Ethnobotanical survey of medicinal plants used in the management of hypertension and diabetes in the Meknes Province (Morocco)

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Research

Abstract

Background: Diabetes mellitus and hypertension are major chronic diseases, and traditional phytotherapy remains widely used in Morocco for their management. This study aimed to document and analyze medicinal plants used in traditional medicine for the treatment of diabetes and hypertension in the Meknes province.

Methods: An ethnobotanical survey was conducted in the Meknes province (Morocco) between April 2024 and June 2025 using semi-structured interviews with 512 informants from both urban and rural areas. Data were analyzed using quantitative indices, including Fidelity Level (FL), Relative Frequency of Citation (RFC), Family Importance Value (FIV), Value of Plant Part (VPP), Criterion of Part Used (CPU), and Criterion of Preparation (CP). Statistical analyses were performed to assess factors influencing the perceived effectiveness of phytotherapy.

Results: A total of 18 plant species belonging to 11 families were identified, including five species also used for hypertension. The most cited species were *Eucalyptus spp.* (RFC = 0.14), *Trigonella foenum-graecum* L. (RFC = 0.12), *Aloe vera* (L.) Burm.f. (RFC = 0.11), and *Olea europaea* L. var. *sativa* (RFC = 0,10). The most represented families were Lamiaceae, Apiaceae, and Asteraceae. Leaves were the most frequently used plant part (45%; VPP = 0.423), while decoction was the dominant preparation method (40%), followed by infusion and powder (22%). The principal component analysis (PCA) explained 85.08% of the total variance (F1 = 60.03%, F2 = 25.04%) and revealed a clear differentiation between highly cited species and those with lower ethnobotanical importance, as well as variations in the diversity of their therapeutic uses. Statistical

analysis revealed that socio-economic status, age, and disease duration significantly influenced therapeutic outcomes ($p < 0.05$), whereas gender showed no significant effect.

Conclusions: The findings highlight the richness of ethnobotanical knowledge and the continued reliance on medicinal plants for the management of diabetes and hypertension in the Meknes province. These results support the potential of these species as sources of bioactive compounds, while emphasizing the need for further pharmacological and toxicological validation to ensure their safe and effective use.

Keywords: Medicinal plants, Phytotherapy, Diabetes mellitus, Hypertension, Ethnobotanical survey, Meknes.

Background

First of all, Medicinal plants represent a natural source of biologically active compounds that are particularly used to prepare drugs to treat numerous diseases (Bouyahya *et al.* 2017). In Africa, aromatic and medicinal plants (AMPs) are commonly employed by most people to treat illnesses (Afrokh *et al.* 2023). Consequently, pharmaceutical industries are becoming more attentive to ethnopharmacological studies of AMPs (Lefrioui *et al.* 2024). In Morocco, aromatic and medicinal plants occupy a very important part of the traditional life (Ghabbour *et al.* 2026a). This will enable a focus on medicinal plants that play an essential role in therapeutic medicine. Traditional knowledge has increasingly served as a basis for studies of biological activity on medicinal plants (Ghabbour *et al.* 2026a). In fact, there are over 500 species and subspecies of potentially fragrant and/or therapeutic plants in Morocco; very few of them are used for industrial purposes (Bourkhiss *et al.* 2006). Moreover, a strong ethnomedical tradition remains alive across all regions of Morocco and the wealth of ethnomedical knowledge accumulated over centuries is at risk of being lost if no action is taken (Salhi *et al.* 2011). Moroccan ethnobotanical knowledge also encompasses traditional fermentation practices that may improve the health-promoting properties of plants (Ghabbour *et al.* 2026b).

Diabetes mellitus is one of the most prevalent metabolic disorders worldwide, characterized by persistent hyperglycemia, and type 2 diabetes is widely recognized as one of the major health challenges of the third millennium (Whiting *et al.* 2011, Magliano *et al.* 2021). The prevalence of diabetes continues to rise worldwide, affecting both developed and developing countries, with an estimated 537 million people living with the disease in 2021, over 75% of whom reside in low- and middle-income countries, and this number is projected to reach 552 million by 2030. (Loud *et al.* 2025, Whiting *et al.* 2011, Magliano *et al.* 2021). In Morocco, the rate of diabetes reaches 10%; in some regions, the incidence of diabetes is increasing and reaches 13.3% (Bnouham *et al.* 2019, Tahraoui *et al.* 2007). Recent ethnobotanical studies conducted across different areas of the Fez–Meknes region have highlighted the richness of plant biodiversity and the value of traditional knowledge (Ghabbour *et al.* 2026a). These studies documented remarkable floristic diversity and a wide spectrum of therapeutic applications, including the treatment of diabetes and hypertension (Saibari *et al.* 2021, Mechchate *et al.* 2020, Ghabbour *et al.* 2023, Tlemcani *et al.* 2023, Jeddi *et al.* 2021, El Hajli *et al.* 2024, El Aboui *et al.* 2024, El Aboui *et al.* 2025, Ghabbour *et al.* 2024a, 2024b, El Aarage *et al.* 2026).

Cardiovascular disorders are widespread health problems and are usually the top-priority health challenges in many countries. Among these, Arterial hypertension (HTA) is a major cardiovascular condition with hypertensive patients experiencing a mortality rate that is double that of the general population (Loud *et al.* 2025). Arterial hypertension contributes significantly to the rise in sudden deaths among individuals with heart disease, exacerbated by risk factors like smoking, diabetes and high serum cholesterol (Baharvand *et al.* 2016). In Morocco, hypertension is estimated to affect adults over the age of 20 years at a prevalence of 34%, this prevalence increases significantly with age, reaching 53.8% for people aged 40 years and 72.2% for those aged 65 years and over (Lahmam *et al.* 2025).

In Meknes province, several medicinal plants can be used to fight several diseases, such as cardiovascular disease, kidney failure, and diabetes. We concentrated much more on plants that can reduce diabetes and hypertension.

For this purpose, an ethnobotanical study has been carried out, which is considered a science that allows for the translation of popular know-how into scientific knowledge. This study has several objectives, such as: Inventorying medicinal plants, knowing the pharmacological properties of certain medicinal plants, also collecting botanical samples, and knowing the rate of patients with diabetes and arterial hypertension, and knowing the effects of traditional medicine

Materials and Methods

Study area

Our survey was carried out in the Meknes province. This city, which spans an area of 172,890 ha (1786.9 km2), is bounded to the north by the province of Sidi Kacem, to the west by the province of Khemisset, to the south by the province of El Hajeb, and to the east by the province of Zouagha Moulay Yaakoub (Fig. 1). Geographically, the Fes-Meknes region consists of two major dissimilar units, the southern portion of the pre-Saïs. The city of Meknes has a semi-arid Mediterranean climate with mild winters, but due to the region's geographical diversity, each of its natural zones exhibits distinct climatic nuances. For example, annual rainfall averages range from 400 to 600 mm (1987-2009), while average temperatures show a wide range of extremes up to 25.4°C, with average maxima in the hottest month ranging from 29°C to 3°C, and average minima in the coldest month ranging from 3°C to 7°C (Labaioui 2024).

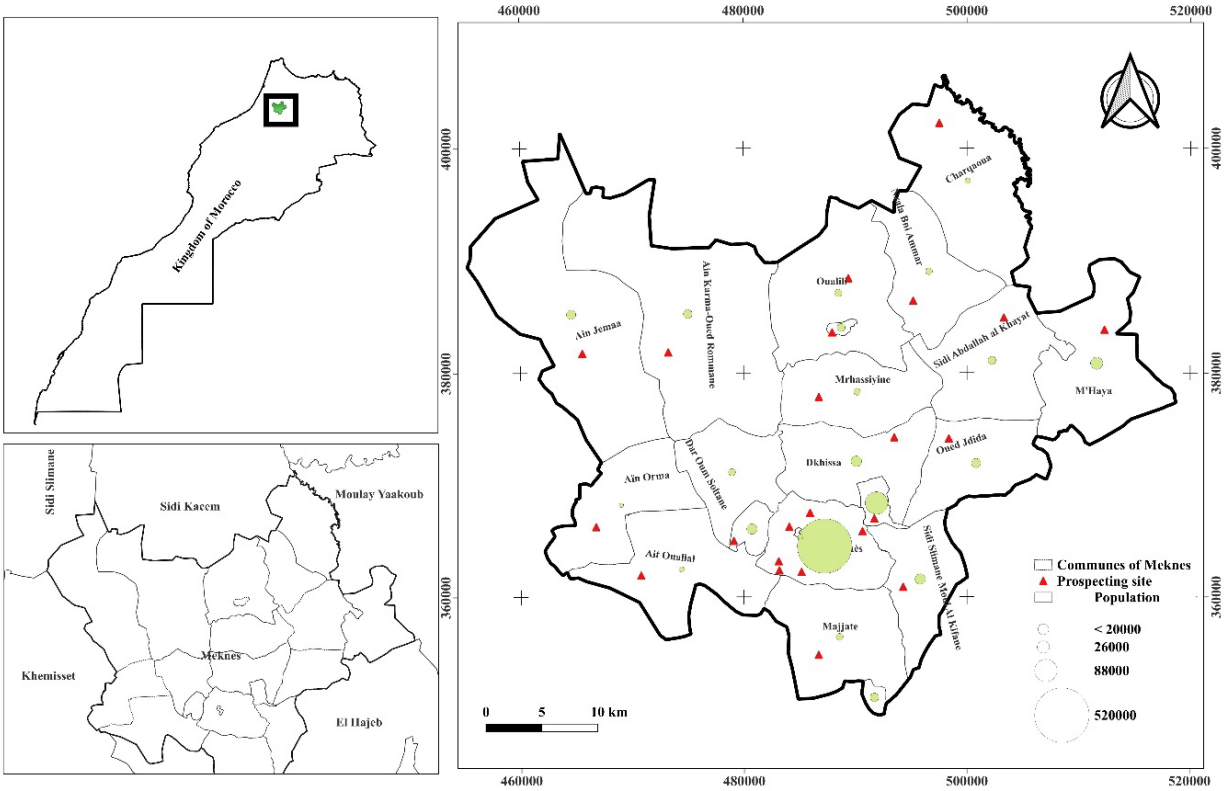

Figure 1. Map of the location of the study of Meknes, communes, indicating the survey site and population rate. The map was prepared using ArcGIS software.

