Comprehensively expanding ethnobotanical insights into traditional health practices in Taza Province, Morocco

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Research

Abstract

Background: This study was conducted among residents of both previously documented communes and communes surveyed for the first time in Taza Province (Morocco). It aimed to update and expand knowledge on medicinal plant species traditionally used in herbal medicine, while highlighting the close relationships between local populations and plant resources, shaped by cultural practices, the transmission of traditional knowledge, and everyday needs.

Methods: An ethnobotanical survey was conducted (March-September 2025) among 186 participants from 10 communities in Taza province, using a semi-structured questionnaire. Data collected, focused on socio-demographic characteristics of the respondents and use of medicinal plants, were exploited for percentages and indices determination. All analyses were performed using IBM SPSS Statistics 26 software and the principal compound analyses (PCA) were done.

Results: The survey of 186 participants revealed a predominance of males (69.89%), married (80.64%), illiterate (65.60%), living mainly in rural areas (77.96%), with a monthly income of less than 2,000MAD (87.63%). Knowledge of medicinal plants came mainly from parents (65.59%). A total of 58 medicinal species, including 35 families, were recorded, with *Mentha pulegium* L., *Rosmarinus officinalis* L. and *Calamintha nepeta* subsp. spruneri (Boiss.) were the most common species. Lamiaceae was the most widely used family (FIV = 203.54; FUV = 1.9). PCA reveals the clear predominance of the Lamiaceae family in local ethnomedicinal practices within the study area. Five species: *Origanum compactum*, *Thymus* spp., *Rosmarinus officinalis*, *Mentha pulegium*, and *Calamintha nepeta subsp. Spruneri* were strongly associated with high ethnobotanical criteria and use frequency.

Conclusions: This study highlights that the use of medicinal plants in the province of Taza reflects both the richness of the local medicinal flora and the importance of ancestral knowledge deeply rooted in the cultural traditions of the population. The strong representation of five species belonging to the Lamiaceae family underscores their central role in local therapeutic practices and provides a relevant basis for the valorization and preservation of ethnobotanical knowledge related to the interaction between communities and plant resources.

Keywords: Medicinal plants, Taza province, Ethnobotanical survey, Quantitative analyses.

Background

Medicinal and aromatic plants (MAP) are a very important natural resource, the exploitation of which requires a thorough understanding of their properties (Ouraini *et al.* 2007). Morocco is considered a rich country in MAP that can be used in various fields (pharmacopoeia, perfumery, cosmetics and agri-food) for their therapeutic, organoleptic and aromatic properties (Jamaleddine *et al*. 2019). Morocco, with its biogeographical diversity, particularly its mountainous and arid areas, is an exceptional reservoir of flora. According to the most recent inventory, Morocco's vascular flora comprises 155 families, 981 genera, 3913 spontaneous species, as well as 426 typical subspecies and 872 additional subspecies (Fennane *et al*. 1999). Of these, 640 species are strictly endemic, representing 16.3% of the national flora. Of the approximately 4000 species identified nationally, around 800 are endemic, while 600 are recognised for their medicinal or aromatic properties (Ismaili *et al*. 2021), 500 of which also have significant economic value (Ennabili *et al*. 2000). Despite significant advances in modern medicine, the therapeutic properties of bioactive molecules of plant origin remain widely recognised and valued. However, to avoid potentially serious side effects associated with the use of certain toxic plants, in-depth knowledge of phytotherapy is essential. Phytotherapy is defined as the set of practices aimed at preventing and treating various pathologies through the use of medicinal plants or their extracts (Létard *et al*. 2015). Historically, plants have been a major resource in the treatment of infectious diseases and have served as the basis for the synthesis of many modern medicines (Verma & Singh 2008). The study of medicinal plants is of interest to many scientific disciplines, among which ethnobotany occupies a central place.

This approach aims to promote empirical knowledge by documenting the traditional knowledge held by local communities and translating it into scientific data. It provides a relevant and reliable means of accessing ancestral knowledge and understanding the interactions between populations and the plants they use, thus highlighting the importance of ethnobotanical studies for the conservation of both plant and cultural heritage (Fleurentin & Balansard 2002). In this context, the present study builds on previous research conducted in the Taza province (Boulfia *et al*. 2018, El Aboui *et al.* 2025, El Brahimi *et al*. 2022, El Hajli *et al*. 2024, El Haouari *et al*. 2018, Ghabbour *et al*. 2023, Ghabbour *et al*. 2024a, Ghabbour *et al*. 2024b, Khabbach *et al*. 2011, Khabbach *et al*. 2012). More specifically, it extends the work of Ghabbour *et al*. (2023), Ghabbour *et al*. (2024a) and Ghabbour *et al*. (2024b), which covered 28 of the 38 municipalities in the province. The present study, therefore, focuses on the remaining 10 municipalities and is based on 186 ethnobotanical interviews conducted with the local population, allowing for the identification of the specific relationship between medicinal plants and their use by the inhabitants.

Materials and Methods

Study area

The province of Taza is part of the Fez-Meknes region, located in north-eastern Morocco. According to data from the general population and housing census of September 2024, the official population reached 500,971 inhabitants (RGPH, 2024). The province comprises 4 urban municipalities and 34 rural municipalities (DRF-M, 2016). This study was conducted among herbalists and ordinary citizens in 10 rural communities in the province of Taza (Figure 1), which are Sidi Ali Bourakba and Bourd (Rif of Morocco), Ait Saghrou, Smià, Zrarda, Tazarin and Bouyablane (Middle Atlas of Morocco), and Brarha, Rbaa El Fouki, Beni Frassen (plains between Rif and Middle Atlas).

Study methodology

Following the study conducted by Ghabbour *et al*. (2023), Ghabbour *et al*. (2024a), Ghabbour *et al*. (2024b) on 28 communities in the Taza region out of a total of 38, this paper will focus on the remaining 10 communities. In addition to the five communities (Brarha, Rbaa El Fouki, Bni Frassen, Bourd, Sidi Ali Bourakba) already surveyed according to the work of (El aboui *et al*. 2024, Khabbach *et al*. 2011), five other communities presenting the Middle Atlas of Morocco (Ait Saghrou, Smià, Zrarda, Tazarin, Bouyablane) are included for the first time in the ethnobotanical survey. This is particularly important given that the study area is rich in natural resources and biodiversity. The majority of the species recorded were herbaceous after harvesting, and a copy of the herbarium was deposited at the Laboratory of Natural Resources and the Environment, Multidisciplinary Faculty of Taza, Sidi Mohamed Ben Abdellah University of Fez. The scientific names were updated (Ghabbour *et al*. 2024a). The botanical family names of the plants were presented, in alphabetical order according to the APG III (Angiosperm Phylogeny Group) system (Haston *et al*. 2009).

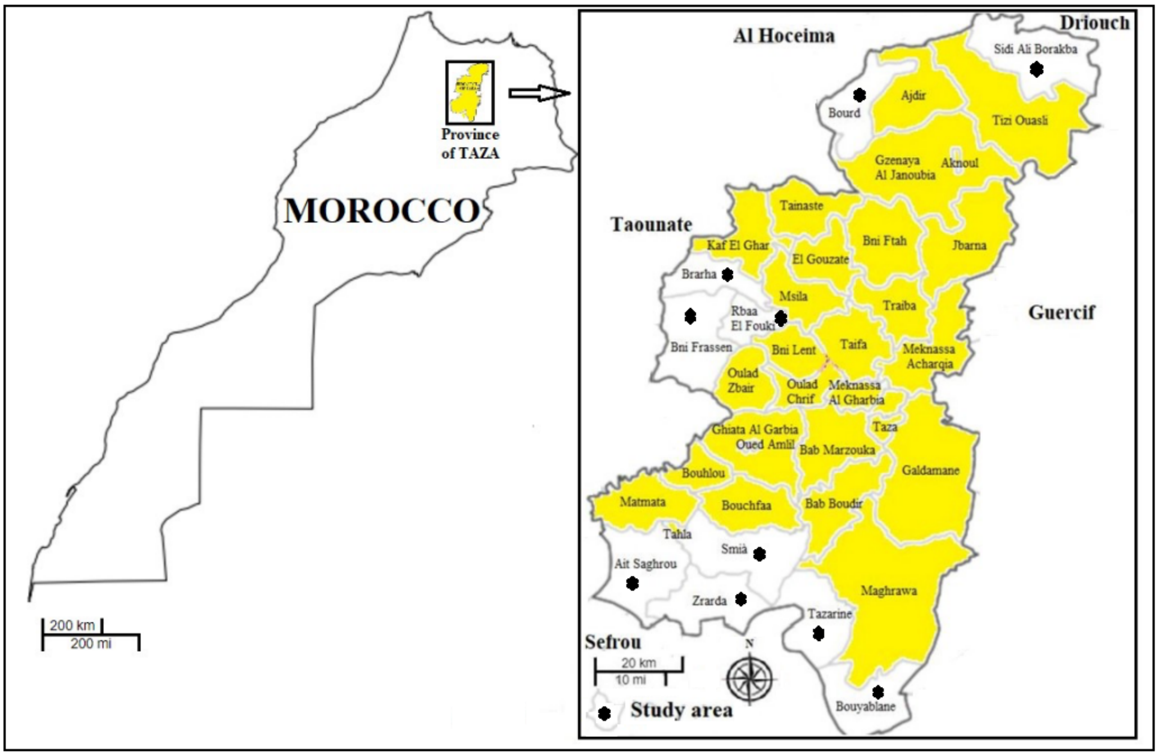

Figure 1. Map showing the study area (studied communities) in the Province of Taza (Ghabbour *et al.* 2023).

Questionnaire

This survey, conducted between March and September 2025, is a descriptive and exploratory ethnobotanical study, carried out face-to-face with herbalists and local people using questionnaires and note-taking. Based on previous work of (Ghabbour *et al*. 2023, Ghabbour *et al*. 2024a, Ghabbour *et al*. 2024b), a semi-structured questionnaire consisting of two main parts was formulated for use in face-to-face interviews, and 186 people (163 ordinary citizens and 23 herbalists) were interviewed. The first part consists of gathering information about the population surveyed (ordinary citizen or herbalist, age, place of residence, gender, family situation, level of education, monthly income, socio-economic status and language spoken). The second part consists of finding out how users of medicinal plants use them by determining the reason for their use, the source(s) of ethnobotanical knowledge, the patient's condition after treatment, drying, storage conditions and whether the medicinal plants are used separately, in mixtures or in combination with medicines. This second part also includes the collection periods, the condition of the plants used, the part(s) used, their methods of preparation and use, the duration of treatment and the diseases to be treated.

Determination of scientific names

A comprehensive list of vernacular names of medicinal plants reported by the surveyed population was compiled, following the same methodological approach previously described by Ghabbour *et al.* (2024a)**.** The phonetic transcription of these vernacular names was established based on the correspondence between Arabic and Latin (French-based) letters as follows: ا = aː, ب = b, ت = t, ث = θ, ج = ʤ / ʒ / g, ح = ħ, خ = x, د = d, ر = r, ز = z, س = s, ش = ʃ, ص = sˤ, ض = dˤ / ðˤ, ط = tˤ, ع = ʔˤ, غ = ɣ, ف = f, ق = q, ك = k, ل = l, م = m, ن = n, ه = h, و = w / uː, and ي = j / iː.

