Ethnobotanical study on the use of medicinal plants to treat cardiovascular diseases in the Fez-Meknes region of Morocco

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Research

Abstract

Background: Cardiovascular diseases represent a major global issue. The Moroccan population possesses ethnobotanical knowledge passed down through generations, enriched by ethnic diversity. The Fez-Meknes region has various aromatic and medicinal plants that can be utilized in multiple ways across several fields. The objective of this study focuses on identifying and collecting data on medicinal plants used to prevent diabetes, hypertension, obesity, atherosclerosis, and hypercholesterolemia, considered the main risk factors for cardiovascular diseases.

Methods: Data collected through surveys of 270 participant were analyzed using four quantitative indices: relative frequency of citation (RFC), fidelity level (FI), informant consensus factor (ICF), and the most used part (PPV).

Results: The study revealed the presence of 80 species belonging to 41 botanical families. The most frequently reported families were Lamiaceae (47%), followed by Fabaceae and Apiaceae (29%). Hypertension had the highest informant consensus factor (ICF) among the treated diseases at 0.923. The survey also showed that leaves were the most used part of the plants (PPV = 32.9%), and maceration were the most common preparation (23.91%).

Conclusions: This study contributes to the exploration and documentation of traditional practices in order to better understand and valorize their therapeutic potential. Further research, combining ethnobotanical knowledge with rigorous scientific analysis, could lead to the development of new strategies for the prevention and treatment of cardiovascular disease.

Keywords: Ethnobotanical study, cardiovascular diseases, traditional medicine, Fez-Meknes, Morocco.

Background

Cardiovascular diseases represent a significant social and economic scourge, with severe consequences in terms of morbidity and mortality. According to the World Health Organization (WHO), over 17.3 million people die each year from cardiovascular diseases (CVD), accounting for 31% of total global mortality (Damorou *et al.* 2014). Among these deaths, 85% were due to heart attacks or strokes (WHO 2021). Several factors can influence the onset of cardiovascular disorders, such as alcohol consumption, increased intake of saturated fats, decreased fiber consumption, obesity, physical inactivity, hypertension (HTA), and diabetes (Orch *et al.* 2015). In Morocco, it is estimated that more than 36% of adults (over 20 years old) suffer from hypertension; 12.4% of the population has diabetes; 55.1% of the population is overweight, with obesity rates at 11% among men and 23% among women (El Boukhrissi *et al.* 2017). The use of plants to treat chronic diseases, such as diabetes and hypertension, is part of an ancient Moroccan tradition. Despite the advancements made by modern pharmaceutical industries in treating chronic diseases, plants continue to fulfill a critical need. Thus, herbal medicines are considered to be less toxic and milder compared to pharmaceutical drugs (Tahri *et al.* 2012). Indeed, aromatic and medicinal plants play an essential role in the treatment of various diseases, and phytotherapy has garnered more attention in recent years (El Hilah *et al.* 2016) due to its lower cost and fewer perceived side effects compared to pharmaceutical medications (Skalli *et al.* 2019). According to the WHO, medicinal plants and phytotherapy are vital in primary healthcare. Since 1990, the organization has encouraged all member states to implement measures to integrate these traditional medicines into their primary healthcare systems and recommends that they deepen their understanding of these different approaches and train healthcare professionals to address the rise of chronic diseases, which are costly to manage (Ghourri *et al.* 2013; Bammou *et al.* 2015; Benkhnigue *et al.* 2022). Morocco is one of the Mediterranean countries with a long history of phytotherapy (Bellakhdar 1997). Thanks to its geographical position and varied climate, its flora is more diverse and unique on a regional scale (Bammou *et al.* 2015), consisting of 5,200 species and subspecies, of which 900 are endemic (Fennane & Tattou 2012). Aromatic and medicinal plants are represented by more than 743 taxa belonging to 101 families and 371 genera, among which 40 taxa are endemic to Morocco (Jamaleddine *et al.* 2017). Its annual production is around 33,000 tons, allowing it to occupy a significant position in the international market (Daoudi *et al.* 2016). Several ethnobotanical studies have been conducted in nearly all regions of the kingdom since the first study conducted by Bellakhdar in 1978 to catalogue the aromatic and medicinal plants used in the treatment of various pathologies (Hachi *et al.* 2015; Ghourri *et al.* 2013; Es-Safi *et al.* 2020; El Hachlafi *et al.* 2020; Yahyaoui 2015; Salhi *et al.* 2010; Tahri *et al.* 2012; El Azzouzi & Zidane 2015). The ethnobotanical and ethnopharmacological study of Moroccan medicinal plants reveals their relative importance in the healthcare system for treating specific diseases. For example, one study focused on indigenous knowledge used to treat neurological diseases in the Rif region (Chaachouay*et al.* 2020). An ethnobotanical survey of medicinal plants used to treat dermatological conditions was conducted in the central plateau of Morocco (El Hilah *et al.* 2016). Another ethnobotanical and ethnopharmacological study examined medicinal plants used to combat anemia in the Haouz-Rehamna region (Benkhnigue *et al.* 2022). In the northeast region of Morocco, 55 species of plants belonging to 36 families were identified as potentially toxic in an ethnobotanical study conducted by Kharchoufa *et al.* (2021). Researchers identified 102 plants used to treat various diseases in the province of Taounate in a survey by El Hilaly in 2003 (El-Hilaly *et al.* 2003). Another ethnobotanical survey focused on herbs used for food preservation (Ez Zoubi *et al.* 2022) found that in southern Morocco (Tarfaya province), 130 aromatic and medicinal plants, spread across 57 species, were used by the local population to treat several diseases (Idm'hand *et al.* 2020). In the southeastern region of Morocco (Tafilalet), a study was conducted on the treatment of digestive and diabetic diseases (El Amrani *et al.* 2010; Es-Safi *et al.* 2020). Several authors have also emphasized phytotherapy for cardiovascular diseases in Morocco, and studies conducted in different regions have shown that the use of plants to treat these chronic diseases is widespread (Orch *et al.* 2015). In the central-northern region of Morocco, an ethnobotanical survey on medicinal plants used for the treatment of diabetes, heart diseases, and kidney diseases was conducted in the Fez-Boulemane region (Jouad *et al.* 2001). Another ethnopharmacological survey was conducted on medicinal plants used for treating diabetes, hypertension, and heart diseases in the southeastern region of Morocco (Tafilalet) (Eddouks *et al.* 2002). In the northern region (Orch *et al.* 2015) contributed to an ethnobotanical study of medicinal plants used in the treatment of diabetes and hypertension. In 2020, Chaachouay studied the various plants traditionally used in the Rif for the treatment of metabolic diseases such as diabetes, anemia, hypercholesterolemia, and obesity (Chaachouay *et al.* 2020). The numerous ethnobotanical studies conducted are an integral part of national research and development programs for medicinal plants, aimed at increasing their added value. However, few experimental studies have been carried out in the Fez-Meknes region to confirm the therapeutic uses, pharmacological properties, and biological properties of plants used to prevent cardiovascular diseases. In this ethnobotanical study, the aim was to inventory the medicinal plants used in the traditional treatment of diabetes, hypertension, obesity, atherosclerosis, and hypercholesterolemia in the Fez-Meknes region in order to identify their modes of use and to enhance certain therapeutic recipes appropriate to the region.

Materials and Methods

Study area

The Fez-Meknes region is located in the central-northern part of Morocco, between 34° 02′ 00″ north and 5° 00′ 00″ west. It covers an area of 40,075 km², which represents 5.7% of the national territory. The region has a population of 4,236,892 inhabitants (13% of the national population) and is composed of two prefectures (Fez and Meknes) and seven provinces (Taounate, Taza, Sefrou, El Hajeb, Boulemane, My Yacoub, and Ifrane) (Es-Safi *et al.* 2020) (Fig. 1). The Fez-Meknes region is characterized by three climates: a continental climate in the northern part, a cold and humid climate in mountainous areas, and a semi-arid climate in the high hills of Boulemane (El Finou *et al.* 2023). This climatic variability leads to a diversity of crops that better adapt to the specific conditions of the region. Geographically, the region mainly consists of hills at the foot of the Rif mountains in the north, the Middle Atlas Mountains, the high hills of Missour, and the plains of Saïss (Amaghnouje *et al.* 2020). The forest and herbaceous cover also present significant potential. The forests in the region are among the most important in the country, featuring beautiful cedar forests in the Middle Atlas around Ifrane-Azrou, Ain Alleuh, Taza, and in the Rif. The agricultural sector places the Fez-Meknes region among the most productive regions at the national level. The total agricultural area is 1,340,826 ha, representing 15% of the national usable agricultural area. The forested area of the region is estimated at 1,246,255 ha, accounting for 14% of the national area (Tlemcani *et al.* 2023). Additionally, this geographical scope and structural and climatic diversity are reflected in the specific richness of spontaneous plants, particularly aromatic and medicinal ones (Monograph of the Fez-Meknes Region 2018).

