New ethnobotanical know-how characterizing the medicinal flora of the province of Taza (northern Morocco): Valorization and quantification of qualitative knowledge

Issam Ghabbour, Nabil Ghabbour, Abdelmajid Khabbach, Said Louahlia and Khalil Hammani

Correspondence

Issam Ghabbour[1*], Nabil Ghabbour[1], Abdelmajid Khabbach [2], Said Louahlia [1] and Khalil Hammani [1]

[1] Natural Resources and Environment Laboratory, Polydisciplinary Faculty of Taza, Sidi Mohamed Ben Abdellah University, Fez, Morocco.
[2] Biotechnology, Conservation and Valorization of Natural Resources Laboratory, Faculty of Sciences Dhar El Mahraz, Sidi Mohamed Ben Abdellah University, Fez, Morocco.

*Corresponding Author: issam.ghabbour@usmba.ac.ma

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Research

Abstract

Background: Understanding how medicinal plants are used allows one to appreciate the richness of traditional medicine practices and to respect and preserve cultural knowledge.

Methods: An ethnobotanical survey including 340 respondents was carried out in 28 communities of Taza province from March 2021 to June 2022. Sociodemographic data and characteristics accompanying the uses of medicinal species were characterized. The percentages of new parts-used, new preparation methods and new methods of administration are calculated for the first time. Encryption of the criteria of collection period (CCP), plant state (CPS), part used (CPU), preparation (CP), administration (CA) and type of use (CTU) is adopted to facilitate the quantitative analysis of these qualitative characteristics. The Literature indices of plant part value (PPV), family importance value (FIV) and family use value (FUV) were calculated. Pearson correlation and principal component analysis (PCA) were performed.

Results: The average age of the studied population was (52±13 years) of which 62.1% were males, 77.9% were married, and 35% were illiterate. Fifty-seven used parts, 91 preparation and 34 administration methods are newly identified. Knowledge sources are parental (82.6%). Plants are used for their high efficiency (84.3%), separately (80.5%), orally (94.3%), dried (68.8%), stored shady (48.1%), airly (61.4%), based on Infusion preparation (61%) and harvested throughout the year (61.5%). Leaves are the most used part (VPP=49.4%). Treatment satisfaction is higher (93.9%). The highest (FIV=120) and (FUV=0.353) are of Oleaceae. The first PCA revealed that (PCI=38.76%) is constructed following a strong positive correlation is significant with socio-economic level, monthly income and education level, which forms three sociodemographic characteristics that tend to be evaluated together. The second PCA revealed that most of the variation was captured by (PC1=40.50%), which

grouped (CPS, CPU, CCP and CP), While (PC2=20.35%) included CA and CTU. The third PCA revealed that (PC1'=76.32%) has a strong positive correlation with FUV and FIV, while (PC2'=23.68%) has a strong positive correlation with FUF.

Conclusions: The way medicinal plants are used can vary greatly depending on cultural traditions and desired therapeutic effects. This know-how strengthens social practice, reflects the heterogeneous ethnocultural sociodemographic profile and deserves to be optimized via the ethnopharmacological experiences of experts.

Keywords: Ethnobotanical survey, Indices, Medicinal plants, Preservation, Taza (Morocco).

Background

Ethnobotany studies the direct interaction of an ethnic group with plants (Bennett 2002, Rahman *et al.* 2019) in terms of food, protection and remedies to treat diseases (Rahman *et al.* 2019). Medicinal plants are the main sources of medicines to treat diseases (Verma & Singh 2008). These traditional plants are characterized by therapeutic activity due to the active ingredients they contain (Ziyyat *et al.* 1997, El Hilaly *et al.* 2003, Tahraoui *et al.* 2007, Khabbach *et al.* 2012, Barkaoui *et al.* 2017, El Haouari *et al.* 2018, Ismaili *et al.* 2021, Beniaich *et al.* 2022, Ghabbour *et al.* 2023, Süntar 2019).

Morocco, a country in the Mediterranean basin, benefits from an ideal geographical position in the far northwest of Africa. It also benefits from a diverse climate allowing a very great diversification and richness of the medicinal flora. Several 602 spontaneous Moroccan taxa were reported by Ennabili *et al.* (2023). Thus, the province of Taza constitutes one of the richest ethnobotanical terrains on a Moroccan scale (Khabbach *et al.* 2011, khabbach *et al.* 2012, Boulfia *et al.* 2018, El Haouari *et al.* 2018, Kachmar *et al.* 2021, Mrabti *et al.* 2021, El Brahimi *et al*. 2022, Ghabbour *et al.* 2023 and Ghabbour *et al.* 2024).

Verification of Moroccan studies on ethnobotany (Ghabbour *et al.* 2023) showed that the methods of use of medicinal plants can vary considerably depending on cultural traditions, regional practices and the desired therapeutic effects. Consultation of the previously cited articles shows agreement on oral administration. Oral consumption of medicinal plants is one of the most common methods. This may include chewing plant raw materials, preparing herbal teas, infusions, decoctions, or using plant extracts in capsule or powder form. Thus, the parts used (leaves, stems, roots, flowers, etc.) differ from one plant to another. Furthermore, plants for medicinal use can have other types of uses, notably in cooking, perfumer and aesthetics. Incorporating medicinal plants into daily meals for nutritional and therapeutic benefits. Several species have multiple modes of use. Certain old uses of plants are gradually starting to be abandoned, which impoverishes know-how (Khabbach *et al.* 2011).

Recently, a checklist of 202 medicinal plants belonging to 75 families, of which 65 have specific endemism, was developed in the province of Taza (Ghabbour *et al.* 2024), and of which 91 species used in the treatment of 14 disease groups were statistically quantified (Ghabbour *et al.* 2023). The literature on Moroccan ethnobotanical surveys and, specifically those carried out among the local population of the province of Taza, showed that the number of species used in the treatment of diseases after the COVID-19 pandemic (El Brahimi *et al*. 2022; Ghabbour *et al*. 2024; El Aboui et *al.* 2024) is higher than before (Khabbach et al. 2012, Boulfia et al. 2018). Thus, the number of medicinal uses increased to 61 medicinal uses for treating 14 disease groups (Ghabbour *et al.* 2023). This suggests that since the covid 19 pandemic, the population of northern Morocco in general, and specifically that of the province of Taza, has turned to traditional medicine for treatment and protection. This work carried out just after the pandemic, consists of updating local knowledge on the traditional characteristics of the use of medicinal flora by the population of the province of Taza via a questionnaire, by broadening the field of ethnobotanical study (28 communities) compared to previous work carried out (14 communities). This study aims at a sociodemographic characterization of the studied Tazi population, a qualitative and quantitative valorization of the sociodemographic studied population and the characteristics of ethnobotanical know-how accompanying the use of medicinal plants identified in the Taza province, and to suggest the conservation of know-how via an adequate transposition based on the transmission of social knowledge to academic knowledge, which can ensure the preservation of the transfer of traditional knowledge of phyto-diversity use to future generations.

Materials and Methods

Study area

The province of Taza (part of the Fez Meknes region) is located in the northeast of Morocco. It presents 4 urban communities and 34 rural communities (DRF-M 2016). The study area (Figure 1) includes 4 urban communities and 24 rural communities for a total of 28 communities out of 38 communities in Taza province.

This study was carried out among herbalists and ordinary citizens of 28 communities in the province of TAZA (Figure 1). The four urban communities are Aknoul, Taza, Oued Amlil, and Tahla. The 24 rural communities are Taifa, Msila, Tainaste, Meknassa Al Gharbia, Meknassa Acharqia, Galdamane, Bab Boudir, Ajdir, Bab Marzouka, Gzenaya Al Janoubia, Bni Lent, Bni Ftah, Bouhlou, Bouchfaa, El Gouzate, Ghiata Al Garbia, Kaf El Ghar, Jbarna, Matmata, Maghrawa, Oulad Chrif, Oulad Zbair, Traiba and Tizi Ouasli.

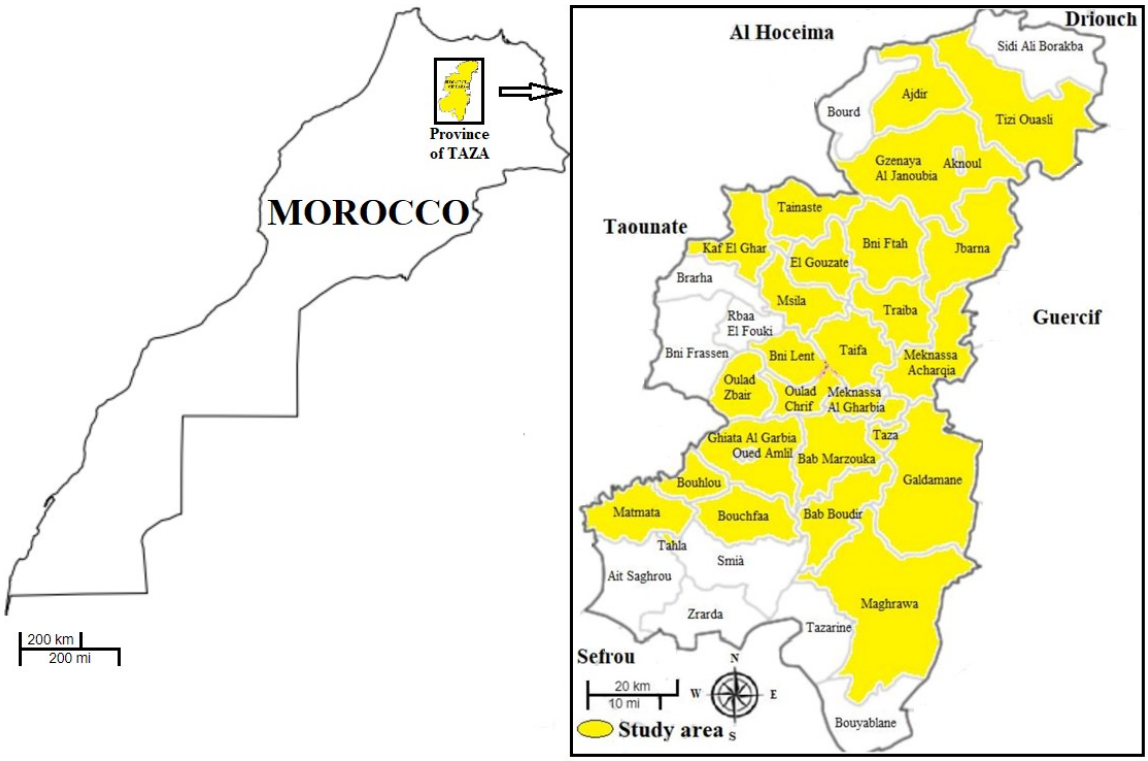

Figure 1. Map showing the study area in the Province of Taza (Ghabbour *et al.* 2023, Ghabbour *et al.* 2024)

Methodology

The methodology followed in this study involves expanding the study area by interviewing 28 communities out of a total of 38 communities in Taza province. In addition to the 14 communities already surveyed according to the work of (Khabbach *et al.* 2012, Boulfia *et al.* 2018, Haouari *et al.* 2018, El Brahimi *et al.* 2022), 14 other communities are included for the first time in survey ethnobotany (Maghrawa, Oulad Chrif, Ghiata Al Garbia, Meknassa Al Gharbia, Kaf El Ghar, Tahla, Bni Lent, Traiba, Bouhlou, Taifa, El Gouzate, Matmata, Tainaste and Oulad Zbair) (Ghabbour *et al.* 2024). This made it possible on the one hand to identify the diseases treated (Ghabbour *et al.* 2023) by identifying new medicinal plants (Ghabbour *et al.* 2024) and on the other hand to renew the ethnobotanical know-how characterizing the medicinal flora.