Almost all plant species cited in local traditional medicine were collected in the field, properly preserved, and prepared as herbarium specimens. Voucher specimens were deposited at the Laboratory of Natural Resources and Environment, Polydisciplinary Faculty of Taza, Sidi Mohamed Ben Abdellah University of Fez.

Botanical identification and validation of scientific names were carried out by the botanist, Pr. Khabbach Abdelmajid (Biotechnology, Environment, Agri-Food and Health Laboratory, Faculty of Sciences, Dhar el Mahraz, Sidi Mohamed Ben Abdellah University, Fez 30000, Morocco) using the same specialised floristic and taxonomic references as those adopted by Ghabbour *et al.* (2024a): Fennane *et al.* (1999, 2014)**,** Nègre (1962), Quezel and Santa (1962-1963) and Valdés *et al.* (2002). This study, therefore, represents a complementary and extended contribution to the work previously reported by (Ghabbour *et al.* 2024a), ensuring methodological consistency and taxonomic reliability.

Quantitative data analysis

Quantitative analysis was used to assess the diversity of use of MAP recorded in the Taza province using several ethnobotanical criteria of (Ghabbour *et al*. 2024b), including the criteria of collection period (CCP), the statut of plant (fresh or dried) (CPS), the parts used (CPU), the methods of preparation (infusion, decoction, maceration, etc.) (CP), and the way of administration (oral, external, inhalation) (CA). Indices such as family importance value (FIV), frequency of use of families (FUF) and family use value (FUV) were calculated according to the formulas reported by Ghabbour *et al*. (2024b), thus enabling a quantitative assessment of the relative importance of the species and botanical families studied.

Principal component analysis (PCA)

A principal component analysis (PCA) of the variables, ethnobotanical indices, and species was performed using IBM SPSS Statistics (version 26), following the same approach as described by Ghabbour *et al*. (2024b). PCA, a multivariate descriptive factorial method, was applied to explore the relationships among these variables and to identify potential groupings within the dataset. The overall dispersion of variables was assessed based on their spatial distribution, allowing the discrimination between strongly correlated variables and those showing weak or no correlation.

Data processing

The data recorded on the survey forms were entered and processed using IBM SPSS Statistics 26 software. Data analysis was based on descriptive statistics using simple methods of calculating percentages and frequencies. The graphs and tables obtained using IBM SPSS Statistics 26 software were represented using Microsoft Office Excel software. The map of the study area used in this study was that reported by Ghabbour *et al*. (2023).

Results and Discussions

Distribution of interviews

The results of the distribution of the surveyed population (186 people) among the 10 studied communities are presented in Table 1. The community of Zrarda stands out with the highest number of interviews (41) compared to the other communities. This situation can be explained in particular by the ease of access, the density of housing and the availability of people to interview, unlike certain areas where difficult roads and rugged terrain limit travel and encounters with residents. The number of people surveyed in the study by Ghabbour *et al*. (2024a) (340) is higher than in our study (186), as the areas studied include four urban communities (Taza, Oued Amlil, Aknoul, Tahla) characterized by a higher population density than the areas covered by our survey.

Table 1. Percentage and frequency refer to the total number of interviews applied.

Community	Frequency	Percentage%
Sidi Ali Bourakba	15	8.06
Bourd	40	21.51
Brarha	18	9.68
Rbaa El Fouki	13	6.99
Bni Frassen	12	6.45
Ait Saghrou	14	7.53
Smià	11	5.91
Zrarda	41	22.04
Tazarine	15	8.06
Bouyablane	7	3.76
Total	**186**	**100**

Sociodemographic profile

The survey population consisted of 186 people, 87.63% of whom were ordinary citizens and 12.37% herbalists (Table 2). The majority of respondents belong to the category of ordinary citizens, while herbalists constitute a minority. This distribution shows that ethnobotanical knowledge is not the preserve of specialists alone but is widely disseminated among the local population. Nevertheless, herbalists play an essential role in the organization, preservation and transmission of traditional medicinal knowledge. Their interaction with plants is more structured, based on continuous practice, precise species identification and in-depth knowledge of preparation methods. Ordinary citizens, on the other hand, mainly possess empirical knowledge derived from everyday use and family heritage, thus promoting informal transmission of knowledge within the community.

The age of the population ranges from 21 to 80 years, with a strong predominance of the 61-80 age group (52.68%), followed by the 41-60 age group (40.11%), while the 21-40 age group remains underrepresented (6.99%). This distribution, also observed in other studies (Chaachouay *et al*. 2019, Ghabbour *et al*. 2024b, Hanae *et al*. 2012, Telli *et al*. 2016), highlights the central role of age in the retention of ethnobotanical knowledge. Older people have accumulated more in-depth knowledge, forged by years of practice, observation and oral transmission of therapeutic uses. On the other hand, younger generations, who are less exposed to local traditions and more oriented towards modern medicine, have more limited knowledge of medicinal plants, which is reflected in their low contribution to local ethnobotanical knowledge.

The distribution of participants by place of residence reveals a clear dominance of rural areas (77.96%) over peri-urban areas (22.04%). This trend is consistent with the findings reported by Khabbach *et al*. (2012), which highlight the central role of rural areas, characterized by a high availability of plant resources. This spatial configuration has a significant impact on knowledge of medicinal plants, as rural dwellers benefit from regular contact with the local flora. This context promotes the enrichment and transmission of traditional knowledge relating to the therapeutic use of plants, whereas in peri-urban areas, less interaction with the natural environment contributes to a gradual reduction in this knowledge.

In terms of gender, men represent the majority of informants (69.89%), compared to 30.11% women, a trend also reported by Ghabbour *et al*. (2024b) and which could be explained by greater male availability during surveys. Nevertheless, this distribution should be interpreted with caution. In ethnobotany, the influence of gender on the acquisition and transmission of medicinal knowledge depends heavily on socio-cultural and regional contexts. In some settings, men are more involved in the collection, marketing and recommendation of plants, which may increase their representation in studies. Conversely, women often play a key role in healthcare within the home and possess significant knowledge about domestic therapeutic uses. Furthermore, several studies indicate that there are no significant differences between the sexes, suggesting a relatively balanced distribution of knowledge. Thus, the observed male predominance may result mainly from factors related to the accessibility and availability of respondents, rather than actual differences in knowledge between men and women.

The family situation reveals that the majority of respondents are married (80.64%), followed by widows/widowers (15.05%), while single people represent only 4.30% (Table 2). These results are consistent with those of Chaachouay *et al*. (2019), Ghabbour *et al*. (2024b) and Ghanimi *et al*. (2022), who also report a high proportion of married people among users of medicinal plants. This predominance can be explained by the fact that married people and widows/widowers generally assume greater family responsibilities, particularly in terms of healthcare within the home, which encourages the acquisition, regular use and transmission of knowledge about medicinal plants. Conversely, single people, who are often less involved in managing family care, tend to make more limited use of this knowledge.

The level of education among participants appears to be low overall, with 65.60% illiterate and 31.18% having only completed primary education, while secondary (2.15%) and higher (1.07%) education levels remain marginally represented. This trend is consistent with the observations of Telli *et al*. (2016), who also reported a high proportion of people with little or no schooling. This educational context plays an important role in the retention of knowledge about medicinal plants, which is based primarily on empirical learning and oral transmission. Less educated individuals, who are often more closely connected to their natural environment, are more likely to preserve and use this traditional knowledge, while more educated individuals tend to favour modern healthcare systems, which can limit the use and transmission of ethnobotanical knowledge.

Socio-economically, the majority of informants (87.63%) have a monthly income of less than MAD 2,000, and 80.11% have a low socio-economic status. These results, similar to those of Ghabbour *et al*. (2024b) and Hanae *et al*. (2012), explain the widespread use of phytotherapy. Medicinal plants are an accessible, inexpensive and culturally valued therapeutic alternative. In this context, the human-plant relationship represents a real adaptation strategy in the face of economic constraints and limited access to modern healthcare. With regard to the language used on a daily basis, 81.18% use Amazigh, 13.44% use Arabic dialect and 5.38% use both languages. Finally, almost all of the people surveyed (96.77%) use medicinal plants, compared to only 3.22% who do not (Table 2). This high prevalence reflects the importance of herbal medicine and highlights the deep-rooted nature of the human-plant relationship in the daily and cultural practices of the local population.

Table 2. Socio-demographic profile of interviewees (MAD: Marocain Dirham)

Socio-demographic variables		Frequency	Percentage%
Population	Ordinary citizen	163	87.63
	Herbalist	23	12.36
Age	21 to 40 years old	13	6.99
	41 to 60 years old	75	40.32
	61 to 80 years old	98	52.68
Residence	Rural	145	77.96
	Suburban	41	22.04
Sexe	Male	130	69.89
	Feminine	56	30.11
Marital status	Single	8	4.30
	Married	150	80.64
	Widowed	28	15.05
Education level	Illiterate	122	65.60
	Primay	58	31.18
	Secondary	4	2.15
	High education	2	1.07
Monthly income	<2000 MAD	163	87.63
	2000 to 10000 MAD	23	12.37
Socio-economic level	High	23	12.36
	Medium	14	7.53
	Low	149	80.11
Usual language	Arabic dialect	25	13.44
	Amazigh	151	81.18
	Arabic dialect & Amazigh	10	5.38

Characteristics of medicinal plants used in traditional medicine

Part used and state of use

The highest criterion for the part used (CPU=4) is noted for a single plant species, *Visnaga daucoides* (Table 3). This result is consistent with that (CPU=4) found by Ghabbour *et al.* (2024b) noted for two plant species, *Anethum foeniculum* L. and *Petroselinum crispum* (Mill.) *Fuss*. Different parts of the plants are used (Figure 2), with the leaves being the most used part (64.08%), followed respectively by aerial part (16.82%), seeds (4.05%), fruits (6.9%), stem (3.45%), flowers (1.3%), roots (1.1%), pericarp (0.6%) and rhizome (1.7%). Several studies have reported that the leaves are the most commonly used plant organ (Barkaoui *et al*. 2017, Boulfia *et al*. 2018, Bouyahya *et al*. 2017, Beniaich *et al*. 2022, Chaachouay *et al*. 2019, Chaachouay *et al*. 2022, Daimari *et al*. 2019, El Aboui *et al*. 2024, El Haouari *et al*. 2018, El Khomsi *et al*. 2022, Ghabbour *et al.* 2024b, Hayat *et al*. 2020, Mikou *et al*. 2016, Salgueiro *et al*. 2018, Singh *et al*. 2022, Souilah *et al*. 2022, Srinivasan *et al*. 2022). This preference can be explained by several factors. The leaves are easily accessible, abundant and renewable, allowing for sustainable harvesting without destroying the plant. Furthermore, they are the main site of photosynthesis, a process during which many secondary metabolites responsible for biological properties are formed. Finally, they are also easier to dry and preserve than other organs. This preference for leaves reflects empirical knowledge passed down from generation to generation, which identifies these organs as the most effective for healing, combining biological efficacy and ease of harvesting. On the other hand, the highest plant status criterion (CPS=2) (Table 3) is noted for 9 plant species. This result is in line with that (CPS=2) of Ghabbour *et al*. (2024b) noted for 36 plant species. The results of 84.40% of plants used in a dry state compared to 15.60% in a fresh state (Table 4) can be explained by the fact that drying allows for better preservation of plants and their active ingredients over a long period of time. Indeed, dried plants are easier to store, transport and use in all seasons, unlike fresh plants, which deteriorate quickly. In addition, drying reduces moisture, thereby limiting the proliferation of microorganisms and the degradation of bioactive compounds.