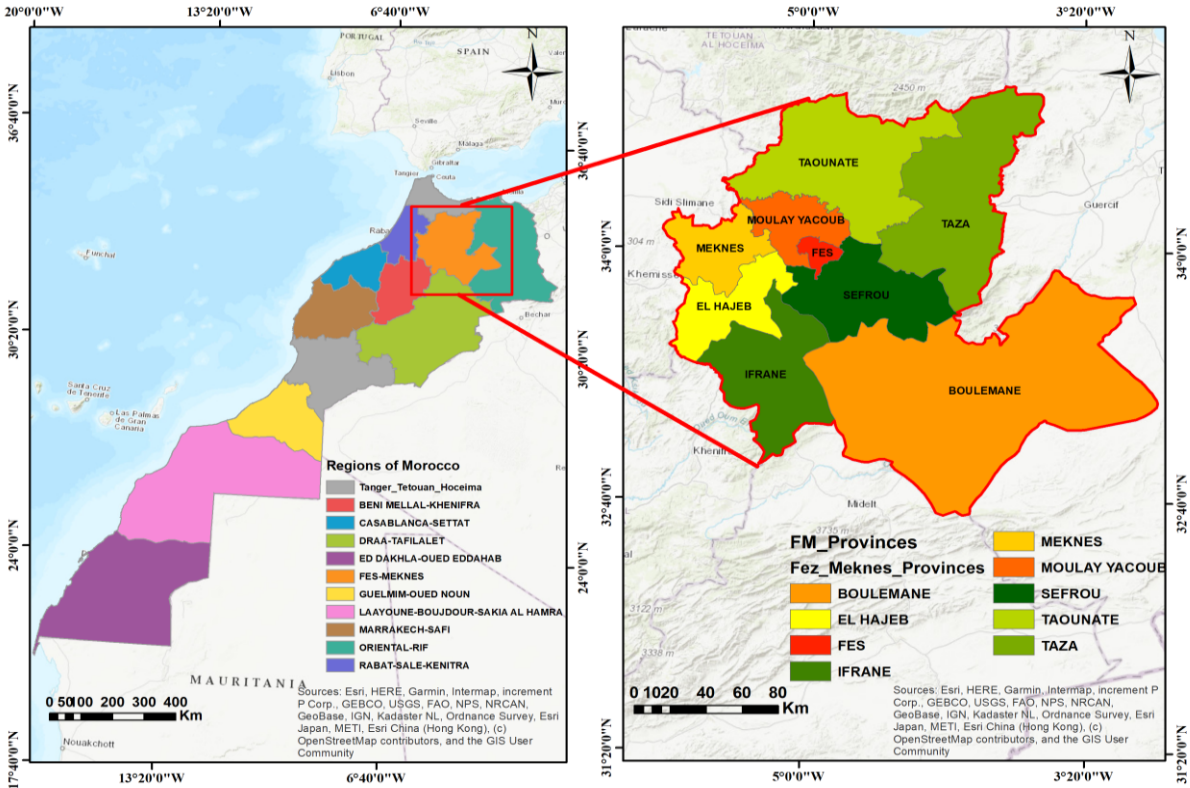

Figure 1. Map of the study sites.

Description of the survey

In this study, the sampling plan is developed using a probabilistic (random) sampling method, it is divided into groups or strata, so we have 9 strata which correspond according to the administrative division of Morocco in 2015 to 2 prefectures and 7 provinces constituting the region of Fez-Meknes (Table 1).

Proportional samples of 30 people are then formed for each of the 9 strata and they are combined to constitute the overall sample of 270 people.

The ethnobotanical surveys were conducted from January to May 2023 in the region of Fez-Meknes among herbalists, pharmacists, druggists, doctors, collectors of aromatic plants, healers, patients and normal population. The respondents were chosen on the basis of their availability and the number of medicinal plants sold in the markets. Individuals were interviewed using a survey form.

The main data collected related to sociodemographic data (gender, age, sociocultural group, educational level, occupation, and marital status) and ethnobotanical data (common name, part used, illnesses treated, category of use, and method of preparing medicinal recipes, etc.).

Table 1. Distribution of the Number of Respondents by Prefectures and Provinces

Stratum No.	Stratum Name	Number of Respondents/Stratum
1	Prefecture of Fez	30
2	Prefecture of Meknes	30
3	Province of Taounate	30
4	Province of Taza	30
5	Province of Sefrou	30
6	Province of El Hajeb	30
7	Province of Boulemane	30
8	Province of Ifrane	30
9	Province of My Yacoub	30
Total		270

Plant species identification

Plant samples were collected during surveys carried out with the local population. Unfortunately, these samples did not represent all the parts needed to assign a reference code. The worldwide database of the European and Mediterranean Plant Protection Organization (EPPO) was used. In this way, an EPPO code was assigned to each plant species, enabling efficient and accurate identification.

Identification of the scientific names of the plants mentioned by the local population was obtained by direct translation of their vernacular names on the basis of specialized bibliographical references such as (Bellakhdar (1987, 1997,1991), El-Hilaly *et al.* 2003).

Data Analysis

The data were analyzed using descriptive statistics, relative frequency citation, and preference ranking.
Ethnobotanical data were organized using Microsoft Excel spreadsheets and IBM SPSS Statistics Base 20, a statistical tool offering essential functionalities for in-depth analysis.

For the analysis of the ethnobotanical data collected, four main indices were used namely, Relative Frequency of Citation (RFC), Part of Plant Use Value (PPV), Level of Fidelity (FL), and Informant Consensus Factor (ICF). These indices allow for a precise evaluation of the importance of the plants, their use, and the degree of consensus among informants regarding their applications.

The socio-demographic characteristics of the participants were analyzed using simple descriptive statistics, including percentages and frequencies. Multiple correspondence analysis (MCA) was used to study the interrelationships between the variables such as belief in aromatic and medicinal plants, Sex, Age, Family status, Education level, Profession and Area.

Relative Frequency of Citation (RFC)

The Relative Frequency of Citation (RFC) for species corresponds to the percentage of respondents who mentioned a specific plant. This index reflects the relative importance of each species in the study area. It is calculated according to formula (1) from Tardío and Pardo (2008) (Tardío & Pardo-de-Santayana 2008):

$$\mathbf{RFC} = \frac{\mathbf{FC}}{\mathbf{N}} \qquad (\mathbf{1})$$
$$\mathbf{0} < \mathbf{RFC} < \mathbf{1}$$

Where, FC representing the frequency of citation of the plant and N the total number of respondents.

Informant Consensus Factor (ICF)

The Informant Consensus Factor (ICF) shows the homogeneity of knowledge in the use of a plant for each disease category (Heinrich *et al.* 1998). It is calculated according to formula (2):

$$\mathbf{ICF} = \frac{\mathbf{Nur} - \mathbf{Nt}}{\mathbf{Nur} - \mathbf{1}} \qquad (\mathbf{2})$$

Where: Nur: The number of usage citations for a disease category; Nt: The number of species used by informants in a given usage category

Level of Fidelity (FL)

The Level of Fidelity (FL) indicates the effectiveness of a plant species against a specific disease. It corresponds to the percentage of respondents citing the use of a plant species to treat a particular disease in the study (Friedman *et al.* 1986; Sreekeesoon & Mahomoodally 2014).

The Level of Fidelity (FL) is calculated according to Friedman (1986) using the following formula (3):

$$\mathbf{FL}\,(\%) = \frac{\mathbf{NP}}{\mathbf{N}} \times 100 \qquad (\mathbf{3})$$

Where: NP: The number of citations of the species used in the treatment of a particular disease**;** N: The total number of citations of the species used in the treatment of any disease.

Part of Plant Value (PPV)

The Part of Plant Value (PPV) is used to show the frequency of use of each part of the plant. The part with the highest PPV is the most commonly used part by the respondents (Gomez-Beloz 2002).

The Part of Plant Value (PPV) is calculated based on the following formula (4):

$$\mathbf{PPV} = \frac{\mathbf{RU}}{\mathbf{RU}} \times \mathbf{100} \qquad (\mathbf{4})$$

Where: RU: The number of reported uses for all parts of the plants; RU The part of plant: The sum of reported uses by part of the plants.

Results and Discussion

The descriptive and quantitative statistical treatment of the data collected in the survey forms using SPSS and Excel software allowed us to present the results in the form of figures and tables to facilitate their interpretation and discussion later on.

Percentage of respondents using aromatic and medicinal plants in the Fez-Meknes region

The results of this ethnobotanical study reveal that 95.19% of the interviewed individuals use aromatic and medicinal plants (AMP) to treat or prevent certain diseases, while only 4.81% of respondents do not believe in phytotherapy (Fig. 2). This finding is consistent with observations by (Jouad et aL 2001) in the Fez-Boulemane region, where a large majority of patients (76%) use medicinal plants for the treatment of conditions such as diabetes, heart disease and kidney disease.

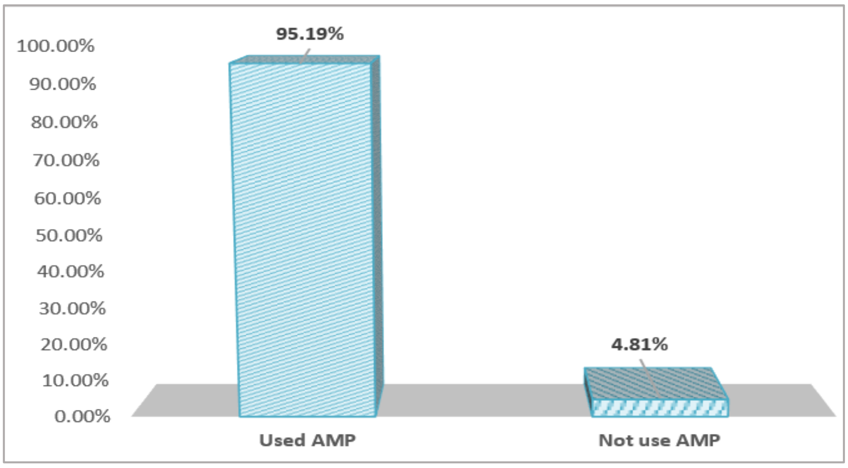

Figure 2. Percentage of respondents using aromatic and medicinal plants

The use of aromatic plants is motivated by several essential reasons. First, their relatively low cost makes them accessible to a large population, particularly in rural areas where financial resources are limited. Second, aromatic plants are often perceived as a natural and safe alternative to modern medicines, which is appealing to those who prefer less invasive treatments that are more in harmony with nature. Additionally, in many regions, access to conventional healthcare is limited by barriers such as a lack of medical services, distance, and high treatment costs. Aromatic plants, often available locally and without a prescription, offer a practical solution for treating or preventing various health issues. Finally, the use of these plants is also rooted in deep cultural traditions, where their benefits are passed down from generation to generation, thereby reinforcing their acceptance and everyday use.