The species were listed by their vernacular names according to a phonetic transcription to facilitate the standardization of the vernacular nomenclature of the medicinal species listed in this survey (Ghabbour *et al.* 2024). The majority of the species reported were herbaceous after harvest and a copy of the herbarium was deposited at the Laboratory of Natural Resources and Environment, Polydisciplinary Faculty of Taza, Sidi Mohamed Ben Abdellah University of Fez. The botanical identification of the scientific names of the species was carried out by the botanist Prof. Khabbach Abdelmajid (Laboratory of Biotechnology, Conservation and Valorization of Natural Resources, Dhar El Mahraz Faculty of Sciences, Sidi Mohamed Ben Abdellah University, Fez, Morocco), from the specialized literature (Nègre 1962, Quezel & Santa 1962-1963, Fennane *et al.* 1999, Valdés *et al.* 2002, Fennane *et al.* 2007, Fennane *et al.* 2014). an update of the scientific names has been carried out (Ghabbour *et al.* 2024). Family and species names were presented in alphabetical order following the APG III system (Haston *et al.* 2009).

Questionnaire

This survey carried out between March and October 2021 constitutes a descriptive and exploratory ethnobotanical study, carried out face-to-face with herbalists and common people using questionnaires and note-taking.

Based on previous works, a semi-structured questionnaire consisting of two main parts used face-to-face has been formulated, and 340 people were interviewed. The first part consists of raising information about the surveyed population (ordinary citizen or Herbalist), age, residence, profession, sex, family situation, level of study, monthly income, socioeconomic level and shared language (dialectal Arabic or/and Amazigh). The second part consists of knowing how the users of the medicinal plants use them by determining the reason at the base of this use, the source (s) of the ethnobotanical knowledge, the state of the patient after treatment, the drying, the conditionings of storage and if medicinal plants are used separately, as a mixture or in combination with drugs. This second part also includes the periods of collection, the condition of the plants used, the part(s) used, their modes of preparation and use and other uses. The collection period and stat of the plant are questioned for the first time in the province of Taza, and Other uses are carefully documented.

Quantitative Data Analysis

The frequency of use of plant families (FUF) was calculated to know the most presented plant families (Ghabbour *et al.* 2024). The percentages of new parts used, new preparation methods and new administration modes were documented. These percentages are for the first time calculated to better promote new knowledge.

Firstly, plant species have a different number of collection periods. Species can be collected during all seasons of the year (four seasons), in three seasons, in two seasons or in a single season (species collected during the summer season for example). second, they present different states of use (dry, fresh or both). Thirdly, the number of parts used (Leaves, fruit, flower, root, stem, grain, seeds, aerial part, bulb, brushes, pericarp, fruit peel and rhizome) differs from one species to others (e.g. for some species we only use the fruits so only one part, while for from other species we only use the leaves, fruits and flowers (three parts)). Fourth, the number of preparation methods (Infusion, decoction, powder, brute, juice, poultice, raw, maceration, essential oils, boiled and dyeing) used for some species differs from others (e.g. for some species only decoction is used, while for other species two methods are used such as maceration and infusion). Fifth, the number of methods of administration varies depending on the species (Inhalation, Oral route and external application). And finally, the number of areas of use of these medicinal species (Culinary, aesthetic, perfumery, food, ornamental, feed, fumigation, joinery, charcoal and clothes) presents significant differences. Thus, each plant species presents a specific cipher for each of these previous criteria. For this reason, we have proceeded to an encryption of the cited criteria. The encryption of the criteria of collection period (CCP), condition of the plant (CPS), part used (CPU), preparation (CP), administration (CA) and type of use (CTU) is carried out to facilitate the quantitative analysis of these qualitative characteristics and allow correlations which will specify each species in a well-determined group of species. These criteria are just used to name the numbers obtained for each qualitative characteristic of the species and will be used in this way:

Criterion of Collection period (CCP)

The Collection Period criterion is the number of seasons (spring, summer, autumn and winter) during which a medicinal plant can be harvested. This criterion varies from 1 to 4 and reflects the temporal availability of the medicinal plant. Understanding when a plant is accessible helps plan sustainable harvesting practices, ensuring collection occurs during appropriate seasons for optimal efficiency.

Criterion of Plant state (CPS)

The plant state criterion is the number of types of medicinal plants in their state before use (fresh or dried). This criterion varies from 1 to 2. This criterion considers the different conditions in which a medicinal plant can be used. Fresh and dried states can have distinct chemical compositions and therapeutic properties. Know the preferred public aid for good preparation for medical applications.

Criterion of Part Used (CPU)

The part used criterion presents the number of parts (leaves, stems, fruits, etc.) of a specific medicinal plant used. This criterion is strictly greater than 1. It highlights the diversity of plant parts used for medicinal purposes. Different parts may contain different concentrations of active compounds. Understanding which parts are used provides insight into the versatility of use and its potential applications.

Criterion of Preparation (CP)

The preparation criterion is the number of preparation methods (infusion, decoction, maceration, etc.) that a specific medicinal plant can present. This criterion is strictly greater than 1.

This criterion indicates the diversity of ways a medicinal plant can be transformed for use. Different preparation methods can extract distinct compounds, influencing the plant's effectiveness and bioavailability. It guides users to the most suitable method to achieve the desired results.

Criterion of Administration (CA)

The administration criterion presents the number of modes of administration (oral or otherwise) that a specific medicinal plant exhibits during its use. This criterion is strictly greater than 1. It lists the different ways of administering a medicinal plant. Whether through ingestion, topical application, or other means, understanding delivery methods is crucial to determining the plant's potential therapeutic pathways and ensuring safe and effective use.

Criterion of type of use (CTU)

The type of use criterion presents the number of main uses that a specific plant can present (medicinal, perfumery, culinary, etc.). This criterion is strictly greater than 1. It reflects the versatility of a medicinal plant beyond medicinal applications. It reflects the plant's multifunctionality, providing a holistic view of its cultural, economic, and culinary importance. Recognition of diverse uses informs sustainable management practices.

Ethnobotanical indices

Ethnobotanical indices are already used to assess the importance of medicinal species used in the provinces (Ghabbour *et al.* 2023). Here are other ethnobotanical indices selected from the literature to highlight the parts used and the botanical families used:

The value of the plant part (VPP)

The value of the plant part (VPP) provides a measure of the relative importance of a specific plant part within the entire plant. It considers how frequently a particular part is used, it was calculated (Gomez-Beloz 2002) using the formula:

$$\mathrm{VPP} = \frac{\mathrm{RU_{Plant\_part}}}{\mathrm{RU}}$$

RU_{Plant_part} the sum of uses reported per part of the plant and RU is the number of uses reported for all parts of the plant).

Family Importance Value (FIV)

Family importance value (FIV) (Mori *et al.* 1983) modified, is an ethnobotanical indices used to assess the significance or importance of a plant family within a specific cultural or geographical context, it was calculated using the formula:

$$\mathrm{FIV} = \frac{\mathrm{FC_{family}}}{\mathrm{N_s}}$$

$\mathrm{FC_{family}}$ is the number of respondents reporting the family and $\mathrm{N_s}$ is the number of species within each family.

Family Use Value (FUV)

Family use value (FUV) (Phillips and Gentry 1993) is an ethnobotanical indices that quantifies the use value of a plant family in a specific cultural or geographic context, it was calculated using the formula:

$$\mathrm{FUV} = \frac{\sum \mathrm{UV_{is}}}{\mathrm{N_s}}$$

$\sum \mathrm{UV_{is}}$ is the sum of use values for all species belonging to a family, and $\mathrm{N_s}$ is the total number of species within each family.

Data processing

The data recorded manually on the survey sheets were entered and processed by the IBM SPSS Statistics 25 software. The data were statistically analyzed in a descriptive framework by determining frequencies and percentages. The tables and graphs obtained are represented by Microsoft Office Excel. IBM SPSS Statistics 25 software and XLSTAT 2016 software were used to perform correlations and principal component analysis.

Results and Discussion

Collection of ethnobotanical data

At the ethnobotanical level, 91 Medicinal plant species were identified belonging to 48 families (Ghabbour *et al.* 2024) and used by the population of the province of Taza in 61 medicinal uses for treating 14 disease groups (Ghabbour *et al.* 2023) and their characteristics are presented in (Table 2). Regarding the three taxa of *Capparis* spp., *Lavandula* spp. and *Thymus* spp., we reported the possibility of finding two species of *Capparis* spp. (Capparaceae): *Capparis orientalis* L. and *Capparis spinosa subsp. spinosa* , three species of *Lavandula* spp. (Lamiaceae): *Lavandula stoechas* L., *Lavandula multifida* L. and *Lavandula officinalis* L. and three species of *Thymus* spp. (Lamiaceae): *Thymus zygis* L. *Thymus vulgaris* L. and *Thymus manbyanus ssp. ciliatus* Bois & Rent. (Ghabbour *et al.* 2023). Plants were exhibited with their scientific names and families as well as their uses. Additionally, previous literature was reviewed to compare and extract similarities, dissimilarities, and highlight the novelty of these research findings.

Socio-demographic profile

The surveyed population amounts to 340 persons, of which herbalists constitute 12.1%, and the rest (87.9%) are ordinary inhabitants. The age of the interviewees varies between 21 and 94 years, with an average age of 52 ± 13 years (Table 1); the average age remains very close to that of (Khabbach *et* al. 2012, Ait Ouakrouch 2015, Maidana *et al.* 2016). The majority of the population (54.1%) belonged to the age group (40-60 years), where family responsibility is imposed, on life, health and security requirements (40-60 years). This result is similar to that reported by (Hanae 2012, Telli *et al.* 2016, Chaachouay *et al.* 2019). Of further, 24.7% of the population was between 61 and 80 years old, which clearly indicates the accumulated experiences of this population group in terms of the traditional use of Medicinal Plants. The distribution of the studied population according to sex showed that the male sex is more present, about 62.1%, than the female one (Table 1). These results are comparable with those reported by the following authors: Sidiq *et al.* (2020) and Telli *et al.* (2016), Ait Ouakrouch (2015), can be attributed to the convenience of interviewing men rather than women in this Province without forgetting its conservative nature, not to mention the constraints and restrictions imposed during the COVID-19 pandemic.

Table 1. Socio-demographic profile of interviewees (MAD: Marocain Dirham)

Socio-demographic variables		Frequency	Percentage
Population	Ordinary citizen	299	87.9 %
	Herbalist	41	12.1%
Age	21 to 40 years old	72	21.2 %
	41 to 60 years old	184	54.1%
	61 to 80 years old	84	24.7%
Sex	Male	211	62.1%
	Feminine	129	37.9%
Education level	Illiterate	119	35%
	Primary	92	27%
	Secondary	71	21%
	High education	58	17%
Socio-economic level	High	12	3.5%
	Medium	158	46.5%
	Low	170	50%
Monthly income	< 2000 MAD	218	64.1%
	2000 to 10000 MAD	105	30.9%
	> 10000 MAD	17	5%
Residence	Rural	94	27.6%
	Suburban	71	20.9%
	Urban	175	51.5%
Usual language	Arabic dialect	258	75.9%
	Amazigh	13	3.8%
	Arabic dialect and Amazigh	69	20.3%
	Married	265	77.9%
	Single	49	14.5 %

Marital status	Widowed	14	4.1%
	Divorced	12	3.5%

The interviewees belong to an urban space of about 51.5% (Table 1). On the other hand, 27.6% represents rural space, and 20.9% relates to suburban areas. The number of interviewees belonging to an urban space (51.5%) remains higher than that (40.91%) reported by (Telli *et al.* 2016). Whereas, 27.6% represents a rural space and 20.9% relates to the suburban area, the study noted, that a respondent interviewed in a rural area can have an urban residence and vice versa. The province of Taza presents a strong rural-urban relationship since a significant number of interviewees who live in urban areas have their parents in rural areas. The survey population uses either dialectal Arabic (75.9%), Amazigh (3.8%), or both languages (20.3%). The interviewees were either single (14.5%), divorced (3.5%), or widowed (4.1%), while 77.9% were married, which is similar to the results reported by (Chaachouay *et al.* 2019, Ghanimi *et al.* 2022). The results of the level of education (Table 1) revealed that 35% of the interviewees were illiterates, 27% had primary education, 21% had secondary education, and only 17% had high education. This decreasing order of these values of the different levels of schooling is similar to that obtained by (Ait Ouakrouch 2015). The percentage of illiterates is close to 38.30% mentioned by Ghanimi *et al.* (2022), 32.95% found by Telli *et al.* (2016), and especially to the one (48%) noted by Hanae (2012). The present results are also similar to other studies (Barkaoui *et al.* 2017, Fougrach *et al.* 2007, Merrouni *et al.* 2021, Kachmar *et al.* 2021).