We conducted this study in various municipal districts such as Al Machouar (old town), Maknassat-Azzaytoun, and Toulal in the Ismailia area, and Hmriya (new town) and Ouislane in the El Menzeh area, as well as rural areas such as Zarhoune, Dkhissa, Ait ouallal, Mejjate, Ain Jemaa, Oued Jdida, Ain Kerma, Ain Arma, and Mhaya (Fig. 1).

Methodology

The ethnobotanical survey was conducted between April 2024 and June 2025 at the endocrinology department of Mohammed V Hospital in Meknes, Morocco, under authorization No. 2626. Data were collected through face-to-face interviews with the local population, including patients attending the department. A total of 512 informants participated in the study. These species were identified by Abdelmounaim Mernich, who is the Head of the Development Zone of the Meknes Forest Territory.

Information was gathered using a semi-structured questionnaire based on direct questions concerning the use of medicinal plants included in the traditional pharmacopoeia for the treatment of hypertension and diabetes. The questionnaire was designed to be simple and clear while allowing respondents to provide detailed information about the plants used, their modes of preparation, and their therapeutic applications.

The objective of this survey was to identify medicinal plants traditionally used by the local population during the study period and to establish an ethnobotanical inventory reflecting the diversity of plant use within the study area. The survey was completed once the targeted number of respondents had been reached.

Data on the prevalence of diabetes were collected from medical records and clinical examinations conducted during the various observation periods. Diabetes rates were expressed as percentages (%) for each period studied. After data collection, the survey data were compiled and analyzed using descriptive statistical methods. Descriptive statistics were calculated for each question to summarize and interpret the information obtained from the informants.

Ethnobotanical survey

In order to achieve the high objectivity of the data obtained from our study, the survey is carried out using a survey sheet or questionnaire. The latter is based on five axes:

1.Patient profile information (name and surname, age, education level)
2.Questions about the disease (type of diabetes, hypertension disease, duration, current treatment)
3.Choice between two types of medicine (traditional or modern) and the reasons mentioned for each choice.
4.Questions on the techniques of phytotherapy of the used plant (name of the plant, part used, method of preparation, dose) are provided.
5.The results of the plants used and the effect of herbal medicine on the human body.

Cronbach's alpha

The reliability of the questionnaire was assessed using Cronbach's alpha coefficient. A total of 13 items were included in the analysis. Cronbach's alpha was calculated to evaluate the internal consistency of the scale and ranged from 0 to 1, with values ≥ 0.70 considered acceptable. All statistical analyses were performed using SPSS software (Kalkbrenner 2023), and the obtained Cronbach's alpha coefficient was used to assess the reliability of the measurement instrument before further data analysis.

Bivariate analysis (Chi-square test)

Bivariate analysis was performed to investigate the associations between socio-demographic variables and the therapeutic outcomes reported by participants. The Pearson Chi-square test (χ^2) was used to assess the relationship between categorical predictors—including age group, gender, socio-economic status, and body weight—and treatment effectiveness. For each variable, cross-tabulations were generated, and Chi-square statistics, degrees of freedom, and p-values were examined to determine statistical significance. A significance threshold of $p < 0.05$ was applied. All analyses were conducted using SPSS, and variables with large or sparse categories were recoded when necessary to ensure valid Chi-square assumptions.

Logistic regression

We used a multivariable logistic regression model to identify socio-demographic and clinical variables associated with the perceived effectiveness of phytotherapy in patients with diabetes. Before model estimation, all categorical variables were appropriately recoded to ensure clear and interpretable comparisons. Socio-economic status, gender, age group, and type of diabetes were included as categorical predictors. In contrast, duration of diabetes and weight were treated as continuous or grouped variables according to their distribution.

All predictors were entered simultaneously into the model to assess their independent effects on treatment outcomes. The dependent variable was the perceived therapeutic effectiveness of phytotherapy, dichotomized as good outcome versus poor outcome. Associations were evaluated using odds ratios (ORs) with 95% confidence intervals (CIs), and statistical significance was defined at $p < 0.05$.

Key assumptions of logistic regression were verified, including the absence of multicollinearity among predictors and the linearity of continuous variables with the logit of the outcome. These statistical analyses were performed using SPSS.

Principal Component Analysis

A Principal Component Analysis (PCA) was performed to explore latent dimensions underlying clinical and sociodemographic variables. All variables were standardized (Z-scores) for analysis. Sampling adequacy was evaluated using the Kaiser–Meyer–Olkin (KMO) measure and Bartlett's Test of Sphericity. Components with eigenvalues > 1 were retained, and the scree plot

was used to confirm factor selection. Varimax orthogonal rotation was applied to improve interpretability. Component scores were estimated using the regression method and used in subsequent analyses.

Descriptive statistics

The results were presented as percentages and illustrated using a line graph showing changes in diabetes rates over time. A descriptive analysis was conducted to compare the variations observed across the different follow-up periods. The threshold for statistical significance was set at $p < 0.05$. However, processed data were evaluated using quantitative measures such as Fidelity Level (FL), Relative Frequency of Citations (RFC), Family Importance Value (FIV), Value of the Plant Part (VPP), Criterion of Part Used (CPU) and Criterion of Preparation (CP).

Fidelity Level (FL)

The Fidelity Level (FL) is a useful metric for figuring out the percentage of plant species that informants frequently utilize to treat specific diseases. The Fidelity level was calculated using the algorithm [1] (Friedman *et al.* 1986).

$$\mathrm{FL} = \frac{\mathrm{Np}}{\mathrm{N}} \times 100 \qquad [1]$$

Where Np: Number of informants who claimed the usage of plant species to treat a specific disease, and N: Total number of informants who used medicinal plants as a remedy for any disease.

Relative Frequency of Citation (RFC)

One metric commonly employed to assess the relative significance of regionally cited plant species in traditional medicine for the treatment of diabetes is the Relative Frequency of Citation (RFC). The RFC value was calculated using the formula [2] (Ahmad *et al.* 2014).

$$\mathrm{RFC} = \left(\frac{\mathrm{FC}}{\mathrm{N}}\right) \qquad [2]$$

where FC is the number of respondents who combat a particular form of diabetes using plant species, and N is the total number of informants who treated any illness with medicinal plants.

Family Importance Value (FIV)

The Family Importance Value (FIV) represents the relative importance of families. It was used to evaluate the biological taxonomic value of plants and is determined by dividing the number of respondents revealing the family (FC family) by the number of species within each family (NS) according to the formula [3] (Sreekeesoon & Mahomoodally 2014).

$$\mathrm{FIV} = \frac{\mathrm{FC\ family}}{\mathrm{NS}} \qquad [3]$$

Value of the Plant Part (VPP)

The Value of the Plant Part (VPP), indicative of the frequency of utilization of each plant component, was calculated by dividing the total number of documented uses per plant part (RU) by the cumulative number of reported uses for all plant parts (RU) [4] (Gomez-Beloz 2002).

$$\mathrm{VPP} = \frac{\mathrm{RU\ Plant\ part}}{\mathrm{RU}} \qquad [4]$$

Criterion of Part Used (CPU)

The Criterion of Part Used (CPU) represents the number of plant parts (leaves, stems, fruits, etc.) used from a given medicinal species (CPU > 1). It reflects the diversity of utilized organs, which may differ in their bioactive compound composition and therapeutic potential (Ghabbour *et al.* 2024b).

Criterion of Preparation (CP)

The Criterion of Preparation (CP) corresponds to the number of preparation methods (infusion, decoction, maceration, etc.) applied to a medicinal plant (CP > 1). It indicates the diversity of processing techniques, which can influence compound extraction, efficacy, and bioavailability (Ghabbour *et al.* 2024b).

Results and Discussion

Study area and distribution of informants

Table 1 shows the number of people who responded to our questionnaires, the area and population of the different municipalities, the total number of people in the study location and the number of respondents involved and divided into several areas.

Table 1. Description of the neighborhoods and villages selected for the study in Meknes

District	Sub-District	Name of Commune	Area (ha)	No. of population	No. of respondents involved in the study
Meknes	Al Ismaïlia	Al Machouar (old town)	300	4664	25
		Maknassat-Azzaytoun	1710	96 145	60
		Toulal	2600	19077	32
	El Menzeh	Hmriya (new town)	3500	142786	125
		Ouislane	2140	87910	40
Total			**10250**	**350582**	
	Rural communities	Zarhoune		11615	30
		Dkhissa		19908	35
		Ait ouallal		5330	20
		Mejjate		9074	23
		Ain Jemaa		15265	30
		Oued Jdida		14935	25
		Ain Kerma		13820	22
		Ain Arma		3495	10
		Mhaya		26395	35
Total			**172890**	**470419**	**512**

Table 1 presents the distribution of the study sites and respondents in both urban districts and rural communities of the Meknes province. In total, 512 informants were interviewed across several neighborhoods and villages. In the urban area of Meknes, five localities were surveyed, including Al Machouar (old town), Maknassat-Azzaytoun, Toulal, Hmriya (new town), and Ouislane, representing a combined population of 350582 inhabitants. Among these, Hmriya recorded the highest number of respondents (125), followed by Maknassat-Azzaytoun (60).