Table 3. Characteristics related to medicinal plants used in traditional medicine by the population of the province of Taza

Family	Scientific name	VN	VC	P.S	Col. Per	CCP	P. S	CPS	Part used	CPU	Pre	CP	Adm	CA	SUF	FUF	FIV	FUV	EN *RL*
Amaranthaceae	*Dysphania ambrosioides* (L.) Mosyakin & Clemants	Mxiːnza:	**1**	Intr Natu	All year	4	Dried Fresh	2	Leaves	1	Infu Deco Raw	3	Oral Ext app	2	14	14	14	0.075	
Anacardiaceae	*Pistacia lentiscus* L.	Fa:dˤiːsˤ	**2**	Spon	All year	4	Dried	1	Leaves	1	Infu	1	Ext app Oral	2	28	28	28	0.15	***LC***
Apiaceae	*Ammodaucus. leucotrichus* Coss. & Dur.	Ka:muːn sˤuːfiː.	**3**	Spon	Summer All year	4	Dried	1	Seeds Fruits	2	Pow Deco Infu	3	Oral	1	6	33	8.25	0.044	**NA**
	Visnaga daucoides Gaertn.	Bʃniːxa:	**4**	Spon	Summer	1	Dried	1	Leaves Aerial part Flowers Fruits	4	Raw Infu Deco	3	Ext app Oral	2	4				
	Carum carvi L.	Lka:rwiːja:	**5**	Cult	Summer	1	Dried	1	Leaves	1	Infu Deco	2	Oral	1	17				
	Coriandrum sativum L.	Quːsˤbr	**6**	Intr Natu	Summer All year	4	Fresh Dried	2	Aerial part Graines	2	Deco Pow	2	Oral	1	6				
Apocynaceae	*Nerium oleander* L.	A:riːriː /Dfla:	**7**	Spon	All year	4	Fresh	1	Leaves	1	Deco	1	Inha	1	10	10	10	0.054	***LC***
Arecaceae	*Chamaerops humilis* L.	Duːm / Lɣa:z	**8**	Spon	Summer	1	Dried	1	Fruits	1	Raw	1	Oral	1	68	68	68	0.365	**NA *LC***
Aristolochiaceae	*Aristolochia fontanesii* Boiss. & Reut.	Brz tˤa:m	**9**	Spon	All year	4	Dried	1	Roots Leaves	2	Pow Deco	2	Ext app	1	39	39	39	0.209	**MA**
Asteraceae	*Artemisia herba-alba* Asso.	ʃiːħ/ ʤaʔˤda	**10**	Spon	All year	4	Dried	1	Leaves	1	Deco Infu	2	Oral	1	139	231	77	0.414	**NA**
	Dittrichia viscosa Greuter	Ma:gra:mn / Ti:dʤr	**11**	Spon	All year	4	Fresh	1	Leaves	1	Pow Deco	2	Ext app	1	49				**NA**
	Matricaria chamomilla L.	Lba:bu:nj	**12**	Spon	Spring	1	Dried	1	Fleurs	1	Infu Deco	2	Oral	1	41				**NA**
Berberidaceae	*Berberis hispanica* Boiss. & Reut.	Aɣri:s	**13**	Spon	Summer	1	Dried	1	Stem	1	Mace Infu Pow	3	Oral	1	4	4	4	0.021	**MIA**
Brassicaceae	*Lepidium sativum* L.	ħabrʃa:d	**14**	Cult	Summer	1	Dried	1	Seeds	1	Infu Raw Pow	3	Oral	1	10	10	10	0.054	
Capparaceae	*Capparis spinosa* L.	Lkbba:r	**15**	Spon	Summer	1	Fresh	1	Fruits	1	Deco Mace	2	Oral	1	4	4	4	0.021	***LC***

Illecebraceae	*Herniaria hirsuta* L.	Hra:st lħdʒa:r	**16**	Spon	Summer	1	Dried	1	Leaves Aerial part	2	Deco Infu	2	Oral	1	22	22	22	0.118	
Coriariaceae	*Coriaria myrtifolia* L.	Owi:z	**17**	Spon	All year	4	Dried	1	Leaves	1	Deco	1	Oral	1	24	24	24	0.13	
Cupressaceae	*Tetraclinis articulata* (Vahl.)	Lʔˤa:rʔˤa:r/ Ama:rzi:	**18**	Spon	All year	4	Fresh	1	Leaves	1	Pow Infu Deco	3	Oral	1	95	95	95	0.511	**NA *LC***
Fabaceae	*Ceratonia siliqua* L.	Lxa:rru:b	**19**	Spon	Summer	1	Dried	1	Fruits	1	Raw Powr	2	Oral	1	96	163	32.6	0.175	***LC***
	Lotus ornithopodioides L.	Ti:zdu:zi:n	**20**	Spon	All year	4	Dried	1	Leaves	1	Infu	1	Oral	1	25				
	Lupinus albus L.	Ti:rmi:s	**21**	Impo	All year	4	Dried	1	Fruits	1	Deco Pow Infu	3	Oral	1	4				***LC***
	Ononis natrix L.	Afza:z	**22**	Spon	All year	4	Dried	1	Leaves	1	Infu	1	Oral	1	11				**NA *LC***
	Trigonella foenum-graecum L.	Lha:lba:	**23**	Cult	All year	4	Dried	1	Leaves Seeds	2	Mace Deco Raw Pow Infu	5	Oral	1	27				
Fagaceae	*Quercus suber* L.	A:dra:n /Lba:llu:tˤ /Lku:rri:ʃ	**24**	Spon	Autumn	1	Fresh	1	Fruits	1	Boil	1	Oral	1	12	12	12	0.064	***LC***
Gentianaceae	*Centaurium erythraea* Rafn.	Kesˤa:t Lha:ya:	**25**	Spon	Summer	1	Dried Fresh	2	Leaves	1	Infu Deco	2	Oral	1	4	4	4	0.021	***LC***
Juglandaceae	*Juglans regia* L.	Elkorka:ʔˤ	**26**	Impo	All year	4	Fresh	1	Stem Fruits Leaves	3	Raw Mace Infu Deco	4	Ext app Oral	2	4	4	4	0.021	***LC***
Lamiaceae	*Calamintha nepeta* subsp. *spruneri (*Boiss.) Nyman	Ma:nta: /Ta:mi:nta:	**27**	Spon	All year	4	Dried Fresh	2	Aerial part Leaves	2	Infu Deco E. O	3	Ext app Oral	2	300	2239	203.54	1.09	**MA**
	Lavandula officinalis L.	Xza:ma:	**28**	Spon	All year	4	Fresh	1	Flowers Leaves Aerial part	3	Pow Deco Raw Infu E. O	5	Oral Ext app	2	91				***VU***
	Lavandula stoeckade L.	Lħa:lħa:l	**29**	Spon	All year	4	Dried	1	Leaves	1	Deco Infu	2	Oral	1	84				**NA**
	Marrubium vulgare L.	Ta:mr-ri:wt	**30**	Spon	All year	4	Fresh Dried	2	Leaves Stem	2	Pow Deco Infu	3	Oral	1	113				

	Mentha rotundifolia Muds.	Ta:ma:r sˤi:tˤa / mʃi:ʃru:	**31**	Spon	All year	4	Dried Fresh	2	Aerial part Leaves	2	Infu	1	Oral	1	79				***LC***
	Mentha pulegium L.	Fli:u:/ Fri:u:	**32**	Spon	Summer All year	 4	Fresh Dried	2	Aerial part Leaves	2	Pow Infu Deco	3	Oral	1	560				**NA** ***LC***
	Origanum compactum Benth.	Zʔˤtˤa:r/ Zu:i:	**33**	Spon	Summer All year	4	Fresh Dried	2	Aerial part Leaves	2	Infu Deco	2	Oral	1	202				**M**
	Origanum majorana L.	Ma:rda:doʃ	**34**	Spon	All year	4	Fresh Dried	2	Aerial part Leaves	2	Infu	1	Oral	1	6				
	Origanum vulgare L.	Zʔˤtˤa:r/ zu:i:	**35**	Spon	Summer All year	4	Fresh Dried	2	Aerial part Leaves	2	Infu Deco	2	Oral	1	48				**NA** ***LC***
	Rosmarinus officinalis L.	A:zi:r	**36**	Spon	All year	4	Dried Fresh	2	Leaves Fleurs Aerial part	3	Infu Deco Pow	3	Oral	1	403				**NA**
	Salvia officinalis L.	Sˤa:lmi:a:/ Mrmi:a :	**37**	Intr Natu	All year	4	Fresh	1	Leaves	1	Infu Deco	2	Oral	1	141				***LC***
	Thymus ssp.	Zʔˤitˤra:/ zu:ʃn /Tsa:i:t	**38**	Spon	All year	4	Dried Fresh	2	Leaves Aerial part	2	Infu Deco Mace	3	Oral	1	212				
Lauraceae	*Cinnamomum cassia* J.Presl	Qa:rfa:	**39**	Impo	Summer	1	Dried	1	Stem	1	Infu Deco Pow	3	Oral	1	4	4	4	0.021	
Malvaceae	*Hibiscus sabdariffa* L.	Ka:rka:di:l	**40**	Cult	Spring	1	Dried	1	Flowers	1	Infu	1	Oral	1	4	4	4	0.021	
Moringaceae	*Moringa oleifera* Lam.	Mu:ri:nga:	**41**	Impo	All year	4	Dried	1	Leaves	1	Deco	1	Oral	1	 4	4	4	0.021	***LC***
Myrtaceae	*Eucalyptus globulus* Labill.	Lka:litˤu:s	**42**	Cult	All year	4	Fresh	1	Leaves	1	Deco	1	Inha	1	7	38	12.67	0.068	***LC***
	Eugenia caryophyllata Thunb.	Lqru:nfl	**43**	Impo	Summer	1	Dried	1	Fruits	1	Raw	1	Oral	1	4				
	Myrtus communis L.	Ri:ħa:n	**44**	Spon	Summer	1	Dried	1	Leaves	1	Deco	1	Oral	1	27				***LC***
Oleaceae	*Olea europaea* subsp. *europaea*	Zi:tu:n	**45**	Spon	All year	4	Fresh	1	Fruits Leaves	2	Mace Raw Infu Deco	4	Oral	1	30	30	30	0.161	**NA**
Pinaceae	*Pinus Halipensis* Mill.	Ta:i:da:	**46**	Spon	All year	4	Dried	1	Leaves	1	Infu	1	Oral	1	5	5	5	0.027	**NA** ***LC***