The socio-economic level of the interviewees showed that is lower for 50%, medium for 46.50% (Table 1), while, only 3.5% had a high level. Concerning the monthly income, 64.10% of the interviewees had less than 2000 MAD, 30.90% had between 2000 and 10000 MAD, and only 5% of the studied population had more than 10000 MAD. Our obtained results of socio-economic level (Table 1) confirm that of (Hanae 2012, Ait Ouakrouch 2015). The lowest percentage (3.5%) of high socio-economic level observed, demonstrates one of many reasons for the development of phytotherapy in the Province of Taza. For the professions of the studied population (Figure 2), farmers occupied the first place with 18.20%, which is similar to that reported by (Ghanimi *et al.* 2022, Khabbach *et al.* 2012). We noted that 32,4 % of the studied population were without a profession. The cost of drugs remains expensive for the poor population (without professions and farmers), which justifies their resort to traditional herbal medicine.

The results of the professions of the studied population are presented in Figure 2. It shows that Farmers occupied the first place with 18.20%, the second place was occupied by herbalists (12.10%), followed by Teachers (9.70%). We noted that 32,4 % of the studied population are without a profession. The recourse to the use of these medicinal plants in the study area could be explained mainly by ethnocultural and socio-economic reasons (lower cost compared to drugs, lower socioeconomic level, high level of the studied population without function and the satisfaction of the population), as well as by their availability, and their fame as very effective medicinal plants.

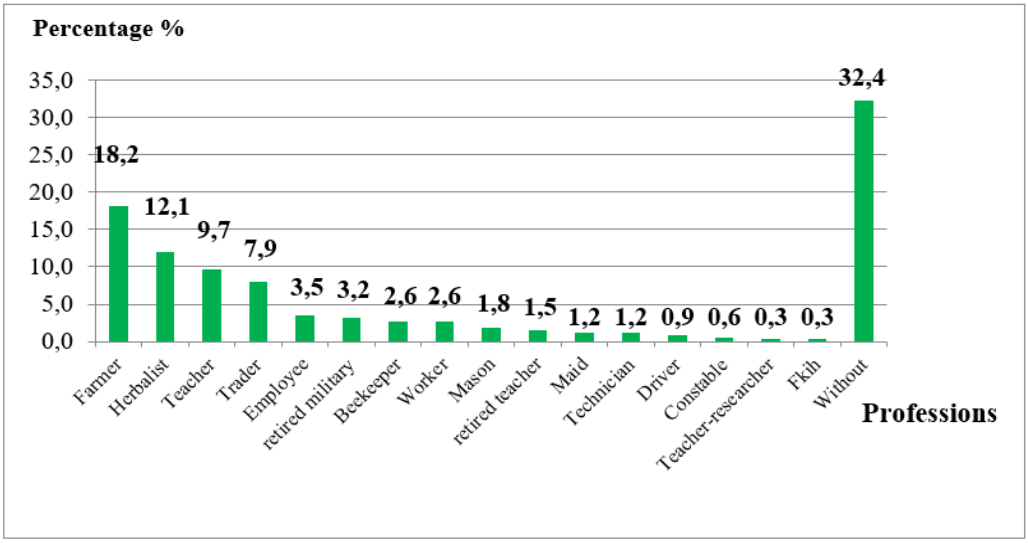

Figure 2. Professions of the studied population.

Characteristics related to medicinal plants used in traditional medicine

Part used and state of use

The value of the plant part (VPP) used was calculated basing the formulation of (Gomez-Beloz 2002). The highest criterion of the part used (CPU=4) is noted for two plant species of *Anethum foeniculum* L. and *Petroselinum crispum* (Mill.) Fuss. Different parts of the plants are used (Figure 3) of which the leaves constitute the most used part (49.4%), followed respectively by the aerial part (13.6%), seeds (13.2%), fruits (7.2%), stem (4.8%), bulb (4.0%), flowers (2.8%), roots (1.7 %), pericarp (1.1%), 0.6% for each of fruit peel, rhizome, brushes, and whole plant by 0.5%. Several works have reported that the Leaves are the most used plant organ (Beniaich *et al.* 2022, Chaachouay *et al.* 2022, El Khomsi *et al.* 2022, Johnny *et al.* 2022, Singh *et al.* 2022, Srinivasan *et al.* 2022, Souilah *et al.* 2021, Hayat *et al.* 2020, Mikou *et al.* 2016, Bouyahya *et al.* 2017, Barkaoui *et al.* 2017, Salgueiro *et al.* 2018, El Haouari *et al.* 2018, Boulfia *et al.* 2018, Daimari *et al.* 2019, Chaachouay *et al.* 2019). This fact may be explained by the efficiency and availability of leaves which are easily and quickly regenerated and harvested compared to the other plant parts.

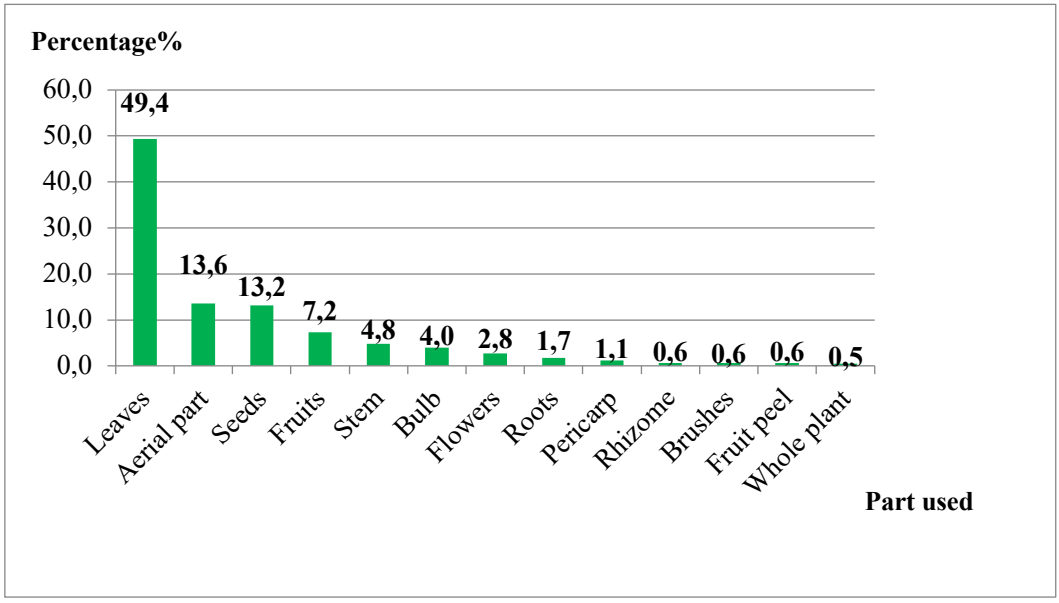

Figure 3. Frequent parts used

The know-how on the new used part of medicinal plants compared to previous ethnobotanical studies [Khabbach *et al.* 2012, Boulfiaâ *et al*. 2018, El Haouari *et al*. 2018, El Brahimi *et al*. 2022] from the province of Taza made it possible to collect 57 new used parts (in bold in Table 2), which corresponds to 38.77% new knowledge on the used parts. The identification of 57 new used parts is significant as it contributes to expanding the existing knowledge base on the ethnobotanical use of medicinal plants in Taza province. The discovery of new plant parts is of great interest since it reflects the dynamic nature of ethnobotanical knowledge. Indeed, this finding indicates that the use of medicinal plants is evolving or that certain practices have not been considered in previous studies. This highlights the importance of ongoing research to continually update and improve our understanding of traditional knowledge related to medicinal plants. Changes in local practices, which may be due to the COVID-19 pandemic, environmental factors or improved research methodologies, could contribute to the identification of new plant parts.

On the other hand, the state of the plant used is questioned for the first time in the province of Taza. The highest plant state criterion (CPS=2) is noted for 36 plant species. The results obtained showed that 68.8% of the plants are used in the dry state compared to 31.2% used in the fresh state (Table 3), which is explained by the conservation of plants (especially seasonal ones) so that their use extends throughout the year by reducing the number of harvests. Dried plants generally had a longer shelf life than fresh plants. The drying process removes moisture, preventing the growth of microorganisms. Drying can lead to the concentration of active compounds present in medicinal plants, which can improve the potency and effectiveness of the plant material when used for medicinal purposes. Among the Tazi population drying is often considered a part of the preparation process that enhances the medicinal properties of the plants.

Table 2:.Characteristics related to medicinal plants used in traditional medicine by the population of the province of Taza

Family	Scientific name	CS	Collection period	CCP	Plant state	CPS	Part Used	CPU	Preparation	CP	Administration	CA	Other uses	CTU	FUF	FIV	FUV
Agavaceae	*Agave sisalana* Perrine	*1*	Summer	1	Fresh	1	**Flowers**	1	**Infusion**	1	**Orally**	1	Aesthetic Ornamental	3	1	1	0.003
Alliaceae	*Allium cepa* L.	*2*	Spring Summer	2	Fresh	1	Bulb	1	**Brute Decoction**	2	Orally	1	Culinary Food	3	70	35	0.103
	Allium sativum L.	*3*	Spring Summer	2	Fresh Dried	2	Bulb	1	Decoction Raw	2	Orally	1	Culinary	2			
Aloaceae	*Aloe vera* (L.) Burm. f.	*4*	Whole the year	4	Fresh	1	**Leaves**	1	**Juice**	1	**Orally**	1	Aesthetic Ornamental	3	3	3	0.009
Amaranthaceae	*Atriplex halimus* L.	*5*	Summer	1	Dried	1	**Leaves**	1	**Decoction**	1	**Orally**	1	Feed	2	42	21	0.062
	Dysphania ambrosioides (L.) Mosyakin & Clemants	*6*	Whole the year Summer	4	Fresh Dried	2	Leaves	1	**Cataplasm Brute Infusion** Decoction	4	External app Orally	2	Feed	2			
Anacardiaceae	*Pistacia lentiscus* L.	*7*	Whole the year Summer	4	Dried	1	Leaves	1	Infusion	1	Orally **External app**	2	Feed	2	4	4	0.012
Apiaceae	*Ammodaucus leucotrichus* Coss. & Durieu	*8*	Whole the year Summer	4	Dried	1	Seeds **Fruits**	2	**Decoction Powder** Infusion	3	Orally	1	Culinary	2	160	17.78	0.049
	Visnaga daucoides Gaertn.	*9*	Summer	1	Dried	1	Fruits **Leaves** Flowers	3	Decoction Infusion **Brute**	3	Orally **External app**	2	Aesthetic	2			
	Apium graveolens L.	*10*	Whole the year Summer	4	Fresh Dried	2	Leaves Seeds	2	**Decoction** Powder	2	Orally	1	Culinary	2			
	Carum carvi L.	*11*	Summer	1	Dried	1	Seeds	1	Decoction Infusion	2	Orally	1	Culinary	2			
	Coriandrum sativum L.	*12*	Whole the year Summer	4	Fresh Dried	2	Aerial part	3	Decoction Infusion	2	Orally	1	Culinary	2			