The use of medicinal plants by age

The results reveal that the use of medicinal plants is widespread in the Fez-Meknes region, affecting all age groups. However, there is a slight predominance among individuals aged 40 to 49, who represent 38.15% of users. The next groups are those aged 50 to 59, with 27.78%, and those aged 30 to 39, with 15.56%. Individuals under 20 and over 60 represent the lowest rates of medicinal plant use, with 4.81% and 13.70%, respectively (Fig. 3)

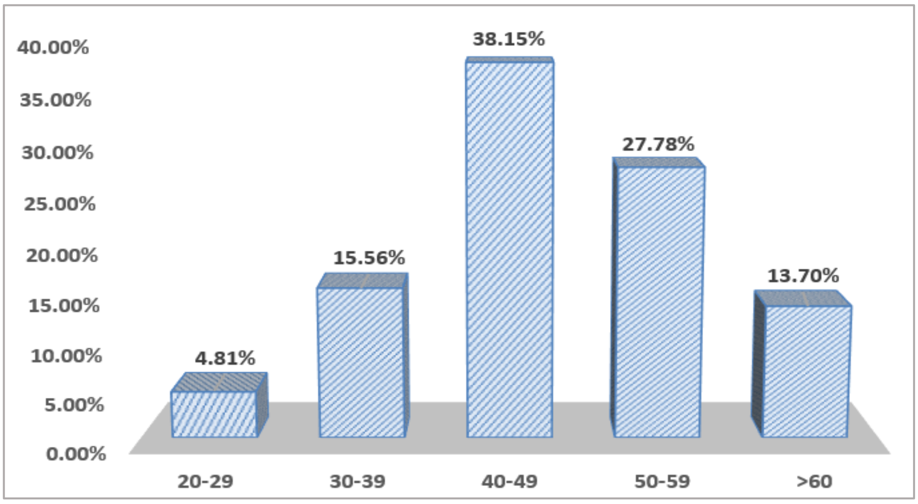

Figure 3. Use of medicinal plants by age

The knowledge of the uses of medicinal plants and their properties is generally acquired through long experience, passed down from generation to generation. Indeed, the experience accumulated over the years constitutes the primary source of local information on the use of plants in traditional medicine. However, there is a trend towards the loss of information regarding these traditional therapeutic uses, partly due to the growing distrust of some individuals, particularly the youth, towards traditional medicine. These results are consistent with findings at the national level by various authors (Rhattas *et al.* 2016; El Hachlafi *et al.* 2020). The use of medicinal plants concerns all age groups, especially those between 45 and 60 years old (53.35%) and over 60 years old (27.79%). For young people (less than 30 years), a low percentage of this practice has been reported compared to other age groups (7.94%).

Use of medicinal plants by gender

The analysis of the data reveals that among the surveyed individuals, 52.22% are women and 47.78% are men (Fig. 4), indicating a slight predominance of women in the use of traditional medicine in this region. This trend can be explained by the fact that women are often responsible for preparing remedies for themselves and their families, as well as for their role in healthcare within the household. Women, being the primary keepers of traditional knowledge about medicinal plants, have more frequent access to and a more proactive use of these resources. In contrast, men, whose traditional roles may be less centered on domestic healthcare, generally show less frequent use of medicinal plants. This result is consistent with observations made by various authors, such as (Es-Safi *et al.* 2020) in the Fez-Meknes region, (Jouad *et al.* 2001) in the Fez-Boulomane prefecture, and (Hamel *et al.* 2018; Rhattas *et al.* 2016; Hamel, Zaafour, & Boumendjel 2018; Boutabia *et al.* 2020) in other regions of Morocco.

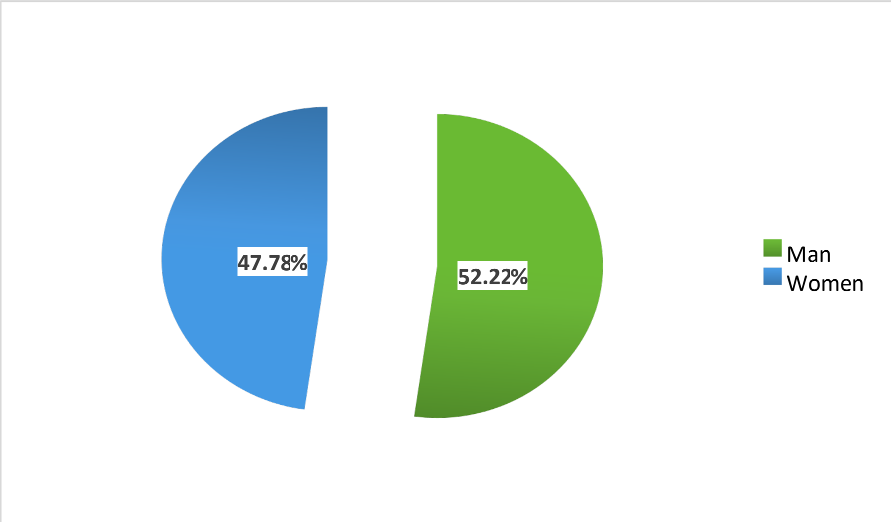

Figure 3. Use of medicinal plants by gender

Use of medicinal plants according to the occupation of informants

The results showed that herbalists utilize medicinal plants with a percentage of 38.87%. In second place are collectors of medicinal plants at 29.43%, followed by patients at 14.72% (Fig. 5). This indicates that herbalists are more involved in phytotherapy and in preparing plant-based remedies to promote the commercialization of aromatic and medicinal plants. These results are consistent with other studies conducted in the same region and in other areas of Morocco by (Bellakhdar *et al.* 1991; Es-Safi *et al.* 2020; El-Assri *et al.* 2021; Eddouks *et al.* 2002).

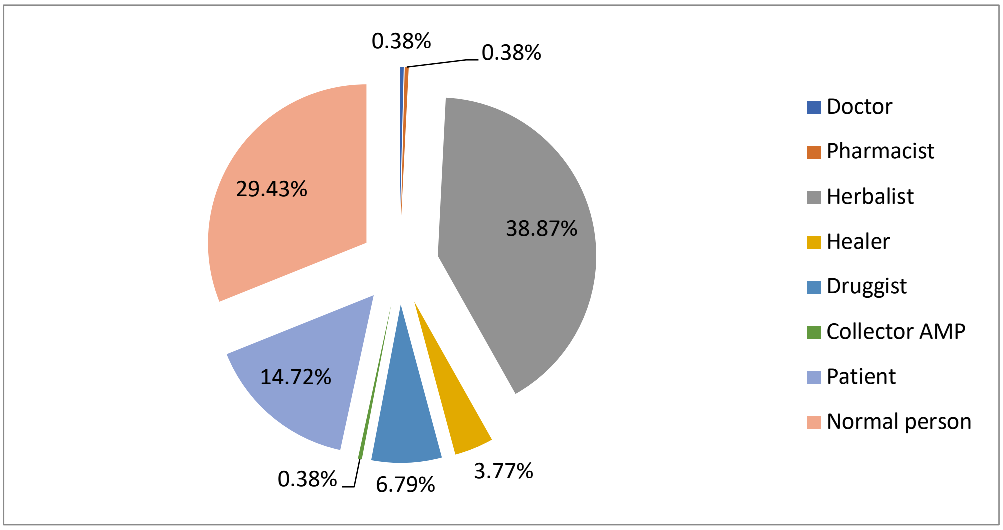

Figure 5. Percentage of the use of medicinal and aromatic plants according to the informant's profession

The use of medicinal and aromatic plants according to the informant's origin

In urban areas, 47.78% of women use medicinal and aromatic plants (MAP) to treat cardiovascular diseases, compared to 44.44% of men. In contrast, in rural areas, only 4.44% of women and 3.33% of men resort to these plants for their health issues (Fig. 6). This difference can be attributed to greater awareness in urban settings regarding the benefits of MAP for treating diseases, as well as a growing tendency to favor phytotherapy over synthetic products, which may have long-term side effects. This trend indicates a higher appreciation for traditional and natural practices in urban environments. The results obtained represent similarities with those of the ethnopharmacological study on the use of medicinal plants in the south-east of Morocco and which showed that users of medicinal plants are concentrated more in the urban environment, with a rate of 72% than the rural environment (28%) (Eddouks et al 2020).

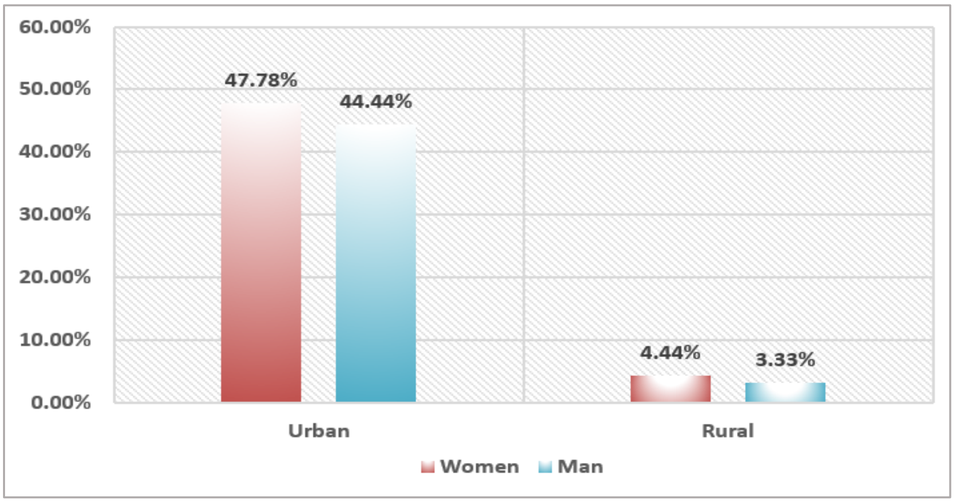

Figure 6. Use of aromatic and medicinal plants according to the origin of the informants

The use of medicinal plants according to education level

The use of aromatic and medicinal plants (AMP) decreases as education level increases. Uneducated individuals (32.98%) and those with primary education (31.11%) use AMP much more frequently than those with secondary education (20.07%) or higher education (11.85%) (Fig.7). This gradual decline reflects a transition towards more modern health practices based on scientific evidence, observed among more educated individuals. The results suggest that less educated individuals are more rooted in local traditions and natural remedies, while those with higher education levels are more inclined to resort to conventional medical treatments. This trend highlights the importance of integrating information about AMP into educational programs to harmonize traditional and modern health approaches. These results are similar to those reported by authors (Barkaoui *et al.* 2017; El Hilah *et al.* 2016; El Hachlafi *et al.* 2020; Daoudi *et al.* 2016), which showed that traditional knowledge is generally held by uneducated individuals.