In addition, the survey covered nine rural communities, including Zarhoune, Dkhissa, Ait Ouallal, Mejjate, Ain Jemaa, Oued Jdida, Ain Kerma, Ain Arma, and Mhaya. These rural areas together represent a population of 470419 inhabitants and contributed a significant portion of the respondents. Overall, the table highlights the broad geographical coverage of the survey and the diversity of informants from both urban and rural settings, ensuring a representative ethnobotanical investigation in the Meknes province.

Reability test

Table 2 displays a Cronbach's Alpha grade of 0.725 for the 13 items in the research, indicating a strong degree of internal consistency. The scale's components are successfully aligned to measure the planned structure, as evidenced by its strong reliability. The scale is regarded as a trustworthy instrument for gathering data since its Alpha value is greater than 0.725. The uniformity of responses across components enhances the validity of the study's findings and conclusions. This high degree of internal consistency also implies that the scale accurately captures the theoretical idea being studied and has good conceptual validity. As a result, the findings probably apply to comparable situations, demonstrating the possibility of generalization. Additionally, the measurement tool's dependability provides a strong basis for future research, enabling additional investigation and concept validation.

Table 2. Reliability statistics

Cronbach's alpha	Number of items
0,725	13

Factors influencing the Perceived Effectiveness of Phytotherapy

A bivariate analysis using the Pearson Chi-square test was carried out to examine the relationship between the sociodemographic features of the participants and the therapeutic outcomes they reported. The results showed that age and socio-economic status are strong predictors of how effective the treatment is, while gender and body weight do not have a significant impact.

There was a highly significant association between age and therapeutic effectiveness ($\chi^2 = 49.10$, $p < 0.001$). Adult patients (under 60 years) reported positive outcomes (31.6%) much more often than elderly patients (60 years and above), who reported good results in only 3.8% of cases. This suggests that herbal treatments may be less effective in older individuals, possibly because diabetes is more advanced at this age.

Socio-economic status also demonstrated a good influence ($\chi^2 = 35.02$, $p < 0.001$). Patients with a medium or high socio-economic level reported good results (36.6%) more frequently than those with a low socio-economic level (14.2%). This may be explained by better access to supportive dietary resources.

On the other hand, no significant differences were found for gender ($\chi^2 = 0.08$, $p = 0.778$) or body weight ($\chi^2 = 0.001$, $p = 0.976$). This indicates that the effectiveness of the medicinal plants does not depend on the patient's sex or weight.

Table 3. Bivariate examination of sociodemographic variables linked to treatment results

Variable	Category	Total (N)	Good Result (n)	Good Result (%)	χ^2 Value	*p*-value
Age	Adults (< 60)	361	114	31.6%	**49.10**	**< 0.001***
	Elderly (≥ 60)	160	6	3.8%		
Socio-economic	Low	316	45	14.2%	**35.02**	**< 0.001***
	Medium / High	205	75	36.6%		
Gender	Male	249	56	22.5%	0.08	0.778 (ns)
	Female	272	64	23.5%		
Weight	≤ 70 kg	299	69	23.1%	0.001	0.976 (ns)
	> 70 kg	222	51	23.0%		

Values are expressed as a number (n) and a percentage (%). Associations between categorical variables and treatment outcome were assessed using the χ^2 (Chi-square) test. A *p*-value < 0.05 was considered statistically significant. *Statistically significant difference; ns: not significant.

Descriptive Statistics

The ethnobotanical survey revealed a total of 18 medicinal plant species traditionally used by the local population for the management of diabetes. Among these species, five plants were also reported to be used for the treatment of hypertension. These findings highlight the diversity of medicinal plants employed in traditional practices to control blood glucose levels and, in some cases, to reduce high blood pressure among patients.

Ethnobotanical analysis

The age extremes of the diabetics surveyed range from 20 to 70 years old; 11% of patients were at least young (between 20 and 30 years old), 22% were between 30 and 40 years old, 6,5% were between 40 and 50 years old, 29,75% were between 50 and 60 years old and 30% were between 60 and 70 years old. Concerning the school level, 49,5% of patients surveyed were illiterate, which is confirmed by the results reported by Ghabbour *et al.* (2024b). The rest are divided between primary schooling (26,5%), and secondary schooling (14,77% with college and 2,3% qualifying), and only 6,9% of diabetics had higher education levels. The minimum weight of the population covered by this study is 50 kg, while the maximum is 140 kg. The highest percentage, 43.2%, of this population weighs between 65 and 80 kg. We also find that the percentage of patients who weigh between 50 and 60 kg is 14.9%, while 2.5% weigh between 100 and 120 kg (Table 4). After collecting responses from people with diabetes regarding the type of diabetes they have, we found that 62.2% of them have type 2 diabetes, while 33.2% have type 1 diabetes. However, 4.6% of the population surveyed does not know what type of diabetes they have (Fig. 2). Regarding the gender of diabetics, women represented 52% compared with 48% of men. 70% of the population questioned do not practice regular physical activity, while only 30% follow regular physical activity. In this study, 60,6% of diabetics have low socio-economic status, 32,6% have a medium socio-economic status, and 6,7% have a high socio-economic status, which is confirmed by the results reported by Ghabbour *et al.* (2024b). In the population studied, the duration of the disease is very different. Indeed, some people have recently discovered the disease (1-6 months with 18,6%), while others have lived with the disease for a long time (15-30 years with 30,4%). Table 4 resumes the sociodemographic profiles of the patients concerned by this study. In this ethnobotanical survey, we recorded information on a total of 18 medicinal plant species, belonging to 11 families (Table 5). We also have information. We also collected much information, such as the local name of plant species, used parts, mode of preparation, and ethnobotanical indices, which are provided for each species.

These results are compatible with the ethnobotanical study in the Mernissa territory (Taounate, Morocco), which reported that the use of medicinal plants is widespread among all age groups, with a slight dominance among the oldest people (>60) with a percentage (23%), however, a rate of 21% is noted for the 51-60 age group, whereas for the youngest informants (<20), the use of medicinal plants (3%) does not represent a great therapeutic interest (Jeddi *et al.* 2021).

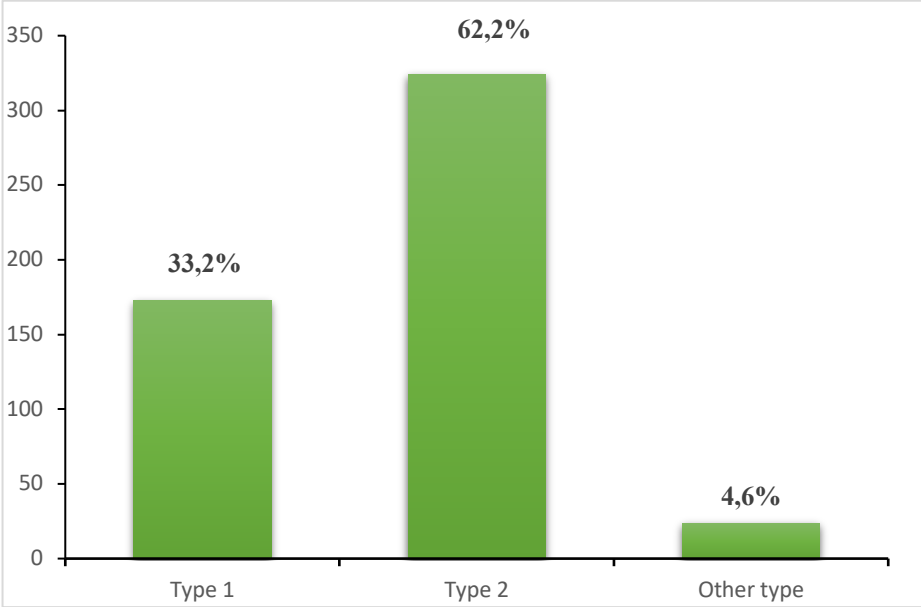

Figure 2. Graphs showing the different types of diabetes found in this study area

Diabetes can be classified as either non-insulin-dependent diabetes with hyperinsulinemia or insulin-dependent diabetes with hypoinsulinemia. Additionally, temporary hyperglycemia can be induced subcutaneously or orally. Conversely, drugs like streptozotocin, which selectively destroy ß cells, and alloxan, which is rarely used since it doesn't kill the ß cells of Langerhans, can be used in experiments to induce insulin-dependent diabetes. The scientists discovered that 60% of non-insulin-dependent diabetics in another survey conducted in eastern Morocco used medicinal herbs to treat their condition (Ziyyat *et al.* 1997).