							Seeds **Fruits**										
	Cuminum cyminum L.	*13*	Summer	1	Dried	1	Seeds	1	**Powder**	1	Orally	1	Culinary	2			
	Anethum foeniculum L.	*14*	Whole the year Summer Spring	4	Fresh Dried	2	Seeds **Fruits Leaves Bulb**	4	Infusion **Brute Decoction**	3	Orally	1	Food Culinary	3			
	Pimpinella anisum L.	*15*	Whole the year Summer	4	Dried	1	Seeds	1	**Infusion**	1	**Orally**	1	Culinary	2			
	Petroselinum crispum (Mill.) Fuss	*16*	Whole the year	4	Fresh Dried	2	Aerial part Leaves Whole plant Seeds	4	Decoction Infusion	2	Orally	1	Culinary	2			
Apocynaceae	*Nerium oleander* L.	*17*	Whole the year	4	Fresh	1	Leaves **Roots**	2	Decoction	1	Inhalation Orally	2	Ornamental	2	18	18	0.053
Arecaceae	*Chamaerops humilis* L.	*18*	Summer	1	Dried	1	**Fruits**	1	**Raw**	1	**Orally**	1	Clothes	2	4	4	0.012
Aristolochiaceae	*Aristolochia fontanesii* Boiss. & Reut.	*19*	Whole the year	4	Dried	1	Leaves Roots	2	Powder	1	Orally External app	2		1	9	9	0.026
Asteraceae	*Artemisia absinthium* L.	*20*	Whole the year	4	Fresh	1	Leaves	1	Infusion Decoction	2	Orally	1	Culinary Aesthetic	3	203	40,6	0.120
	Artemisia herba-alba Asso.	*21*	Whole the year Summer	4	Fresh Dried	2	Leaves Aerial part	2	**Infusion** Decoction	2	Orally	1	Culinary Aesthetic Fumigation	4			
	Dittrichia viscosa (L.) Greuter	*22*	Whole the year Summer	4	Fresh Dried	2	Leaves	1	Infusion Powder	2	Orally External app	2	Aesthetic Perfumery Ornamental	4			
	Matricaria chamomilla L.	*23*	Spring Summer	2	Fresh Dried	2	Flowers Leaves	2	Infusion Decoction	4	Orally External app	2	Aesthetic Perfumery	3			

								Powder **Essential oils**									
	Scolymus hispanicus L.	*24*	Spring	1	Dried	1	**Roots**	1	**Brute**	1	**Orally**	1	Culinary Food	3			
Berberidaceae	*Berberis hispanica* Boiss. & Reut.	*25*	Whole the year Summer	4	Dried	1	**Stem**	1	**Infusion** **Maceration** Powder	3	Orally **External app**	2		1	27	27	0.079
Brassicaceae	*Brassica oleracea subsp. capitata* (L.) Duchesne	*26*	Summer	1	Fresh	1	**Fruits**	1	**Decoction**	1	**Orally**	1	Culinary Food	3	46	23	0.068
	Lepidium sativum L.	*27*	Whole the year Summer	4	Dried	1	Seeds	1	Powder **Infusion Raw** **Brute**	4	Orally **External app**	2	Culinary	2			
Cactaceae	*Opuntia ficus-indica* (L.) Mill	*28*	Whole the year Summer	4	Fresh Dried	2	Leaves Fruits Flowers	3	**Juice** Decoction **Brute** Powder	4	Orally	1	Food	2	42	42	0.124
Caesalpiniaceae	*Ceratonia siliqua* L.	*29*	Summer	1	Dried	1	Fruits **Leaves** **Flowers**	3	**Brute** **Infusion Raw**	3	Orally	1	Food	2	7	7	0.021
Capparaceae	*Capparis* sp.	*30*	Summer	1	Fresh Dried	2	**Leaves** Fruits	2	**Maceration** **Decoction** **Cataplasm**	3	Orally External app	2	Food	2	6	6	0.018
Caryophyllaceae	*Corrigiola telephiifolia* Pour.	*31*	Whole the year Summer	4	Dried	1	Roots **Stem**	2	**Infusion** Powder Decoction	3	Orally External app	2	Feed	2	24	24	0.070
Cucurbitaceae	*Citrullus colocynthis* (L.) Sch.	*32*	Summer	1	Fresh	1	**Fruits**	1	**Juice**	1	**External app**	1	Food	2	11	11	0.032
Cupressaceae	*Tetraclinis articulata (Vahl) Mast.*	*33*	Whole the year Summer	4	Fresh Dried	2	Leaves **Seeds**	2	**Infusion** Decoction Powder **Cataplasm**	4	Orally **Inhalation**	2	Joinery Fumigation	3	33	33	0.097
Euphorbiaceae	*Croton tiglium L.*	*34*	Summer	1	Fresh	1	**Seeds**	1	**Decoction**	1	**Orally**	1	Food	2	38	19	0.056

	Euphorbia resinifera O. Berg.	*35*	Whole the year Summer Winter	4	Fresh Dried	2	Aerial part **Roots Stem**	3	**Juice** Powder **Decoction Dyeing Brute**	5	Orally	1	Aesthetic	2			
Fabaceae	*Cicer arietinum* L.	*36*	Summer	1	Dried	1	Seeds	1	Maceration	1	Orally	1	Food	2	187	37.4	0.110
	Glycine max (L.) Merr.	*37*	Summer	1	Fresh	1	**Seeds**	1	**Powder**	1	**Orally**	1	Food	2			
	Glycyrrhiza glabra L.	*38*	Whole the year Summer	4	Dried	1	Stem	1	**Brute** Powder **Infusion**	3	Orally **External app**	2	Aesthetic	2			
	Lupinus albus L.	*39*	Whole the year Summer	4	Dried	1	Seeds **Fruits**	2	**Infusion Decoction** Powder	3	Orally	1	Food	2			
	Trigonella foenum-graecum L.	*40*	Whole the year Summer Spring	4	Fresh Dried	2	Seeds **Leaves Aerial part**	3	Infusion Decoction Powder Maceration **Raw**	5	Orally	1	Food	2			
Fagaceae	*Quercus ilex* L.	*41*	Autumn	1	Fresh	1	**Fruits**	1	**Boiled**	1	Orally	1	Food Charcoal Joinery	4	3	3	0.009
Gentianaceae	*Centaurium erythraea* Rafn	*42*	Summer	1	Fresh Dried	2	Leaves	1	Infusion Decoction	2	Orally	1	Feed Aesthetic	3	13	13	0.038
Globulariaceae	*Globularia alypum* L.	*43*	Summer	1	Dried	1	Leaves	1	**Infusion**	1	**Orally**	1	Feed	2	15	15	0.044
Illecebraceae	*Herniaria hirsuta* L.	*44*	Whole the year Summer	4	Fresh Dried	2	Aerial part **Leaves Whole plant**	3	Infusion Decoction	2	Orally	1		1	30	30	0.088
Juglandaceae	*Juglans regia* L.	*45*	Whole the year Spring	4	Fresh Dried	2	Leaves Fruits **Stem**	3	**Infusion Brute** Decoction **Maceration**	4	Orally External app	2	Food	2	18	18	0.053
Lamiaceae	*Ajuga iva* (L.) Schreb.	*46*	Summer	1	Fresh Dried	2	Aerial part Leaves	2	Infusion Decoction	2	Orally	1	Perfumery Culinary Aesthetic	4	763	47.69	0.140

Calamintha nepeta subsp. spruneri (Boiss.) *Nyman*	*47*	Whole the year Summer Spring	4	Dried	1	Aerial part Leaves	2	Infusion Decoction	2	Orally	1	Perfumery Culinary Aesthetic	4
Lavandula sp.	*48*	Whole the year Summer	4	Fresh Dried	2	**Flowers** Leaves Aerial part	3	Infusion Decoction **Brute** **Essential oils**	4	Orally External app	2	Perfumery Culinary Aesthetic Ornamental	5
Lavandula stoechas L.	*49*	Whole the year Summer	4	Dried	1	Leaves	1	Infusion Decoction	2	Orally	1	Perfumery Culinary Aesthetic	4
Marrubium vulgare L.	*50*	Whole the year	4	Fresh Dried	2	Stem **Whole plant** Aerial part	3	Infusion Decoction Powder	3	Orally **External app**	2	Perfumery Culinary Aesthetic	4
Mentha pulegium L.	*51*	Whole the year Summer Spring	4	Fresh Dried	2	Leaves Aerial part	2	Infusion Decoction **Cataplasm** Powder	4	Orally	1	Perfumery Culinary Aesthetic	4
Mentha rotundifolia Muds.	*52*	Spring	1	Fresh Dried	2	Leaves Aerial part	2	Infusion	1	Orally	1	Perfumery Culinary Aesthetic	4
Mentha spicata L.	*53*	Whole the year	4	Fresh	1	**Aerial part**	1	**Infusion**	1	**Orally**	1	Perfumery Culinary Aesthetic	4
Micromeria graeca (L.) Benth. ex Rchb.	*54*	Spring	1	Fresh Dried	2	**Leaves** **Aerial part**	2	**Infusion**	1	**Orally**	1	Perfumery Culinary Aesthetic	4
Ocimum basilicum L.	*55*	Whole the year	4	Fresh	1	**Leaves**	1	**Infusion**	1	**Orally**	1	Perfumery Culinary	5

												Aesthetic Ornamental					
	Origanum compactum Benth.	*56*	Whole the year Summer Spring	4	Fresh Dried	2	Leaves Aerial part Seeds	3	Infusion Decoction	2	Orally	1	Perfumery Culinary Aesthetic	4			
	Origanum majorana L.	*57*	Whole the year Summer	4	Fresh Dried	2	Leaves Aerial part **Whole plant**	3	Infusion	1	Orally	1	Perfumery Culinary Aesthetic	4			
	Origanum vulgare L.	*58*	Whole the year Summer Spring	4	Fresh Dried	2	**Leaves Aerial part Seeds**	3	**Infusion Decoction**	2	**Orally**	1	Perfumery Culinary Aesthetic	4			
	Rosmarinus officinalis L.	*59*	Whole the year Summer Spring	4	Fresh Dried	2	Leaves Aerial part **Flowers**	3	Infusion Decoction **Powder**	3	Orally	1	Perfumery Culinary Aesthetic Ornamental Fumigation	6			
	Salvia officinalis L.	*60*	Whole the year Summer Spring	4	Fresh Dried	2	Leaves	1	Infusion Decoction	2	Orally	1	Perfumery Culinary Aesthetic Ornamental	5			
	Thymus sp.	*61*	Whole the year Winter Summer	4	Fresh Dried	2	Leaves	1	Infusion	1	Orally	1	Perfumery Culinary Aesthetic	4			
Lauraceae	*Cinnamomum cassia* Lour.	*62*	Whole the year Summer	4	Dried	1	Stem	1	Infusion Powder Decoction	3	Orally	1	Culinary	2	50	50	0.147