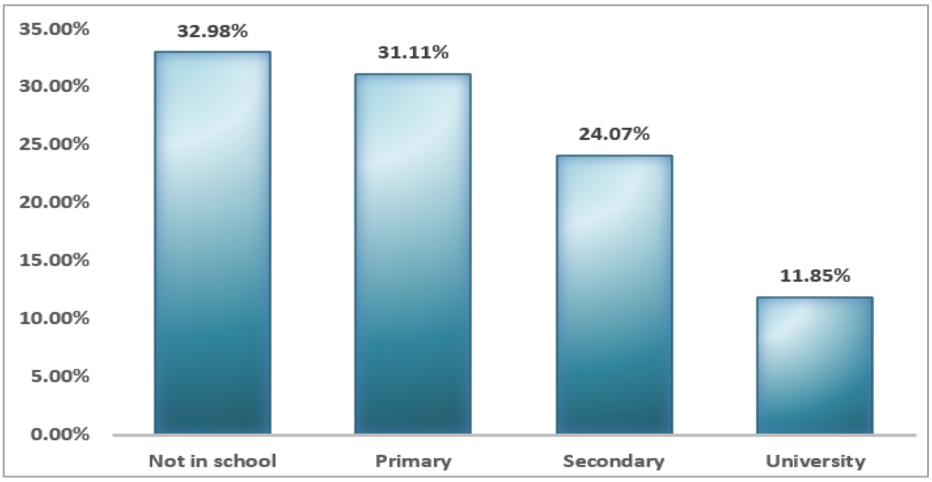

Figure 7. Use of aromatic and medicinal plants according to the level of education

Source of information regarding the use of plants

The results regarding the sources of information about plant use reveal that individuals primarily learn about aromatic and medicinal plants through family heritage (38.06%) and popular culture (21.36%), highlighting the importance of traditions and cultural beliefs in these practices. Media also significantly contribute to the dissemination of this knowledge (24.27%), while personal experience plays a notable but secondary role (14.56%) (Fig. 8). In contrast, scientific sources, despite their low percentage (1.75%), are rarely consulted, indicating an opportunity to better integrate scientific research into current practices. These results underscore the need to balance traditional knowledge with evidence-based information to enhance the understanding and use of plants. These findings are consistent with other studies conducted in the same region and in different areas of Morocco (Eddouks *et al.* 2002; Es-Safi *et al.* 2020; El-Assri *et al.* 2021; Bellakhdar *et al.* 1991).

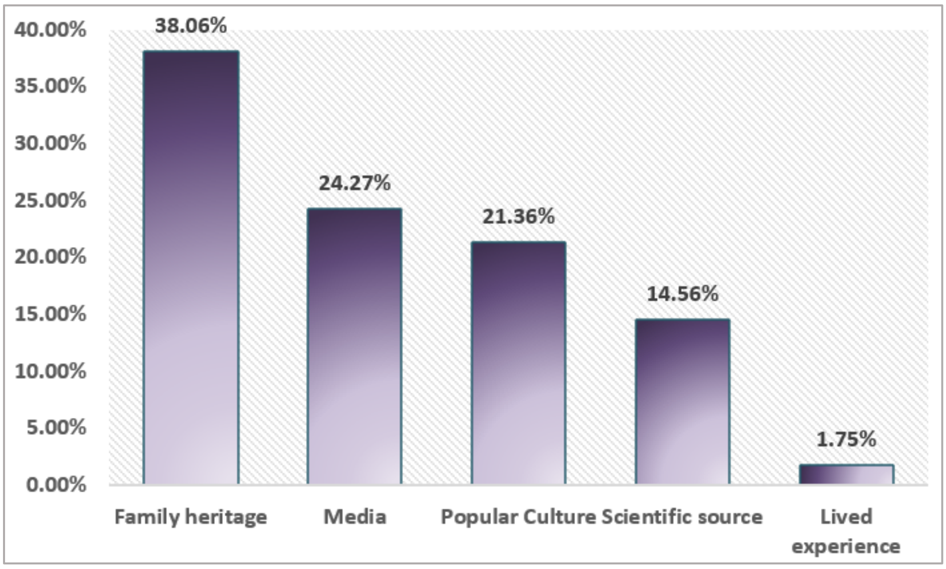

Figure 8. Source of information regarding the use of medicinal plants

Statistical treatment

Belief in herbal medicine

The aim of this analysis is to examine the influence of socio-demographic characteristics (gender, age, living environment, level of education) on belief in herbal medicine. To do this, a Chi-square test was used to assess the association between each variable and the belief in question. Here is an overall and interpretative analysis of the results (Table 2).

Table 2. Results of statistical treatment: Chi-square test

Socio-demographic characteristics	Believe in herbal medcine		
	Chi-Square	P-value	Phi/ v cramer
Gender	0.457	0.491	---
Age	1.291	0.863	---
Living environnment	1.152	0.283	---
Level of education	9.117	0,028	0.184

Gender and belief in herbal medicine

The absence of significance ($p > 0.05$) indicates that belief in herbal medicine is independent of gender in the sample analyzed. This may reflect a similar perception or use of traditional medicine among men and women. This may be attributed to cultural or social factors that standardize attitudes towards herbal medicine, irrespective of gender (Table 2).

Age and belief in herbal medicine

The result also indicates a lack of association between age and belief in herbal medicine. This suggests that in this sample, belief is evenly distributed across the different age groups. This may indicate a generalized acceptance or disinterest in the practice, regardless of age (Table 2).

Living environment and belief in herbal medicine

Although this variable is not significant, the analysis may offer some avenues of interpretation. Living environment (urban or rural) may not play an important role in herbal medicine beliefs in this population. This could be linked to an increased diffusion of alternative medical practices in urban areas, or a decrease in traditional use in rural areas, balancing overall beliefs (Table 2).

Level of education and belief in herbal medicine

This is the only variable with a statistically significant association with belief in herbal medicine ($p < 0.05$). Cramer's Phi/V index (0.184) suggests a weak to moderate relationship (Table 2).

This result may indicate that education level influences the perception of traditional medicine. People with higher levels of education may be more skeptical of these practices, favoring modern medical approaches based on scientific evidence.

Conversely, those with lower levels of education may place greater trust in traditional practices, often rooted in cultural beliefs.

In this analysis, only level of education shows a significant influence on belief in herbal medicine. This underlines the importance of education in shaping health attitudes and beliefs. Other variables (gender, age, living environment) do not appear to play a significant role in this context, which may reflect a generalized acceptance or indifference, transcending these demographic characteristics.

These results call for further investigation into the role of education in the adoption or rejection of alternative medical practices.

The multiple correspondence analysis (MCA)

This graph (fig. 9) is a modality point diagram derived from a multiple correspondence analysis (MCA), which explores relationships between categories of qualitative variables. Dimension 1 (horizontal axis) and Dimension 2 (vertical axis) represent the two main components explaining variability in the data. Each dimension corresponds to a linear combination of variables that maximize differences between categories. Points close together (on the graph) represent modalities (categories) that are correlated or frequently associated in the data. Distant points indicate modalities that are unrelated or in opposition. In Fig. 9, we can see that the “Higher education” category is far away on the Dimension 2 axis, probably associated with specific traits or opposed to modalities such as “Illiterate”. The modalities “Rural” (rural environment) and “>60” (age over 60 years) are close to each other, suggesting an association. “Urban” (urban environment), “Male”, and the age groups “40-49” and “30-39” seem to share a certain proximity, indicating that they could often be related. Belief in traditional medicine (“Yes” or “No”) appears to be distributed along Dimension 1, perhaps influenced by factors such as education or living environment. The “Female” variable is associated with “Primary” and “Illiterate”, which may reflect a link in the sample analyzed. Dimensions can be used to visualize oppositions, for example; dimension 1 could reflect an opposition between belief in traditional medicine and level of education, while dimension 2 could reflect an opposition between rural/urban environments and age groups.

