Documentation of ethnobotanical data on anti-periodontal flora among the population of the Fez-Meknes region in Morocco

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Research

Abstract

Background: Periodontal diseases represent a public health issue; they involve inflammation of the tissues supporting the teeth and the periodontium, which, in advanced stages, can lead to gum recession and tooth loss, with repercussions on quality of life and general health. Despite the limitations of certain conventional treatments, the abundance of bioactive compounds in medicinal plants makes phytotherapy a promising therapeutic alternative. Given their effectiveness, accessibility, and the natural properties of medicinal plants in the Fez-Meknes region, an ethnobotanical study was conducted in this region to identify the plants most commonly used to treat periodontal disease.

Methods: This study was conducted over a period of four months, involving 559 informants across 20 different sites, using a semi-structured questionnaire. Quantitative indices (relative frequency of citation, family importance value, fidelity level and informant consensus factor) were calculated to evaluate the importance of plant taxa. Multiple correspondence analysis was used to analyze the relationships between the various qualitative variables.

Results: A total of 57 plant taxa belonging to 51 genera and 30 botanical families were recorded in the context of periodontal disease treatment. The most abundant family was Lamiaceae. The most frequently cited taxa were *Syzygium aromaticum*, *Origanum* spp., *Juglans regia* and *Olea europaea* subsp. *europaea*. In terms of plant type, wild plants accounted for the largest proportion. Leaves were the most commonly harvested part. Decoction is the most commonly used preparation method. The most frequently reported oral disease was gingival inflammation with the highest ICF (0.82). Most respondents (63.4%) preferred to use plants alone, 99% reported improvement, and 91% reported no side effects.

Conclusions: These findings provide a solid foundation for the preservation of traditional knowledge regarding plants used to treat periodontal disease and offer promising prospects for both future pharmaceutical research and the sustainable use of plant resources.

Keywords: Periodontal disease; Fez-Meknes; Traditional medicine; Multiple Correspondence Analysis (MCA)

Background

Over the past few decades, the study of medicinal plants and their traditional uses in various parts of the world has attracted growing interest, against the backdrop of a renewed appreciation for traditional medicine. According to the World Health Organization (WHO), nearly 80 % of the world's population relies on traditional medicine for their primary health care. Significant economic benefits have been observed in the improvement of traditional medicine and in the use of medicinal flora to treat various conditions (El Rhaffari and Zaid 2002, Muthu *et al.* 2006).

It is noteworthy that plant extracts with antimicrobial activity are considered broad-spectrum antimicrobial agents, as they can help the emergence of resistance, inhibit microbial growth, reduce virulence factors, and exhibit antibiofilm activity (Furquim dos Santos Cardoso *et al.* 2021). In addition, medicinal plants possess various other biological properties, including antioxidant, antifungals, antiseptics, analgesic, and antiviral activities (Gloria-Garza *et al.* 2025, Zougagh *et al.* 2019). These biological activities are mainly attributed to the presence of secondary metabolites in plants, such as flavonoids, alkaloids, phenolic compounds and tannins (El-Assri *et al.* 2021, Gloria-Garza *et al.* 2025).

Periodontology is a branch of dentistry focused on the prevention, diagnosis, and treatment of diseases affecting the supporting structures of the teeth, including the gums, periodontal ligament, and alveolar bone. If untreated, these conditions may lead to gum recession and tooth loss (Cock *et al.* 2023). Oral diseases, particularly periodontal diseases, represent a major public health concern because of their high prevalence and their association with systemic disorders such as cardiovascular and gastric diseases (Colette *et al.* 2016, Zaoui *et al.* 1996). These diseases are mainly linked to Gram-negative anaerobic bacteria, including *Porphyromonas gingivalis*, *Aggregatibacter actinomycetemcomitans*, *Fusobacterium nucleatum*, and *Prevotella* spp. (Rosas-Piñón *et al.* 2012). According to the World Health Organization (2022), oral diseases affect nearly half of the world's population (45 %, or 3.5 billion people) across the life course from childhood to old age, which makes preventive care essential. Given the high prevalence of periodontal and oral diseases, access to appropriate dental care remains essential. However, dental treatments are often expensive and difficult to access, particularly in developing countries, leading many populations to rely on medicinal plants to prevent and treat oral disorders, including dental caries (Goldman *et al.* 2008). In Morocco, especially in mountainous regions, geographic isolation, limited access to primary oral healthcare services, and low household incomes further encourage the use of traditional herbal remedies for oral conditions (Najem *et al.* 2020).

At the national level, several ethnobotanical studies have identified numerous plant taxa traditionally used against oral infections. In the city of Meknes, commonly cited species include *Syzygium aromaticum* (L.) Merr. & L.M. Perry, *Juglans regia* L., and *Visnaga daucoides* Gaertn. (Benabderrahmane *et al.* 2024, Harouak *et al.* 2018). In the Fez-Meknes region, frequently used plants include *S. aromaticum*, *J. regia*, *V. daucoides*, *Olea europaea* subsp. *europaea*, *Origanum vulgare* L. subsp. *vulgare*, *Glycyrrhiza glabra* L., and *Punica granatum* L. (Beniaich *et al.* 2021). In the Central Middle Atlas, *Ruta montana* L., *Marrubium vulgare* L., and *V. daucoides* are widely used (Najem *et al.* 2020). Other plants reported for oral healthcare include *Vachellia nilotica* (L.) P.J.H.Hurter & Mabb.; *Mentha pulegium* L., and *Thymus vulgaris* L. in Casablanca (Zougagh *et al.* 2019), as well as *Rosa centifolia* Mill. and *Trigonella foenum-graecum* L. in the former Meknes-Tafilalet region (Fadil *et al.* 2015).

Morocco is one of the Mediterranean countries where the use of medicinal plants is particularly important, supported by its rich ecological and floristic diversity resulting from its biogeographic position. According to a recent inventory, Morocco's rich floristic diversity, comprising approximately 5,784 taxa, includes a significant proportion of wild species related to crops (ESAC) and wild harvested plants (PSR), amounting to approximately 4,682 specific and infraspecific taxa (81% of the Moroccan flora), belonging to 152 botanical families and 789 genera (Labrighli *et al.* 2025). The traditional Moroccan pharmacopoeia comprises nearly 863 plant species, 13 subspecies, and 14 varieties distributed across 104 botanical families. Among these, 602 taxa are spontaneous and/or locally acclimatized, whereas 181 taxa are cultivated or naturalized, and 114 taxa consist of imported derivatives originating from outside the country (Bellakhdar 1997). This botanical richness, combined with the reliance on traditional remedies highlighted in previous studies, partly explains the extensive use of medicinal plants in oral healthcare across different regions of Morocco.

Building on the extensive use of medicinal plants in oral healthcare and the rich floristic diversity of Morocco, the country's medicinal plant resources also face significant pressures. Excessive and unregulated exploitation of national medicinal plants represents a real threat to biodiversity, particularly in the absence of sufficient knowledge on the biology, taxonomy, and phenology of the taxa involved. Although medicinal plants are highly diverse and play an important role in economic development, their sustainable use and conservation require stronger scientific research to ensure their availability for present and future generations (Fennane and Rejdali 2016). Accurate botanical identification is therefore essential for the proper valorization of vascular plants, yet it is often based on vernacular names. Reliance on common names instead of scientific nomenclature remains a major source of confusion and incorrect plant use, which can pose serious risks to consumers (Ennabili *et al.* 2023).

In Morocco, medicinal plants are widely used in traditional healthcare, particularly for the prevention and treatment of oral diseases. This practice is supported by the country's rich floristic diversity and strong ethnobotanical heritage. However, this traditional knowledge is increasingly threatened by unsustainable harvesting and limited scientific documentation, as well as by the overexploitation of plant resources and the erosion of intergenerational knowledge transfer (Chen *et al.* 2016, Duche-Pérez *et al.* 2025, Khabbach *et al.* 2012, Ourgha *et al.* 2025). This study helps to rigorously document the scientific and vernacular names of the medicinal species used, their methods of preparation, the parts of the plants utilized, and their therapeutic indications, whilst contributing to the promotion and preservation of an oral cultural heritage that is gradually disappearing as a result of modernization and rural depopulation.

Although several regional studies have reported plants used in oral healthcare (e.g. Fadil *et al.* 2015, Harouak *et al.* 2018, Zougagh *et al.* 2019, Beniaich *et al.* 2021, Najem *et al.* 2020, Benabderrahmane *et al.* 2024), the information remains fragmented and poorly synthesized. Therefore, a comprehensive ethnobotanical study is needed to systematically document, validate, and preserve traditional knowledge related to medicinal plants used in periodontal treatments.

Several ethnobotanical studies have been carried out in Morocco, but few, if any, focus specifically on ethnobotanical practices used in the management of periodontal diseases in the Fez-Meknes region; in particular, no studies have been conducted in this field in Taza, Outat El Haj and Taounat. Consequently, this ethnobotanical data remains scientifically undocumented and fragmentary, with the region's rich flora and the diversity of traditional knowledge remaining insufficiently explored. This limits the scientific exploitation of these plant resources and the identification of species that may be of interest for future pharmacological research.
Unlike general inventories of medicinal plants, this study focuses exclusively on periodontal conditions, thereby providing an in-depth analysis of specific usage patterns and methods of preparation. Furthermore, the relationships between sociodemographic characteristics and users' traditional knowledge have rarely been analyzed by combining quantitative ethnobotanical indices with multivariate statistical approaches such as multiple correspondence analysis (MCA).

In order to address this knowledge gap, promote sustainable use and contribute to the conservation and better utilization of this ethnobotanical heritage of plant resources, this research aims to: (i) document and identify the medicinal plants used by local populations and herbalists in the Fez-Meknes region for the treatment of periodontal diseases. It further seeks to record the associated ethnobotanical knowledge, including the plant species involved, the plant parts used, modes of preparation and administration, targeted oral conditions, perceived therapeutic outcomes, and any reported side effects. (ii) assess their ethnobotanical significance using standardized quantitative indices. (iii) analyze, using multiple correspondence analysis (MCA), the relationships between the socio-demographic characteristics of informants and traditional knowledge.

Materials and Methods

Study area

This study was conducted in the Fez-Meknes region, located in north-central Morocco and covering an area of 40,075 km², representing approximately 5.7 % of the national territory (Mechchate *et al.* 2020). The region occupies a strategic geographical position, bordered to the north by the Tangier-Tetouan-Al Hoceima region, to the west by the Rabat-Sale-Kenitra and Beni Mellal-Khenifra regions, to the east by the Oriental region, and to the south by the Drâa-Tafilalet region (Figure 1) (Monographie Generale 2015).