Linaceae	*Linum usitatissimum* L.	*63*	Summer	1	Dried	1	Seeds	1	Powder **Infusion**	2	Orally	1	Culinary Aesthetic	3	4	4	0.012
Malvaceae	*Hibiscus sabdariffa* L.	*64*	Spring	1	Dried	1	**Flowers**	1	**Infusion**	1	Orally	1	Perfumery Ornamental Aesthetic	4	15	7.5	0.022
	Malva pusilla Sm.	*65*	Spring	1	Fresh	1	**Aerial part**	1	Decoction	1	Orally	1	Culinary Feed	3			
Moraceae	*Ficus carica* L.	*66*	Summer	1	Dried	1	Fruits	1	**Infusion**	1	Orally	1	Food	2	2	2	0.006
Moringaceae	*Moringa oleifera* Lam.	*67*	Whole the year	4	Dried	1	**Leaves**	1	**Decoction**	1	**Orally**	1	Food	2	2	2	0.006
Myrtaceae	*Eucalyptus globulus* Labill.	*68*	Whole the year Summer	4	Fresh Dried	2	Leaves	1	Decoction **Infusion**	2	Inhalation Orally	2	Charcoal Joinery	3	93	31	0.091
	Eugenia caryophyllata Thunb.	*69*	Summer	1	Dried	1	**Fruits Seeds**	2	**Infusion Brute Decoction**	3	Orally **External app**	2	Perfumery Aesthetic Fumigation	4			
	Myrtus communis L.	*70*	Spring Summer	2	Fresh Dried	2	Leaves	1	Infusion Decoction	2	Orally	1	Food Aesthetic	3			
Oleaceae	*Olea europaea* L. *subsp. europaea*	*71*	Whole the year Summer Autumn	4	Fresh Dried	2	Leaves Fruits	2	Infusion Decoction **Brute Maceration**	4	Orally	1	Food Culinary	3	120	120	0.353
Pedaliaceae	*Sesamum indicum* L.	*72*	Summer	1	Dried	1	**Seeds**	1	**Brute**	1	**Orally**	1	Culinary	2	1	1	0.003
Poaceae	*Cenchrus americanus* (L.) *Morrone*	*73*	Summer	1	Dried	1	**Seeds**	1	**Decoction**	1	**Orally**	1	Culinary	2	18	6	0.018
	Triticum turgidum L.	*74*	Summer	1	Dried	1	**Fruits**	1	**Decoction**	1	**Orally**	1	Culinary Food	3			
	Zea mays L.	*75*	Summer	1	Dried	1	**Brushes**	1	**Infusion**	1	Orally	1	Culinary Food	3			
Polygonaceae	*Emex spinosa* (L.) *Campd*	*76*	Summer	1	Fresh	1	**Aerial part**	1	Decoction	1	Orally	1	Culinary Feed	3	1	1	0.003
Punicaceae	*Punica granatum* L.	*77*	Autumn	1	Dried	1	**Pericarp** Fruit peel	3	Powder Decoction Infusion	3	Orally	1	Food	2	39	39	0.115

Ranunculaceae	*Nigella sativa* L.	*78*	Whole the year Summer	4	Dried	1	Seeds	1	Powder **Infusion Raw**	3	Orally	1	Culinary	2	21	21	0.062
Rhamnaceae	*Rhamnus alaternus* L.	*79*	Summer	1	Dried	1	**Leaves**	1	**Infusion**	1	**Orally**	1	Food	2	9	4.5	0.013
	Ziziphus lotus (L.) Lam.	*80*	Summer	1	Fresh Dried	2	Leaves Fruits	2	**Brute** Powder Decoction	3	Orally	1	Food	2			
Rosaceae	*Crataegus monogyna* Jacq.	*81*	Summer	1	Dried	1	Leaves Fruits	2	**Infusion** Decoction	2	Orally	1	Food	2	56	18.67	0.055
	Fragaria vesca L.	*82*	Whole the year	4	Fresh	1	**Leaves**	1	**Infusion**	1	**Orally**	1	Food	2			
	Prunus dulcis (Mill.) D.A. Webb	*83*	Summer	1	Dried	1	Fruits Seeds	2	**Brute Raw** Essential oils	3	**Orally External app**	2	Food	2			
Rubiaceae	*Coffea arabica* L.	*84*	Summer	1	Dried	1	**Seeds**	1	**Decoction**	1	**Orally**	1	Food	2	4	4	0.012
Salicaceae	*Populus alba* L.	*85*	Whole the year	4	Dried	1	Leaves	1	Decoction	1	Orally	1	Charcoal Joinery	3	2	2	0.006
Sapotaceae	*Argania spinosa (L.) Skeels*	*86*	Autumn	1	Dried	1	Seeds	1	**Maceration**	1	Orally	1	Culinary Food	3	1	1	0.003
Solanaceae	*Capsicum annuum* L.	*87*	Whole the year	4	Fresh	1	**Fruits**	1	**Brute**	1	**Orally**	1	Food	1	4	4	0.012
Urticaceae	*Urtica dioica* L.	*88*	Spring Summer	2	Fresh Dried	2	Leaves	1	Decoction Infusion **Cataplasm**	3	Orally **External app**	2	Feed	1	8	8	0.023
Verbenaceae	*Aloysia citriodora* Palau.	*89*	Whole the year Summer Spring	4	Fresh Dried	2	Leaves	1	Infusion Decoction	2	Orally	1	Culinary	1	36	36	0.106
Zingiberaceae	*Zingiber officinale* Roscoe.	*90*	Summer	1	Fresh Dried	2	Rhizome	1	Powder **Decoction**	2	Orally	1	Culinary	1	14	14	0.041
Zygophyllaceae	*Peganum harmala* L.	*91*	Summer	1	Dried	1	Seeds	1	**Decoction**	1	Orally	1	Fumigation	1	1	1	0.003
Percentages of new information of Part Used, Preparation and Administration			**-**		**-**		**38.77%**		**49.18%**		**33.66%**		**-**				
Mean value of Criteria			2.604±1.467		1.396±0.492		1.615±0.840		2.033±1.110		1.220±0.416		2.648±0.416				

In bold: know-how on the new **part used**, **administration** and **preparation** of medicinal plants compared to previous ethnobotanical studies [Khabbach *et al.* 2012, Boulfiaâ *et al.* 2018, El Haouari *et al.* 2018, El Brahimi *et al.* 2022] of the Taza province.

CCP: Criterion of Collection period. CPS: Criterion of Plant state. CPU: Criterion of Part Used. CP: Criterion of Preparation. CA: Criterion of Administration. CTU: Criterion of type of use [(CTU= number of Other uses + 1) +1 because these plants already have medicinal use].

Methods of preparation

Regarding the preparation methods (Figure 4), a high number of preparations were made by infusion (61.0%), while decoction occupied (20.3%), powder (6.8%), in brute (5.3%), juice (3.0%), poultice (1.2%), in raw (1.1%), in maceration (1.3%), essential oils (0.2%) and boiled and dyeing (0.1%). The high number of preparations infusion (61.0%) indicates that infusion is a very important and adequate method of preparation, which is confirmed by many authors (Beniaich *et al.* 2022, El Khomsi *et al.* 2022, Mikou *et al.* 2016, Daoudi *et al.* 2016, Salgueiro *et al.* 2018, Chaachouay *et al.* 2019). The highest preparation criterion (CP=5) is noted for two plant species of *Euphorbia resinifera* O. Berg and *Trigonella foenum-graecum* L..

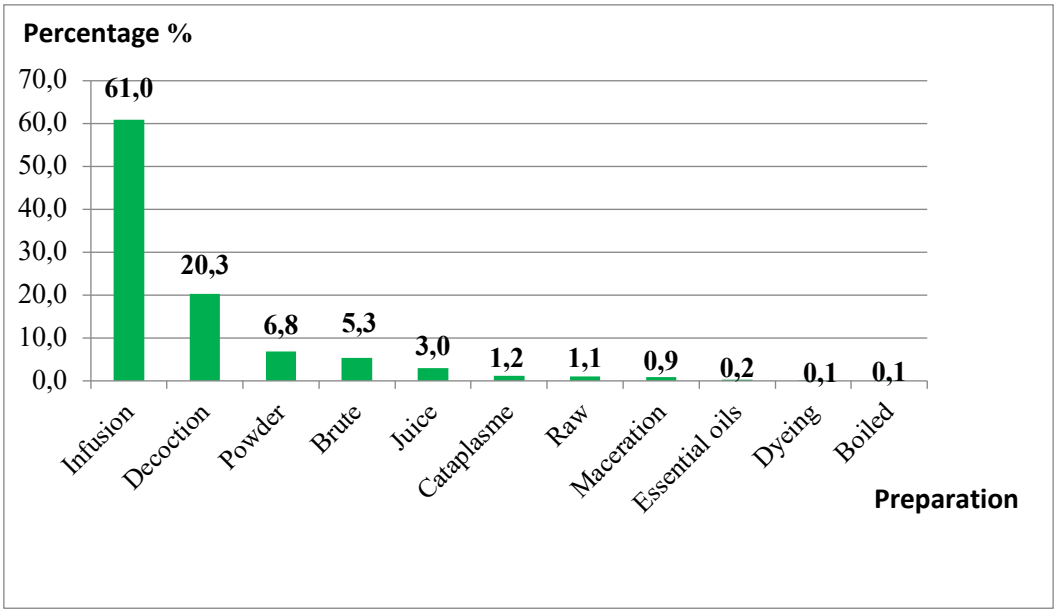

Figure 4. Frequent preparation types.

The know-how on new methods of preparing medicinal plants compared to previous ethnobotanical studies [Khabbach *et al*. 2012, Boulfiaâ *et al*. 2018, El Haouari *et al*. 2018, El Brahimi *et al*. 2022] from the province of Taza made it possible to collect 91 new preparation methods (in bold in Table 2), which corresponds to 49.18% of new knowledge on the preparation method used. The identification of 91 new preparation methods is important because it represents a substantial expansion of the existing knowledge base on how medicinal plants are processed and used in Taza Province. The discovery of new preparation methods demonstrates the diversity of traditional practices and highlights that there may be different ways of transforming medicinal plants for various therapeutic purposes. The introduction of new preparation methods suggests that traditional knowledge is not static, it evolves over time. Local communities in Taza can innovate and adapt their practices based on various factors such as environmental and/or cultural changes. The evolution of local practices, technological progress or a better understanding of the medicinal properties of certain plants could contribute to the identification of new methods of preparation. Understanding new preparation methods is crucial for the sustainable use of medicinal plants. The discovery of new preparation methods opens the way to more in-depth research.

Mode of administration

Oral administration (94.3%) (Table 3) dominated other modes, and the same finding applies to the following works (Ammar *et al.* 2021, Khabbach *et al.* 2012, El Haouari *et al.* 2018, Bouyahya *et al.* 2017). External application and inhalation only represented 4.1% and 1.6% respectively (Table 3). The highest administration criterion (AI=2) was noted for 20 plant species. The high level of oral administration 94.3% (Table 3) drew our attention, which provides information on a very strong informant-trust-plant relationship, estimating the non-toxicity of plants administered orally. However, the administration of a high dose may constitute a risk of undesirable toxicity for the population. This finding could pave the way for future ethnopharmacological works based mainly on the determination of the toxicities of these species highly administered orally.

The know-how on new methods of administering medicinal plants compared to previous ethnobotanical studies [Khabbach *et al*. 2012, Boulfiaâ *et al*. 2018, El Haouari *et al*. 2018, El Brahimi *et al*. 2022] in the province of Taza made it possible to collect 34 new methods of administration (in bold in Table 2), which corresponds to 33.66% of new knowledge on the methods of administration used. The identification of 34 new delivery methods was significant because it represents an expansion of the existing knowledge base on how medicinal plants are administered in Taza Province. The discovery of new

delivery methods demonstrated the diversity of traditional practices and suggests that different communities or individuals may have unique ways of administering medicinal plants. The introduction of new methods of administration requires that traditional knowledge be dynamic and capable of adapting to changing circumstances. Local communities can innovate based on factors such as accessibility, cultural preferences or environmental changes. The discovery of new methods of administration of certain medicinal plants has implications for healthcare practices, especially if these methods present therapeutic benefits. This may influence the way medicinal plants are used in traditional and, potentially, modern healthcare settings.