Poaceae	*Pennisetum typhoides* Rich.	I:lla:n /A:ʤba:r	**47**	Cult	Summer	1	Dried	1	Seeds	1	Deco	1	Oral	1	67	67	67	0.36	
Punicaceae	*Punica granatum* L.	Rma:n	**48**	Cult	Autumn	1	Dried	1	Pericarp	1	Pow	1	Oral	1	20	20	20	0.107	***LC***
Ranunculaceae	*Nigella sativa* L.	Sˤa:nu:ʤ/ Lħa:ba swda :	**49**	Cult	Summer	1	Dried	1	Seeds	1	Pow	1	Oral	1	26	26	26	0.14	
Rhamnaceae	*Rhamnus alaternus* L.	A:mli:la:s	**50**	Spon	Summer	1	Dried	1	Leaves	1	Infu	1	Oral	1	65	115	57.5	0.309	**NA *LC***
	*Ziziphus lotus (*L.*)* Lam.	Sa:dra:	**51**	Spon	Summer	1	Dried	1	Fruits	1	Raw Pow	2	Oral	1	50				
Rubiaceae	*Rubia tinctrorum* L.	Lfu:wa:	**52**	Cult	Autumn	1	Dried	1	Rhizomes	1	Infu	1	Oral	1	61	61	61	0.328	**NA**
Rutaceae	*Ruta chalipensis* L.	A:wra:m /Fi:ʤa:l	**53**	Spon	All year	4	Dried	1	Leaves	1	Deco	1	Oral	1	10	10	10	0.054	
Salicaceae	*Populus alba* L.	Sˤa:fsˤa:f	**54**	Spon	All year	4	Dried	1	Leaves	1	Deco	1	Oral	1	4	4	4	0.021	***LC***
Solanaceae	*Solanum nigrum* L.	ʔˤi:n la:rna:b	**55**	Spon	Summer	1	Dried	1	Leaves	1	Infu	1	Oral	1	4	4	4	0.021	
Thymelaeaceae	*Daphne gnidium* L.	A:la:zza:z	**56**	Spon	Spring	1	Dried	1	Leaves	1	Deco	1	Ext app	1	45	45	45	0.242	**NA *LC***
Urticaceae	*Urtica dioica* L.	Hu:rri:ga:	**57**	Spon	Summer	1	Fresh	1	Leaves	1	Deco	1	Oral	1	4	4	4	0.021	***LC***
Verbenaceae	*Aloysia citriodora* Palau.	Lwi:za:	**58**	Cult	Summer	1	Dried	1	Leaves	1	Infu	1	Oral	1	60	60	60	0.322	
Total	**58**															**3505**			

Legend: Plant statue: **P.S** (Introduced: **Intr**; Naturalised: **Natu**; Spontaneous: **Spon**; Cultivated: **Cult**; imported: **Impo**). Collection period: **Col. Per**. **CCP**: Criterion of Collection period. **CPS**: Criterion of Plant state. **CPU**: Criterion of Part Used. Preparation: **Pre** (**Raw**; Boiled: **Boil**; Infusion: **Infu**; Decoction: **Deco**; Powder: **Pow**; Maceration: **Mace**; Essential oil: **E.O**). **CP**: Criterion of Preparation. Administration: **Adm** (**Oral**; External application: **Ext app**; Inhalation: **Inha**). **CA**: Criterion of Administration. **FUF**: frequency of use of families. **FIV**: Family Importance Value and **FUV**: Family Use Value. **VC**: Voucher codes, **VN**: Vernacular name, **SUF**: Species use frequency. And [**En**: Endimism (**MA**: Morocco-Algeria, **MIA**: Morocco-Iberia-Algeria, **NA**: North Africa, **M**: Morocco), ***RL***: Red List (***LC***: Least Concern, ***VU***: Vulnerable).] based on (Ghabbour *et al*. 2024b; UICN, 2025)

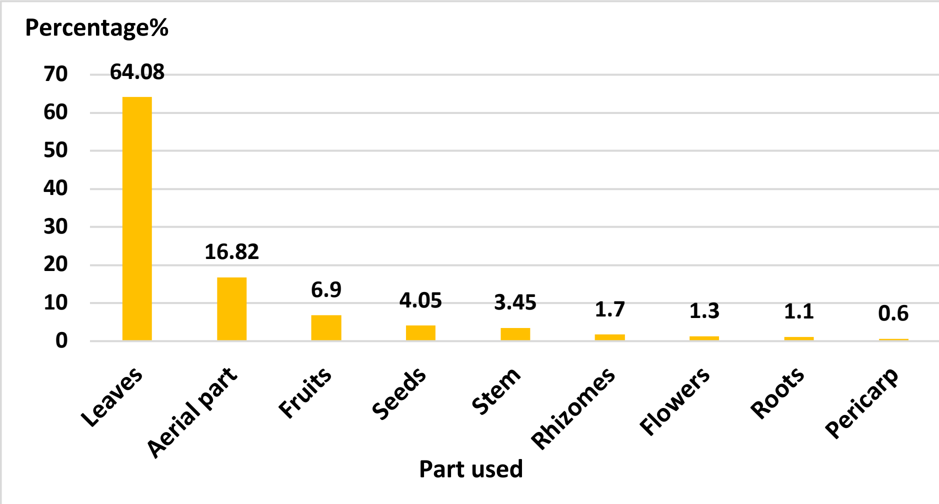

Figure 2. Frequent parts used.

Preparation methods

The highest preparation criterion (PC = 5) (Table 3), already reported by Ghabbour *et al*. (2024b), was attributed in this study to two plant species, *Lavandula officinalis* L. and *Trigonella foenum-graecum* L. Analysis of preparation methods (Figure 3) shows a strong predominance of infusion (69.01%), followed by decoction (16.94%), powder (5.45%), use in raw form (5.33%), essential oils (2.51%), maceration (1.4%) and, marginally, boiling (0.34%). This high frequency of infusion confirms its importance as the preferred method of preparation, a result consistent with several previous studies (Beniaich *et al*. 2022, Chaachouay *et al*. 2019, El Aboui *et al*. 2024, El Khomsi *et al*. 2022, Ghabbour *et al*. 2024b, Mikou *et al*. 2016 and Salgueiro *et al*. 2018). This dominance can be explained by the simplicity of infusion, its ease of use and its ability to effectively extract water-soluble active ingredients. Decoction, although less frequently used, remains suitable for more resistant plant parts, such as roots. Powdered preparations and the use of raw plants are valued for their long shelf life and versatility, while essential oils and maceration require specific techniques and longer preparation times. Boiling remains exceptional and is reserved for specific therapeutic uses. Overall, these proportions reflect choices guided by practicality, accessibility and the nature of the plant organs used. The predominance of infusion can also be explained by its deep roots in traditional practices, stemming from the close and ancient relationship between humans and plants, with water being a natural, easily accessible and culturally accepted solvent. However, this dominance does not exclude other methods of preparation, which are used in a complementary manner depending on the nature of the plants and therapeutic needs, thus illustrating the diversity of ethnobotanical practices in which each method has its place.

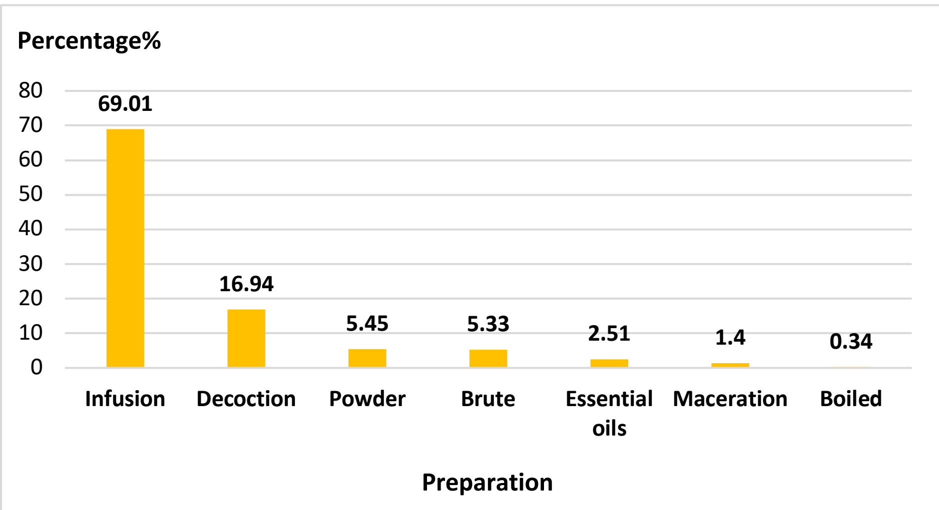

Figure 3. Frequent preparation types.

Method of administration

The results indicate that oral administration is the predominant method of administering medicinal plants, with a frequency of 92.67% (Table 4), in line with several previous studies conducted in the province of Taza (Bouyahya *et al*. 2017, El Aboui *et al*. 2024, El Haouari *et al*. 2018, Ghabbour *et al*. 2024b and Khabbach et al. 2012). Conversely, external application and inhalation remain marginal, accounting for 6.85% and 0.49% of recorded uses, respectively. Furthermore, the highest administration criterion (CA = 2) (Table 3) was assigned to six plant species, a result comparable to that reported by Ghabbour *et al*. (2024b).

The predominance of the oral route can be explained by its ease of use, accessibility and effectiveness in treating a wide range of conditions, particularly those with systemic effects. It is closely associated with the most common traditional forms of preparation, such as infusions and decoctions, which promote the extraction of active ingredients and their gradual absorption by the body. In addition, this route is generally perceived as safer and better integrated into daily therapeutic practices, which contributes to its widespread adoption.

Nevertheless, the predominance of oral administration does not exclude the benefits of other modes of use. Inhalation allows for rapid and targeted action, particularly suitable for respiratory conditions. Similarly, external application remains essential for the treatment of skin, muscle and joint disorders, ensuring direct local action while reducing systemic effects. Thus, the diversity of modes of administration observed reflects an adaptation of traditional practices to therapeutic objectives, the nature of the pathologies and the specific properties of the plants used.

Reasons for using medicinal plants

The results in Table 4 show that the use of medicinal plants is mainly motivated by their perceived effectiveness. Indeed, 44.09% of respondents use them exclusively for this reason, while 18.28% associate their effectiveness with their low cost and 10.75% with the absence of risk. Thus, a total of 73.12% of users cite effectiveness, either alone or in combination with other factors, as the main reason for using medicinal plants. The other reasons cited remain in the minority, notably low cost alone (16.13%), high accessibility (6.45%) and the absence of risk as the sole criterion (4.31%). This high proportion reflects the population's strong confidence in herbal treatments, a finding consistent with previous work by Hanae *et al*. (2012), who report a rate of 90.6%, and Ghabbour *et al*. (2024b), with 84.3%. This confidence is largely based on the perception of the real effectiveness of plants, reinforced by positive experiences accumulated within families and passed down from generation to generation.