Table 4. Sociodemographic characteristics of diabetic patients

Variable	Subgroup	Percentage
Age	20-30 years old	11%
	30-40 years old	22%
	40-50 years old	6,5%
	50-60 years old	29,75%
	60-75 years old	30%
Gender	Women	52,2%
	Men	47,8%
School level	Illiteracy	49,5%
	Primary	26,5%
	College	14,77%
	Qualify	2,3%
	University	6,9%
Weight	50-65 kg	39,34%
	65-80 kg	43,2%
	80-100 kg	14,9%
	100-120 kg	2,5%
Type of diabetes	Type 1	33,2%
	Type 2	62,2%
	Not informed	4,6%
Physical activity	Yes	29,2%

Variable	Subgroup	Percentage
	No	70,2%
Socio-economic level	Low socio-economic level	60,56%
	Medium socio-economic level	32,63%
	High socioeconomic level	6,72%
Duration of illness	1-6 months	18,6%
	1-3 years	7,1%
	3-6 years	13%
	6-9 years	10%
	9-12 years	4%
	12-15 years	13%
	15-30 years	33,4%

Folk medicine in Morocco uses a variety of medicinal herbs to treat various illnesses. In the province of Meknes, several dozen plant species are widely used to treat hypertension and diabetes. These plant species are: *Carum carvi* L., *Foeniculum vulgare* Mill., *Coriandrum sativum* L., *Petroselinum crispum* Mill., *Opuntia ficus-indica* Mill., *Artemisia herba-alba* Asso, *Cynara cardunculus* L., *Tetraclinis articulata* Masters, *Rosmarinus officinalis* L., *Salvia officinalis* L., *Thymus vulgaris* L., *Trigonella foenum-graecum* L., *Aloe vera* Burm., *Eucalyptus* spp., *Myrtus communis* L., *Olea europaea* L. var sativa Loud, *Prunus dulcis* Mill., *Ruta montana* L. The families that contain the species of medicinal plants most used for their antidiabetic effects are the following (Table 5): Asteraceae (2 species), Lamiaceae (3 species), Leguminosae (1 sp), Liliaceae (1 sp), Apiaceae (4 sp), Myrtaceae (2 sp) Oleaceae (1 sp) Rosaceae (1 sp) and Rutaceae (1 sp) (Fig. 3). The general public is already aware of these medicinal species and has long utilized them to treat those diseases (Ghabbour *et al.* 2023). However, in this study, their usage was evaluated based on the perceptions of individuals who are already affected by these conditions.

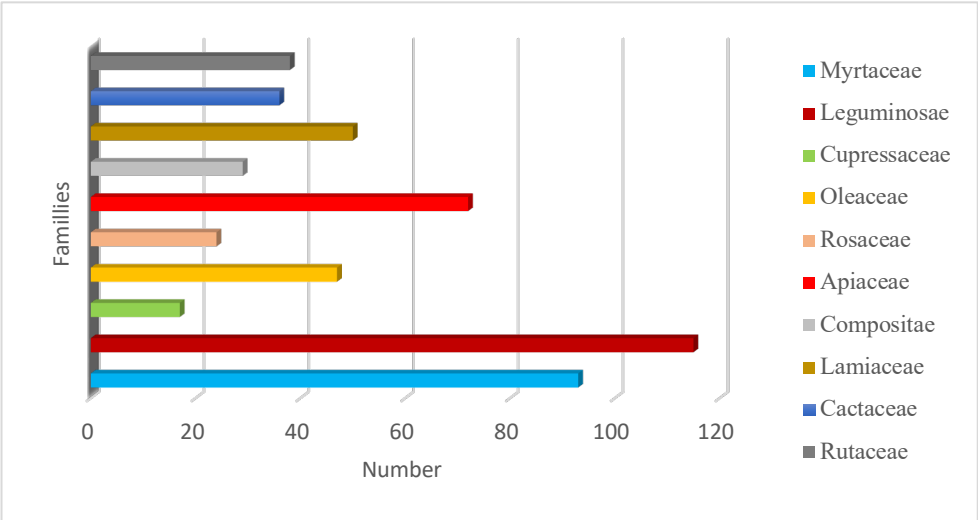

Figure 3. Number of families mentioned by the diabetic patients.

Regarding the Fidelity level (FL) in this study, we found that *Eucalyptus* spp. is the plant with the highest level of fidelity (FL = 16%), followed by *Trigonella foenum-graecum* L (FL = 14%), *Aloe vera* Borum (FL = 12.8%), *Opuntia ficus-indica* Mill (FL = 11.6%), *Olea europaea* L var sativa Loud (FL = 11.2%), *Myrtus communis* L (FL = 10%), *Carum carvi* L (FL = 8.8%), *Salvia officinalis* L and *Ruta montana* L (FL= 8%), *Rosmarinus officinalis* L (FL = 6.8%), *Artemisia herba-alba* Asso (FL= 6%), *Coriandrum sativum* L (FL = 5.6%), *Prunus dulcis* Mill (FL = 5.2%), *Petroselinum crispum* Mill (FL= 4,4%), *Tetraclinis articulata* Masters (FL = 4%), *Thymus vulgaris* L (FL = 3.2%), *Foeniculum vulgare* Mill and *Cynara cardunculus* L (FL = 1.2%). The fidelity level varies from one species to another and provides clear guidance on the most preferred and trusted plants for the management of hypertension and diabetes diseases in accordance with the local population (Ghabbour *et al.* 2023).

Among the 18 plants identified in this study that have been used to treat diabetes, 5 are also used to treat hypertension. The species vary in their Relative Frequency of Citation (RFC): *Eucalyptus* spp (RFC = 0,01), *Trigonella foenum graecum* (RFC = 0,12), *Aleo vera* (RFC = 0,11), *Olea europaea* (RFC = 0,10), *Myrtus communis* (RFC = 0,08), *Opuntia ficus-indica* (RFC = 0,08), *Carum carvi* (RFC = 0,06), *Artemisia herba-alba* (RFC = 0,05) , *Coriandrum sativum* and *Salvia officinalis* (RFC = 0,05),

Rosmarinus officinalis (RFC = 0,04), *Prunus dulcis* and *Ruta montana* (RFC = 0,04), *Tetraclinis articulata* (RFC = 0,024), *Petroselinum crispum* and *Thymus vulgaris* (RFC = 0,02), *Foeniculum vulgare* (RFC= 0,008), *Cynara cardunculus* (RFC = 0,004) (Table 5). Most of these medicinal species showed significant results in terms of Relative Frequency of Citation (RFC), confirming the findings of Ghabbour *et al.* (2023) *Olea europaea* L. had the highest RFC values, followed by *Trigonella foenum-graecum* L., *Salvia officinalis* L., and *Rosmarinus officinalis* L. (RFC = 0.294, RFC = 0.235, RFC = 0.232, and RFC = 0.126, respectively) which are in agreement with our current results.

Tlemcani *et al.* (2023) showed the most cited species in the region of Fes Meknes were *Plantago major* L (RFC = 0,27), *Olea europaea* L (RFC = 0,03), and *Daphne gnidium* L (RFC = 0,03). While Mechchate and his co-authors identified the most frequently used plants in the same of region to treat diabetes are *Trigonella foenum graecum* (RFC = 0,08), *Olea europaea* (RFC = 0.08), *Prunus amygdalus* var amara (RFC = 0.08), *Caralluma europaea* (RFC = 0.06), *Marrubium vulgare* (RFC = 0.04) and *Zingiber officinale* (RFC = 0.04) (Mechchate *et al.* 2020). The study in Kser Kbir performed by Hinad *et al.* (2022) shows that the most frequently used plants were *Olea europea* L with the highest (RFC = 0,14) then they found *Trigonella foenum-graecum* L with (RFC = 0,12), *Salvia officinalis* L and *Origanum compactum* Benth (RFC=0.08). In the region of Laayoun Sakia Hamra, a study was conducted by Loud *et al.* (2025) and he identified 43 plants was used in the treatment of hypertension, 8 have also been used to treat diabetes, these include: *Oleander europaea* L (RFC = 0,20), *Ajuga iva* L (RFC = 0,17), *Tetraclinis articulata Benth* (RFC = 0,14), *Eucalyptus globulus* Labill (RFC = 0,00025), *Syzygium aromaticum* (RFC = 0,01), *Myrtus communis* L (RFC = 0,0013), *Chamaemelum nobile* L (RFC = 0.009), *Atriplex halimus* L (RFC = 0.006).

The data collected enabled us to identify 18 species belonging to 11 families used in phytotherapy (Fig. 4). Table 3 shows that the Apiaceae is the most represented family with 4 species (FIV = 3.30), followed by the Lamiaceae family with 3 species (FIV = 3.60), then there are the families represented by 2 species which are respictively Asteraceae (FIV = 2.80), Myrtaceae (FIV = 11.80) and finally 7 families represented by a single species respictively, Leguminosae (FIV = 12.0), Liliaceae (FIV = 11.20), Oleaceae (FIV = 10.80), Cactaceae (FIV = 8.0), Rosaceae and Rutaceae (FIV = 4.0) and Cupressaceae (FIV = 2.4). An ethnobotanical study in the Fes Meknes showed the Lamiaceae to be the dominant family, with 38% (Saibari *et al.* 2021). While another study in the same region also showed the Asteraceae family to be the most represented, with 12 species (Tlemcani *et al.* 2023).

For the aforementioned preparations, the intake frequency is 1 to 3 doses per day or week. Respondents also reported using some plants instead of water and in infusion form (Table 3). In this case, it is more difficult to determine the exact dosage. For hypoglycemic purposes, diabetics use a large number of plants. According to the statements of the respondents, other plants can be hyperglycemic: *Artemisia herba-alba Asso*., *Trigonella foenum-graecum* L., *Rosmarinus officinalis* L., *Eucalyptus* spp, *Marrubium vulgare* L., *Aloe vera*, *Myrtus communis* L. These plants are taken most often in the form of herbal teas, whose most pronounced taste is bitterness. It is necessary to justify the use of therapeutic plants and assess any potential risks. Therefore, research on these goals is essential, as is a deeper understanding of the active chemicals and how they work.