Table 3: Characteristics related to medicinal plants used by the population of Taza

		Frequency	Percentage
Source of ethnobotanical knowledge	Parents	242	82.6%
	Training in the field	14	4.8%
	Experiences	17	5.8%
	Herbalists	9	3.1%
	Parents & Herbalists	11	3.8%
Reason for using MP	More efficient	162	55.3%
	Cheaper	19	6.5%
	More accessible	25	8.5%
	Absence of risks	44	0.7%
	More efficient & Cheaper	15	5.1%
	More efficient & More accessible	26	8.9%
	More efficient & Absence of risks	2	15.0%
MP drying	Conventional processes	107	36.5%
	Industrial	5	1.7%
	In the shade	141	48.1%
	Under the sun	19	6.5%
	In the shade& Under the sun	21	7.2%
Conditioning and storage of MP	Ventilated location	180	61.4%
	Little ventilated	80	27.3%
	Open containers	2	0.7%
	Hermetically sealed containers	31	10.6%
MP are Used	Separately	235	80.5%
	In association	5	1.7%
	In combination with drugs	12	4.1%
	Separately & In association	31	10.6%
	Separately & In association & In combination with drugs	9	3.1%
State of the patient after treatment	Stable	18	6.1%
	Generally improved	136	46.4%
	Improved	139	47.4%
Collection period	Whole the year	1153	50.6%
	Autumn	44	1.9%
	Winter	5	0.2%
	Spring	98	4.3%
	Summer	978	42.9%
Plants state	Fresh	710	31.2%
	Dried	1568	68.8%
Administration	Orally	2148	94.3%
	Inhalation	36	1.6%
	External app	94	4.1%
Treatment period	Short (a few days to a few weeks)	1397	61.5%
	Average (a few months)	173	7.6%
	Long (more than a year)	700	30.8%

Reasons for the use of medicinal plants

Based on the results presented in (Table 3), 55.3% of the surveyed population used medicinal plants for their high efficacy, 15% because of the high efficacy associated with no risk, 8.9% used them for the high efficiency associated with high accessibility, 8.5% due to high accessibility, 5.1% due to high efficiency associated with their cheapness, 6.5% due to cheaper cost and only 0.7% for the absence of risk. The use of medicinal plants for their high efficiencies alone or combined with other reasons occupies such a large percentage (84.3%), which corroborates with that reported by (Hanae 2012), with a percentage of 90.6%. These results show that the population believes in the great effectiveness of the plants used in phytotherapy. This well-established belief is based on healing experiences (strong repetition-reputation-belief relationship) passed down from grandparents to other generations.

Sources of ethnobotanical knowledge

Regarding the source of ethnobotanical knowledge (Table 3), the results obtained showed that parents are the main source of information (82.6%), followed respectively by the experience of the informant (5.8%), field training (4.8%), followed by the experience of parents associated with herbalists (3.8 %) and the Herbalists' Council alone (3.1%). This predominance of parents as a source of information was confirmed by the same authors (Daimari *et al.* 2019, Gbolade 2009). This result could be explained by the bias of ethnobotanical knowledge transfer from one generation to another and also by the sustainability of the use of these plants for a long time.

Methods of using medicinal plants

In our study, 80.5% of the population indicated that medicinal plants are used separately, 12.3% indicated that these plants are used either separately or in combination, 4.1% are for a combined form of use with drugs, while the remainder (3.1%) indicated that the use may be in a separate form, associated or combined with medication (Table 3). The large percentage of medicinal plants used separately (80.5%) shows the specificity of each plant in the treatment of a specific type of disease. However, the combined use of medicinal plants, even at low levels, indicates that the population is aware of the synergistic effect of combined plants. Hence the possibility of researching bioactive molecules from combined plants.

Drying and storage of medicinal plants

The results of the drying and storage of medicinal plants are shown in (Table 3). According to the studied population, drying of medicinal plants was done in 48.1% of cases in the shade, in 36.5% of cases with conventional processes, in 6.5% of cases under the sun, whereas in 7.2% of the cases were done by a combination under the sun and in the shade and 1.7% of the cases industrially. The storage was mainly done in a ventilated location (61.4%), or semi-ventilated (27.3%), while 10.60% of this population favored storage in hermetically sealed containers and only 0.7% chose open containers. The dominant type of drying (in the shade) and that of storage (ventilated location) are the basis for a better conservation of the chemical components of medicinal plants and consequently for a good conservation of their biological activities and their effectiveness.

State of the patient after treatment

The results obtained (Table 3) showed that the condition state of the patient after treatment remains stable only for 6.1% of cases. While 93.9 % of cases that their state were improved. This result demonstrated clearly the effectiveness of medicinal plants used after treatment. This satisfaction of the population was confirmed by Jouad *et al.* (2001).

Plant Collection and treatment periods

Regarding the collection period of the plant used (questioned for the first time in the province of Taza). The highest collection period criterion (CCP=4) was noted for 47 plant species (51.65%). 50.6% of the majority of these plants were collected throughout the year, 42.9% in summer, 4.3% in spring, 1.9% in autumn and 0.2% in winter (Table 3). This finding is due to the availability of parts of certain plants throughout the year and the harvesting of most of them in early summer (harvest season). The distribution of plant collection period in Taza province, with the majority collected throughout the year (50.6%), reflected the diversity of ecological and climatic conditions of the province, as well as the availability and the life cycles of plant species. Some plant species in the region may have parts (leaves, stems, roots, etc.) that remain available and usable throughout the year. These plants may not be strongly tied to specific seasons, making them accessible for collection year-round. Harvesting most plants in early summer (42.9%) indicates that this season is particularly important for plant harvesting. Early summer could be a peak time for the availability of certain plant parts or the optimal time to harvest specific species.

The short treatment duration (a few days to a few weeks) was the most important with 61.5%, while long (over a year) constituted only 30.8% of the cases and medium (a few months) only 7.6%. The important percentage of the short treatment

duration showed that people believe in plants for quick healing, contrary to the drug which requires a directed use with a precise duration.

Other uses

The medicinal plants identified in our survey undoubtedly have other uses (table 2). These other uses were carefully documented in the province of Taza. The type of use criterion (CTU=6) was noted for a single plant species of *Rosmarinus officinalis* L.. Figure 5 shows its different uses. The results obtained showed that these plants are used in culinary (28,62%) (44 species), aesthetic (22,37%) (30 species), perfumery (16,88%) (20 species), food (11,86%) (29 species), ornamental (9,29%) (9 species), feed (6,33%) (9 species), fumigation (2,17%) (5 species), joinery (1,56%) (4 species), charcoal (0,84%) (3 species) and clothes (0,08%) (1 species). Other uses of plants (culinary, food, feed, fumigation …) were already illustrated in some Taza communities more than 10 years ago (Khabbach *et al.* 2011).

Comparing our results. The numbers of medicinal plants used in culinary, aesthetic, feed and fumigation were, respectively, higher than (12 species) (10 species) (6 species) and (4 species) (Khabbach *et al.* 2011). However, the number of plants used in food and culinary and in clothes (65 species) (1 species) was the same as (Khabbach *et al.* 2011). Several species had multiple uses. Some ancient uses of plants are gradually beginning to be abandoned which impoverished the know-how (Khabbach *et al.* 2011). Also, this part releases the points of junction between the medicinal plants in the other practices of uses in the province of Taza.

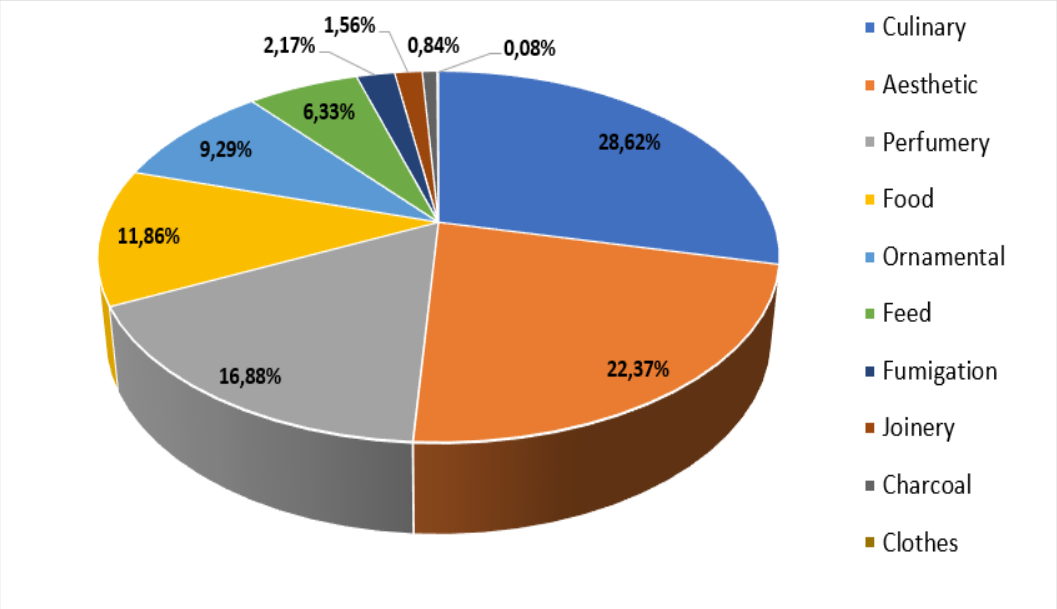

Figure 5. Other uses of Medicinal Plants

Family Importance Value (FIV) and Family Use Value (FUV)

The family importance value (FIV) qualified 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 were respectively cues of Oleaceae (FIV=120), Lauraceae (FIV=50), Lamiaceae (FIV=47.69), Cactaceae (FIV=42) and Asteraceae (FIV=40,6). Family use value (FUV) provided 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 within that family. The highest FUV were respectively cues of Oleaceae (FUV=0.353), Lauraceae (FUV=0.147), Lamiaceae (FUV=0.140), Fabaceae (FUV=0.110), Cactaceae (FUV=0.124) and Asteraceae (FUV=0.120). This suggested that these plant families were the most significant in the local ethnobotanical knowledge of the province of Taza. The FIV and FUV provided a quantitative measure that allows plant families to be prioritized for further study or conservation efforts based on their importance in local knowledge and practices in Taza Province. These results confirm and enhance the results obtained for FUF, showing that the families cited were the most important (Ghabbour *et al*. 2024). The analysis of Family Importance Value (FIV) and Family Use Value (FUV) highlights the significant role of specific plant families in the ethnobotanical knowledge of the Taza province. The highest FIVs and FUVs, attributed to families such as Oleaceae, Lauraceae, Lamiaceae, Cactaceae, and Asteraceae, indicate their prominent position in local practices and knowledge. These metrics provide a clear, quantitative basis for prioritizing

these families for further study and conservation efforts. The consistent results across FIV, FUV, and FUF underscore the importance of these families, confirming their central role in the ethnobotanical landscape of the region.

Correlations and principal component analysis (PCA)

A Pearson correlation (bilateral) was carried out between the different characteristics of the population studied in relation to the traditional use of medicinal plants (Type of population, herbalist seniority, age, residence, sex-ratio, marital status, education level, monthly income, socio-economic level, usual language, are you among the PM users?, reason for using MP, source of ethnobotanical knowledge, state of the patient after treatment, MP drying, conditioning and storage of MP and how MP are used ?). The results obtained (Table 4) showed positive (56.25%) and negative (43.75%) correlations. Thus, 50.78% of the correlation values are significant ($P<0.05$) of which 39.06% are significant at ($P<0.01$).

The most relevant correlations were positive and very significant ($P<0.01$) presented between socio-economic level and monthly income (0.735), education level and socio-economic level (0.596), education level and monthly income (0.531) and age and marital status (0.514).

Table 4. Pearson correlation between the different characteristics of the population studied in relation to the traditional use of medicinal plants.