The region is characterized by a diverse topography resulting from the convergence of three major landforms: the Middle Atlas Mountains in the south, the Saïss Plain in the center, and the Rif Mountains to the north (Kessabi *et al.* 2022). This geographical diversity contributes to a wide range of climatic conditions. Overall, the climate is Mediterranean with

continental influences, characterized by hot, dry summers and mild to cool winters in the Saïss Plain, particularly around Fez and Meknes. In contrast, the Atlas and Rif mountainous areas, especially around Ifrane, experience colder winters with frequent snowfall (Kessabi *et al.* 2022). According to the RGPH (2024), the Fez-Meknes region has an estimated population of approximately 4,468,000 inhabitants. Economically, it ranks among the leading agricultural regions in Morocco, with a usable agricultural area of 1,340,826 hectares, representing nearly 15% of the national agricultural land. In addition, its forested area extends over 1,246,255 hectares, accounting for about 14% of the country's total forest cover (Tlemcani *et al.* 2023).

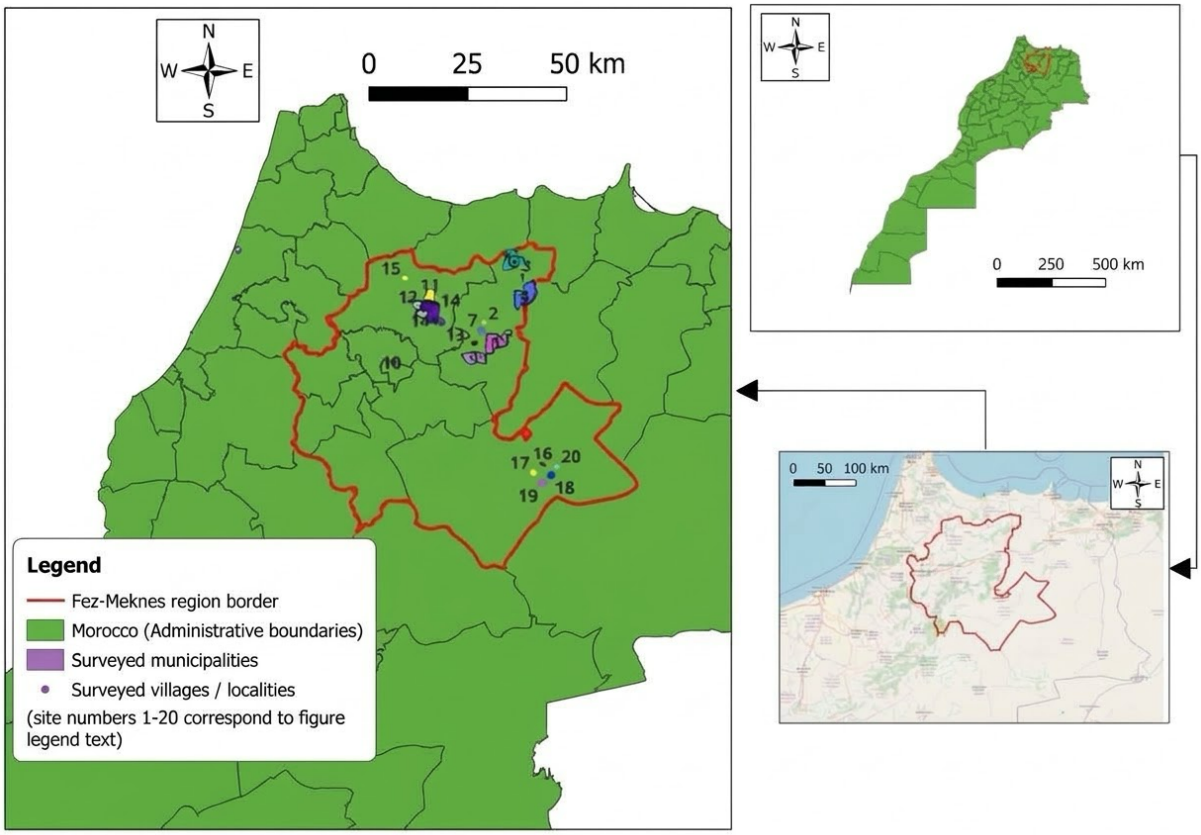


Figure 1. Map of 20 surveyed sites in the municipalities of the Fez-Meknes region. Created using QGIS software by overlaying base map data (OpenStreetMap Contributors 2024; Extracted via Geofabrik 2024) with the official administrative boundaries (Haut-Commissariat au plan 2024). Legend: Red line: Border of the Fez-Meknes region; 1: Taza center; 2: Had Msila; 3: Aknoul; 4: Jbarna; 5: Oued Amlil; 6: Ajdir; 7: Sabt Bouklal; 8: Marzouka; 9: Bouchfaa; 10: Fez center; 11: Taounate center; 12: Oulad Daoud; 13: Tissa; 14: Ain Aicha; 15: Ghafssay; 16: Outat lhaj center; 17: El Karti; 18: Douar El Haja; 19: Douar Ahl Bouchrifa; 20: Ouled El Mir.

Ethnobotanical Survey

The ethnobotanical study was conducted between November 2025 and February 2026, using a semi-structured questionnaire and in-person interviews, based on the standard methodology defined by El Rhaffari and Zaid (2002) and approved by the members of the Biotechnology, Agri-Food Environment and Health Laboratory, Faculty of Sciences of Fez, Sidi Mohamed Ben Abdellah University (USMBA). Selected individuals, including residents, patients, and herbalists, were informed in strict confidence of the research objectives and the importance of their participation, and their consent to participate was obtained. The method used to interact with the informants was based on dialogue in the local language, with each conversation lasting approximately 30 minutes. In this context, a questionnaire was administered to 559 participants and was structured into four major sections:

• Sociodemographic data: relating to the informant's profile (local name), including age, gender, educational level, and the name of the area (El Aboui *et al.* 2024, Es-Safi *et al.* 2020, Ghabbour et al. 2024a, 2024b, Khabbach *et al.* 2012, Mechchate *et al.* 2020, Tlemcani *et al.* 2023).

• Information on herbal medicine: regarding the region's anti-periodontitis plants, the type of plant, the part of the plant used, and the preparation method, as well as the conditions treated with these plants (Harouak *et al.* 2018a, Najem *et al.* 2020, Rosas-Piñón *et al.* 2012, Zougagh *et al.* 2019).
• Information on the formulation: this section discusses the combination of plants with one another or with other natural products (Khabbach *et al.* 2012, Rosas-Piñón *et al.* 2012, Zougagh *et al.* 2019).
• Information on efficacy and tolerability assessment: this section would cover the benefits and any potential side effects observed following the use of the plants (Harouak *et al.* 2018a).

Ethical considerations

Before starting the interviews, we explained the purpose of the survey to all informants and asked for their verbal informed consent. Because illiteracy is high in these rural communities and interviews took place in informal field settings, obtaining written signatures was not practical. For the 15 informants under 18 years old, we obtained verbal permission from their parents or legal guardians, as well as the agreement of the young participants themselves. This study was reviewed and approved by the Institutional Review Board of the Laboratory of Natural Resources and Environment, Polydisciplinary Faculty of Taza, Sidi Mohamed Ben Abdellah University (approved on May 14, 2026), which confirmed that the study has no direct negative impact on the participants or the local biodiversity. All interviews followed the ethical principles of the International Society of Ethnobiology (ISE Code of Ethics).

Plants collection, Handling, and Identification

The plants used by the local population were recorded at 20 sites (see Figure 1) within the Fez-Meknes region.
The identification and authentication of the medicinal plants mentioned by the informants was carried out in two complementary phases. Firstly, field visits were conducted in the presence of some of the informants to directly observe the plants mentioned in their natural habitat or in domestic gardens, and to collect fresh samples of the plants. Subsequently, the samples collected were botanically identified using reference flora of Morocco (Fennane *et al.* 1999, 2007, 2014; Valdés *et al.* 2002). This scientific identification was then verified by the botanist Prof. Abdelmajid Khabbach at the Laboratory of Natural Resources and the Environment (LRNE) of the Polydisciplinary Faculty of Taza (PFT) (Sidi Mohamed Ben Abdellah University). Four taxa (*Lavandula* spp., *Origanum* spp., *Eucalyptus* spp., *Rosa* spp.) were identified only to the genus level. Because these samples were obtained from local informants and herbalists as dried, fragmented plant material and often consisted of mixtures of closely related species, they lacked the complete diagnostic and reproductive structures required for reliable species-level identification. Using spp. allowed us to avoid misidentification while accurately recording the local ethnobotanical data. The names of all plant taxa recorded in this study have been updated in accordance with international taxonomic databases (African Plant Database (APB, 2026) and Plants of the World Online (POWO, 2026)). The scientific names and descriptions of medicinal plants imported from abroad were based on scientific studies conducted either locally, in the study area, or elsewhere (Bellakhdar 1997, Benali *et al.* 2017, El Aboui *et al.* 2024, Es-Safi *et al.* 2020, Ghabbour et al. 2024a, 2024b, Khabbach *et al.* 2012, Mechchate *et al.* 2020, Tlemcani *et al.* 2023, Zougagh *et al.* 2019). Thus, each taxon mentioned as being used against oral infections was collected, botanically identified, and assigned a voucher number as indicated in Table 3. The voucher specimens were preserved in the LRNE, PFT, USMBA herbarium in Taza, using a coding system based on the first one or two letters of the family name, the taxon number (T1, T2, T3, etc.), the laboratory acronym (LRNE), and the collection year (2026).

In order to surpass the diversity of the vernacular names of medicinal plants, we have opted to adopt the standardization system presented in Table 1, as proposed by Ennabili *et al.* (2023). This approach is based on assigning a specific symbol to each Arabic letter. In some cases, they are associated with one of the symbols listed in the table. Thus, according to Ennabili *et al.* 2023, certain phonetic transcriptions may be simplified as follows: "d" replaces "th," "g" substitutes for "gh" and "rh," "h" corresponds to "kh," "s" replaces "ch" and "sh," and "u" substitutes for "w." These adjustments help standardize transliterations and ensure greater consistency and readability of scientific data (El Aboui *et al.* 2025).

Data Analysis

The ethnobotanical data collected during the surveys were entered, processed, and statistically analyzed using a database with IBM SPSS STATISTICS 26 software and Microsoft Office Excel. The names of taxa and botanical families were verified and updated using reliable sources, including the African Plant Database (APB, 2026) and (POWO, 2026), to ensure accuracy and taxonomic rigor.

Table 1. Arabic letter coding used for the transliteration of vernacular names (Ennabili *et al.* 2023).