Table 5. List of medicinal plants used in Morocco's Meknes province's traditional medicine to treat diabetes and hypertension

Family *Scientific name*	Vaucher Numbers	Local name	Common name	Eco-Distr	Part used	CP	Preparation used	CPU	Therapeutic use		FC	FL%	RFC	FIV
									Diabetes	HTA				
Apiaceae														1,61
***Carum carvi* L.**	DHT 0002	El-qarwiya	Caraway	Cultivated	Seed	1	Decoc	1	X	X	44	8,59	0,03	
***Foeniculum vulgare* Mill.**	D 0011	Basbās	Sweet fennel	Cultivated	Seed	1	Decoc	1	X		6	1,17	0,0004	
***Coriandrum sativum* L.**	D 0012	Qasbur	Coriander	Cultivated	Seed, Leaf	2	Decoc	1	X		28	5,47	0,02	
***Petroselinum crispum* Mill.**	D 0013	Maadnouss	Parsley	Cultivated	Seed, Leaf	2	Decoc	1	X		22	4,30	0,01	
Cactaceae														8,0
***Opuntia ficus-indica* Mill.**	D 0014	Hindiya	Prickly pear	Cultivated	Flower, Fruit	2	Powder	1	X		58	11,33	0,04	
Asteraceae														1,37
Artemisia herba-alba* Asso. *[T]	DHT 0005	Chih	White mugwort	Wild	Leaf, Root	2	Powder	1	X	X	30	5,86	0,03	
***Cynara cardunculus* L.**	D 0015	Khourchouf	Artichoke thistle	Cultivated	Root	1	Decoc	1	X		6	1,17	0,002	
Cupressaceae														2,40
***Tetraclinis articulata* Masters**	DHT 0008	El-arar	Berber thuya, Arar tree	Cultivated	Leaf, AP	2	Macer/Powder	2	X	X	20	3,91	0,01	
Lamiaceae														1,76
***Rosmarinus officinalis* L.**	DHT 0009	Azır	Rosemary	Cultivated	Leaf, AP	2	Decoc/Infus	2	X	X	35	6,84	0,02	
***Salvia officinalis* L.**	D 0016	Salmiya	Sage	Cultivated	Leaf	1	Infus	1	X		40	7,81	0,02	

Family *Scientific name*	Vaucher Numbers	Local name	Common name	Eco-Distr	Part used	CP	Preparation used	CPU	Therapeutic use		FC	FL%	RFC	FIV
									Diabetes	HTA				
***Thymus vulgaris* L.**	D 0019	Zaîtra	Thyme	Wild	Leaf	1	Infus/Powder	2	X		16	3,13	0,01	
Leguminosae														12,0
***Trigonella foenum-graecum* L.**	D 0022	El-halba	Fenugreek	Cultived	Seed	1	Decoc/Mac/ Powder	3	X		70	13,67	0,06	
Liliaceae							Powder							11,20
***Aloe vera* Burm.**	D 0025	Siber	Aloe	Imported	AP, Leaf	2		1	X		64	12,5	0,05	
Myrtaceae														5,47
***Eucalyptus* spp.**	D 0028	Kalituse	Eucalyptus	Cultivated	Leaf	1	Decoc/Infus	2	X		80	15,63	0,07	
Myrtus communis L.	D 0030	Rihan	Myrtle	Imported	Leaf, Fruit	2	Decoc/Infus	2	X		50	9,77	0,04	
Oleaceae														10,80
Olea europaea L.var. sativa Loud.	D 0032	Zaytun	Wild olive	Cultivated	Leaf	1	Decoc	1	X	X	56	10,94	0,05	
Rosaceae														4,0
Prunus dulcis Mill.	D 0035	Louz har	Almond	Cultivated	Seed	1	Decoc/Infus / Raw	3	X		26	5,08	0,02	
Rutaceae														4,0
Ruta montana L.[T]	D 0038	Fijel	Common rue	Wild	AP	1	Decoc/Infus / Powd	3	X		40	7,81	0,02	

[T]: Toxic plant Decoc: Decoction AP: Aerial Part Infus: Infusion Macer: Maceration HTA: Hypertension FC: Frequency RFC: Relative Frequency of Citation FL: Fidelity Level FIV: Family Importance Value CPU: Criterion of Part Used CP: Criterion of Preparation

Adverse effects of medicinal plants

Table 6. Verification of the ethnomedical usage of various Moroccan plants, as indicated in Table 5, by research on experimental animals

Plant	Check	References
Aloe vera	This plant has been confirmed to have a beneficial effect on diabetes.	(Okyar *et al.* 2001, Rajasekaran *et al.* 2004, Rajasekaran *et al.* 2006)
***Artemisia herba alba* Asso**	This plant has been confirmed to have a hypoglycemic effect and hypertension.	(Sekiou *et al.* 2021)
***Eucalyptus* spp.**	These articles have shown that this plant can reduce the rate of diabetes.	(Afsharmanesh *et al.* 2024, Bello *et al.* 2021, Gallagher *et al.* 2003, Uadia *et al.* 2024)
***Myrtus communis* L.**	The use of this plant in scientific research has shown that it has a reducing effect on diabetes.	(El Sawi *et al.* 2022, Önal *et al.* 2005, Sepici *et al.* 2004)
***Salvia officinalis* L.**	With the help of a decoction, the plant confirmed that it has an important role as a hypoglycemic.	(Alharbi *et al.* 2022, Alharbi *et al.* 2025, Ashkani-Esfahani *et al.* 2021, Bouteldja *et al.* 2023, Eidi *et al.* 2005)
***Rosmarinus officinalis* L.**	This plant can reduce the rate of diabetes by using a decoction or infusion of the leaves.	(Haloui *et al.* 2000, Kabubii *et al.* 2024, Oliveira *et al.* 2025, Sharaf Mohamed, 2021).
***Trigonella foenum–graecum* L.**	The use of this plant as a powder has a reducing effect on diabetes.	(Hinad *et al.* 2022, Hosseini *et al.* 2023, Riyad *et al.* 2007, Sarker *et al.* 2024, Shakil *et al.* 2024)

Health effects of plants

This study was carried out in Hospital Mohamed V in the city of Meknes, the diabetes and endocrinology department. This allows us to follow diabetic patients with a treatment well adapted to our study, including the use of *Aloe vera* and *Eucalyptus* spp and *Olea europaea L.* leaves. Figure 4 demonstrated that leaves accounted for 45% of the plant parts utilized in the management of diabetes. This is confirmed by the results reported by Ghabbour *et al.* (2024b) while the seeds have a significant therapeutic effect with a percentage (21%). Other parts of plants that have a beneficial effect are also found, aerial parts (17%), roots (7%), fruits (7%), and the part that is less used is flowers (3%).

In an ethnobotanical survey by Loud *et al.* (2025) the most frequently used part of medicinal plants in the survey region was the leaves (30.87%), followed by aerial parts (20.99%), seeds (14.84%), fruits (9.87%), roots (6.17%), flowers (4.94%) stems and barks (3.70% each) while the other parts of medicinal plants (bulbs, gums and pericarps) were represented by a variable percentage of use of less than 3%. These results are in line with the findings from most studies conducted in this study, in Morocco and other countries, which reported that plant leaves are widely used in the treatment of diabetes and hypertension (Douira & Zidane 2015, Keter & Mutiso 2012, Kpodar *et al.* 2016, Mrabti *et al.* 2019, Yaseen *et al.* 2015). The extensive use of leaves for therapeutic purposes can be attributed to their accessibility and high content of pharmacologically active substances, especially as they are easier to harvest compared to different parts of plants such as roots, fruits, bark and flowers (Fah *et al.* 2013).

Depending on the sociocultural category, different methods were used to prepare therapeutic plant extracts. According to our study, 40% of medicinal plants used to treat diabetes were prepared by decoction, which was followed by infusion, maceration, powder, and raw form (22%, 22%,11%, and 5%, respectively) (Fig. 5).

In an ethnobotanical study performed by Loud *et al.* (2025), the decoction was the most often used method for preparing phytotherapeutic remedies (54%), followed by the powder preparation method (20%), then infusion and maceration (11%) and raw form (4%). Our results (Fig. 6) corroborate previous reports in Morocco and some African countries (Barkaoui *et al.* 2017, Diop *et al.* 2022, Eddouks *et al.* 2017, Fouad *et al.* 2019, Hinad *et al.* 2022, Idrissi *et al.* 2025, Mrabti *et al.* 2019). But they disagree with other ethnomedicinal surveys carried out in Rabat and Casablanca-Settat regions of Morocco (Arraji *et al.* 2024, Sekkat *et al.* 2023), indicating that most recipes based on plant species are often prepared by infusion. In another ethnobotanical survey in Sidi Kacem by Rhazi Filali *et al.* (2016) revealed that the leaf accounted for 44.89% of all medical

plant uses, followed by the entire plant (23.46%) and seeds (14.28%). Other plant parts, such as the stem, fruit, bark, rhizome, root, bulb, and flower, accounted for a combined 17.37%. Another ethnobothanical study carried out in Mechraâ Bel Ksiri (Region of Gharb) by Benkhnigue *et al.* (2010) showed that leaves and seeds are the most widely used with a percentage (17.89%), the leafy stem and the fruit occupy second place, with percentages of 14.74% and 13.16% respectively, the root occupies an average position with a rate of 9.47%, the remaining used parts, that is bulbs, rhizomes, bark and stems, are represented by a cumulative rate of 26.85%. Also, Katiri *et al.* (2017) identified that the most parts used were leaves and decoction was the most common method to prepare the formulations.