Beyond the therapeutic aspect, these results illustrate the close link between local communities and their plant environment. The continued use of medicinal plants, based on empirical knowledge and the transmission of traditional knowledge, reflects a lasting interaction between humans and plants, where plant species occupy a central place as therapeutic resources, cultural references and constituent elements of local identity. These dynamic highlights the importance of medicinal plants in promoting and preserving ethnobotanical heritage.

Sources of ethnobotanical knowledge

The results relating to the source of ethnobotanical knowledge (Table 4) indicate that parents are the main source of information, accounting for 65.59% of responses. This finding is consistent with previous studies that have also highlighted the central role of the family in the transmission of ethnobotanical knowledge (Daimari *et al*. 2019, Ghabbour *et al*. 2024b). This predominance can be explained mainly by the intergenerational transmission of knowledge, which takes place orally and through practice from an early age, thus ensuring the continuity and sustainability of the use of medicinal plants within the communities studied. The trust placed in family members, as well as the practical learning of plant collection and preparation techniques, reinforces this mode of transmission. The informant's personal experience is the second source of knowledge, cited by 21.51% of respondents. This result highlights the importance of learning through individual practice, based on observation, experimentation and adaptation to local conditions. This direct relationship between the individual and their natural environment contributes to the enrichment and validation of inherited knowledge. On the other hand, the combination of parental experience and advice from herbalists remains relatively limited (10.75%), while only a small proportion of respondents (2.15%) rely exclusively on herbalists. This situation can be explained by limited access to these specialists or by a greater trust in family knowledge. Overall, these results show that knowledge of medicinal plants is based mainly on family heritage, supplemented by individual experience and, to a lesser extent, by the expertise of herbalists, thus contributing to the preservation and sustainability of ethnobotanical practices.

Table 4. Characteristics related to medicinal plants used by the population of the Taza study area.

		Frequency	Percentage%
Collection period	Whole the year	2530	72.18
	Spring	93	2.65
	Autumn	90	2.57
	Summer	792	22.60
Plants state	Fresh	546	15.60
	Dried	2959	84.40
Administration	Orally	3248	92.67
	Inhalation	17	0.49
	External application	240	6.85
Treatement period	Short (a few days to a few weekd)	2308	65.85
	Average (a few months)	324	9.24
	Long (more than a year)	873	24.91
Reason for using MP	More efficient	82	44,09
	Absence of risks	8	4.31
	More efficient & Absence of risks	20	10.75
	More accessible	12	6.45
	Cheaper	30	16.13
	More efficient & Cheaper	34	18.28
Source of ethnobotanical knowledge	Parents	122	65.59
	Experiences	40	21,51
	Herbalists	4	2.15
	Parents & Herbalists	20	10.75
State of the patient after treatment	stable	6	3.22
	Improved	130	69.90
	Generally improved	50	26.88
MP drying	In the shade	124	66.67
	Conventional processes	37	19.89
	Industrial	3	1.61
	Under the sun	13	6.99
	In the shade& Under the sun	9	4.84
Conditioning and storage of MP	Ventilated location	160	86.02
	Hermetically sealed containers	8	4.30
	Open containers	3	1.61
	Little ventilated	15	8.07
MP are Used	Separately	130	69.89
	In association	4	2.15
	In combination with drugs	13	6.99
	Separately & In association & In combination with drugs	9	4.84
	Separately & In association	30	16.13

Methods of using medicinal plants

In our study, 69.89% of respondents indicated that these plants are used separately, while 16.13% use them either separately or in combination with other plants. In addition, 6.99% of respondents said they use them in combination with medicines, 4.84% use them in different forms (separately, in combination or combined with medicines), and finally, 2.15% use them in combination. (Table 4). The results obtained are consistent with those reported by Ghabbour *et al*. (2024b). Most people prefer to use plants separately to observe their effects and avoid the risk of interactions. Some of the population uses them in combination or with medicines to increase their effectiveness or complement treatment, while very few use them only in combination, which remains a less common practice.

Drying and storage of plants

The results of drying and storing medicinal plants are presented in Table 4. In 66.67% of cases, medicinal plants are dried in the shade, in 19.89% of cases using conventional methods, in 6.99% of cases in the sun, in 4.84% of cases using a combination of sun and shade, and in 1.61% of cases industrially. Storage is mainly carried out in a well-ventilated location (86.02%), while 8.07% are dried in a poorly ventilated environment, 4.30% in hermetically sealed containers and only 1.61% opt for open containers (Table 4). These results corroborate those reported by Ghabbour *et al*. (2024b). Storage is mainly carried out in a well-ventilated environment, followed by a poorly ventilated environment, and then in hermetically sealed or open containers. The fact that plant drying is mainly carried out in the shade can be explained by the desire to preserve bioactive compounds that are sensitive to heat and light. Shade drying reduces the thermal and photochemical degradation of bioactive compounds while maintaining the organoleptic and therapeutic quality of the plants. With regard to storage, the choice of a well-ventilated location is intended to prevent mold growth and fermentation due to humidity.

Patient status after treatment

The results obtained (Table 4) show that the health status of patients after treatment remains stable in only 3.22% of cases, while a general improvement is observed in 69.90% of patients and an improvement in 26.88% of them. These results are similar to the work of Ghabbour *et al*. (2024b), which demonstrated an improvement in health in 93.9% of cases. These results highlight the effectiveness of the medicinal plants used after treatment. This effectiveness, as well as the population's satisfaction with them, which was also confirmed by Jouad *et al*. (2001), could be explained by the fact that the plant species used are the result of a long accumulation of empirical knowledge, based on collective experience and intergenerational transmission. This traditional expertise promotes an appropriate match between the chosen plant, the plant part used, the preparation process, and the targeted disorder, thereby improving the effectiveness of traditional care. In addition, patients' cultural adherence to these practices, combined with the availability of plant resources and their continued use, reinforces the therapeutic impact observed. The improvement noted, therefore, demonstrates both the effectiveness of the plants used and the robustness of local ethnobotanical knowledge systems.

Treatment period

Short treatment periods (a few days to a few weeks) are the most common, accounting for 65.85% of cases, while long treatment periods (more than a year) account for only 24.91% of cases and average treatment periods (a few months) account for only 9.24% (Table 4). These results are similar to those of Ghabbour *et al*. (2024b), who also observed that the majority of treatments involve a short period (61.5%). Short treatments predominate, which can be explained by the fact that common ailments for which medicinal plants selected on the basis of empirical knowledge act quickly, allowing for observable improvement in a short period of time. Long treatment periods, which are less frequent, are associated with chronic or recurrent conditions and demonstrate the ability of communities to adapt traditional uses to prolonged care needs, while considering the availability and accessibility of plants. Average treatment periods represent intermediate situations requiring regular but limited follow-up. This diversity highlights the flexibility of the ethnobotanical system and the way in which humans adjust their practices according to the properties of plants and their interaction with the environment.

Collection period

With regard to the collection period for plants, the highest collection period criterion (CCP = 4) (Table 3) was observed for 32 plant species, or 56.14% of the total. Of these, 72.18% are collected throughout the year, 22.6% in summer, 2.65% in spring and 2.57% in autumn (Table 4). These results are consistent with those reported by Ghabbour *et al*. (2024a), who also noted a CCP = 4 for 51.65% of the species studied, of which 50.6% are harvested throughout the year, 42.9% in summer, and only 1.9% in spring. These results can be attributed to the permanent availability of parts of certain plant species and the fact that most of them are harvested mainly in early summer, which is the optimal harvesting season. The high proportion of plants collected throughout the year (72.18%) in the province of Taza reflects the region's great ecological and climatic diversity, as well as the variability of the biological cycles of local species. Certain plants have parts (leaves, stems, roots, etc.) that remain present and usable in all seasons, which allow their continuous harvesting. The higher collection rate observed in summer (22.6%) reflects a favorable harvesting period, often corresponding to flowering or when plants have the highest content of bioactive compounds (Ghabbour *et al*. 2024a).

Family importance value (FIV) and family utilisation value (FUV)

The family importance value (FIV) rates the importance of a plant family based on the number of respondents who report using plants belonging to that family and the total number of species within that family. The highest FIVs correspond to the indices for Lamiaceae (FIV= 203.54), Cupressaceae (FIV= 95), Asteraceae (FIV= 77), Arecaceae (FIV= 68) and Poaceae (FIV= 67) (Table 3). The family use value (FUV) is a numerical representation of the importance of a plant family based on the number of informants who mention the use of plants from that family and the total number of species in that family. The highest FUVs are those of Lamiaceae (FUV=1.09), Cupressaceae (FUV=0.511), Asteraceae (FUV=0.414), Arecaceae (FUV=0.365) and Rubiaceae (FUV=0.328) (Table 3). These results are similar to those reported by Ghabbour *et al*. (2024b), who also observed that the highest IVFs were for Lamiaceae (IVF = 47.69) and Asteraceae (IVF = 40.6). Similarly, these authors noted that the highest FUV values were recorded for Lamiaceae (FUV = 0.140) and Asteraceae (FUV = 0.120). The high values of the FIV and FUV indices reveal that certain plant families, such as Lamiaceae, Cupressaceae, Asteraceae, Arecaceae, and Poaceae, are of particular importance to the local population. This is explained by the combination of a high species diversity and a high frequency of use in ethnobotanical practices, indicating that these plants are widely integrated into daily activities and popular knowledge. Even the less frequently cited families contribute to the ethnobotanical richness of the region, highlighting the variety and cultural value of local plants. Thus, FIV and FUV reflect the biological, cultural, and practical importance of plants. The concordance between FIV, FUV, and FUF values clearly confirms the central role of these families in the local ethnobotanical heritage.

Medicinal plant species used in the province of Taza

The results concerning the medicinal plant species used in traditional medicine by the population of the province of Taza and their characteristics are presented in Table 3. Fifty-eight medicinal plant species were identified, whose scientific and vernacular names and herbarium codes are listed in Table 3. Comparing the number of plant species (58) obtained in this ethnobotanical study with that found in certain international studies conducted in 2024-2025, we found that our result is lower than that of Alshaqhaa *et al.* (2025) in the province of Aseer (south-western Saudi Arabia) (80 species), Basirat *et al.* (2025) in 32 of Nigeria's 36 states, covering its six geographical regions (North-Central, North-East, North-West, South-East, South-South and South-West (963 species)), Bensizerara *et al.* (2025) in rural areas and mountainous and hilly habitats in north-eastern Algeria in the province of Khenchela (158 species), Irfan *et al*. (2025) in urban areas of three districts in the province of Khyber Pakhtunkhwa in Pakistan (138 species), Jaric *et al.* (2024) in the Mt Stara Planina (Balkan Mountains) region (136 species) and Ljiljana *et al.* (2024) in two regions in north-western Croatia, namely Valpovo and Durdevac (131 species).