Symbol	Arabic letter	Symbol	Arabic letter	Symbol	Arabic letter	Symbol	Arabic letter
a	أ	f	ف	l	ل	t	ت - ة
ä	ع	g	ك -گ	n	ن	ṭ	ط
ā (1)	ا _ ى -أ	ġ	غ	o	ؤ	ṯ	ث
å	ئ-ء	h	ه -ھ	ō (1)	و	ū	و
b	ب	ḥ	ح	p	پ	u (2)	و
d	د	ḫ	خ	q	ق	v	ف
ḍ	ذ	i	إ	r	ر	w (2)	و
ḏ	ض	ī (1)	ي	s	س	y (2)	ي
e	ؤ	j	ج	š	ش	z	ز
ẽ (1)	و	k	ك -ك	ṣ	ص	ż	ظ

(1) Long vowels; (2) short vowels.

Statistical Analysis: Multiple Correspondence Analysis (MCA)

To analyze the relationships between the various categorical variables, we used multiple correspondence analysis (MCA) using the R software (version 4.5.2), employing the FactoMineR package to perform the MCA and the factoextra package to visualize the results. This method is suitable for categorical data and allows us to reduce the dimensionality of the data, identify associations between variables, highlight individual profiles, and visualize underlying structures graphically (Lê *et al.* 2008). The quality of representation is estimated by raw inertia. To retain only the significant dimensions, we filter the noise by applying the correction of Benzécri (Benzécri 1979).

There are other multivariate methods, but they were not suitable for our purpose, such as Principal Component Analysis (PCA), which is designed for quantitative variables, whereas our aim was not to predict a particular variable, but rather to explore the overall structure of the ethnobotanical data.

In this analysis, the selected variables include: city, profile, gender, educational level, type of crop, part of the plant used, method of preparation, use of mixtures (Plant_Mixture), as well as variables related to therapeutic indications and perception (efficacy and safety). These variables are considered active because they were selected on the basis of their role in the direct description of the ethnobotanical practices under study and their contribution to the construction of the MCA's factor axes. The age variable was treated as an illustrative variable, so as not to influence the construction of the principal axes, while still allowing for the interpretation of the results. The ellipses shown in Figure 9 were generated using the fviz.mca_ind() function from the factoextra package in R; the individuals in the different age groups are represented using the addEllipses=TRUE option.

To facilitate the analysis, however, certain variables were pre-processed. In particular, the 'therapeutic indication' variable was recoded into several binary variables (Yes/No) corresponding to the main symptoms studied (gingival inflammation, gingival bleeding, bad breath and periodontal abscesses). This helped to reduce the heterogeneity of the categories and make the data easier to interpret. Age was already categorized into classes (<18, 18-29, 30-49, 50-69 and ≥70 years) during the ethnobotanical survey. Consequently, no further transformation was necessary as no continuous quantitative variables were included in the MCA.

With regard to missing data, rows containing at least one missing value were removed using R's na.omit() function prior to performing the MCA. Furthermore, the analysis was carried out only on complete observations.

Relative Citation Frequency (RFC)

The importance of each plant taxa in the region is demonstrated by calculating the RFC index, obtained by dividing the number of respondents citing the species (Citation Frequency: CF) by the total number of informants participating in the study (N), according to the formula [1] (Tardío & Pardo-De-Santayana 2008, Tlemcani *et al.* 2023).

$$[1] \quad RFC=FC/N*100$$

Family Importance Value (FIV)

The importance of each botanical family in the study area is assessed by calculating the FIV index, which is determined by dividing the relative frequency of citation of the family (RFC family, expressed as a percentage) by the total number of taxa within each family (NC) according to the formula [2] (Sreekeesoon & Mahomoodally 2014, Tlemcani *et al.* 2023).

[2] FIV=RFC family/NC= (FC family/N*100)/NC

Where FC family is the number of informants citing the family, N is the total number of informants (N=559), and NC is the total number of taxa within each family.

Fidelity Level (FL)

The FL index was used to identify the taxa best suited to address a specific health issue. We calculate it by dividing the number of informants who reported using a specific species to treat a disease (Np) by the total number of informants who cited the species for any use, according to the formula below [3] (Najem *et al.* 2020, Zougagh *et al.* 2019):

[3] FL=Np/N*100

Informant Consensus Factor (ICF)

To determine the degree of agreement among informants regarding the use of plants for specific categories of use, we calculated the ICF using the following formula (Heinrich *et al.* 1998):

[4] ICF=(Nur-Nt)/(Nur-1)

Where Nur is the number of usage reports for a specific type of disease, and Nt is the number of plants cited for treating that type of disease.

If plants are selected at random or if there is no sharing of information regarding their use among informants, ICF values tend to be low (close to 0), whereas they approach 1 when the majority of informants use the same taxa to treat the same conditions (Heinrich *et al.* 1998, Zashim Uddin & Hassan 2014).

Results and Discussion

Sociodemographic Data

Use of anti-periodontitis plants by gender

Data collection was conducted at 20 sites in the Fez-Meknes region. Of the 559 informants, 58.6 % were women, while 41.3 % were men (Table 2). It is clear that in the study area, women dominate the practice of traditional medicine. These findings are consistent with other studies conducted in various regions of Morocco (El Aboui *et al.* 2024, 2025, El Rhaffari and Zaid 2002, Es-Safi *et al.* 2020, Ilyass *et al.* 2021, Mechchate *et al.* 2020, Sekkat *et al.* 2023, Tlemcani *et al.* 2023) as well as international studies (Boutabia *et al.* 2020, Jdaidi & Hasnaoui 2016, Rosas-Piñón *et al.* 2012), which indicate that women possess knowledge that constitutes an original cultural creation, both in terms of plant knowledge and their medical applications. Just as women readily exchange knowledge among themselves, they also take charge of care for themselves and their families and prepare therapeutic remedies (Tlemcani *et al.* 2023).

Women's participation has become increasingly visible in recent years through the creation of cooperatives, associations, and even pharmacies specializing in medicinal plants; this reflects a clear trend toward valuing women's work and recognizing their undeniable contribution to the development process by society (Najem *et al.* 2020).

Use of anti-periodontitis plants by age

The use of anti-periodontitis plants by the population in this study area is widespread across different age groups, with a particularly high prevalence among individuals aged 30-49 (35.9 %), and those aged 50-69 (31.6 %), followed by the 18-29 age group (21.1 %), for those aged 70 and older, the rate was 8.6 %, and the lowest percentage, 2.7 %, was observed in the under-18 age group (Table 2).

The predominance of the 30-49 (35.9 %), and 50-69 (31.6 %) age groups indicates that traditional knowledge of anti-periodontitis plants is actively maintained among middle-aged and mature adults in the Fez-Meknes region, supporting its continued transmission across generations and the continued use of natural and traditional treatments, given the limited

access to conventional care caused by geographical and socio-economic constraints and the lack of healthcare infrastructure in rural communities in the Fez-Meknes region. These results are consistent with those identified by (Benali *et al.* 2017, Es-Safi *et al.* 2020, Mechchate *et al.* 2020).

Use of anti-periodontitis plants by educational level

According to Table 2, the largest group of respondents was illiterate, accounting for 31.8 %, followed by those with secondary and university education, at 25.9 % and 25.5 %, respectively. In contrast, those with a primary education represent only 16.6 %. These results are consistent with those identified in previous studies (Barkaoui *et al.* 2017, El-Assri *et al.* 2021, El Hilah *et al.* 2016).

Table 2. Sociodemographic characteristics of the informants

		Frequency	Percentage (%)
Age	<18	15	2.7
	18-29	118	21.1
	30-49	201	35.9
	50-69	177	31.6
	≥70	48	8.6
Gender	Female	328	58.6
	Male	231	41.3
Level of education	Not educated	178	31.8
	Primary	93	16.6
	Secondary	145	25.9
	University	143	25.5

Information on herbal medicine

Botanical families

The data collected allowed us to identify 57 taxa belonging to 30 families used in the treatment of oral infections (Table 3). The Lamiaceae were the most represented family group with 11 taxa (FIV = 2.20), followed by the Asteraceae, Apiaceae, and Myrtaceae with 4 taxa (FIV = 3.98, 0.45, and 3.80, respectively), followed by the Fabaceae with 3 taxa (FIV= 0.83), then the Amaryllidaceae, Lythraceae, Oleaceae, Rosaceae, Solanaceae and Zingiberaceae with 2 taxa (FIV = 1.16, 0.98, 5.37, 0.18, 0.18 and 1.07 respectively), and the other families are represented by a single species with varying FIV values. Also, the Lamiaceae was the most cited family, followed by the Asteraceae and Myrtaceae, which are cited 135, 89 and 85 times during this survey (Figure 2). Similar ethnobotanical studies (e.g., Harouak *et al.* 2018a, Zougagh *et al.* 2019) have also shown that the Lamiaceae were the dominant family with 10 and 13 taxa, respectively. Other ethnobotanical surveys in the same region have revealed the predominance of the Lamiaceae family (El Abidine *et al.* 2021, El Aboui *et al.* 2024, Khabbach *et al.* 2012, Libiad *et al.* 2011, Tlemcani *et al.* 2023).

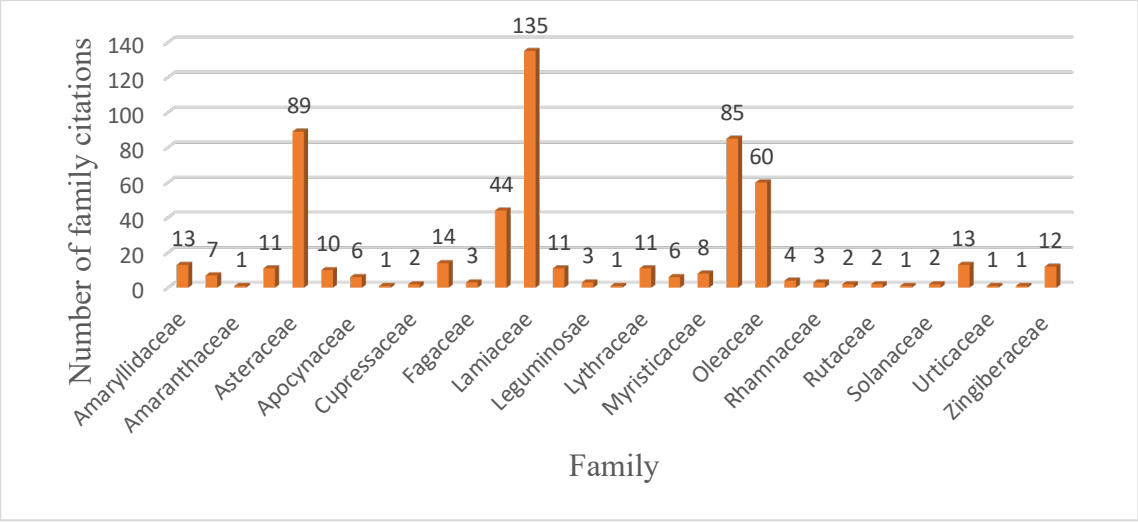


Figure 2. Importance of the botanical families used in the treatment of oral infections.