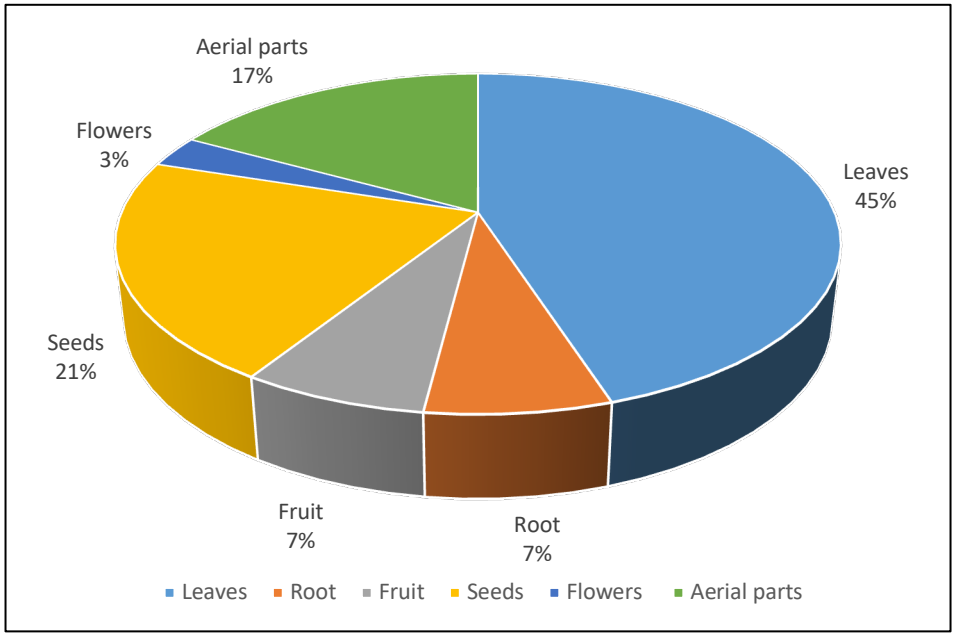

Figure 4. Plant parts that are usually employed to treat diabetes.

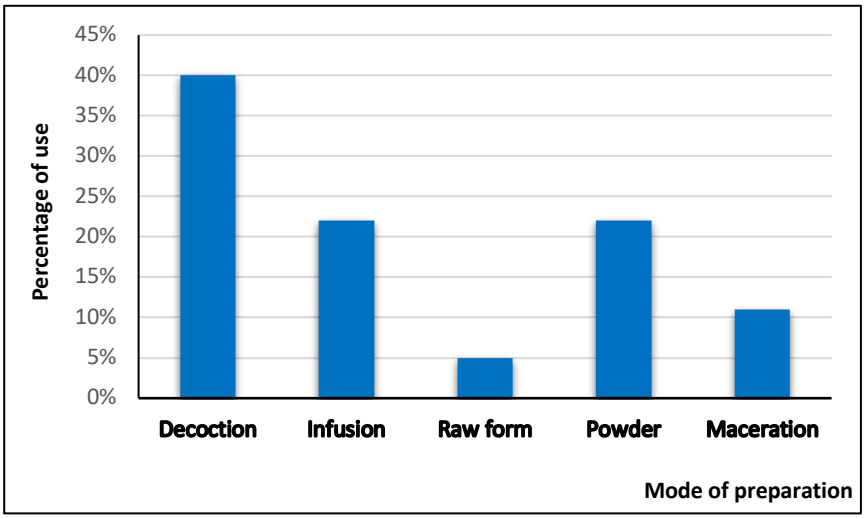

Figure 5. Percentage of diabetes patients' preparation methods.

Regarding the preparation of remedies, leaves were the most widely used part with (VPP = 0.423), followed by seeds (VPP = 0.231), aerial parts (VPP = 0.154), then roots and fruits (VPP = 0.077) and finally flowers (VPP = 0.038) (Fig. 6). Although these results have some similarities with those of (Jeddi *et al.* 2021, Salhi *et al.* 2011, Tlemcani *et al.* 2023), however they contrast with those of Mechchate *et al.* (2020), who showed that seeds are the most used parts with a percentage of 33%. Indeed, the use of leaves is explained by the fact that they are easy to harvest and constitute the center of photosynthesis and storage of secondary metabolites responsible for biological properties (Slimani *et al.* 2016, Tahri *et al.* 2012).

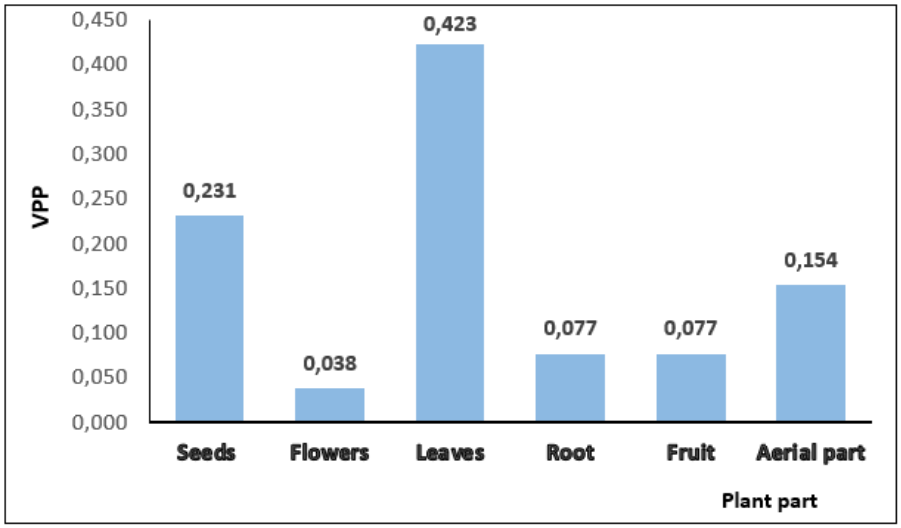

Figure 6. Parts of the plant used.

The results were presented as a graph plotting the observed diabetes rates against the different months of follow-up (January, April, June, September, and December), allowing for a visualization of the overall trend in diabetes rates over the course of the year. A gradual reduction in diabetes rates was observed among participants using medicinal plants during the follow-up period. This decrease may be attributed to the combined effects of phytotherapy and adherence to a diabetes-specific dietary regimen. The temporal variations in diabetes rates were illustrated using a line graph, which depicts the trend in patients' health status throughout the phytotherapeutic follow-up period. (Fig. 7).

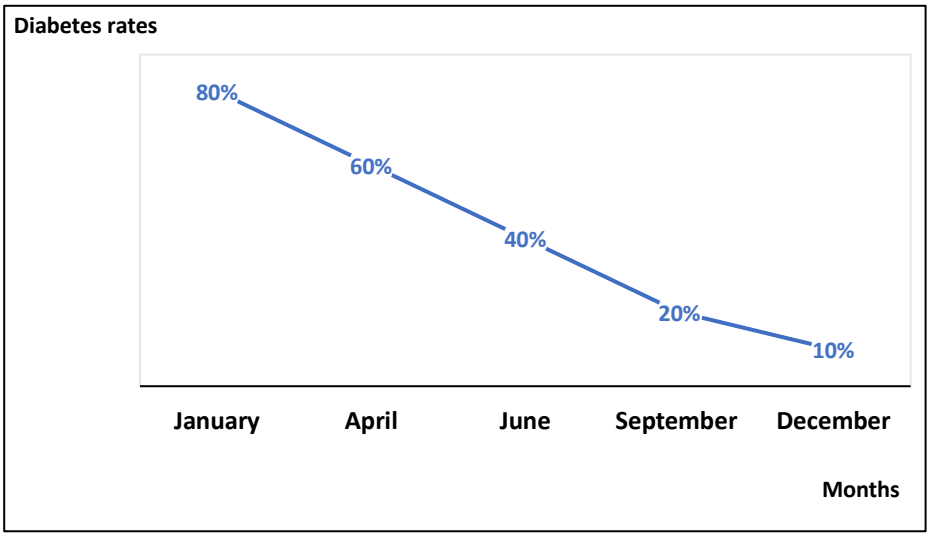

Figure 7. A curve that shows the variation in the rate of diabetes after the use of medicinal plants.

Attitude towards therapy and medication

Regarding attitudes toward medication, all diabetic patients were satisfied with the use of medication for the treatment of diabetes. In this study, interested diabetics had variable results in therapy; we can distinguish that 23% thought that therapy had a good result, 30% said that the result was variable, and 50% found that the result was average (Fig. 8).

In an ethnobotanical survey carried out by Tlemcani *et al.* (2023), a wide range of respondents (49%) prefer traditional medicine over modern medicine, citing the efficacy of medicinal plants as justification. Of the study population, 29% stated that the low cost of plants was the reason they used herbs, and 22% stated that the availability of plants was the reason.

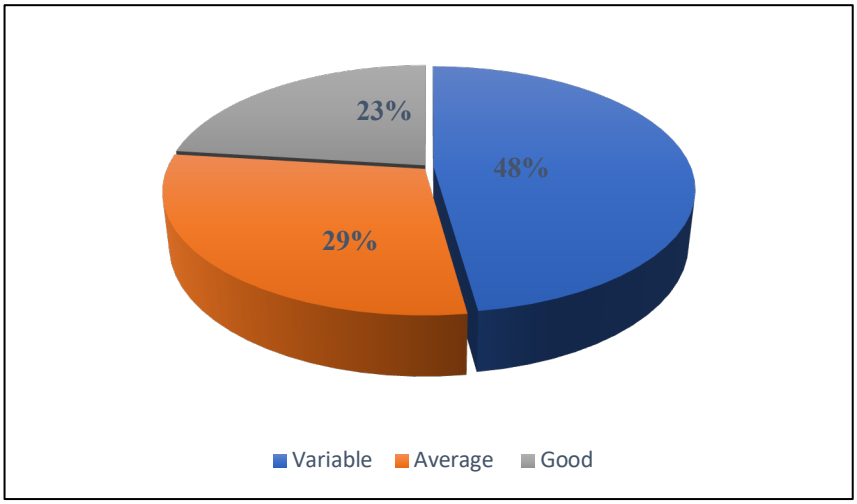

Figure 8. Attitudes of diabetic patients towards the outcome of therapy.