	Type of popu-lation	Herbalist seniority	Age	Residence	Sexe	Marital status	Education level	Monthly income	Socio-economic level	Usual language	Are you among the PM users?	Reason for using MP	Source of ethnobotanical knowledge	State of the patient after treatment	MP drying	Conditioning and storage of MP	How MP are Used ?
Type of population		.[a]	-0.160**	0.129*	-0.252**	-0.153**	0.133*	0.143**	0.097	-0.058	-0.148**	-0.168**	0.003	0.213**	0.001	0.076	-0.01
Herbalist seniority (years)			0.129	-0.137	-0.241	0.153	-0.137	-0.015	0.116	-0.002	.[a]	0.205	-0.359*	0.327*	0.355*	-0.282	0.360*
Age				-0.192**	-0.076	0.514**	-0.441**	-0.067	-0.154**	0.006	-0.031	0.099	0.155**	0.008	0.052	-0.022	0.172**
Residence					0.299**	-0.105	0.332**	0.170**	0.301**	-0.170**	0.117*	-0.166**	0.174**	0.052	-0.216**	-0.066	0.009
Sexe						0.118*	-0.067	-0.236**	-0.108*	-0.197**	0.021	0.035	0.059	-0.262**	-0.180**	0.064	-0.049
Marital status							-0.338**	-0.08	-0.188**	-0.025	0.018	0.139*	0.191**	-0.061	0.085	0.009	0.161**
Education level								0.531**	0.596**	-0.018	0.163**	-0.255**	0.017	0.096	0.153**	0.014	-0.044
Monthly income									0.735**s	-0.017	0.143**	-0.091	0.109	0.153**	0.198**	-0.129*	0.162**
Socio-economic level										-0.031	0.163**	-0.146*	0.183**	0.134*	0.295**	-0.140*	0.226**
Usual language											0.044	-0.102	-0.057	0.049	0.159**	-0.11	-0.004
Are you among the PM users?												.[a]	.[a]	.[a]	.[a]	.[a]	.[a]
Reason for using MP													0.055	-0.094	0.163**	0.087	0.082
Source of ethnobotanical knowledge														0.011	0.199**	-0.061	0.325**
State of the patient after treatment															0.188**	-0.228**	0.108
MP drying																-0.083	0.306**
Conditioning and storage of MP																	-0.141*
How MP are Used ?																	

**: The correlation is significant at the 0.01 level (bilateral),*: The correlation is significant at the 0.05 level (bilateral), a: Calculation impossible, because at least one of the variables is a constant.

PCA differentiates groups by examining similar units (Duby & Robin 2006). It consists of showing the overall dispersion of objects by examining their positions (Cazes et al. 1997) and identifying strong and weak correlations between variables (Duby & Robin 2006).

The results obtained in PCA (Figure 6) revealed that a large part of the variation is captured by the first two components (PCI=38.76% and PCII=27.1%) which are sufficient to interpret the results. The first component (PCI) was constructed following a strong positive correlation that is significant with socioeconomic level, monthly income and education level which forms three sociodemographic characteristics that tend to be evaluated together. The second component (PCII) was constructed following a strong positive correlation with age, patient status after treatment and herbarest seniority.

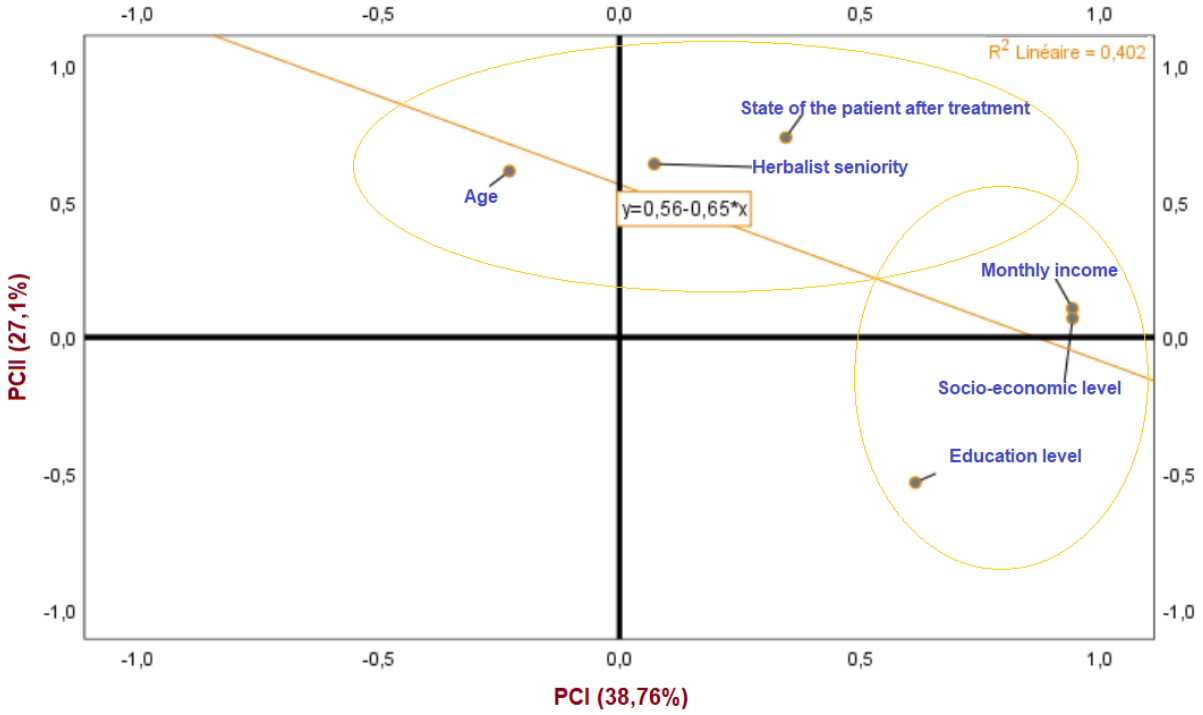

Figure 6. Principal components analysis of Age, Herbalist seniority, Education level, Monthly income, Socio-economic level and the State of the patient after treatment according to the two components of (PCI) and of (PCII).

The results obtained in Table 4 and Figure 6 summarize the socio-demographic face of the population of Tazi in relation to their knowledge of medicinal plants. These findings suggest that individuals with higher monthly incomes or higher education levels tend to have a higher socioeconomic status. The people with higher education levels tend to have higher monthly incomes and older people are more likely to be married. The positive correlation between age and seniority of the herbalist indicates that ethnobotanical knowledge tends to accumulate, increasing day by day. The correlations found in the study highlight important relationships between various sociodemographic factors and knowledge of medicinal plants among the Tazi population. The study highlights the interdependence of sociodemographic factors and their impact on the knowledge and use of medicinal plants within the Tazi population. Understanding these relationships can inform targeted interventions to address socioeconomic disparities and promote community well-being. Efforts to document and transfer ethnobotanical knowledge from seasoned herbalists to younger generations are crucial to preserving cultural heritage and traditional practices.

A correlation matrix (Pearson) between all ethnobotanical knowledge criteria was carried out. The results obtained (Table 5) showed positive (86.67%) and negative (13.33%) correlations. Thus, 60% of the correlation values are (were) significant at ($P < 0.05$) in which 55.55% were significant at ($P < 0.001$).

The CCP presented a very significant positive correlation with CP ($P < 0.001$), significant with CPS ($P < 0.01$) and CPU ($P < 0.01$), slightly significant with CA ($P < 0.05$) and no significance with CTU. CPS presented a very significant positive correlation with CPU ($P < 0.001$) and CP ($P < 0.001$), significant with CTU ($P < 0.05$), and not significant with CA. CPU presented a very significant positive correlation with CP ($P < 0.001$) and non-significant with CA and CTU. CP presented a very significant

positive correlation with CA (P < 0.001), and a weak, non-significant negative correlation with CTU. CA presented a weak, non-significant negative correlation with CTU. The most important correlations were respectively those of CPU with CP, CPS with CPU and CPS with CP.

Table 5. Correlation matrix (Pearson) among criterion of Collection period, criterion of Plant state, criterion of Part Used, criterion of Preparation, criterion of Administration and criterion of type of use.

Variables	CCP	CPS	CPU	CP	CA	CTU
CCP		0,327**	0,308**	0,376***	0,216*	0,131
CPS			0,507***	0,464***	0,113	0,249*
CPU				0,526***	0,117	0,134
IP					0,417***	-0,028
CA						-0,100
CTU						

*Significant at 0.05 probability level, **Significant at 0.01 probability level; ***Significant at 0.001 probability level.

The presence of both positive and negative correlations indicated diverse relationships between criteria of ethnobotanical knowledge. This level of significance suggested a robust statistical relationship between the criteria. The results obtained suggest that cultural practices were closely linked to the use of different parts of plants, preparation and plant state which are also closely interconnected between them. Tazi cultural practices had significant associations, suggesting that ethnobotanical knowledge of the use of plant species was closely linked to the manner of their use. These findings contribute to a comprehensive understanding of how different aspects of ethnobotanical knowledge are interrelated in Taza province.

The significant positive correlations between cultural practices, preparation styles, and plant use highlighted the cohesive nature of these practices within the community and suggested that knowledge and use of medicinal plants were deeply rooted in cultural traditions. The results provide a nuanced understanding of the interconnectedness of ethnobotanical knowledge in Taza, highlighting the importance of cultural practices in shaping methods of plant use and preparation.

Principal component analysis (PCA) conducted on different ethnobotanical knowledge criteria, as shown in Figure 7, provided insight into the relationships and patterns among the criteria. The results obtained in Figure 7A revealed that the first two axes are sufficient for the interpretation of the results (the cumulative variance on PCA 1 and PC2 is equal to 60.85%).

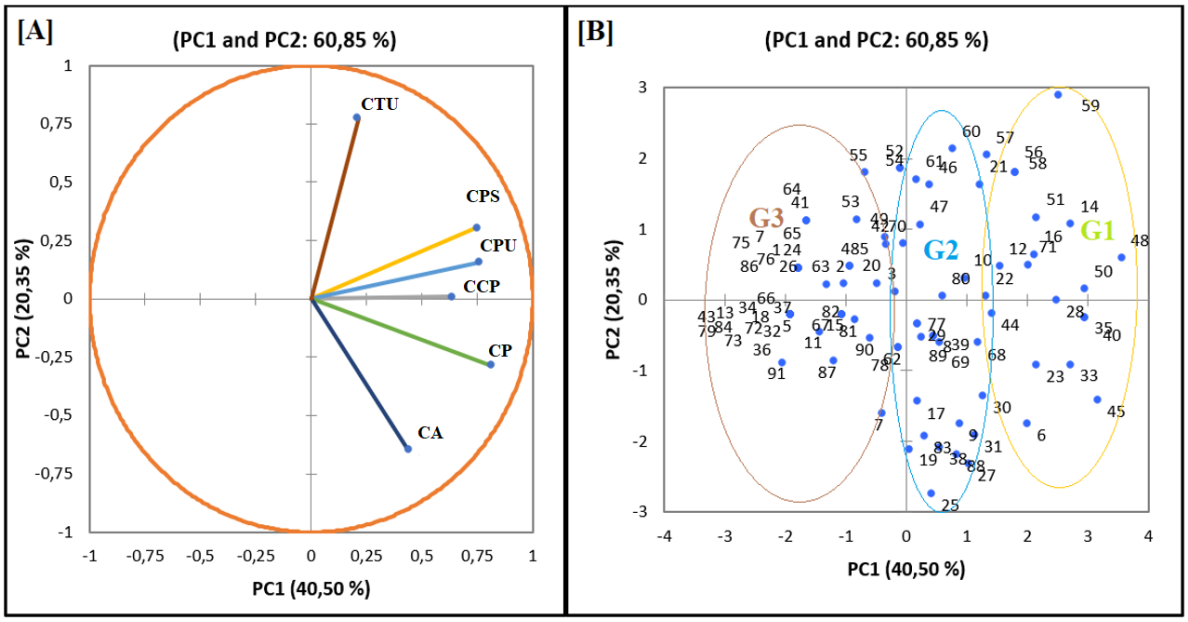

Figure 7. Principal components analysis of the criteria of ethnobotanical knowledge (A) and Biplot (B) for plant species (according to their number codes in Table 2) according to the two components of (PC1) and of (PC2).

The first component (PC1) which significantly brings together CPS, CPU, CCP and CP represented the majority of the variation (40.50%). While the second component (PC2) which significantly includes CA and CTU presented 20.35% of the variation. The results obtained (Figure 7) showed that CPS, CPU, CCP and CP are significantly positively correlated with each other, and all have a positive correlation with PC1 and therefore contributed strongly to the construction of axis 1. The positive correlation suggests that these criteria tend to vary together, indicating a commonality in the ethnobotanical knowledge of these four criteria. While the AI and the CTU, which are negatively correlated with each other, contributed strongly to the construction of axis 2. The combination of PC1 and PC2 offers a global vision of the ethnobotanical knowledge of the Taza province. The fact that the first two axes are very informative (cumulative variance of 60.85%) suggested that these components effectively capture the key dimensions of ethnobotanical knowledge of the Taza province. This information is very informative, representative and is crucial for understanding the structure and patterns of how Tazi communities perceive and use plant resources.