Medicinal taxa

Our survey showed that the most commonly used taxa as anti-periodontitis agents in this study area are *Syzygium aromaticum* (L.) Merr. & L.M. Perry (RFC=10.7), *Origanum* spp. (RFC=10.7), *Juglans regia* L. (RFC=7.9), *Olea europaea* subsp. *europaea* (RFC=7.5), *Dittrichia viscosa* (L.) Greuter (RFC=6.6), and *Matricaria chamomilla* L. (RFC=3.9). The other taxa have an RFC value <3.9 (Fig. 3, Table 3). The widespread use of these plants is likely attributable to their therapeutic properties and their broad distribution within the study area. Similar studies conducted in other regions of Morocco have shown that high usage values were obtained for plants different from those in the present study, these include *Marrubium vulgare* L. (RFC=44.8), *Ruta montana* L. (RFC=43.1) and *Atractylis gummifera* L. (RFC=37.9) in the central Middle Atlas (Najem *et al.* 2020) and *Rosa* spp., *Trigonella foenum-graecum* L. in the Meknes-Tafilalet region (Fadil *et al.* 2015).

A literature review from Gloria-Garza *et al.* (2025) in Mexico on the medicinal plants used to treat dental caries, also revealed that the taxa *S. aromaticum*, *Curcuma longa* L., *Zingiber officinale* Roscoe, *Allium sativum* L., *Aloe vera* (L.) Burm.f., *Camellia sinensis* (L.) Kuntze, *Nigella sativa* L. and *Azadirachta indica* A. Juss., have effects on oral bacteria, as well as other taxa unidentified in our study such as: *Terminalia chebula* Retz.; *Psidium guajava* L., *Pongamia pinnata* (L.) Pierre, *Mentha piperita* L., *Dennettia tripetala* Baker f., *Jatropha curcas* L., *Copaifera langsdorffii* var. *langsdorffii* and *Cinnamomum verum* J. Presl (Gloria-Garza *et al.* 2025).

Our findings reveal a specific use of the various taxa mentioned for treating oral and dental infections. For example, the taxon *Ziziphus lotus* (L.) Lam. in Morocco is widely cited in the ethnobotanical literature for the treatment of skin conditions, diabetes and gastrointestinal disorders (Khabbach *et al.* 2012). However, its specific use for treating these infections has been reported only very rarely, if at all, in previous ethnobotanical inventories of Morocco.

Common names of plants

Plants identified in the study area may have two to four different common names. Among 57 taxa, after its first appearance, "*D. viscosa*" is known by four different names: "Mgrmān/Bagramān/Bayramān/Tirlān", two plants are known by three different names, and seven plants are referred to by two different names (Table 3). This diversity of vernacular names can be explained by the use of distinct dialects (cultural and linguistic differences) among communities settled in the areas of the Fez-Meknes region; thus, it illustrates the variety of tribes living there, each having its own way of naming these plants, which results in a plurality of designations for the same medicinal plant. This has already been noted in other studies (El Aboui *et al.* 2025, Ghabbour *et al.* 2024a, Khabbach *et al.* 2011).

Plant Type

Based on total informant citations (N= 559 respondents), this ethnobotanical survey shows that wild plants account for the largest proportion (43.8 %) compared to other plant types, followed by cultivated ones (28.8 %) and introduced plants (27.4 %). This preference for wild plants is due to their year-round availability, highlighting the importance of local natural resources. These findings are also reported by (El Aboui *et al.* 2024, El-Hilaly *et al.* 2003, Ennabili *et al.* 2000, Khabbach *et al.* 2012).

Plant Parts

Leaves are the most commonly used part (55.7 % of total informant citations; N= 559 respondents), followed by flowers (9.1 %), fruits (8.8 %), stems and seeds (7.9 %), roots (4.8 %) and bark (3.8 %), with other parts accounting for smaller percentages (Figure 4). This predominance of leaves can be explained by their role in producing organic matter, storing secondary metabolites responsible for biological properties, and the ease and speed of their harvest (Benlamdini *et al.* 2014, Salhi *et al.* 2010, Zougagh *et al.* 2019). These results are consistent with previous similar surveys at the national level (Fadil *et al.* 2015, Harouak *et al.* 2018b, Najem *et al.* 2020, Zougagh *et al.* 2019) and at the international level (Cock *et al.* 2023, Makgobole *et al.* 2023, Rosas-Piñón *et al.* 2012).

Method of Preparation

Several preparation methods were used to facilitate the administration of the active ingredient for the treatment of oral diseases. In our study, we found that decoction is the most commonly used preparation method in traditional preparations of the plant, accounting for 50.2 %, followed by infusion (20.7 %), powder (10.4 %), raw form (9.1 %), and poultice (6.6 %). The percentage of other preparation methods does not exceed 2 % (Figure 5). The fact that decoction is the most commonly used method indicates that it is the most effective for extracting and assimilating the active compounds from plants (Benlamdini *et al.* 2014). Its frequent use is confirmed by ethnobotanical studies in Morocco (Benali *et al.* 2017, Mechchate *et al.* 2020, Tlemcani *et al.* 2023).

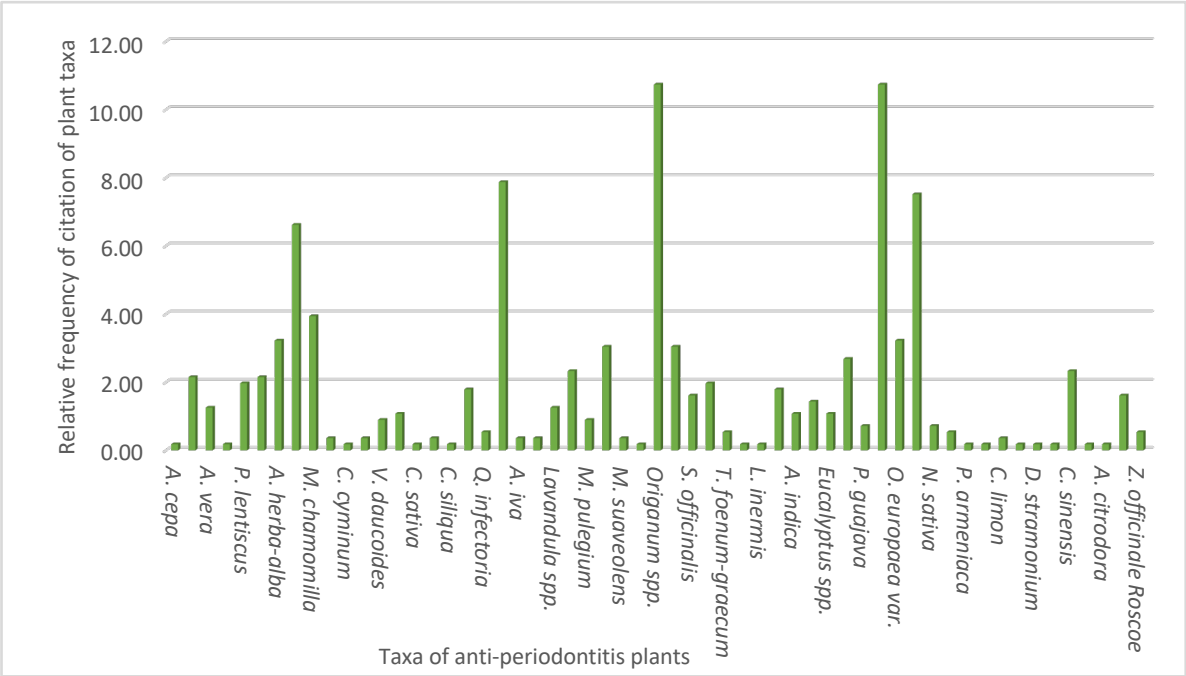


Figure 3. Relative citation frequency of taxa used in the treatment of oral infections.

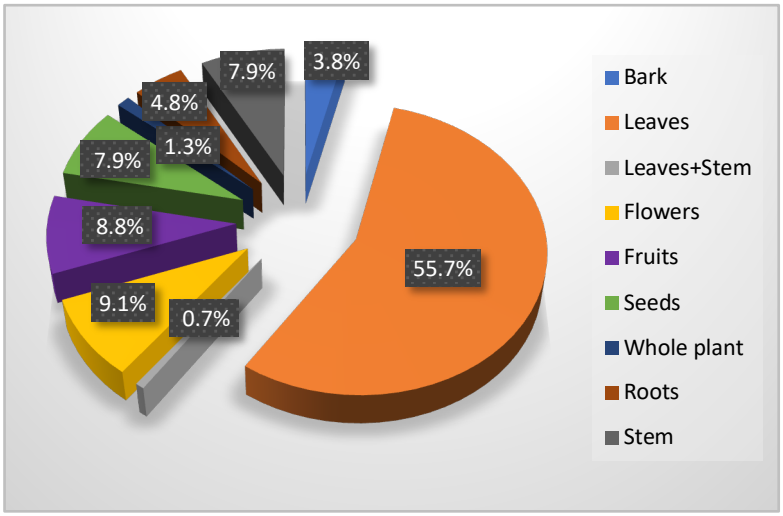


Figure 4. Parts of plants with anti-periodontitis properties identified in the Fez-Meknes region.

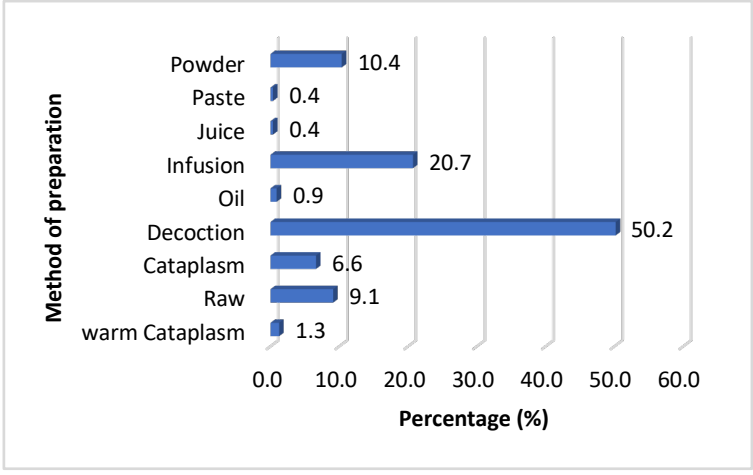


Figure 5. Methods for preparing plants used to treat periodontitis in the Fez-Meknes region.