Logistic regression

The logistic regression analysis (Table 7) showed that several socio-demographic and clinical factors significantly predicted the perceived effectiveness of phytotherapy. Socio-economic level was an important predictor: patients with medium or high socio-economic status had lower odds of reporting poor outcomes (OR = 0.38, $p < 0.001$), meaning they were more likely to experience good therapeutic effects. Age also had a strong influence on treatment success. The age category showed a very large effect (OR = 11.17, $p < 0.001$), indicating that the patient's age group plays a major role in their response to medicinal plants. Duration of illness was another significant factor (OR = 2.25, $p = 0.004$), suggesting that changes in the length of the disease are linked to differences in treatment response. Body weight showed a smaller but statistically significant effect (OR = 1.70, $p = 0.037$). In contrast, gender was not a significant predictor (OR = 0.95, $p = 0.821$), meaning men and women reported similar levels of improvement. Overall, the model suggests that social and clinical characteristics especially socioeconomic status, age, and duration of illness are the main predictors of perceived efficacy of phytotherapy.

Table 7. Multivariable logistic regression identifying predictors of perceived phytotherapy effectiveness in diabetic patients

Predictor	**B**	***p*-value**	**Exp(B)**	**Interpretation**
Weight	0.528	0.037	1.696	Slightly increases the odds of improvement
Socio-economic	–0.977	< 0.001	0.376	HIGHLY significant
Gender	–0.055	0.821	0.947	Not significant
Age	2.413	< 0.001	11.168	VERY strong predictor
Duration of illness	0.812	0.004	2.252	Significant
Constant	–4.487	<0.001	—	Baseline model

Principal Component Analysis

The Principal Component Analysis (PCA) conducted on the current dataset identified two components with eigenvalues greater than 1, jointly explaining 48.64% of the total variance (Fig. 9). Component 1 accounted for 26.65% of the variance and primarily represents a Socioeconomic–Outcome Dimension. This component is defined by strong positive loadings of socioeconomic level and treatment outcome, indicating that patients with higher socioeconomic status tend to report better therapeutic results.

Component 2 explained 21.99% of the variance and forms a Gender–Duration–Weight Dimension, characterized by strong loadings of gender, illness duration, and weight changes. This highlights patterns linking sex differences with disease chronicity and weight variation. Age showed weak loadings on both components, suggesting a minimal contribution to the overall structure.

The rotated component matrix demonstrated a clear separation between the two factors, and the component plot confirmed their orthogonality and interpretability. A regression line superimposed on the PCA plot revealed a very weak association between the two components ($R^2 = 0.054$), supporting their relative independence.

Overall, this PCA effectively summarizes patient-level characteristics into two meaningful latent dimensions: one linking socioeconomic factors with therapeutic outcomes (Component 1) and another reflecting the interplay of gender, illness duration, and weight changes (Component 2), while age remains largely independent. These findings are consistent with the PCA outcomes reported by Ghabbour *et al.* (2024b), which analyzed Age, Herbalist seniority, Education level, Monthly income, Socio-economic level, and the patient's state after treatment according to the two components (PC I and PC II).

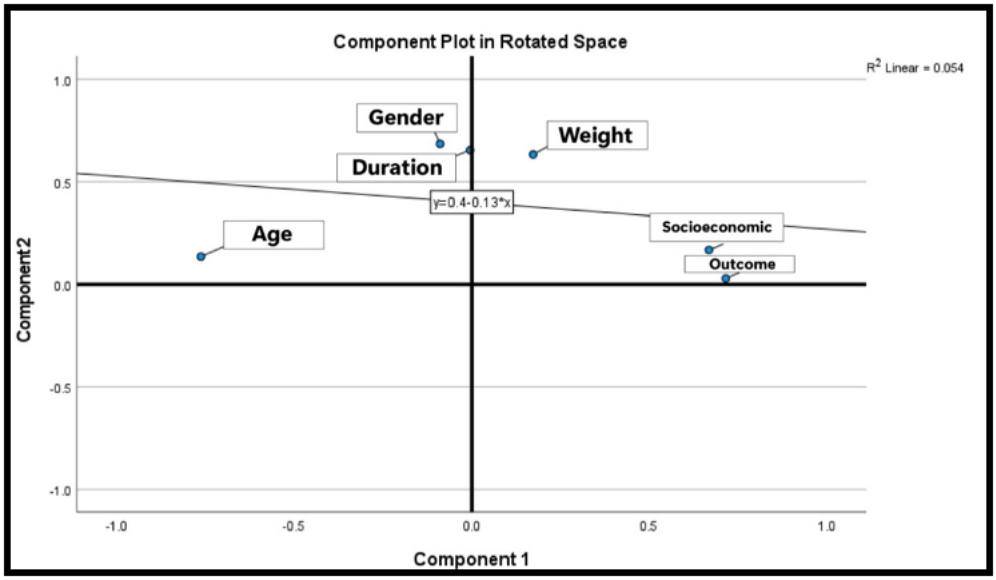

Figure 9. Component Plot in Rotated Space (PCA) of Sociodemographic and Clinical Variables.

The principal component analysis (Fig. 10) explains a high proportion of the total variance (F1 = 60.03% and F2 = 25.04%, totaling 85.08%), indicating a reliable representation of the relationships between species and ethnobotanical indices. The first axis (F1) clearly separates the two main groups. On the positive side, species such as *Olea europaea*, *Trigonella foenum-graecum*, *Eucalyptus spp.*, *Opuntia ficus-indica*, and *Aloe vera* are strongly associated with high values of RFC, FC, and F, reflecting their high citation frequency and major importance in the treatment of diabetes and hypertension. In contrast, the negative side of F1 includes species like *Rosmarinus officinalis*, *Salvia officinalis*, *Coriandrum sativum*, and *Artemisia herba-alba*, which are less associated with these indices and appear to be more moderately used.

The second axis (F2) highlights differences in use diversity. Species located in the upper part of the plot, such as *Ruta montana*, *Prunus dulcis*, *Thymus vulgaris*, and *Cynara cardunculus*, are positively correlated with CPU, suggesting a wider range of therapeutic uses. Conversely, species in the lower part, including *Aloe vera*, *Opuntia ficus-indica*, and *Petroselinum crispum*, are negatively correlated with CP, indicating more specific or targeted uses.

Overall, the PCA reveals a clear distinction between highly cited and widely used species and those with more limited or specialized uses, while also showing variation in the diversity of therapeutic applications among the recorded medicinal plants.

Other ethnobotanical studies

The comparison of ethnobotanical studies across different Moroccan regions (Table 8) reveals a high diversity of medicinal plants used in diabetes management, with the number of species ranging from about 29 to 59, depending on the study. Despite this variability, several plants consistently emerge as the most cited, particularly *Trigonella foenum-graecum* L., *Salvia officinalis* L., and *Olea europaea* L., indicating a strong consensus on their antidiabetic potential. Additionally, species such as *Artemisia herba-alba* Asso. and *Allium sativum* L. are frequently reported. These similarities suggest a shared traditional knowledge across regions, although some studies also highlight locally specific or newly reported species, reflecting regional biodiversity and cultural practices.

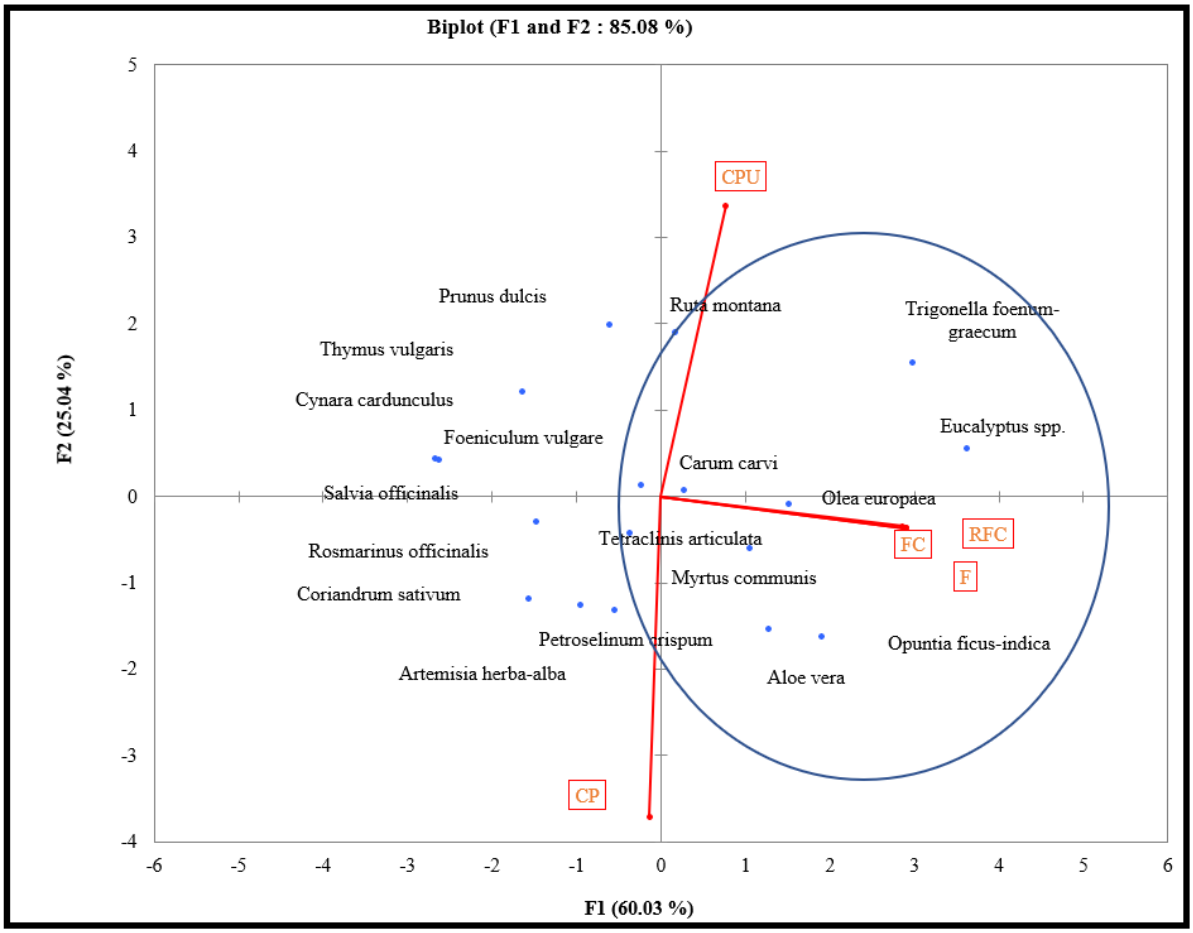

Figure 10. PCA-Based Differentiation of Antidiabetic and Antihypertensive Medicinal Plants According to Ethnobotanical Indices.