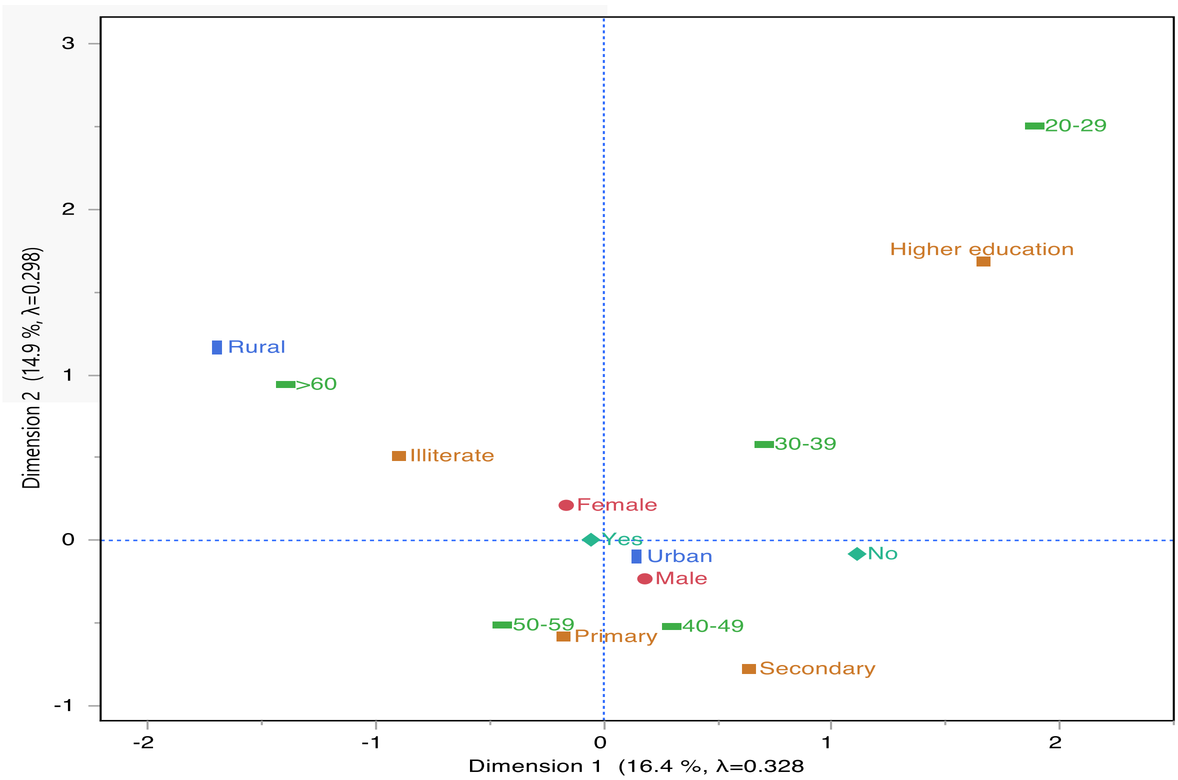

Figure 9. Graphic representation of the multiple correspondence analysis (MCA)

Diversity of medicinal species used in the Fez-Meknes region

Recorded botanical families

Eighty medicinal plants belonging to forty-one families were identified. The most represented families in traditional phytotherapy in the Fez-Meknes region are Lamiaceae (47%), followed by Fabaceae and Apiaceae (29% each), as well as Amaryllidaceae (26%). Oleaceae account for 16%, Asteraceae 15%, and Lauraceae 14%. Zingiberaceae make up 12%, while Verbenaceae and Linaceae each account for 9%, and Myrtaceae for 7% (Fig. 10).

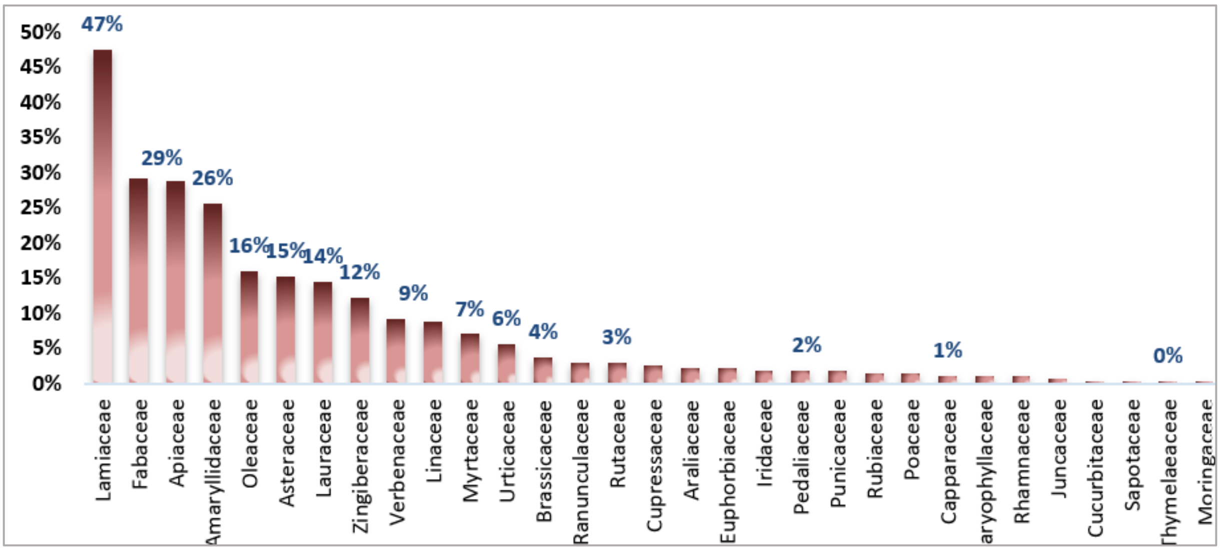

Figure 10. The representation of inventoried plants according to botanical families

Inventoried species

The importance of each species in preventing cardiovascular diseases was evaluated by calculating the Relative Frequency of Citation (RFC). The RFC values of the recorded plants range from 0.004 to 0.219. The species with the most significant RFC values are as follows: *Allium sativum L* (RFC = 0.219), *Trigonella foenum-graecum* (RFC = 0.167), *Olea europaea L* (RFC = 0.159), *Origanum vulgare L* (RFC = 0.141), *Lavandula angustifolia* Mill (RFC = 0.104), and *Zingiber officinale* Roxb (RFC = 0.096) (Table 3).

Fidelity Level (FL)

The fidelity level (FL) is an essential indicator for determining the effectiveness of a plant species in treating a specific condition. In the current study area, the FL of plant species for treating cardiovascular disease ranged from 50% to 100%. 57 plant species with a maximum FL of 100% were identified (Table 3). This variation reflects the wealth of information regarding species use in the studied area. Generally, an FL of 100% for a specific plant indicates that all reports of use mentioned the same plant for treating a specific disease (Srithi *et al.* 2009). According to Bhatia et al., plant species that have not been previously studied and have a maximum FL should be recommended for further research related to their use. Conversely, a low FL value is obtained for plants used for multiple purposes (Bhatia *et al.* 2014).

Use of plants in the prevention and treatment of cardiovascular diseases

Categories of treated diseases and their ICF values

The informant consensus factor (ICF) depends on the availability of the plant in the study area for treating diseases, with values ranging from 0 to 1. The highest ICF value indicates agreement among informants in selecting taxa, while a low value indicates disagreement. The analysis of ICF has recently been used as an essential tool for analyzing ethnobotanical data (Uprety *et al.* 2010). In this study, ICF values ranged from 0.896 to 0.923 by category. The results show that the cardiovascular disease with the highest degree of informant agreement (ICF) was hypertension (0.923), followed by hypercholesterolemia (0.917), diabetes (0.915), atherosclerosis (0.909), and finally obesity (0.896) (Table 4). The ICF results demonstrated that common cardiovascular diseases had the highest consensus among informants (values ranging from 0.896 to 0.923). These high ICF values indicated informants' reasonable reliability regarding plant species use (Kharchoufa *et al.* 2021). The consensus values among informants also stated that they shared knowledge of the most essential PAM species for treating the most frequently encountered cardiovascular diseases in the study area.

Table 3. The list of inventoried plants for treating cardiovascular diseases in the Fez-Meknes region

Families and Scientific name (EPPO code)	Vernacular name	Used part	Treated diseases	Number of citation	RFC	FL (%)	References
Amaryllidaceae							
Allium cepa L. **(ALLCE)**	**Bassal**	Bulb	HT- DB-AT-HC	10	0.037	100.0	(Bouayyadi *et al.* 2015a; Barkaoui *et al.* 2017)
Allium sativum L. **(ALLSA)**	**Touma**	Bulb (cloves)	HT- DB-OB-AT-HC	59	0.219	100.0	(Bellakhdar *et al.* 1991; Orch *et al.* 2015; M. Eddouks *et al.* 2002)
Anacardiaceae							
Pistacia lentiscus L. **(PIALE)**	**Drou**	Resin (mastic)	DB	7	0.026	92.15	(Hedidi *et al.* 2024)
Apiaceae							
Visnaga daucoides Gaertn. **(PIAAT)**	**Bechnikha**	Fruits (seeds)	HC	1	0.004	87.10	(El-Hilaly *et al.* 2003a; Bellakhdar 1997a)
Ammodaucus leucotrichus Coss. **(AMKLE)**	**Kamoun soufi**	Seeds	HT	9	0.033	98.6	(Barkaoui *et al.* 2017; M. Eddouks *et al.* 2002)
Apium graveolens L. **(APUGV)**	**Krafs**	Leaves, stems, seeds	HT-DB	4	0.015	100.0	(Bellakhdar 1997b; El-Hilaly *et al.* 2003a)
Petroselinum sativum Hoffm. **(PARCR)**	**Maadnouss**	Leaves	DB	1	0.004	70.0	(Tahraoui *et al.* 2007; Bellakhdar 1997a)
Carum carvi L. **(CRYCA)**	**Karwia**	Seeds	HT-DB-OB	10	0.037	80.0	(M. Eddouks *et al.* 2002; Bellakhdar 1997a) ;
Coriandrum sativum L. **(CORSA)**	**Kasbour**	Leaves, seeds	HT-DB-OB	15	0.056	100.0	(El-Hilaly *et al.* 2003a; Bellakhdar *et al.* 1991; Tahraoui *et al.* 2007; Es-Safi *et al.* 2020),
Cuminum cyminum L **(CVUCY)**	**Kamoun**	Seeds	HT	7	0.026	100.0	(Bouayyadi et al 2015a; Bellakhdar *et al.* 1991)
Foeniculum vulgare Mill. **(FOEVU)**	**Besbas**	Seeds	HT-OB	25	0.093	100.0	(Mechchate *et al.* 2020; Bellakhdar 1997a)
Pimpinella anisum L. **(PIMAN)**	**Habat hlawa**	Fruits	HT	6	0.022	65.12	(Tahraoui *et al.* 2007)
Araliaceae							
Phalaris canariensis L. **(LOLRI)**	**Zwan**	Seeds	DB-AT	6	0.022	100.0	(Bellakhdar 1997a)