Conditions Treated by Herbal Remedies for Periodontitis

Gingival inflammation was the most frequently treated symptom (45%), followed by bleeding gums (18.2 %), bad breath (12.3 %), and periodontal abscesses (10.9 %). Other symptoms, or combinations of two or more symptoms, are much less common (Figure 6). According to the results of the study by Lewis *et al.* (2004), more than 90 % of herbalists in the Zonkiziwe and Dube regions of South Africa correctly identified photographs of gingival inflammation, dental caries, and oral candidiasis (Lewis *et al.* 2004).

Based on our results (Tables 4 and 5), it can be observed that the majority of the plants listed are used to treat gingival inflammation, with the highest ICF (0.82), comprising 47 taxa, 14 of which showed a high FL (100 %): *Allium cepa* L., *Aloysia citrodora* Paláu, *Ammoides pusilla* (Brot.) Breistr, *Cannabis sativa* L., *Ceratonia siliqua* L., *Datura stramonium* L., *Dysphania ambrosioides* (L.) Mosyakin & Clemants, *Illicium verum* Hook.f., *Linum bienne* Mill., *Nicotiana tabacum* L., *Quercus infectoria* Olivier, *Tetraclinis articulata* (Vahl) Mast., *Urtica dioica* L., *Ziziphus lotus* (L.) Lam. Followed by gingival bleeding with an ICF of 0.71 (30 taxa), of which 2 taxa showed a high FL (100 %): *Cuminum cyminum* L., *Origanum majorana* L. This indicates that the majority of informants use the same taxa to treat the same conditions. Next, bad breath showed an ICF value of 0.68 with 23 taxa, of which one species showed a high FL (100 %): *Rosa* spp. While periodontal abscesses recorded an ICF of 0.57, with 27 taxa, of which 2 taxa showed a high FL (100 %): *Lawsonia inermis* L., *Prunus armeniaca* L. Meanwhile, the following conditions, tooth sensitivity, pain relief, and gum swelling, exhibited lower ICF values. A decline in the ICF toward 0 indicates that plants are selected at random or that there is no sharing of information regarding their use among informants. Taxa used to treat more than one disease at the same time exhibit a low FL. Thus, high FL values indicate a high degree of specificity and informant consensus regarding the use of a medicinal plant for treating a single specific ailment, whereas low FL values suggest that the plant is used across multiple disease categories rather than being dedicated to one condition. Consequently, medicinal plants identified as specific remedies for a single disease category show an FL of 100 % compared to those used to treat various diseases (Zougagh *et al.* 2019).

The use of medicinal plants to treat oral conditions varies from country to country. For example, at the national level, and more specifically in the Central Middle Atlas, the taxa *Visnaga daucoides* Gaertn., *Pistacia atlantica* Desf., and *J. regia* are used to treat dental caries (Najem *et al.* 2020). Meanwhile, in the Casablanca region, they are treated with *S. aromaticum* and *Mentha pulegium* L. (Zougagh *et al.* 2019). Internationally, in the Altiplano region of Mexico, these conditions are treated with various plants such as: *Amphipterygium adstringens* (Schltdl.) Standl., *Argemone mexicana* L., *Bursera simaruba* (L.) Sarg. (Rosas-Piñón *et al.* 2012). These differences in regional pharmacopoeial practices can be explained in particular by the specificity of the local flora as well as by sociocultural variations (Najem *et al.* 2020).

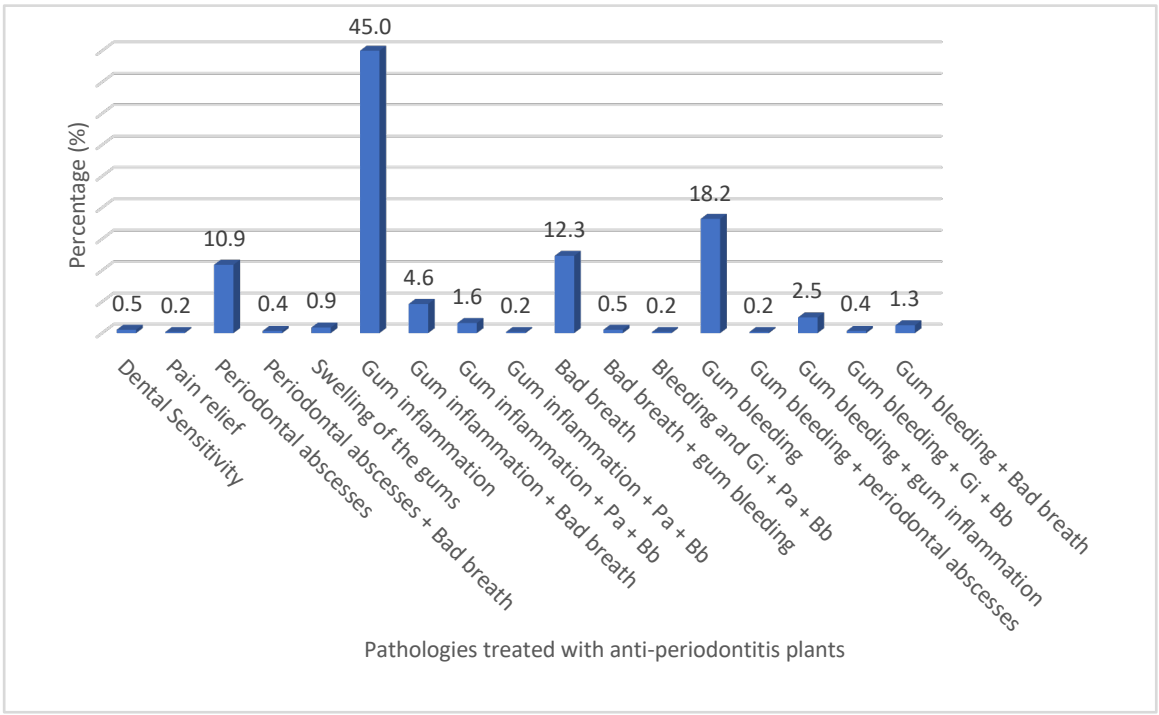


Figure 6. Oral diseases treated with anti-periodontitis herbs in the Fez-Meknes region. Legend: Bb- Bad breath; Gi- Gum inflammation; Pa- Periodontal abscesses.

Table 3. Diversity of anti-periodontitis plants: Taxonomy, common name, plant type, part used, frequency, relative citation frequency (RFC) and family importance value (FIV).

Family	Scientific name	Voucher number	Vernacular name/ Arabic name	Tp	Mp	Pu	FC	RFC	FIV
Amaranthaceae	*Dysphania ambrosioides* (L.) Mosyakin & Clemants	AmT1-RNE _2026	Mẖinza مخينزة	Sp	Rw	L	1	0.2	**0.18**
Amaryllidaceae	*Allium cepa* L.	AmaT1-RNE _2026	baŞla البصلة	Cl	Hc	Bu	1	0.2	**1.16**
	Allium sativum L.	AmaT2-RNE _2026	tēmā تومة	Cl; Sp	C	Bu	12	2.1	
Anacardiaceae	*Pistacia lentiscus* L.	AnT1-RNE _2026	Drū/ Trū درو/ طرو	Sp	D; I; Rw	L	11	2.0	**1.97**
Apiaceae	*Ammoides pusilla* (Brot.) Breistr.	ApT1-RNE _2026	Nūnẖa/Nūẖa نونخا/نوخا	Sp	D	L	2	0.4	**0.45**
	Cuminum cyminum L.	ApT2-RNE _2026	Alkāmēn الكامون	Im	Po	Sd	1	0.2	
	Petroselinum crispum (Mill.) Fuss subsp. *crispum*	ApT3-RNE _2026	Lmädnūs معدنوس	Cl	D; I	L; S	2	0.4	**0.45**
	Visnaga daucoides Gaertn.	ApT4-RNE _2026	Bešniẖa بشنيخة	Sp	D	F; Fr; Sd	5	0.9	
Apocynaceae	*Nerium oleander* L.	ApoT1-RNE _2026	Dflā دفلة	Sp	Hc	L; S	6	1.1	**1.07**
Asphodelaceae	*Aloe vera* (L.) Burm.f.	AsT1-RNE _2026	ālēīvirā ألويفرا	Cl	C	L	7	1.3	**1.25**
Asteraceae	*Artemisia absinthium* L.	AstT1-RNE _2026	šībā شيبة	Cl; Sp	D	L; S	12	2.1	**3.98**
	Artemisia herba-alba Asso	AstT2-RNE _2026	šīḥ شيح	Cl; Sp	D; I	L; Wp	18	3.2	
	Dittrichia viscosa (L.) Greuter	AstT3-RNE _2026	Mgrmān/Bagramān/Bayramān/Tirlān مكرمان/بكرمان/بيرمان/ترلان	Sp	D; Rw	L	37	6.6	
	Matricaria chamomilla L.	AstT4-RNE _2026	Bābūnj بابونج	Sp	D; I; O	F	22	3.9	
Cannabaceae	*Cannabis sativa* L.	CT1-RNE _2026	Elkīf الكيف	Sp	Rw	L	1	0.2	**0.18**
Cupressaceae	*Tetraclinis articulata* (Vahl) Mast.	CuT1-RNE _2026	lārāār العرعار	Sp	D; Pa	L	2	0.4	**0.36**