In the province of Taza, the number of species listed as medicinal plants is lower than that reported by El Aboui *et al.* (2025), El Brahimi *et al.* (2022), El Hajli *et al.* (2024), El Haouari *et al.* (2018), Ghabbour *et al.* (2024a) and Khabbach *et al.* (2012), who identified 96, 105, 75, 104, 91 and 73 species, respectively. This difference could be explained by the methodology adopted in the survey, as well as by the size and diversity of the studied areas in these works, which are generally larger and encompass a greater variety of ecological niches and habitats. Compared to other Moroccan provinces such as Chtouka Ait Baha, Tiznit, Al Hoceima, Boujdour, Sidi Slimane, Nador, Settat, Fez, Errachidia and Casablanca, documented respectively by Barkaoui *et al.* (2017), El Aboui *et al.* (2025), Elharas *et al.* (2025), Laadim *et al.* (2017), Hayat *et al.* (2020), Lahyaoui *et al.* (2025), Mechchate *et al.* (2020), Tahraoui *et al.* (2007) and Zougagh *et al.* (2019), the province of Taza stands out for its superior floristic richness. With inventories totalling 48, 96, 64, 59, 44, 51, 50, 45 and 46 species in these regions, respectively, our results highlight the uniqueness of Taza's ecological and ethnobotanical diversity on a national scale. Building on the work of Ghabbour *et al.* (2024a), the merger of these two studies has identified a total of 99 unique species. This comprehensive approach now covers, for the first time, all 38 municipalities in the province (including the 28 municipalities already studied and 10 covered in this study).

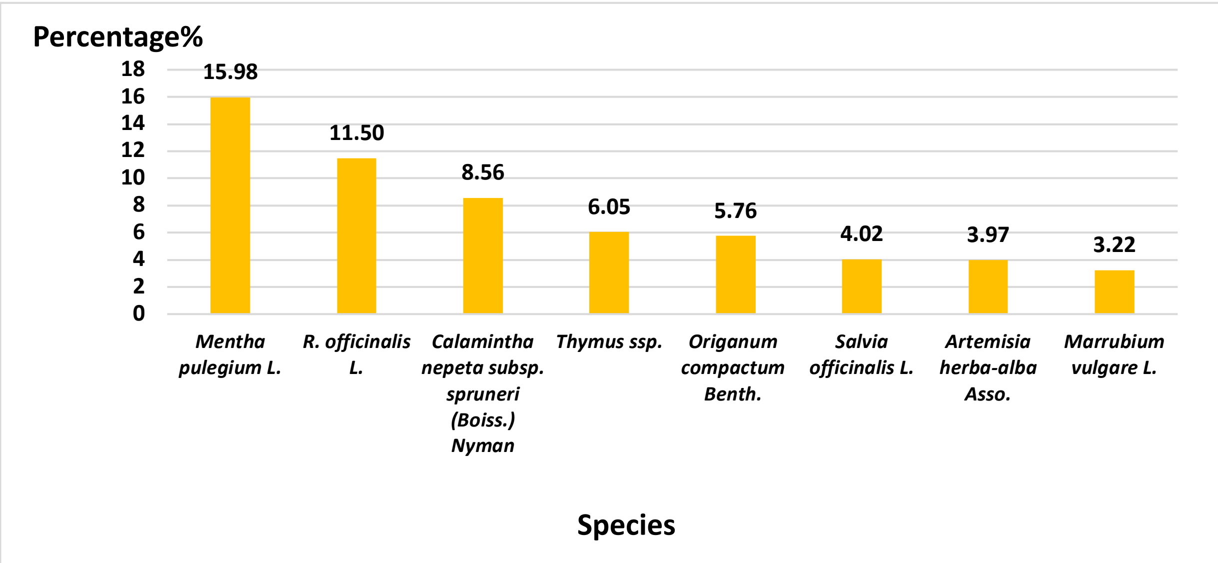

Figure 4. The most used medicinal species in the study area of the province of Taza.

The results obtained show that the most frequent species (SUF) (Table 3) are respectively: *Mentha pulegium* L. (560), *Rosmarinus officinalis* L. (403), *Calamintha nepeta* subsp. spruneri (Boiss.) Nyman (300), *Thymus* ssp. (212), *Origanum compactum* Benth. (202), *Salvia officinalis* L. (141), *Artemisia herba-alba* Asso. (139) and *Marrubium vulgare* L. (113) (Table 3), with respective percentages of (15.98%, 11.5%, 8.56%, 6.05%, 5.76%, 4.02%, 3.97%, 3.22%) (Figure 4). Some of these 58 species have been mentioned in other Moroccan ethnobotanical surveys. The most frequently cited species is *Mentha pulegium* L., which has also been cited among the most widely used species in several previous surveys of El aboui *et al.* (2025), Ghabbour *et al.* (2024a) and Khabbach *et al.* (2012). The second most widely used species is *Rosmarinus officinalis* L., frequently mentioned in other Moroccan provinces (El aboui *et al.* 2025, El hajli *et al.* 2024, Beniaich *et al.* 2022, Chaachouay *et al.* (2019, 2022), Ghabbour *et al.* 2024a, Ghourri *et al.* 2013, Khabbach *et al.* 2012, Lahyaoui *et al.* 2025 and Tahraoui *et al.* 2007) and in Algeria (Telli *et al.* 2016). In third place, *Calamintha nepeta* is also among the most commonly used plants according to several studies of El Aboui *et al*. (2025), El Hajli *et al.* (2024), Ghabbour *et al.* (2024a) and Khabbach *et al.* (2012). The fourth species, *Thymus* ssp, was identified as the most common by El Aboui *et al.* (2025), El Hajli *et al*. (2024) and Khabbach *et al.* (2012). The fifth species, *Origanum compactum* Benth., was also reported as frequently used in other studies (El Aboui *et al.* 2025, El Hajli *et al.* 2024, Ghabbour *et al.* 2024a and Khabbach *et al.* 2012). The sixth, Salvia officinalis L., was identified as the most common by El aboui et al. (2025), El Hajli *et al.* (2024) and Ghabbour *et al.* (2024a). It is also widely mentioned in several regions of Morocco by Barkaoui *et al*. (2017), Boulfia *et al.* (2018), Chaachouay *et al.* (2022), El Haouari *et al.* (2018), Hanae *et al.* (2012), Khabbach *et al.* (2012) and Laadim *et al.* (2017), as well as in other Moroccan surveys (Chaachouay *et al.* 2019, Ghourri *et al.* 2013, Tahraoui *et al.* 2007). The seventh most commonly used species, *Artemisia herba-alba*, was also reported among the most frequently cited in the works of El Aboui *et al.* (2025), Ghabbour *et al.* (2024a) and Khabbach *et al.* (2012). Finally, *Marrubium vulgare* L. ranks eighth and is also among the most frequently mentioned species according to Khabbach *et al.* (2012).

The results of this study reveal a strong similarity between the plants most frequently cited and used in the 10 municipalities studied and those identified by Ghabbour *et al*. (2024a) in the 28 other municipalities in the province. The combination of these two sets of results thus provides, for the first time, a comprehensive and integrated view of the distribution of the most widely used medicinal and aromatic plants throughout the province of Taza. This marked similarity is observed despite the biogeographical diversity of the region, which encompasses the Rif, the Middle Atlas, and the transition zone between the Rif and the Middle Atlas. It reflects a long-standing, close, and lasting relationship between local populations and their plant environment, based on empirical knowledge of available natural resources. The high frequency of these species in the 38 municipalities is mainly explained by their natural abundance and accessibility within the province's various ecosystems. These results are consistent with those reported by Khabbach *et al*. (2011) and El Aboui *et al*. (2025), whose work focused on five municipalities included in our study area. The similarity of the species recorded highlights the existence of a common plant heritage, shaped by comparable ecological conditions and lifestyles closely linked to nature. Whether Berber-speaking or Arabic-speaking, local communities share a deeply rooted relationship with plants, maintained through the intergenerational transmission of knowledge and reinforced by historical, social, and commercial interactions between communities, beyond the environmental contrasts specific to the province's different ecological units.

Systematic analysis of local medicinal flora.

Botanical family

35 families were identified for 58 species (Table 3). The seven most common families (Figure 5) are Lamiaceae (63.94%) with 11 species, followed by Asteraceae (6.53%), Caesalpiniaceae (4.65%), Rhamnaceae (3.28%), Cupressaceae (2.71%) and Arecaceae (1.94%), and Poaceae (1.91%). In Morocco, the Lamiaceae and Asteraceae families also occupy a dominant position according to several studies of Boulfia *et al.* (2018), El Aboui *et al.* (2025), El Hajli *et al.* (2024), Elharas *et al.* (2025), El Khomsi *et al.* (2022), Fatiha *et al.* (2019), Ghabbour *et al.* (2024a), Khabbach *et al.* (2012) and Lahyaoui *et al.* (2025). The predominance of Lamiaceae has also been confirmed by numerous studies (Barkaoui *et al.* 2017, Beniaich *et al.* 2022, Bouyahya *et al.* 2017, El Brahimi *et al.* 2022, El Haouari *et al.* 2018, Ghanimi *et al.* 2022 and Hayat *et al.* 2020). Internationally, this family also remains among the most common, as reported by Souilah *et al.* (2022), confirming its ethnobotanical importance at the national and international levels, while other studies, such as that by Megersa and Woldetsadik (2022), highlight the predominance of Asteraceae. The number of botanical families of medicinal flora reported by other authors at the national level is approximately 70 families (Chaachouay *et al*. 2022), 51 families (El Aboui *et al.* 2025), 42 families (El Hajli *et al.* 2024), 26 families (Elharas *et al.* 2025), 46 families (El Khomsi *et al.* 2022), 74 families (Fatiha *et al.* 2019), 48 families (Ghabbour *et al.* 2024a), 34 families (Ghanimi *et al.* 2022), 28 families (Laadim *et al.* 2017) and 23 families (Lahyaoui *et al.* 2025).

The strong representation of Lamiaceae illustrates their central role in local practices, linked to their frequent presence in living spaces, their easy recognition, and their longstanding integration into daily habits. These plants, widely known and used, benefit from oral transmission that ensures the preservation of knowledge across generations.

The results for the 10 municipalities studied converge with those of Ghabbour *et al*. (2024a) for the other 28 municipalities, indicating that the 38 municipalities of Taza share a similar ethnobotanical profile. The dominance of Lamiaceae and Asteraceae, followed by secondary families, reflects a common repertoire of knowledge, shaped by the widespread distribution of species, their adaptability to different ecological contexts, and shared social and cultural factors, such as family ties, inter-municipal exchanges, and oral transmission. Thus, despite the ecological diversity of the province (Rif, Middle Atlas, and the transition zone between the Rif and Middle Atlas), populations mobilize a core of common plant families. These results show that the variety of natural environments does not necessarily imply diversification of uses but coexists with ethnobotanical consistency at the provincial level.

