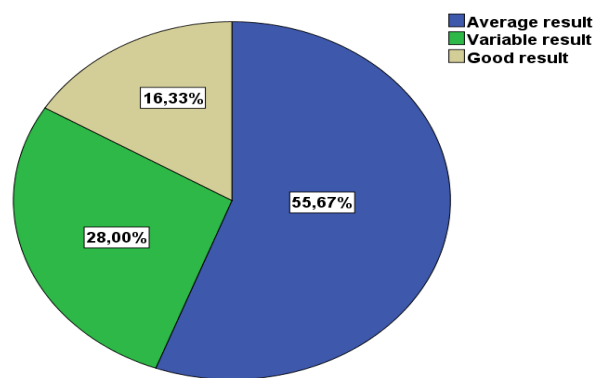


Figure 3. Histograms of the different parts used

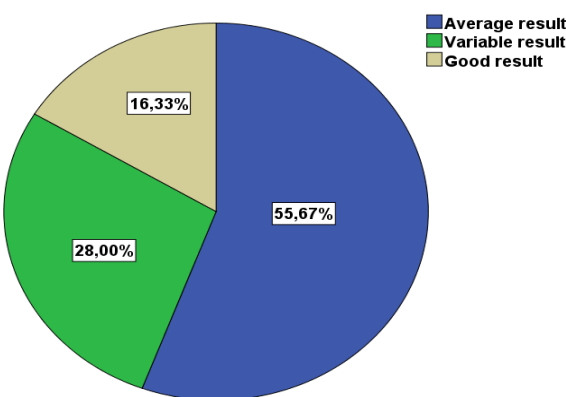
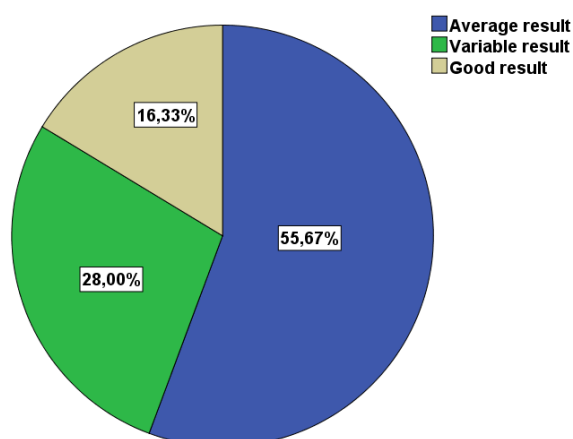


Figure 4. The percentage of preparation methods used by diabetic patients



**Figure 5.** The attitude of diabetic patients towards the outcome of traditional therapy.

The survey revealed that many patients did not engage in physical activity, this observation aligns with other studies, indicating that sports and physical activities are neglected by diabetic patients, with only a minority participating in sports activities [13,23]. The majority of this population had a low socioeconomic status (Table 1), but other surveys reported lower percentages of patients with low socioeconomic status (ranging from 15.85% to 46%) and higher percentages with medium socioeconomic status (ranging from 54% to 84%) [13,23]; while another study reported that all diabetic patients belonged to a middle socioeconomic level [26].

The pathophysiological abnormality caused by increased insulin secretion in the early phase of insulin resistance during the natural course of diabetes affects over time the choice of diabetes treatment in patients with long-standing type 2 diabetes [27]. For this purpose, we asked these patients about the duration of their disease, and we found that our survey showed varied durations, with the most common being 2-6 years, this indicates that there are always new complications with this disease, which is spreading rapidly in this studied area. In contrast, other studies reported different durations, such as a median duration of 7 years or 5-6 years as the most common duration [13,24]. Most of these patients surveyed were used oral hypoglycemic agents to manage their hyperglycemia, but a recent study reported different proportions, with 53.31% managing their diabetes with oral hypoglycemia and 38.95% using insulin therapy [19], and another study indicated that 57% used oral antidiabetics, and 34% used insulin therapy [21]. This survey revealed that all interviewed patients had used or were currently using herbal remedies to treat diabetes, the main sources of information on herbal remedies were recommendations from other diabetic patients and from herbalists. This result is consistent with previous studies where the choice to use herbal remedies was based on advice