Fabaceae	*Ceratonia siliqua* L.	FT1-RNE _2026	ẖrēb خروب	Sp	I	Fr	1	0.2	**0.83**
	Glycyrrhiza glabra L	FT2-RNE _2026	ärq sūs عرق السوس	Im	C; Rw	R	10	1.8	
	Trigonella foenum-graecum L.	FT3-RNE _2026	ḥalba حلبة	Im	Po	Sd	3	0.5	
Fagaceae	*Quercus infectoria* Olivier	FaT1-RNE _2026	äafs عفص	Im	Po	G	3	0.5	**0.54**
Juglandaceae	*Juglans regia* L.	JT1-RNE _2026	Swāk سواك	Cl; Im	D; C; Rw	B; S; R	44	7.9	**7.87**
Lamiaceae	*Ajuga iva* (L.) Schreb.	*LT1-RNE _2026*	šantgùra شنتكورة	Sp	I	L	2	0.4	**2.20**
	Calamintha sylvatica Bromf. subsp. *sylvatica*	LT2-RNE _2026	Māntā مانتة	Sp	D	L	2	0.4	
	Lavandula spp.	LT3-RNE _2026	ẖzāmā خزامة	Cl; Sp	D; I; Po	L; F	7	1.3	
	Marrubium vulgare L.	LT4-RNE _2026	Mrīūā/Mrīwt/Amrīw مريوة/مريوت/أمريو	Sp	D; I; Rw	L	13	2.3	
	Mentha pulegium L.	LT5-RNE _2026	Flīū فليو	Cl	D	L	5	0.9	
	Mentha spicata L. subsp. *spicata*	*LT6-RNE _2026*	Nänää نعناع	Cl; Sp	D; I; Rw; O	L	17	3.0	
	Mentha suaveolens Ehrh.	LT7-RNE _2026	Mšaštrū مشاشترو	Sp	D; I	L	2	0.4	
	Origanum majorana L.	LT8-RNE _2026	mrddēš مرددوش	Im	Pa	L	1	0.2	
	Origanum spp.	LT9-RNE _2026	Zaätr/Saḥtar زعتر/سحتر	Cl; Sp	D; I; Rw; Po	L	60	10.7	
	Rosmarinus officinalis L.	LT10-RNE _2026	Azīr/Iklīl ljabal أزير/إكليل الجبل	Cl; Sp	D; I	L	17	3.0	
	Salvia officinalis L.	LT11-RNE _2026	sālmīt/Sālmīā/Mrimīā سالميت/سالمية/مرمية	Cl; Sp	D; I; Rw	L	9	1.6	
Lauraceae	*Cinnamomum verum* J.Presl	LaT1-RNE _2026	qrft قرفة	Im	Po	B	11	2.0	**1.97**

Linaceae	*Linum bienne* Mill.	LiT1-RNE _2026	zrīät ktān زريعة الكتان	Im	D	Sd	1	0.2	**0.18**
Lythraceae	*Lawsonia inermis* L.	LyT1-RNE _2026	ḥennā حنا	Cl	D	L	1	0.2	**0.98**
	Punica granatum L.	LyT2-RNE _2026	rmāne الرمان	Cl; Sp	D; Po	B	10	1.8	
Meliaceae	*Azadirachta indica* A.Juss.	MT1-RNE _2026	nīme نيم	Im	D; I	L	6	1.1	**1.07**
Myristicaceae	*Myristica fragrans* Houtt.	MyT1-RNE _2026	Algūza الكوزة	Im	D; Po	Sd	8	1.4	**1.43**
Myrtaceae	*Eucalyptus* spp.	MyrT1-RNE _2026	Klītūs الكليتوس	Cl	D; I	L	6	1.1	**3.80**
	Myrtus communis L.	MyrT2-RNE _2026	rīḥān ريحان	Sp	D; Rw	L	15	2.7	
	Psidium guajava L.	MyrT3-RNE _2026	Gūwāfā كوافا	Im	D; I	L	4	0.7	
	Syzygium aromaticum (L.) Merr. & L.M.Perry	MyrT4-RNE _2026	Qrnfl/Àaūd nūar قرنفل/ عود نوار	Im	D; I; Po; O	Fb	60	10.7	
Oleaceae	*Olea europaea* var. *sylvestris* (Mill.) Lehr	OT1-RNE _2026	Barī بري	Sp	D; I; Rw	L	18	3.2	**5.37**
	Olea europaea subsp. *europaea*	OT2-RNE _2026	Zītūn زيتون	Cl	D; I; Rw	L	42	7.5	
Ranunculaceae	*Nigella sativa* L.	RT1-RNE _2026	ālḥbā ālsēdāå الحبة السوداء	Im	D; I	Sd	4	0.7	**0.72**
Rhamnaceae	*Ziziphus lotus* (L.) Lam.	RhT1-RNE _2026	Sidr سدر	Sp	D; Po	L	3	0.5	**0.54**
Rosaceae	*Prunus armeniaca* L.	RoT1-RNE _2026	Mešmaš مشمش	Cl	D	B	1	0.2	**0.18**
	Rosa spp.	RoT2-RNE _2026	lēard الورد	Sp	I	F	1	0.2	
Rutaceae	*Citrus limon* (L.) Osbeck	RuT1-RNE _2026	ḥāmd حامض	Cl; Sp	J	Fr	2	0.4	**0.36**
Schisandraceae	*Illicium verum* Hook.f.	ST1-RNE _2026	Badyāna/Najmāt lyānūs بديانة/نجمة اليانوس	Im	D	Fr	1	0.2	**0.18**

Solanaceae	*Datura stramonium* L.	SoT1-RNE _2026	tqâ تقا	Sp	Po	Sd	1	0.2	**0.18**
	Nicotiana tabacum L.	SoT2-RNE _2026	tāba طابا	Cl	Po	L	1	0.2	
Theaceae	*Camellia sinensis* (L.) Kuntze	TT1-RNE _2026	atāī أتاي	Im	D; I	L	13	2.3	**2.33**
Urticaceae	*Urtica dioica* L.	UT1-RNE _2026	Taqndīšt/ḥrīga lḥarša تقنديشت/حريكة لحرشة	Sp	D	L	1	0.2	**0.18**
Verbenaceae	*Aloysia citrodora* Paláu	VT1-RNE _2026	lūiza لويزة	Sp	D	L	1	0.2	**0.18**
Zingiberaceae	*Curcuma longa* L.	ZT1-RNE _2026	ẖarqūm خرقوم	Cl; Im	D; I; Po	R	9	1.6	**1.07**
	Zingiber officinale Roscoe	ZT2-RNE _2026	skīnjbīr سكينجبير	Im	D; Po	R	3	0.5	

Legend:

AmT1-RNE= Amaranthaceae (Family). Taxonomy 1. Natural Resources and Environment Laboratory **; B=** Bark **; Bu**= Bulb; **C=** Cataplasm **; Cl=** Cultivated **; D=** Decoction **; F=** Flowers **; Fb**= Flower buds; **Fc**= Frequency**; FIV**= Family importance value; **Fr=** Fruits **; J=** Juice ; **Hc=** Hot cataplasm ; **I=** Infusion ; **Im=** Imported ; **G**= Galls; **L=** Leaves ; **Mp**= Mode of preparation; **O=** Oil ; **Pa=** Paste ; **Po=** Powder ; **Pu=** Part used**; R=** Roots ; **RFC**= Relative citation frequency**; Rw=** Raw ; **S=** Stems ; **Sd=** Seeds ; **Sp=** Spontaneous ; **Tp =** Type of plant**; Wp=** Whole plant; **ḍ**=th"; **ġ** = gh= rh; **ẖ**= kh; **š** = ch =sh; **u**= ou.

Table 4. Level of fidelity of medicinal plants used to treat periodontal diseases in the Fez-Meknes region.

Illness category	**Fidelity level of species (%)**
Dental Sensitivity	*J. regia* (4.54 %), *Olea europaea* var. (5.5 %).
Pain relief	*Z. officinale* (33.33 %)
Periodontal abscesses	*A. iva* (50 %), *A. sativum* (33.33 %), *A. vera* (14.28 %), *A. absinthium* (25 %), *A. herba-alba* (16.66 %), *C. sinensis* (23.07 %), *C. verum* (27.27 %), *C. longa* (55.55 %), *D. viscosa* (5.40 %), *Eucalyptus* spp. (16.66 %), J. regia (13.63 %), *Lavandula* spp. (14.28 %), *L. inermis* (100 %), *M. vulgare* (7.7 %), *M. chamomilla* (9.1 %), *M. suaveolens* (50 %), *N. oleander* (16.66 %), *O. europaea* var. (11.11 %), *O. europaea* subsp. (9.52 %), *Origanum* spp. (1.66 %), *P. lentiscus* (9.1 %), *P. armeniaca* (100 %), *P. granatum* (30 %), *R. officinalis* (5.88 %), *S. officinalis* (22.22 %), S. *aromaticum* (16.66 %), *V. daucoides* (40 %).
Periodontal abscesses + Bad breath	*M. spicata* (5.88 %), *S. aromaticum* (1.66 %).
Swelling of the gums	*C. sinensis* (7.7 %), *C. verum* (9.1 %), *D. viscosa* (2.70 %), *M. communis* (6.66 %), *S. aromaticum* (1.66 %).
Gum inflammation	*A. cepa* (100 %), *A. sativum* (33.33 %), *A. vera* (42.86 %), *A. citrodora* (100 %), *A. pusilla* (100 %), *A. absinthium* (25 %), *A. herba-alba* (44.44 %), *C. sylvatica* (50 %), *C. sinensis* (46.15 %), *C. sativa* (100 %), *C. siliqua* (100 %), *C. verum* (54.54 %), *C. limon* (50 %), *C. longa* (11.11 %), *D. stramonium*