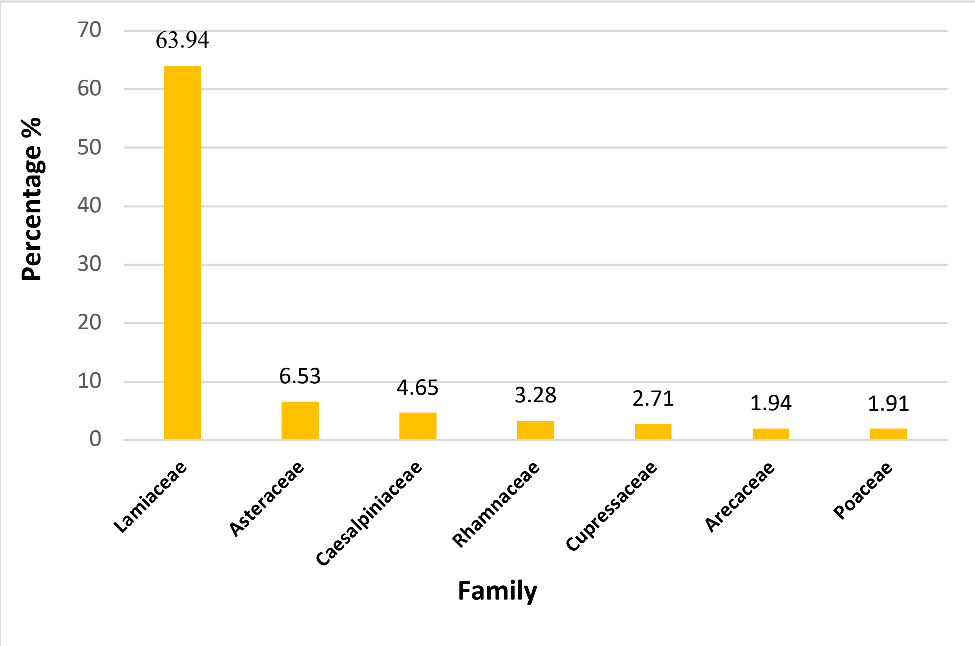

Figure 5. The most used families in the study area of the province of Taza.

Status of medicinal plants

The results obtained (Figure 6) show that the status of the plants used is dominated by wild plants, which account for 86.31% of the total. Cultivated plants account for 8.53%, introduced naturalized plants account for 4.59% and the rest (0.57%) is imported (Table 3). The dominance of spontaneous plants reflects the natural floristic richness of the surveyed communities, which is adapted to local conditions, and reflects a close and lasting interaction between local populations and their environment.

Ethnobotanical knowledge is built through observation, experimentation, and intergenerational transmission, and spontaneous species thus form the basis of traditional practices. The heavy use of these plants is explained by the communities' historical dependence on local natural resources and promotes in-depth knowledge of plants, their habitats, and their uses, strengthening the link between the population and its environment. Cultivated plants rank second, followed by naturalized introduced plants and imported plants, reflecting a strategy by communities to secure certain important species and integrate new resources into their repertoire as they acclimatize to the environment. The very low proportion of imported plants can be explained by the preference given to local species, which are considered more accessible, better known, and culturally legitimate. These results are similar to those reported by El Aboui *et al*. (2024), Ghabbour *et al*. (2024a) and Mikou *et al*. (2016), who also observed a high proportion of spontaneous plants and emphasized that imported plants are the least common.

Overall, the combined presence of wild, cultivated, introduced, naturalized, and imported plants illustrates the dynamic and evolving nature of the province's plant landscape. This diversity reflects not only the richness of local flora but also the ability of communities to continually adjust and enrich their ethnobotanical knowledge in response to environmental, social, and cultural changes, while maintaining a close and sustainable relationship between humans and plants.

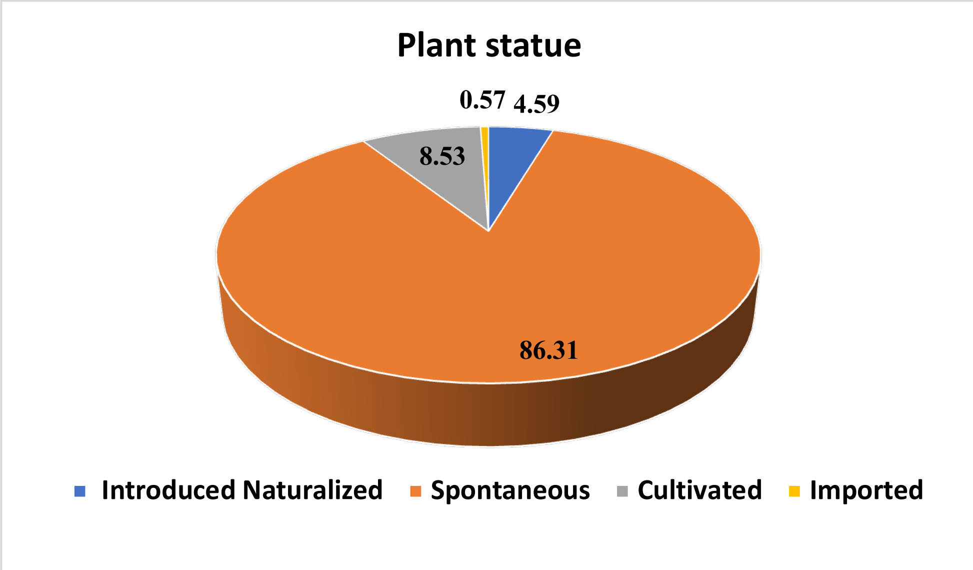

Figure 6. Statue of medicinal plants used by the population of the study area in Taza.

Endemism and Red List

Of the 58 medicinal species identified in this study, 20 are specific endemics. Of these, 80% (16 species) are endemic to North Africa, 10% are endemic to Morocco and Algeria, 5% are endemic to Morocco, the Iberian Peninsula and Algeria, and 5% are endemic to Morocco alone (Table 3). These results are similar to those reported by Ghabbour *et al*. (2024a), who found that 70.77% of species were endemic to North Africa, 16.92% were endemic to Morocco and Algeria, 10.77% endemic to Morocco, and 1.54% endemic to Morocco, the Iberian Peninsula, and Algeria. These data highlight both the richness and uniqueness of the local flora and demonstrate biogeographical continuity with neighboring regions. From an ethnobotanical perspective, the strong presence of endemic species reflects the cultural and practical importance of plants in the daily lives of local communities. Local inhabitants have developed detailed knowledge of plant identification, management and conservation, illustrating a close and long-standing connection with their environment. This human-plant relationship goes beyond a role limited to everyday use and is part of a cultural heritage passed down from generation to generation. Biogeographical continuity also suggests that this knowledge is part of a regional network of shared practices, contributing to the dynamics and evolution of ethnobotanical knowledge.

Of the 58 species studied, 25 are on the Red List, with 96% classified as of least concern and 4% as vulnerable. Although the majority of plants are well preserved, some require special protection measures to prevent their disappearance. The preservation of these species is therefore essential not only for biodiversity but also for the transmission of knowledge and the maintenance of local cultural practices. The consistency of these results with those of Ghabbour *et al*. (2024a) reinforces their reliability and highlights a similar regional trend in plant conservation.

Principal Component Analysis (PCA)

The PCA biplot illustrates the distribution of the studied medicinal plant species according to several ethnobotanical criteria and one ethnobotanical index. The first two principal components explain 64.14% of the total variance, with PC1 accounting for 43.59% and PC2 for 20.55%, indicating a good representation of the ethnobotanical dataset. The ethnobotanical criteria considered include criteria of collection period (CCP), plant state (CPS), part used (CPU), preparation (CP), and mode of administration (CA), while species use frequency (SUF) represents an ethnobotanical index reflecting the frequency of use of each species by the local population. The red vectors correspond to these criteria and the index, and their direction and length indicate the strength and orientation of their relationships with the plant species.

The first principal component mainly reflects the overall ethnobotanical relevance of the species, integrating both the diversity of traditional practices and the frequency of use. Species positioned on the positive side of PC1 are strongly associated with higher values of the ethnobotanical criteria and the SUF index, whereas those located on the negative side exhibit lower levels of traditional importance. The second principal component further discriminates species according to specific ethnobotanical practices, particularly differences in preparation methods, plant parts used, and modes of administration.

A distinct group of species is observed on the positive side of PC1, highlighted in the figure, including *Origanum compactum*, *Thymus* spp., *Rosmarinus officinalis*, *Mentha pulegium*, and *Calamintha nepeta* subsp. spruneri. These species show strong positive associations with CCP, CPS, and SUF, indicating their frequent use, broad cultural acceptance, and collection under specific periods and conditions, and therefore deserve to be valorised through further phytochemical, biological, and pharmacological investigations. These results highlight the predominant and distinctive use of the five studied species, all belonging to the Lamiaceae family, and confirm the findings previously reported by Ghabbour *et al.* (2024b). This consistency further emphasizes the ethnobotanical importance of the Lamiaceae family and its central role in traditional medicinal practices within the studied Province (Ghabbour *et al*. 2023, Ghabbour *et al*. 2024b). In contrast, most other species are clustered near the origin or on the negative side of PC1, suggesting more limited or less diversified traditional uses.

Overall, this analysis highlights clear differences among medicinal plants based on ethnobotanical criteria and species use frequency, allowing the identification of the most culturally important species within the surveyed area and providing a solid ethnobotanical basis for their further phytochemical and biological investigation.