Asteraceae							
Silybum marianum L. **(SLYMA)**	**Chouklahmir**	Leaves	HT	1	0.004	100.0	(El Hachlafi *et al.* 2020; Orch *et al.* 2015, Louafi *et al.* 2024a)
Artemisia absinthium L. **(ARTAB)**	**Cheba**	Leaves	HT	1	0.004	64.5	(Mechchate *et al.* 2020; Bouayyadi *et al.* 2015b; M. Eddouks *et al.* 2002)
Artemisia herba-alba Asso. **(ARTHA)**	**Chih**	Leaves, Flowers	DB	20	0.074	90.0	(Bellakhdar 1997a; Mohamed Eddouks 2017; Mechchate *et al.* 2020)
Chamaemelum nobile L. **(MATCH)**	**Babonj**	Flowers	HT	15	0.056	80.0	(Bouayyadi *et al.* 2015a; Salhi *et al.* 2010; Tahraoui *et al.* 2007)
Cynara cardunculus L. **(CYUCA)**	**Kharchouf**	Flowers, leaves	OB	4	0.015	100.0	(Bouayyadi *et al.* 2015a; Bellakhdar 1997a)
Brassicaceae							
Lepidium sativum L. **(LEPSA)**	**Hab rchad**	Seeds	DB-HC	7	0.026	100.0	(M. Eddouks *et al.* 2002; Tahraoui *et al.* 2007; Mechchate *et al.* 2020)
Raphanus sativus L. **(RAPSR)**	**Fjel**	Root	HT-OB	3	0.011	100.0	(Bellakhdar 1997a)
Capparaceae							
Capparis spinosa L. ***(*CPPSP)**	**Kebar**	Flowers , fruits	HT	3	0.011	70.40	(Bouayyadi *et al.* 2015a; Ziyyat *et al.* 1997)
Caryophyllaceae							
Corrigiola thelephifol Pourr. **(CGLTE)**	**Serghina**	Leaves	DB	3	0.011	66.7	(M. Eddouks *et al.* 2002)
Cleomaceae							
Cleome gynandra L. **(GYAGY)**	**Akaya**	Leaves	DB	1	0.004	100.0	
Costaceae							
Saussurea costus (Falc.) Lipsch. **(SAULA)**	**3oud hindi**	Root	HT	1	0.004	59.0	(Bellakhdar 1997b)
Cucurbitaceae							
Cucurbita maxima Duche **(CUUMA)**	**Guer3a hamra**	Fruits, seeds	DB	1	0.004	100.0	(Bellakhdar *et al.* 1991)

Euphorbiaceae							
Euphorbia lathyris L. **(EPHLA)**	**Daghmouss**	Latex	HT-AT	6	0.022	100.0	(Hachi *et al.* 2015; Bellakhdar 1997a)
Cupressaceae							
Juniperus phoenicea L. **(IUPPH)**	**Araar**	Leaves	DB-HT	7	0.026	100.0	(El Kourchi *et al.* 2024)
Fabaceae							
Senna alexandrina Mill. **(CASSE)**	**Senameki**	Leaves	DB-OB	6	0.022	50.0	(El Kourchi *et al.* 2024)
Ceratonia siliqua L. ***(*CEQSI)**	**Kharoube**	Pods	HC	3	0.011	100.0	(El-Hilaly *et al.* 2003a; Mechchate *et al.* 2020; Louafi et al 2024b)
Glycine max L. **(GLXMA)**	**Soja**	Seeds	DB	2	0.007	100.0	(Tahraoui *et al.* 2007)
Glycyrrhiza glabra L. **(GYCGL)**	**Ark souss**	Root	HC	3	0.011	100.0	(Bouayyadie et el. 2015a; El hilah *et al.* 2016)
Lupinus luteus L. **(LUPLU)**	**Termss**	Seeds	DB	1	0.004	100.0	(El Finou *et al.* 2023)
Cassia senna L. ***(CASSE)***	**Sannâ haram**	Leaves, pods	DB	11	0.041	100.0	(M. Eddouks *et al.* 2002)
Trigonella foenum-graecum L. (**TRKFG)**	**Helba**	Seeds	DB-HC	45	0.167	100.0	(Barkaoui *et al.* 2017; Tahraoui *et al.* 2007; Ziyyat *et al.* 1997)
Vachellia gummifera L. **(ACAGU)**	**Talh**	Leaves , flowers	HC	8	0.030	62.0	(Bellakhdar *et al.* 1991)
Iridaceae							
Crocus sativus L. **(CVOSA)**	**Zaafran**	Flowers (stigmas)	DB	5	0.019	100.0	(Najem *et al.* 2024)
Juglandaceae							
Juglans regia L. ***(*IUGRE)**	**Guequa3**	Nuts, leaves	HT-DB	1	0.004	100.0	(Tahraoui *et al.* 2007; Ziyyat *et al.* 1997)
Juncaceae							
Juncus acutus L. **(IUNAC)**	**Semar**	Stems	HT	2	0.007	100.0	(Bellakhdar *et al.* 1991)

Lamiaceae							
Lavandula angustifolia Mill. **(LAVAN)**	**Khzama**	Flowers, leaves	HT-DB	28	0.104	85.7	(Tahri *et al.* 2012; Hedidi *et al.* 2024; M. Eddouks *et al.* 2002)
Mentha pulegium L. **(MENPU)**	**Fliou**	Leaves	HT-DB	7	0.026	100.0	(Mechchate *et al.* 2020; Ziyyat *et al.* 1997; Salhi *et al.* 2010)
Ocimum basilicum L. **(OCIBA)**	**Lhbak**	Leaves	HT	5	0.019	89.40	(M. Eddouks *et al.* 2002; Bouayyadi *et al.* 2015a)
Origanum majorana L. **(MAJHO)**	**Merddouch**	Leaves, flowers	HT-DB	2	0.007	90.65	(El-Hilaly, Hmammouchi, et Lyoussi 2003a; Tahraoui *et al.* 2007)
Origanum vulgare L. **(ORIVU)**	**Zaatar**	Root	HT	38	0.141	92.1	(Ziyyat *et al.* 1997; Tahraoui *et al.* 2007)
Ajuga iva L. **(AIUIV)**	**chandgoura**	Leaves	DB	2	0.007	100.0	(Ziyyat *et al.* 1997)
Salvia officinalis L. **(SALOF)**	**Salmia**	Leaves	HT-DB	23	0.085	100.0	(Orch *et al.* 2015; El-Hilaly *et al.* 2003a)
Rosmarinus officinalis L. **(RMSOF)**	**Azir**	Leaves, flowers	HT-DB	17	0.063	90.6	(M. Eddouks *et al.* 2002; Salhi *et al.* 2010)
Thymus vulgaris L. **(THYVU)**	**Ziitra**	Leaves, flowers	HT	6	0.022	100.0	(Mechchate *et al.* 2020; M. Eddouks *et al.* 2002) ;
Lauraceae							
Cinnamomum camphora L. **(CINCA)**	**Kafour beldi**	Resin	DB	1	0.004	100.0	(Tahraoui *et al.* 2007; Orch *et al.* 2015)
Cinnamomum verum J. Presl. **(CINZE)**	**Kerfa**	Bark	HT-DB	23	0.085	95.7	(Mechchate *et al.* 2020; Orch *et al.* 2015)
Laurus nobilis L. **(LURNO)**	**Wrkat sidna mossa**	Leaves	AT-HC	15	0.056	100.0	(Hachi *et al.* 2015)
Malvaceae							
Hibiscus syriacus L. **(HIBSY)**	**Karkadia**	Flowers	HT	5	0.019	100.0	(Bellakhdar 1997a; El Hachlafi *et al.* 2020)
Linaceae							
Linum usitatissimum L. **(LIUUT)**	**Zriat ketan**	Seeds, stem fibers	AT- HC	24	0.089	100.0	(El Hachlafi *et al.* 2020),(Yahyaoui 2015; El Hachlafi *et al.* 2020; Mechchate *et al.* 2020)

Moraceae							
Ficus carica L. **(FIUCA)**	**Karmouss**	Leaves	DB	4	0.015	100.0	(El Hachlafi *et al.* 2020; Mechchate *et al.* 2020)
Moringaceae							
Moringa oleifera Lam. **(MOHOL)**	**Chouee**	Leaves, seeds, roots	DB	1	0.004	100.0	(El Kourchi *et al.* 2024)
Myrtaceae							
Eucalyptus globulus Labill **(EUCGL)**	**Kaliptus**	Leaves	DB	3	0.011	100.0	(Bellakhdar 1997a; El hilah *et al.* 2016; El-Hilaly *et al.* 2003a)
Myrtus communis L. **(MYVCO)**	**Ray7an**	Leaves, berries	AT	10	0.037	100.0	(Bellakhdar *et al.* 1991; Yahyaoui 2015)
Syzygium aromaticum L. **(SYZAR)**	**Kronfel**	Flowers (buds)	HT	6	0.022	100.0	(El hilah *et al.* 2016; Salhi *et al.* 2010)
Nitrariaceae							
Peganum harmala L. **(PEGHA)**	**Alhrmel**	Seeds	DB	2	0.007	100.0	(Bellakhdar *et al.* 1991; Salhi *et al.* 2010)
Papaveraceae							
Papaver rhoeas L. **(PAPRH)**	**Balaâmane**	Seeds, roots	HT	4	0.015	100.0	(Bellakhdar *et al.* 1991; El-Hilaly, Hmammouchi, et Lyoussi 2003a)
Oleaceae							
Olea europaea L. **(OLVEU)**	**Zitoune**	Leaves, fruits (olives)	HT-DB-HC	43	0.159	100.0	(Orch, Douira, et Zidane 2015; Bellakhdar *et al.* 1991; El-Hilaly *et al.* 2003a)
Plantaginaceae							
Plantago ovata L. **(EUCOV)**	**Katouna**	Seeds (psyllium)	DB	1	0.004	100.0	(Naceiri Mrabti *et al.* 2021)
Pedaliaceae							
Sesamum indicum L. **(SEGIN)**	**Zanjlan**	Seeds	HC	5	0.019	100.0	(Chaachouay *et al.* 2020)
Poaceae							
Avena sativa L. **(AVESA)**	**Chofan**	Seeds	HC	2	0.007	100.0	(Hedidi *et al.* 2024)