Table 8. Other Ethnobotanical Studies

Study results	Region	References
This study documented the utilization of 34 plant species for diabetes therapy, with the most frequently employed being *Trigonella foenum-graecum* L., *Globularia alypum* L., *Artemisia herba-alba* Asso., *Citrullus colocynthis* L., and *Tetraclinis articulate* L.	Oriental Morocco	(Ziyyat *et al.* 1997)
A study indicated that 700 diabetic patients identified 59 plant species for diabetes control, with five plants—*Trigonella foenum-graecum*, *Oreganum vulgare*, *Salvia officinalis*, *Marrubium vulgare*, and *Olea europaea*—being the most often utilized.	Sidi Slimane (northwest Morocco)	(Laadim *et al.* 2017)
They identified 29 plants utilized in the treatment of diabetes mellitus, including *Allium cepa L.*, *Chenopodium ambrosioides* L., *Allium sativum* L., *Coriandrum sativum* L., *Petroselinum crispum* L., *Caralluma europaea* L., *Artemisia absinthium* L., *Inula viscosa* L., *Lepidium sativum* L., *Opuntia ficusindica* L., *Ucumis sativus* L., *Trigonella foenum-graecum* L., *Medicago sativa* L., Salvia officinalis L., *Rosmarinus officinalis* L., *Laurus nobilis* L., *Cinnamomum verum*, *Linum usitatissimum* L., *Punica granatum* L., *Abelmoschus esculentus* L., *Ficus carica* L., *Olea europaea* L., *Nigella sativa* L., *Ziziphus lotus* L., *Prunus dulcis* L.	Ksar Elkebir Region (North-Western Morocco)	(Hinad *et al.* 2022)
40 medicinal plant species used against diabetes are: *Trigonella foenum-graecum* L., *Artemisia herba-alba Asso.*, *Ammi visnaga* L., *Centaurium erythreae* L., *Myrtus communis* L., *Globularia alypum*, *Nigella sativa* L.,	Izarene forest (Northern Morocco)	(Douira & Zidane, 2015)

Study results	Region	References
Tetraena gaetula L., *Olea europaea* L., *Rosmarinus officinalis* L., *Marrubium vulgare*, *Allium cepa* L., *Salvia officinalis* L..		
The most cited species in this study were *Artemisia herba-alba* Asso., *Cistus creticus* L., *Lavandula maroccana* L., *Salvia officinalis* L and Olea europaea L	Tizi n'Test Region (Taroudant Province)	(Katiri *et al.* 2017)
In this study, the most species cited have been used against diabetes were: *Allium sativum* L., *Salvia officinalis* L., *Marrubium vulgare* L. and *Lavandula dentata* L.. Six plants were reported for the first time as hypoglycemic plants: *Dracaena draco* L., *Euphorbia officinarum* L., *Eryngium ilicifolium* Lam, *Pastinaca sativa* L., *Scorzonera undulata* L., and *Ephedra altissima* Desf.	Region Tiznit (Western Anti-Atlas)	(Barkaoui *et al.* 2017)
These species were identified in this region as used against diabetes: *Chamaerops humilis* L., *Cladanthus arabicus* L., *Centaurea maroccana* L., *Matricaria chamomilla* L., *Tanacetum vulgare* L., *Diplotaxis pitardiana* L., *Berberis vulgaris* sub sp australis L., *Corrigiola litoralis* sub sp *telephiifolia*, *Cistus laurifolius* L., *Quercus coccifera* L., *Ballota hirsute* L., *Buxus balearica* L., *Lavandula stoechas* L., *Ocimum basilicum* L., *Thymus satureioides* L., *Ruta montana* L., *Taxus baccata* L. and *Thymelaea virgate* Desf.	Region of Al Haouz-Rhamna	(Benkhnigue *et al.* 2014)
In this study, these species were identified as used against diabetes : *Cynomorium coccineum* L., *Atriplex halimus* L. and *Salsola tetragona* L., but they found others were toxic, including *Aristolochia fontanesii* L., *Euphorbia officinarum* L. and *Nerium oleander* L.	Region of Tan-Tan (South of Morocco)	(Ghourri *et al.* 2013)
The most used species were: *Olea europaea* L., *Salvia officinalis* L., *Allium sativum* L. and *Trigonella foenum-graecum* L.	Beni Mellal region	(Mrabti *et al.* 2019)
This study showed that the most frequently used plants were *Trigonella foenum-graecum* L., *Salvia officinalis* L. and *Olea europaea* L.	Rabat	(Skalli *et al.* 2019)
The most plants reported in this study were *Olea europaea* L., *Salvia officinalis* L., *Trigonella foenum-graecum* L., *Euphorbia officinarum* L., *Globularia alypum* L. and *Coriandrum sativum* L.	Sefrou region	(Bousta *et al.* 2014)
In this study, they found 54 plants were cited, of which the most cited were *Artemisia herba alba Asso.*, *Trigonella foenum-graecum* L. and *Tetraena gaetula* L.	Region Fez-Boulemane	(Jouad *et al.* 2004)
The most frequently used plants include *Allium cepa* L., *Artemisia herba-alba* Asso. and *Trigonella foenum graecum* L.	Region of Meknes-Tafilalet	(Alami *et al.* 2015)
Most plants cited to be used against diabetes were *Ajuga iva* L., *Allium cepa* L., *Artemisia herba-alba* Asso., *Carum carvi* L., *Lepidium sativum* L., *Nigella sativa* L., *Olea europaea* L., *Peganum harmala* L., *Phoenix dactylifera* L., *Rosmarinus officinalis* L. and *Tetraena gaetula* L.	Errachidia province (south-eastern Morocco)	(Tahraoui *et al.* 2007)

Conclusion

This study provides a comprehensive ethnobotanical assessment of medicinal plants used in the Meknes province for the management of diabetes and hypertension. The identification of 18 species belonging to 11 families highlights the richness and diversity of traditional knowledge, with a predominance of families such as Lamiaceae and Apiaceae. The frequent use of species such as *Eucalyptus spp.*, *Trigonella foenum-graecum* L., *Aloe vera* (L.) Burm.f., and *Olea europaea* L. var. *sativa* reflect their therapeutic importance in local practices.

The most popular plant portion was the leaves, and the most popular method of preparation was decoction, indicating both practical accessibility and potential phytochemical efficiency. The application of ethnobotanical indices (FL, RFC, FIV, VPP, CPU, and CP) allowed for a quantitative evaluation of plant importance and use patterns.

Furthermore, the results demonstrated that socio-economic status, age, and disease duration significantly influence the perceived effectiveness of phytotherapy, emphasizing the role of patient-related factors in treatment outcomes. Despite the

widespread use and reported benefits of these medicinal plants, variability in efficacy and potential risks associated with improper use underline the need for further pharmacological and toxicological studies.

Overall, this work contributes to the preservation of traditional knowledge and provides a scientific basis for future research aimed at the development of safe and effective plant-based therapies.

Declarations

List of abbreviations: FC: Frequency of Citations, FL: Fidelity Level, RFC: Relative Frequency Citation, FIV: Family Importance Value, VPP: Value of the Plant Part, RU: Reported Uses, N: Total number of respondents, NS: Number of Species, [T]: Toxic plant, Decoc: Decoction, AP: Aerial Part, Infus: Infusion, Macer: Maceration, HTA: Hypertension

Ethical approval and consent to participate : Data were collected with respect for confidentiality, anonymity, and consent. All respondents were informed of the purpose of the study.

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Author contributions: IL: Contribution to study design, ethnobotanical survey, participation in structuring the methodology, data analysis and interpretation; manuscript writing, submission, and handling of revisions. **IG:** Methodology reorganization, study orientation, research coordination, verification and quantitative valorization, statistical analysis and supervision of data analysis, interpretation of results, manuscript review and editing. **YEO:** Concepts or Ideas, Literature search, Manuscript preparation, Data acquisition, Data analysis, Statistical analysis, Manuscript editing. **IK:** Data acquisition, Data analysis, Statistical analysis, Manuscript editing. **NG:** Coherence analysis, critical revision of the manuscript, improvement of the English language. **AM:** Identification of different species. **AA:** Study design and supervision, description of the methodology and valorization of the results obtained. **MLO :**Supervision of the work, active contribution to the methodology, improvement and revision of the manuscript. All authors read, examined and approved the final version of the manuscript.

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