Based on the first two axes forming our main components (PC1 and PC2), the creation of a biplane (Figure 7B) was carried out to show the simple diffusion (The distribution of plant species used according to their numbers of codes in Table 2) species according to the ethnobotanical knowledge criteria studied, and a selection was made to classify three groups of plant species (G1, G2 and G3) which differ in their ethnobotanical knowledge.

G1 showed the species distributed on the right (among others: (48) *Lavandula* sp., (50) *Marrubium vulgare* L. and (59): *Rosmarinus officinalis* L.) and which were positively and strongly linked to the constriction of PC1, these species are strongly and positively correlated with CPS, CPU, CCP and CP. G2 showed the species distributed centrally along PC2 (among others: (25) *Berberis hispanica* Boiss. & Reut. and (60) *Salvia officinalis* L.), contributing to the construction of this second component. The species forming G2 showed a strong opposite correlation between CTU and CA. G3 showed the species distributed on the left (among others: (84) *Coffea arabica* L. and (91) *Peganum harmala* L.) on the negative side of PC1 contributing weakly to the construction of PC1 and PC2. The strong diffusion observed among medicinal species showed that each species has specific ethnobotanical knowledge. These results based on specific quantifications of ethnobotanical knowledge may strongly contributed to their preservation and give a new vision of valorizing the know-how inherited from previous generations of the province of Taza.

The PCA analysis effectively captured key dimensions of ethnobotanical knowledge in Taza province. The strong positive correlations on PC1 suggest a consistent structure in how these criteria were practiced and perceived. The negative correlation on PC2 highlighted different dynamics in the appreciation and transmission of knowledge. The classification of plant species into three groups (G1, G2 and G3) based on their ethnobotanical knowledge criteria highlights the diverse ways in which these plants were valued and used within the community. This nuanced understanding contributes to the preservation and enhancement of traditional knowledge, ensuring that the ethnobotanical heritage of Taza is effectively documented.

The results obtained in PCA (Figure 8) revealed that the first two axes are sufficient to interpret all the results since the cumulative percentage of variance on PC1'=76.32% and PC2'=23.68% is equal to 100% (the two axes capture all the variation in the data). Most of the variation was presented by the first component (PC1') constructed following a strong positive correlation with FUV and FIV. These last two indices were almost entirely positively correlated with each other, which was very significant ($P < 0.001$). The second component (PC2') was constructed following a strong positive correlation with FUF. FUF was significantly ($P < 0.01$) positively correlated with FUV and FIV.

The biplot showed a scatterplot of botanical families. Most points of the families form a straight line almost parallel (indicates a constant positive relationship between most botanical families and these indices) to that formed by FUV and FIV, thus indicating that most botanical families (Written in black like this is the case of Oleaceae) contributed to a strong positive and significant correlation with these two indices and therefore with PC1'. The fact that most botanical families align with FUV and FIV in the biplot indicates that these families correlated positively with each other and contributed strongly to the variation captured by PC1'. This suggests that the knowledge and importance of these families were well shared within the Taza province. Certain points of specific families contributed to a strong significant positive correlation with FUF thus contributing to the construction of PC2' and this was the case of eight botanical families (entities of accentuated orange color as is the case of Lamiaceae). This implies that these families are associated with a higher frequency of plant use, thus contributing to the variation captured by PC2'. The visual representation in the biplot may improve our understanding of the relationships between botanical families based on their ethnobotanical indices.

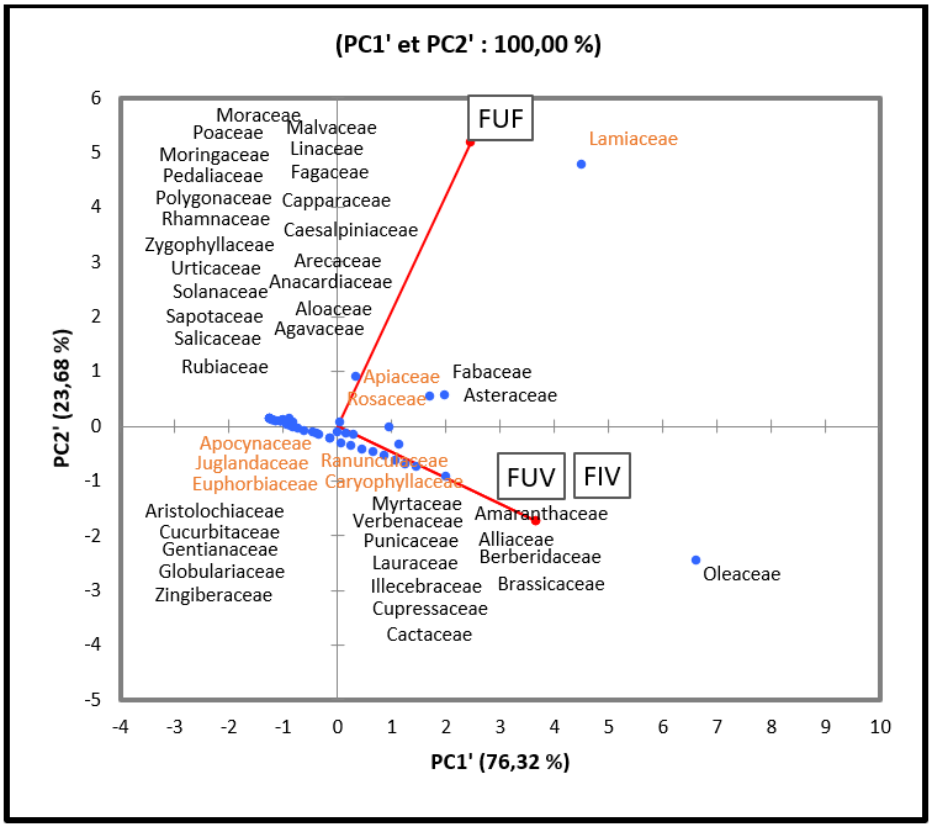

Figure 8. Principal component analysis of family indices with Biplot showing the distribution of families according to the two components of (PC1') and (PC2').

The biplot visualization enhanced the understanding of how different botanical families relate to each other based on ethnobotanical indices. It showed that while most families contribute to PC1' through FUV and FIV, a specific subset of families also significantly contributed to PC2' through FUF. This comprehensive capture of variation emphasized the integral role of certain botanical families in the ethnobotanical landscape of Taza, reflecting both the shared and unique aspects of plant use within the community.

Suggestion of transposition of know-how of medicinal plant use

Based on the results of socio-demographic characteristics, showing that the richness of phyto-diversity-use for treating diseases (Ghabbour *et al.* 2023) is closely related to the skills of the local population in the province of Taza, the high illiteracy rate of 35%, poverty diffused within of the population studied 50%, accentuated urbanization 51.5%, use of medicinal plants in rural areas more than in urban areas, transfer of know-how by the older generation 82.6%... all these reasons hinder or promote continuity and maintain the transfer of phyto-diversity know-how for future generations. Although several ethnobotanical surveys have been conducted in different regions of the world , which have yielded at least some of our suggestive reasons (Ziyyat *et al.* 1997, Ennabili *et al.* 2000, Jouad *et al.* 2001, Eddouks *et al.* 2002, El Hilaly *et al.* 2003, Tahraoui *et al.* 2007, Benkhnigue *et al.* 2010, El Amrani *et al.* 2010, Khabbach *et al.* 2012, Hanae, 2012, Ghourri *et al.* 2013, Hassani *et al.* 2013, Benkhnigue *et al.* 2014, Bousta *et al.* 2014, El Yahyaoui *et al.* 2015, Daoudi *et al.* 2016, Mikou *et al.* 2016, Barkaoui *et al.* 2017, Benali *et al.* 2017, Bouyahya *et al.* 2017, Eddouks *et al.* 2017, Laadim *et al.* 2017, Boulfia *et al.* 2018, El Haouari *et al.* 2018, Fatiha *et al.* 2019 , Mrabti *et al.* 2019 , Chaachouay *et al.* 2019 , Zougagh *et al.* 2019 , Hayat *et al.* 2020 , Idm'hand *et al.* 2020 and Mechchate *et al.* 2020, Souilah *et al.* 2021, Ammar *et al.* 2021, Singh *et al.* 2022, Megersa & Wold et sadik, 2022, Dutta *et al.* 2022, Srinivasan *et al.* 2022, Johnny *et al.* 2022, El brahimi *et al.* 2022, Ghabbour *et al.* 2023), none of them have suggested that traditional findings should be learned in the curricula taught in schools in order to combat the abandonment of traditional cultural knowledge.

To overcome this problem, the idea of transposing the know-how of phyto-diversity use is indispensable. It consists of transmitting social knowledge to school knowledge through an appropriate transposition of learning among learners, which may ensure the preservation of the traditional knowledge transfer of phyto-diversity-use to future generations. This part is centered on the conceptual tool of " Ethnobotanical Transposition" that we introduced in the field of ethnobotanical studies

to increase its explanatory fruitfulness to apprehend the policy of traditional use of medicinal plants within the province of Taza. Today, the migration from the countryside to the cities continues to increase, may contribute to a decrease of the traditional phytotherapeutic knowledge. The suggestion of the practices of social heritage information on the traditional use of PAM through its transposition into targeted educational content at the school level may contribute to the preservation and the transfer of the know-how to future generations. Thus, the laters must be warned of toxic plants (morphological resemblance between toxic and non-toxic plants), and also of non-toxic plants which are toxic in high doses.

Conclusion

Based on this ethnobotanical survey carried out in almost all communities in the province of Taza. The results of the characteristics related to medicinal plants used by the population of Taza revealed that the plants are used separately, without mixing and used in dried form. Based on a social practice of the studied population, the new study has significantly enriched the understanding of traditional knowledge by identifying new parts used, methods of preparation and modes of administration of medicinal plants used by local populations and must be optimized by the experience of experts to transpose it to school knowledge. The results clearly indicate the heterogeneous aspect of the studied population could provide a very important cognitive basis that could be exploited via ethnopharmacological studies to reveal biologically active molecules in the treatment of diseases.

Declarations

List of abbreviations: MP: Medicinal plant, MAD: Marocain Dirham, VPP: The value of the plant part, FUF: frequency of uses of families, FIV: Family importance value, FUV: Family Use Value (FUV), CCP: Criterion of Collection period, CPS: Criterion of Plant state, CPU: Criterion of Part Used, CP: Criterion of Preparation, CA: Criterion of Administration, CTU: Criterion of type of use, PCA: principal component analysis.

Ethics approval and consent to participate: The authors confirm that the study was reviewed and approved by an Institutional Review Board of the Laboratory of Natural Resources and Environmental, Polydisciplinary Faculty of Taza, University of Sidi Mohammed Ben Abdellah. The committee further approved that the study will 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 publication: Oral permission. All authors agreed for submission.

Availability of data and materials: Data is available on demand.

Competing interests: Authors have no conflict of interest.

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Author contributions: K.HAMMANI (https://orcid.org/0000-0002-4005-4244) and S.LOUAHLIA (https://orcid.org/ 0000-0002-1741-8927) supervised and selected the study design. A.KHABBACH (https://orcid.org/ 0000-0002-6779-9078) selected the study design, identified scientific species names and corrected manuscript. N.GHABBOUR (https://orcid.org/0000-0002-5822-5224) selected the study design, conducted the survey, Data entry, wrote the manuscript, corrections and editing. I.GHABBOUR (https://orcid.org/0009-0001-5969-4233) selected the study design, conducted the survey, wrote the manuscript, database creation, data entry, statistical-factorial analysis, corrections and editing. All authors read and approved the manuscript.

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