	(100 %), *P. crispum* (50 %), *D. viscosa* (70.27 %), *D. ambrosioides* (100 %), *Eucalyptus* spp. (50 %), *G. glabra* (30 %), *I. verum* (100 %), *J. regia* (36.36 %), *Lavandula* spp. (42.86 %), *L. bienne* (100 %), *M. chamomilla* (54.54 %), *M. pulegium* (20 %), *M. spicata* (11.76 %), *M. communis* (46.66 %), *N. oleander* (50 %), *N. tabacum* (100 %), *N. sativa* (75 %), *O. europaea* var. (55.55 %), *O. europaea* subsp. (50 %), *Origanum* spp. (56.66 %), *P. lentiscus* (90.90 %), *P. guajava* (25 %), *P. granatum* (30 %), *Q. infectoria* (100 %), *R. officinalis* (58.82 %), *S. officinalis* (55.55 %), *S. aromaticum* (15 %), *T. articulata* (100 %), *T. foenum-graecum* (66.66 %), *U. dioica* (100 %), *V. daucoides* (40 %), *Z. officinale* (33.33 %), *Z. lotus* (100 %).
Gum inflammation + Bad breath	*A. absinthium* (8.33 %), *A. herba-alba* (16.66 %), *J. regia* (4.54 %), *M. chamomilla* (4.54 %), *M. spicata* (11.76 %), *O. europaea* var. (5.55 %), *O. europaea* subsp. (9.52 %), *Origanum* spp. (3.33 %), *R. officinalis* (11.76 %), *S. aromaticum* (11.66 %), *V. daucoides* (20 %) .
Gum inflammation + periodontal abscesses	*A. absinthium* (8.33 %), *D. viscosa* (5.40 %), *M. vulgare* (7.7 %), *M. suaveolens* (50 %), *M. communis* (6.66 %), *N. oleander* (16.66 %), *O. europaea* var. (2.38 %), *S. aromaticum* (1.66 %).
Gum inflammation + Periodontal abscess + Bad breath	*S. aromaticum* (1.66 %)
Bad breath	*J. regia* (9.1 %), *A. sativum* (8.33 %), *A. absinthium* (8.33 %), *A. herba-alba* (5.55 %), *A. indica* (66.66 %), *C. sinensis* (7.69 %), *C. longa* (11.11 %), *Eucalyptus* spp. (16.66 %), *G. glabra* (60 %), *Lavandula* spp. (14.28 %), *M. vulgare* (7.69 %), *M. chamomilla* (18.18 %), *M. pulegium* (40 %), *M. spicata* (58.82 %), *M. fragrans* (37.5 %), *M. communis* (26.66 %), *O. europaea* subsp. (7.14 %), *Origanum* spp. (5 %), *P. crispum* (50 %), *Rosa* spp. (100 %), *R. officinalis* (17.65 %), *S. officinalis* (11.11 %), *S. aromaticum* (18.33 %).
Bad breath + gum bleeding	*A. herba-alba* (5.55 %), *R. officinalis* (5.88 %), *S. aromaticum* (1.66 %).
Bleeding and gum inflammation + Periodontal abscesses + Bad breath	*Origanum* spp. (1.66 %).
Gum bleeding	*C. cyminum* (100 %), *A. sativum* (8.33 %), *A. vera* (42.86 %), *A. absinthium* (8.33 %), *A. herba-alba* (5.55 %), *A. indica* (33.33 %), *C. sylvatica* (50 %), *C. sinensis* (15.38 %), *C. verum* (9.09 %), *C. longa* (33.33 %), *D. viscosa* (13.51 %), *Eucalyptus* spp. (16.66 %), *G. glabra* (10 %), *J. regia* (27.27 %), *Lavandula* spp. (14.28 %), *M. vulgare* (15.38 %), *M. chamomilla* (9.09 %), *M. pulegium* (20 %), *M. spicata* (11.76 %), *M. fragrans* (62.5 %), *M. communis* (13.33 %), *O. europaea* var. (11.11 %), *O. europaea* subsp. (21.43 %), *O. majorana* (100 %), *Origanum* spp. (25 %), *P. guajava* (75 %), *P. granatum* (20 %), *S. aromaticum* (26.66 %), *T. foenum-graecum* (33.33 %), *Z. officinale* (33.33 %).
Gum bleeding + periodontal abscesses	*O. europaea* var. (5.55 %).
Gum bleeding + gum inflammation	*A. iva* (50 %), *C. limon* (50 %), *D. viscosa* (2.70 %), *A. absinthium* (16.66 %), *J. regia* (2.27 %), *M. vulgare* (7.69 %), *N. oleander* (16.66 %), *N. sativa* (25 %), *O. europaea* subsp. (2.38 %), *Origanum* spp. (5 %), *S. officinalis* (11.11 %).
Gum bleeding + gum inflammation + bad breath	*A. herba-alba* (5.55 %), *S. aromaticum* (1.66 %).
Gum bleeding + Bad breath	*J. regia* (2.27 %), *M. chamomilla* (4.54 %), *M. pulegium* (20 %), *Origanum* spp. (1.66 %), *P. granatum* (20 %), *S. aromaticum* (1.66 %).

Information regarding the recipes

Our survey highlighted that the majority of the population in the Fez-Meknes region (63.4 % of respondents) stated that they prefer to use plants exclusively, without combining them with other plants or natural products, while 36.6 % favored combining anti-periodontitis plants with other plants and products. These results are similar to those found in the province of Taza (Khabbach *et al.* 2012). However, Ennabili *et al.* (2000) note that, due to common synergistic effects, plants are also used in combination with olive oil, honey, or milk.

Improvement and side effects noticed after using anti-periodontitis herbs

The survey results reveal that after using plants to treat oral and periodontal infections, 99 % of respondents reported experiencing improvements, and 91 % reported experiencing no side effects. These results were observed because the treatment was administered as a mouthwash or external application. These results are similar to those reported by Harouak et al. (2018a, 2018b). However, medicinal plants can become a threat to human health if not used correctly (Hammiche *et al.* 2013).

Table 5. Informant Consensus Factor (ICF) values by category for treating periodontal diseases.

Illness category	Nur	Nt	ICF
Dental Sensitivity	3	2	0.50
Pain relief	1	1	-
Periodontal abscesses	61	27	0.57
Periodontal abscesses + Bad breath	2	2	0.00
Swelling of the gums	5	5	0.00
Gum inflammation	252	47	0.82
Gum inflammation + Bad breath	26	11	0.60
Gum inflammation + periodontal abscesses	9	8	0.13
Gum inflammation + Periodontal abscess + Bad breath	1	1	-
Bad breath	69	23	0.68
Bad breath + gum bleeding	3	3	0.00
Bleeding and gum inflammation + Periodontal abscesses + Bad breath	1	1	-
Gum bleeding	102	30	0.71
Gum bleeding + periodontal abscesses	1	1	-
Gum bleeding + gum inflammation	14	11	0.23
Gum bleeding + gum inflammation + bad breath	2	2	0.00
Gum bleeding + Bad breath	7	6	0.17

Legend: Nur: Number of reports of use for a specific type of disease; **Nt:** Number of plants cited to treat this type of disease. Note: (-): ICF is mathematically undefined when Nur=1 (Since Nur-1=0).

Statistical analysis: Multiple Correspondence Analysis (MCA)

Relationships between variables

The correlations between the different modalities are displayed in the variable graph (Figure 7).

Axis 1 (dim 1= 53 %) (Axis of geographical and therapeutic specialization) largely indicates a strong regional and functional organization of phytotherapeutic techniques. Specific indications (such as inflammation) and preparation procedures vary substantially with the area (city) examined.

The vertical axis (Dimension 2: 18.8 %) is essentially an axis of differentiation of practices based on the section of the plant utilized, a factor highly associated with geographical location (City) and to a lesser extent, to the level of education (education_ level) and the use of mixtures (Plant_ mixture).

So, the city variable is the only one substantially connected with both dim 1 and dim 2 (placed in the upper right). It is the most discriminating aspect in the entire study, indicating that ethnobotanical practices (what is treated, how it is prepared, which part is used) are essentially reliant on the geographical location analyzed. And the variables with low discriminatory power stay clustered quite near to the origin in the bottom left corner (Effectiveness, safety, profile, gender, bad breath, abscesses). This shows that these factors are highly homogeneous in our sample or that they do not explain the total variety of practice along these two main axes.

The age variable (in blue) is projected quite near to the origin. As an illustrative (or supplemental) variable, its position suggests that the respondent's age is only very weakly linked with the main axis and has almost no influence on the structure of the observed practices.

Overall synthesis of the MCA Biplot

The Biplot (Figure 8) overlays the cloud of persons (grey dots) and that of categories (red triangles), allowing us to understand the structure of the information from two perspectives: the dispersion of the population and its correlation with ethnobotanical factors. With 71.8 % cumulative inertia on the first two axes, the representation is extremely dependable for expressing the variety of activities.

Simultaneous analysis finds three typical profiles that shape phytotherapeutic practices. The first profile (Upper right quadrant) emphasizes urban and academic practices; it is dominated by the city of Fez. Individuals located here are highly related with the youngest age groups (<18 and 18-29 years) and university education. Their practices are defined by the utilization of often imported materials and specific plant parts (flowers, stem and seeds), favoring poultices. Next, the second profile (lower right quadrant) focuses more on specialized and technical practices, the group of individuals located around Outat El Haj demonstrates the strongest visual identity (highly distinctive points). This profile is characterized by a specific application for the bleeding, systematic recourse to the mixture (Plant_ Mixture_ Yes) and utilization of fruit and powder. In these specific processes, the proximity to the safety_ Yes reflects greater confidence. As for the third (left hemisphere) contains users from Taza and Taounate. The significant concentration of data points surrounding the decoction, raw, spontaneous and unschooled modalities speak to ancestral information communicated orally. "First aid" procedures (treatment of abscesses and inflammation) based on direct harvesting from nature are observed here. In this region, the presence of herbalists highlights their role as pillars of this traditional knowledge network.

We notice that, the age groups (in green) are positioned very close to the center of gravity of the cloud, except for the youngest. This reveals that, with the exception of younger generations who tend to adopt the "Urban" profile, age does not constitute a determining factor in plant use, unlike location or level of education.

The biplot thus confirms that the geographical criterion is the first element of segmentation. The opposition between rural/ traditional knowledge (left) and urban or technical practices (right) is mainly responsible for the global inertia of the cloud. The clear grouping of people around geographical centers validates the relevance of the factorial design for representing the ethnobotanical diversity of the region.

Influence of age

The impact of age on practices is evaluated by the representation of individuals according to age groups (Figure 9).

The distribution of respondents in the MCA space is examined by the projection of individuals on the factorial plane, coloring them according to their age group, considered as an illustrative variable.

We notice that the confidence ellipses of various age categories overlap considerably on both dimensions, indicating a lack of clear separation between the age groups in the factor space. This result agrees with the weak correlation between age and the first axes, already observed in the variable graph.

The 30-49-year (In red) and 18-29-year (In grey) age groups indicate the largest and most central scatter plots, which illustrates their numerical dominance in the sample as well as the diversity of their ethnobotanical uses.

The 50-69 age group (light blue) tends to shift slightly to the right of dim1, suggesting a stronger association with geographically differentiated practices. The ≥ 70 and < 18 age groups are underrepresented, which limits the interpretation of their positioning.

From the visual interpretation of the graph in figure 9, we observe that the age group is not a major differentiating factor in ethnobotanical practices in this study. Practices appear to be determined more by city of origin and level of education than by the age of the respondents.