Pennisetum typhoides Burm. **(PESGL)**	**Illane**	Seeds	HC -DB	1	0.004	100.0	(Najem *et al.* 2024; El Kourchi *et al.* 2024)
Zea mays L. **(ZEAMX)**	**Dra**	Seeds	DB-HT -HC	1	0.004	100.0	(Hachi *et al.* 2015; Tahraoui *et al.* 2007; El Kourchi *et al.* 2024)
Ranunculaceae							
Nigella sativa L. **(NIGSA)**	**Sanouj**	Seeds	HT	8	0.030	100.0	(Bellakhdar 1997a; Orch *et al.* 2015)
Lythraceae							
Punica granatum L. **(PUNGR)**	**Reman**	Fruits, seeds	DB	5	0.019	100.0	(El-Hilaly *et al.* 2003a; Mechchate *et al.* 2020; El Hachlafi *et al.* 2020; Tlemcani *et al.* 2023)
Rosaceae							
Crataegus monogyna L. **(CSCMO)**	**Zarour**	Flowers, fruits	HT-DB-HC	20	0.074	100.0	(El Finou *et al.* 2023; Hachi *et al.* 2015)
Prunus amygdalus L. **(PRNDA)**	**Louz mer**	Seeds (almonds)	DB	1	0.004	100.0	(Tahraoui *et al.* 2007)
Rhamnaceae							
Ziziphus lotus (L.) Lam. **(ZIPNU)**	**Nebk**	Fruits	DB	3	0.011	100.0	(El Hachlafi *et al.* 2020)
Rutaceae							
Citrus x limon L. **(CIDLI)**	**Hamid**	Fruits (juice, zest)	DB-HC	8	0.030	100.0	(Hachi *et al.* 2015)
Rubiaceae							
Rubia peregrina L. **(RBIPE)**	**Elfowa**	Root	AT	4	0.015	100.0	(Hachi *et al.* 2015)
Thymelaeaceae							
Aquilaria sinensis (Lour.) Spreng. **(AQAMA)**	**Aghriss**	Wood	HT	1	0.004	55.5	(Bellakhdar 1997a)
Sapotaceae							
Argania spinosa L. **(ARJSI)**	**Kchour argan**	Fruits , seeds	DB	1	0.004	100.0	(Bouayyadi *et al.* 2015a; Yahyaoui 2015)

Urticaceae							
Urtica dioica L. **(URTDI)**	**Hrigua**	Leaves, roots	HT-DB	15	0.056	100.0	(Bouayyadi *et al.* 2015b; El-Hilaly *et al.* 2003b; Tahri *et al.* 2012; M. Eddouks *et al.* 2002)
Verbenaceae							
Verbena officinalis L. **(VEBOF)**	**Lwiza**	Leaves	HT	25	0.093	85.52	(Bellakhdar 1997a; Bouayyadi *et al.* 2015a)
Zingiberaceae							
Aframomum melegueta K. Schum. **(AFRME)**	**Gouza sahraouia**	Seeds	DB	1	0.004	100.0	(Najem *et al.* 2024)
Alpinia officinarum Hance **(AIIOF)**	**Khodnjal**	Rhizome	AT-HC	2	0.007	100.0	(Bouayyadi *et al.* 2015a)
Curcuma xanthorrhiza Roxb **(CURZA)**	**Kherkoum**	Rhizome	DB-HC	4	0.015	75.0	(Najem *et al.* 2024; El Kourchi *et al.* 2024)
Zingiber officinale Roxb **(ZINOF)**	**Skinjbir**	Rhizome	DB-HC	26	0.096	100.0	(Yahyaoui 2015; Bouayyadi *et al.* 2015b)

HT: Hypertension • **DB**: Diabetes • **OB**: Obesity •**AT**: Atherosclerosis • **HC**: Hypercholesterolemia

Table 4.The Value of the informants' Consensus Factor (ICF) by the category of treated cardiovascular disease

Cardiovascular disease	Species used and citation number	Nt	Nur	ICF
Arterial hypertension	*Allium cepa L (6), Allium sativum L (59), Ammodaucus leucotrichus Coss (8), Apium graveolens var (2), Capparis spinosa (1), Euphorbia lathyris L (5), Carum carvi L (1), Chamaemelum nobile L (15), Cinnamomum verum J (23), Coriandrum sativum L (15), Crataegus monogyna (20), Crocus sativus (5), Cuminum cyminum L (7), Foeniculum vulgare mill (25), Hibiscus syriacus L (5), Lavandula angustifolia Mill. (25), Mentha pulegium L (6), Nigella sativa L (7), Ocimum basilicum L (5), Olea europaea L (43), Origanum vulgare L (38), Peganum harmala L (2), Pimpinella anisum (6), Prunus amygdalus var a (1), Punica granatum L (5), Raphanus sativus L (3), Salvia officinalis L (23), Rosmarinus officinalis L (17), Senna alexandrina* Mill *(11), Thymus vulgaris (6), Trigonella foenum-grae (5), Urtica dioica L (12), Vachellia gummifera (8), Verbena officinalis L (25).*	**445**	**34**	**0.923**
Diabetes	*Allium cepa L (4), Allium sativum L (59), Apium graveolens var. (1), Argania spinosa (1), Artemisia herba-alba* Asso *(20), Avena sativa L (2), Carum carvi L (7), Cinnamomum camphora L (1), Cinnamomum verum J (22), Citrus x limon (8), Coriandrum sativum L (15), Corrigiola thelephifol Pourr (1), Saussurea costus (1), Crataegus monogyna (16), Foeniculum vulgare* mill *(25), Hibiscus syriacus L (4), Juniperus phoenicea L (7), Lepidium sativum L (7), Lupinus luteus L (1), Mentha pulegium L (6), Moringa oleifera* Lam *(1), Olea europaea L (43), Phalaris canariensis L (6), Peganum harmala L (2), Pimpinella anisum L (6), Pistacia lentiscus L (5), Prunus amygdalus var a (1), Raphanus sativus L (1), Rubia tinctorum L (4), Ajuga iva (L.) (1), Salvia officinalis L (23), Trigonella foenum-graecum (45), Urtica dioica L (12), Vachellia gummifera (8), Zingiber officinale Roxb (26), Ziziphus lotus (L.) Lam (1).*	**436**	**38**	**0.915**
Obesity	*Senna alexandrina* Mill *(4), Avena sativa L (2), Carum carvi L (9), Citrus x limon L (8), Coriandrum sativum L (14), Cynara cardunculus* var *(1), Foeniculum vulgare* mill *(17), Mentha pulegium L (6), Olea europaea L (43), Plantago ovata (1), Raphanus sativus L (1), Ajuga iva (L.) (1), Urtica dioica L (1), Zingiber officinale Roxb (26), Ziziphus lotus (L.) Lam (1).*	**135**	**15**	**0.896**
Atherosclerosis	*Allium cepa (4), Allium sativum L (59), Alpinia officinarum* Hance *(2), Euphorbia lathyris L (5), Citrus x limon L (8), Coriandrum sativum L (15), Curcuma xanthorrhiza* Roxb *(4), Foeniculum vulgare* mill *(25), Lauris nobilis L (11), Linum usitatissimum L (24), Myrtus communis L (10), Nigella sativa L (7), Phalaris canariensis L (5), Pimpinella anisum L (4), Rubia tinctorum L (2), Sesamum indicum L (5), Trigonella foenum-graecum (5), Urtica dioica L (2), Ziziphus lotus L* Lam *(1).*	**198**	**19**	**0.909**
Hypercholesterolemia	*Allium cepa (4), Allium sativum L (55), Alpinia officinarum* Hance *(2), Visnaga daucoides* Gaertn. *(1), Ceratonia siliqua (3), Citrus x limon L (8), Coriandrum sativum L (9), Crataegus monogyna L (16), Curcuma xanthorrhiza Roxb (4), Cynara cardunculus var (4), Foeniculum vulgare* mill *(19), Glycine max L (2), Glycyrrhiza glabraL (3), Laurus nobilis L (13), Lepidium sativum L (1), Linum usitatissimum L (20), Nigella sativa L (7), Olea europaea L (43), Urtica dioica L (2), Zingiber officinale (26), Ziziphus lotus L Lam (1).*	**243**	**21**	**0.917**

Nt : Citations total number ; **Nur** : Species total number

Parts of the used medicinal and aromatic plants (pam): ppv

In the study area, leaves are the most commonly used part, with a Partial Plant Value (PPV) of 32.9%. Seeds come in second place with a PPV of 30.2%, followed by roots (PPV = 16.5%), flowers (PPV = 7.8%), the whole plant (PPV = 6.1%), branches (PPV = 3.3%), and bark (PPV = 3.2%) (Fig.11). These results show some similarities with those of Salhi *et al.* (2010), but differ from those of Mechchate *et al.* (2020), which indicate that seeds are the most frequently used organs. Indeed, the use of leaves is explained by the fact that they are easy to collect and serve as the center of photosynthesis and storage for secondary metabolites responsible for biological properties (El-Assri *et al.* 2021).