from other diabetics and herbalists [10,19,23,25,28]. This dissemination of knowledge about medicinal plants among women could be attributed to their cultural practices of sharing daily issues. Patients reported various reasons for using herbal medicine, including the easy acquisition of antidiabetic plants, perceived effectiveness compared to modern drugs and cost-effectiveness, this is similar to previous studies that have highlighted the ease of acquisition of herbal remedies as the main reason for their use (62.5%) and the belief that they are more effective than modern drugs (95.86%) [13]. Others have also reported patients use herbal medicine because of their perceived effectiveness (69.2%) and low cost with minimal side effects (30.8%) [25]; while Hinad et al. [13] finds that the easy acquisition of these natural remedies is the main reason for using medicinal plants (62.5%). Also, the study of Laadim et al. [23] finds that the high use of medicinal plants (95.86%) is due to the strong belief of diabetic patients that they are more effective than modern drugs, (81.1%); thought, they can potentiate the effect of drug treatments and can help them better control their diabetes. While only 7% think that the drugs are not effective as they should [24], others have used it for their effectiveness (69.2%), their availability, low cost, and near absence of side effect (30.8%) [25]. Despite their ease of use, some herbal remedies may have negative side effects, and the main factor affecting human health is the dose used [29]. In our survey, most of patients used antidiabetic herbs with non-precise doses, while the study of Laadim et al. [23] found that 54.19% of diabetics use these antidiabetic herbs according to specific doses, 24.42% at non-specific doses and 21.40% of the use by easy acquisition. It was also found that approximately most of the patients (95.3%) do not know about some poisonous plants and only 4.7% have information about the toxicity of some plants (Table 1), which is consistent with the results of Errajraji et al. [21] who reported that all the patients surveyed said they had little or no concrete information on the toxicity of the plants used.

Ethnopharmacological data obtained from diabetic patients led to the identification of 32 plants used in the traditional treatment of diabetes mellitus, belonging to 19 different families and the most represented family was Lamiaceae with eight species, followed by Apiaceae with three species. *Olea europaea* L. had the highest relative frequency of citation, followed by *Coriandrum sativum* L., and *Trigonella foenum-graecum* L., then *Marrubium vulgare* L., *Lepidium sativum* L., *Lawsonia inermis* L., *Capparis spinosa* L. and *Artemisia absinthium* were cited (Table 2). These findings are consistent with previous studies in other areas, which also reported Lamiaceae and Apiaceae as the most plant families commonly used in diabetes treatment, *Olea europaea* and *Trigonella foenum-graecum* were the most cited plants [19,23,25,30]. Parts of plants most used in the preparation of traditional antidiabetic remedies are the leaves, followed by the



seeds, fruits and whole plants (Figure 3). The prevalence of leaves as the most cited plant part aligns with previous ethnobotanical studies conducted in Morocco and other countries [18,19,30-34]. Leaves are known to contain numerous antidiabetic chemical compounds and are primary sites for secondary metabolite synthesis in plants, making them a popular choice for traditional diabetes treatment [35]. Additionally, leaves are easily accessible and quick to harvest, further contributing to their frequent use [36]. These diabetic patients have used several techniques of preparation of these antidiabetic plants parts. Infusion and decoction are among the most used methods, and all these prepared phyto-drugs have been prescribed for oral consumption (Figure 4). These techniques are favoured as they allow for the collection of the most active constituents while mitigating or neutralizing any potential toxic effects of the preparations [37]. These findings align with other ethnobotanical studies, where infusion and decoction were also reported as the most prevalent methods of preparation [36-38]. The effects of therapy are not uniform among the diabetic patients surveyed who participated in this study; as a result, most say that the outcome of therapy is variable; while others think that the therapy has an average or good outcome (Figure 5), which is in agreement with a previous study [13] in which 35.79% said that the outcome of the therapy was variable and 52.63% found the outcome of the therapy to be average.

## Conclusion

This ethnobotanical survey involving 300 diabetic patients in the health centers of SALÉ City has shed light on the traditional use of medicinal plants for diabetes treatment and revealed that traditional ethnobotanical practices commonly used in the treatment of diabetes mellitus still play an important role. The study identified thirty-two medicinal species from diverse families that are utilized in antidiabetic remedies, with leaves being the most commonly-used part, and decoction was the preparation technique recommended in the treatment of this pathology.

This survey is a crucial source for understanding how people use antidiabetic medicinal herbs in SALÉ, the second most populous city in Morocco. Additionally, it can be employed as guidelines for phytochemical, toxicological, and pharmacological research and can contribute to the preservation of traditional knowledge and provide valuable insights for future investigations into potential antidiabetic agents derived from medicinal plants. It highlighted the need for further research on the efficacy and safety of these herbal remedies.

However, caution should be exercised in the administration of these herbal preparations, considering the varying dosages used and the lack of awareness regarding potentially toxic plants among diabetic patients. Further studies and clinical trials are necessary to validate the efficacy and safety of these traditional remedies for diabetes man-

agement.

## Conflict of Interests

None.

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