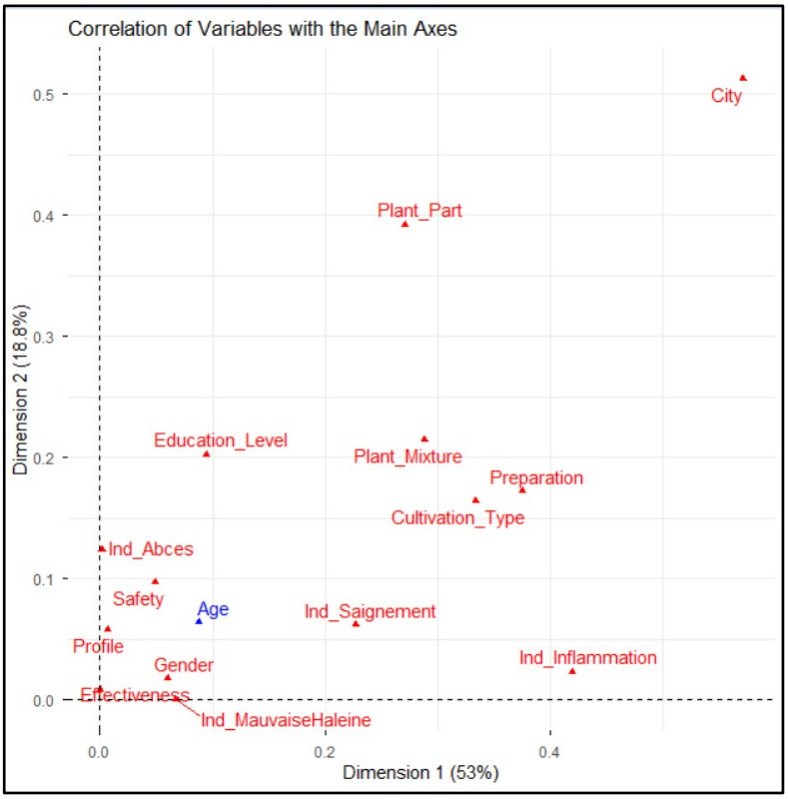


Figure 7. Correlation of variables with the principal axes of the MCA.

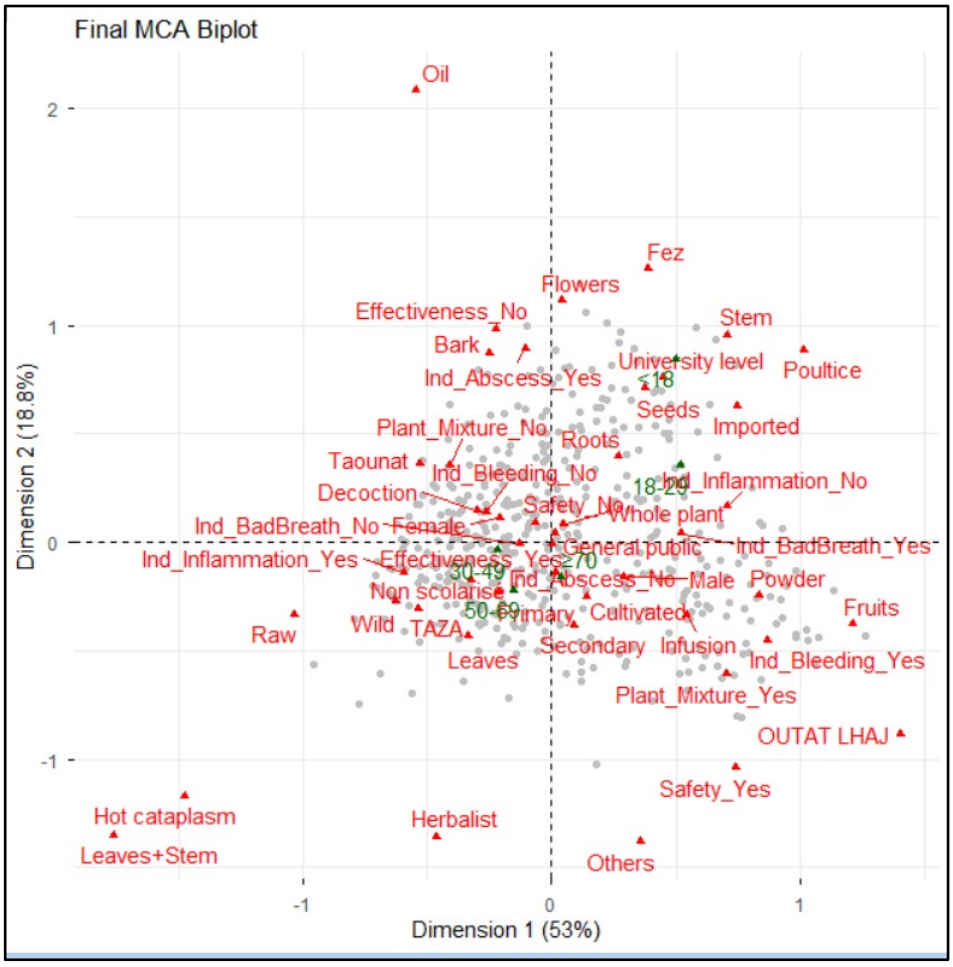


Figure 8. Representation of individuals and variable categories in the factorial space (Cumulative inertia: 71.8 %).

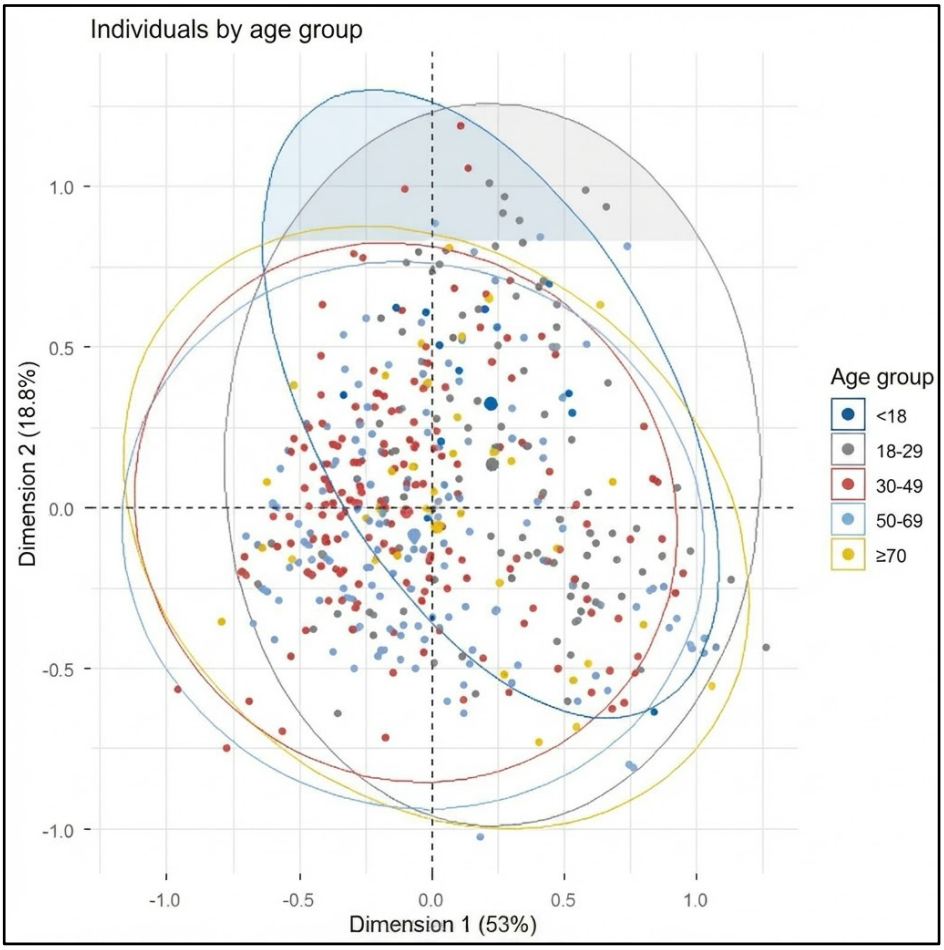


Figure 9. Distribution of individuals by age group in the MCA factorial space. The colors indicate the different age groups: 18-29 years (grey), 30-49 years (red), 50-69 years (light blue), ≥70 years and <18 years (underrepresented) (Cumulative inertia: 71.8 %).

Multiple correspondence analysis (MCA) was incorporated into our study to provide an in-depth understanding of the factors likely to influence the use and transmission of traditional knowledge in the Fez-Meknes region. This approach explores the relationships between the socio-demographic characteristics of respondents and their ethnobotanical knowledge, unlike most ethnobotanical studies carried out in Morocco, which are mainly limited to the description of medicinal species and their traditional uses.

Conclusion

This ethnobotanical survey conducted in the Fez-Meknes region revealed a diverse flora rich in anti-periodontal plants and enabled the inventory and analysis of the traditional use of these species by the local population for the treatment of oral diseases. The survey data indicate that the leaves of wild plants were the most commonly used plant parts, while decoction was the predominant method of preparation. The study identified 57 taxa belonging to 30 families, with the Lamiaceae family being the most represented. These plants were mainly used to treat gingival inflammation.

The findings form a preliminary ethnobotanical knowledge base. They offer promising avenues to guide future research in pharmacology and phytochemistry, which ultimately aims to explore the potential of these species for developing natural alternatives for oral hygiene.

Declarations

List of abbreviations: APB- African Plant Database; B- Bark ; C- Cataplasm ; Cl- Cultivated ; D- Decoction ; F- Flowers ; Fc- Frequency; Fig.- Figure; FIV-Family importance value; Fr- Fruits ; J- Juice ; Hc- Hot cataplasm; HCP- High Commission for Planning; I- Infusion ; Im- Imported ; L- Leaves ; Mp- Mode of preparation; O- Oil ; Pa- Paste ; Po- Powder ; Pu- Part used;

POWO- Plants of the World Online; R- Roots; RFC- Relative citation frequency; RGPH- General Population and Housing Census; Rw- Raw ; S- Stems ; Sd- Seeds ; Sp- Spontaneous ; Tp- Type of plant; Wp- Whole plant; WHO- World Health Organization.

Approval and consent to participate: This study was reviewed and approved by the Institutional Review Board of the Laboratory of Natural Resources and Environment, Polydisciplinary Faculty of Taza, Sidi Mohamed Ben Abdellah University (approved on May 14, 2026), which confirmed that the study has no direct negative impact on the participants or the biodiversity of the study area. The survey followed the International Society of Ethnobiology (ISE) Code of Ethics. Before each interview, the purpose of the study was explained, and oral prior informed consent was obtained from all adult participants, as well as from parents or legal guardians (along with the verbal assent of the minors) for the 15 participants under 18 years of age. Because illiteracy is high in these rural communities and interviews took place in informal field settings, obtaining written signatures was not practical.

Consent for publication: Not applicable.

Availability of data and materials: The data are available from the corresponding author upon reasonable request.

Competing interests: Authors have no conflict of interest.

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Author contributions: AK, KH and TB: Study design and supervision. AK: Identification of scientific names of species, orientation and corrected the manuscript. HA: Study design, conducted the survey, compiled the database, analyzed, interpreted the statistical data and manuscript writing. ML: orientation and correction of the manuscript. FZ, IB, SL. and NG: study design and conducted the survey. All authors have read, approved and corrected the manuscript.

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