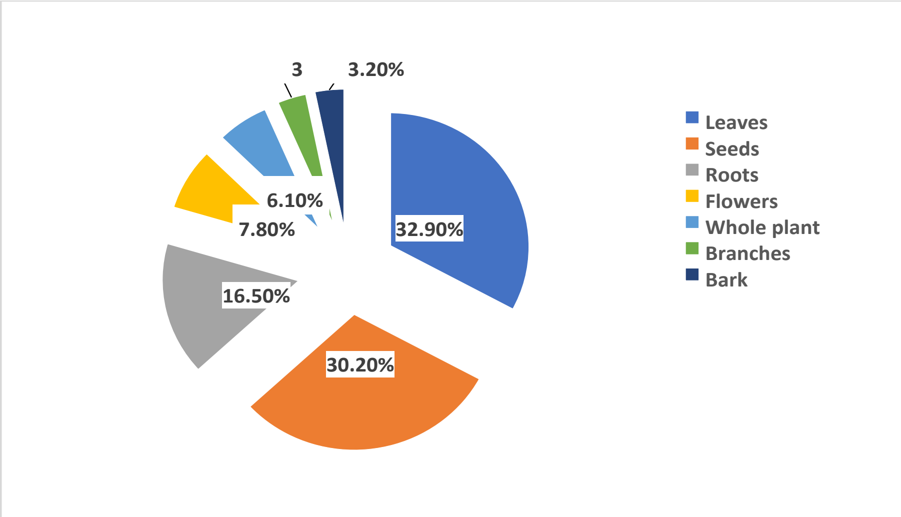

Figure 11. The parts of plants used

Methods of preparation of plants

Various methods for preparing medicinal plants in the studied area are adopted, including decoction, infusion, fumigation, paste, oil, and powder. The maceration is the preparation method used to extract the active principles from the plants, with a percentage of 23.91%. This involves soaking the plants in cold or lukewarm water for 10 to 12 hours. Water macerations should not exceed twelve hours due to the risk of oxidation and fermentation of the liquid. Decoction comes in second place with a rate of 20.25%, followed by infusion at 17.75% and powder at 17.32%. As for other preparation methods, grinding of the medicinal plants is used at 15.30%, oil and paste at 1.90%, fumigation at 1.03%, and distillation at 0.66% (Fig. 12).

An ethnopharmacological study of medicinal plants used in the treatment of chronic diseases in the Rabat-Sale-Kenitra region (Morocco) conducted by (El Hachlafi et AL 2020) showed that decoction is the most commonly used preparation method by the population studied (37.7%), followed by infusion (27.37%), powder (22.69%), while poultice, maceration and fumigation are rarely used; This difference may be related to variables such as the context of each study, the target populations or local cultural habits.

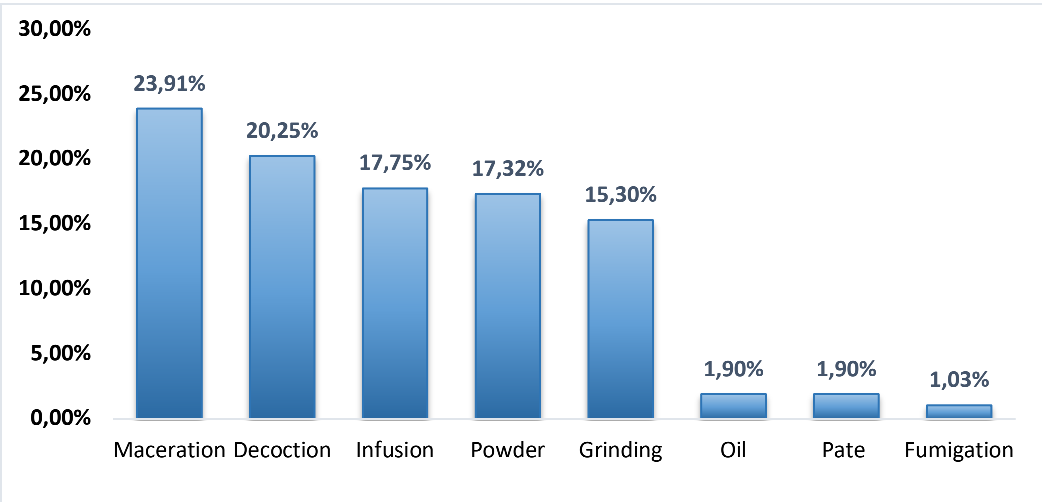

Figure 12. The preparation methods of medicinal plants in the study area

Method of administration of plants

Oral administration remains the most well-known and recommended method, with a percentage of 85.25%, followed by massage at 10.12% and rinsing at 4.63% (Fig. 13). This result is similar to that found in the floristic and ethnobotanical study of medicinal flora in the Gharb region, Morocco carried out by (Bouayyadi et al 2015) and which revealed that oral administration remains the best known and most recommended with a high percentage of 63.62%.

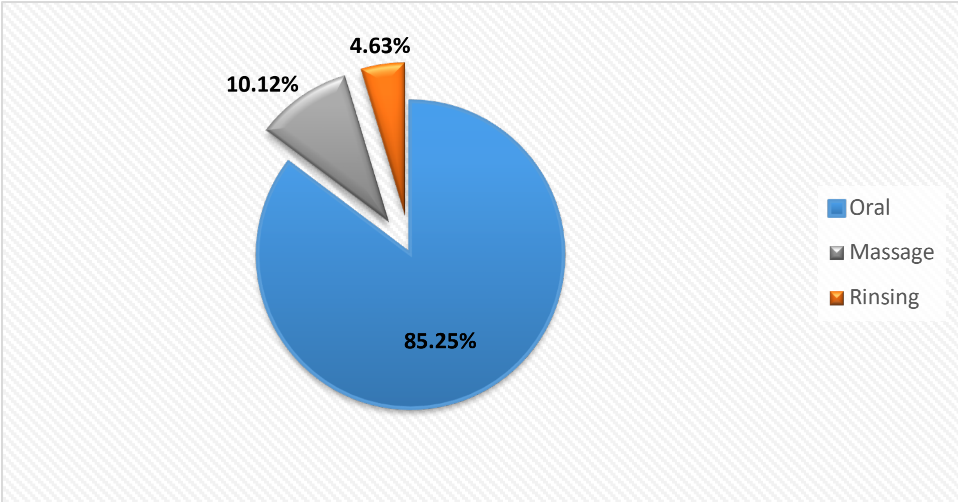

Figure 13. The mode of administration of medicinal plants in the study area

Duration and dosage of plant use

The doses used were often vague or sometimes imprecise (80%); they were frequently described as a pinch, a handful, or one to two teaspoons over varying durations, from one day to a week, and sometimes even up to a month or until healing.

Toxicity of plants

This study shows that the majority of users of plant-based medicine have very little knowledge about the toxicity of these plants. Nearly 95% of informants responded "No" to the question about the toxicity of the plant used, while the percentage of informants who answered "Yes" to this question was 5% (Fig. 14).

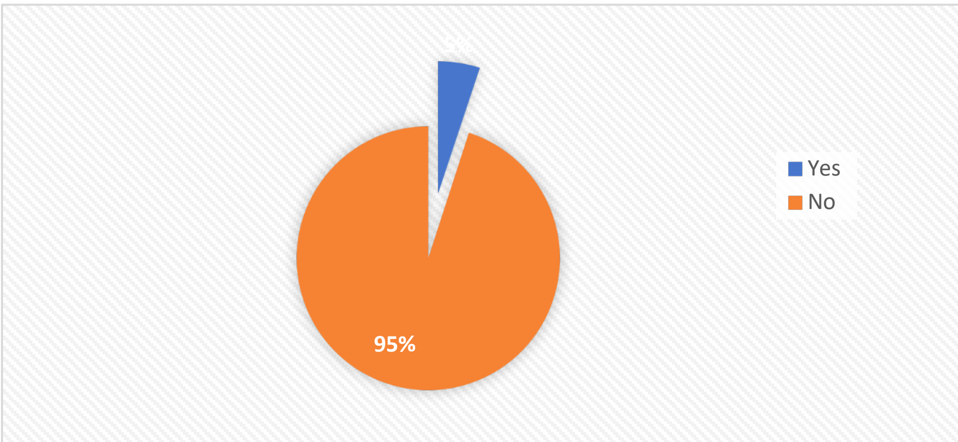

Figure 13. The distribution of the toxicity of inventoried plants

Conclusion

This ethnobotanical study highlighted the floristic wealth of the Fès-Meknès region, revealing the use of eighty medicinal plants from forty-one families for the treatment of cardiovascular disease. Informant Consensus Factor (ICF) and Level of Reliability (LF) values, respectively ranging from 0.896 to 0.923 and from 50% to 100%, testify to the unity and consistency of shared knowledge about these plants. These results provide a valuable basis for future research in phytochemistry and pharmacology, and contribute to the conservation of traditional knowledge linked to medicinal plants in Morocco.

Nevertheless, several limitations need to be taken into account, such as the restricted selection of participants, biases in data collection, constraints linked to plant seasonality and access to harvesting areas. In addition, scientific validation of medicinal properties remains insufficient, and the gradual loss of traditional knowledge could restrict the diversity of knowledge available. Despite these challenges, the study offers important insights for the preservation of ethnobotanical practices and their scientific valorization.

Prospects for this research include the need for further studies to scientifically validate the medicinal properties of the plants identified, in particular through pharmacological and clinical testing. An integrated approach, combining traditional phytotherapy with advances in modern medicine, could also open up new avenues for the treatment of cardiovascular disease. It would also be appropriate to broaden the sample of participants to better reflect the diversity of knowledge present in the region's different communities. Finally, efforts should be made to document and preserve traditional knowledge, in particular by involving younger generations and using modern technologies to safeguard this knowledge before it is lost.

Declarations

Ethics approval and consent to participate: Confidentiality, anonymity, and informed approval were rigorously maintained throughout the study. Participants were thoroughly informed about the study's objectives and gave their consent before taking part.

Consent for publication: Not applicable.

Availability of data and materials: Requests for the data used in this article are welcome and will be accommodated.

Competing interests: It is stated by the authors that they do not possess any conflicting interests.

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Author contributions: BM Designing the study, NH, JK KF, KC, LB and FH conducting the ethnobotanical survey ,actively participating instructuring the methodology, BL, BM,H.T and RA analyzing and interpreting data (including statistical processing), writing the original draft, TZ,MY, BL and RB revising and editing the final version. All authors have reviewed, read and endorsed the final article.

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