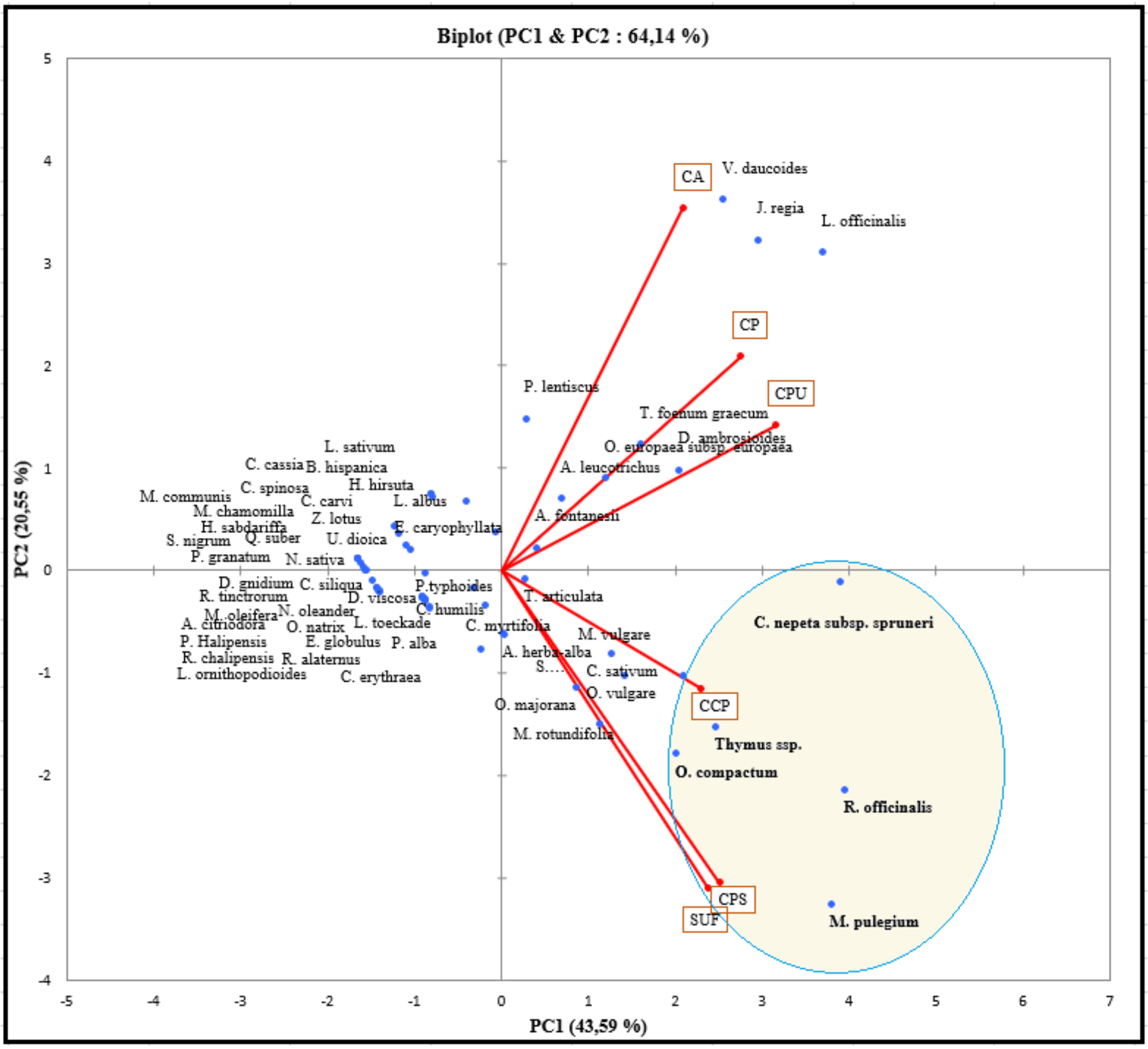

Figure 7. Principal Component Analysis (PCA) of Ethnobotanical Criteria and Species Use Frequency families according to the first two principal components (PC1 and PC2)

The principal component analysis (PCA) of family-level ethnobotanical indices shows the distribution of plant families according to the first two principal components (PC1 and PC2), which together explain 100.00% of the total variance. PC1 accounts for 92.15% of the variance, while PC2 explains 7.85%, indicating that the ethnobotanical information is largely structured along the first axis. The analysis is based on three family-related ethnobotanical indices: frequency of use of families (FUF), Family Importance Value (FIV), and Family Use Value (FUV). The biplot vectors illustrate the contribution of these indices to family discrimination. Families located in the direction of the vectors show strong positive associations with the corresponding indices.

A clear separation of the Lamiaceae family is observed on the positive side of PC1, indicating a strong association with high values of FIV and FUV. This positioning highlights the dominant ethnobotanical importance of Lamiaceae compared with the other plant families, which are mostly grouped near the origin or on the negative side of PC1, reflecting lower ethnobotanical relevance.

These results are fully consistent with those reported by Ghabbour *et al*. (2024b), who also found that PC1 and PC2 explained 100% of the variance and identified Lamiaceae as the most ethnobotanically relevant family based on family-level indices. The present PCA therefore clearly demonstrates its complementarity with the previous study, as it confirms and strengthens the conclusion that the Lamiaceae family plays a central role in traditional medicinal practices within the study area (Ghabbour *et al*. 2023, Ghabbour *et al*. 2024b).

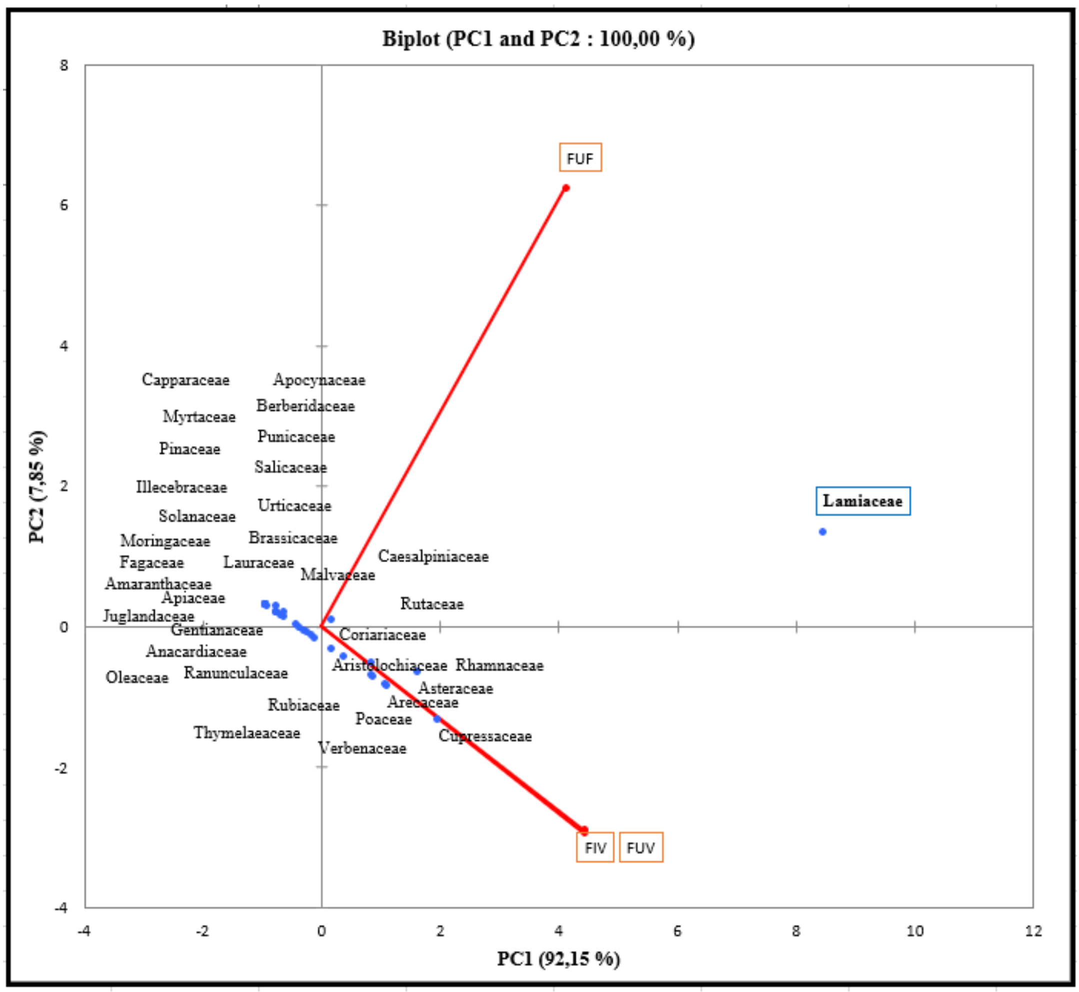

Figure 8. Principal component analysis of family indices with Biplot showing the distribution of families according to the two components of (PC1) and (PC2).

Conclusion

This ethnobotanical study conducted in the province of Taza places strong emphasis on a cross-disciplinary ethnographic and botanical approach, providing an in-depth understanding of the complex relationships between humans and medicinal plants in their ecological and sociocultural context. It reveals the richness, diversity and dynamics of local traditional knowledge, constituting a valuable intangible heritage to be documented, preserved and passed on to future generations. This research updates and enriches previous work by including, for the first time, five municipalities that have never been studied before, while re-examining other municipalities in order to analyze changes in practices, uses and perceptions of medicinal plants. Covering all 38 municipalities in the province and listing 99 plant species, this study provides an original database that sheds light on the interactions between local communities and their natural environment.

The results provide new insights into how ethnobotanical knowledge is constructed, transmitted and transformed according to geographical, cultural and environmental contexts. They demonstrate a close and lasting link between local populations and their natural environment, while highlighting the vulnerability of certain endemic or threatened species in the face of socio-environmental changes. This study opens up ethnobotanical perspectives focused on in-depth analysis of local knowledge systems, modes of intergenerational transmission, cultural representations of plants and the evolution of traditional uses in the face of social and environmental change. It also highlights the importance of participatory approaches involving local communities to document, safeguard and sustainably promote the ethnobotanical heritage and plant diversity of the province of Taza.

Declarations

List of abbreviations: P.S: Plant status (Introduced: **Intr**; Naturalized: **Natu**; Spontaneous: **Spon**; Cultivated: **Cult**; Imported: **Impo**); Collection period: **Col. Per**.; **CCP**: Criterion of Collection Period; **CPS**: Criterion of Plant Status; **CPU**: Criterion of Part Used; Preparation: **Pre** (Boiled: **Boil**; Infusion: **Infu**; Decoction: **Deco**; Powder: **Pow**; Maceration: **Mace**; Essential Oil: **E.O**); **CP**: Criterion of Preparation; Administration: **Adm** (External Application: **Ext app**; Inhalation: **Inha**); **CA**: Criterion of Administration; **FUF**: Frequency of Use of Families; **FIV**: Family Importance Value; **FUV**: Family Use Value; **VC**: Voucher Codes; **VN**: Vernacular Name; **SUF**: Species Use Frequency; **En**: Endemism (**MA**: Morocco-Algeria; **MIA**: Morocco-Iberia-Algeria; **NA**: North Africa; **M**: Morocco); **PC1**, **PC2**: Principal Components 1 and 2; ***RL***: Red List (***LC***: Least Concern; ***VU***: Vulnerable); **PCA**=Principal component analysis,

Ethics Approval: The authors confirm that the study was reviewed and approved by an Institutional Review Board of the Laboratory of Natural Resources and Environment, Polydisciplinary Faculty of Taza, University of Sidi Mohammed Ben Abdellah. The committee further approved that the study would have no direct negative impact on the participants and the biodiversity of the study area. All participants provided oral prior informed consent before the interviews.

Consent for publications: Oral permission. All authors agreed to the submission.

Data Availability: Data is available on demand.

Conflict of Interest: Authors have no conflict of interest.

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Authors' Contribution: N. GHABBOUR selected the study design, supervised, conducted the survey, orientation and corrected the manuscript. K. HAMMANI supervised, selected the study design, and corrected the manuscript. A. KHABBACH identified, updated scientific species names and corrected the manuscript. I. GHABBOUR selected the study design, conducted the survey, database preparation, statistical analysis, orientation and validation, and corrected the manuscript and submission. B. El Aarage conducted the survey, database compilation, statistical analysis, wrote the manuscript, updated, performed corrections, and edited. All authors read and approved the manuscript.

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