Ethnobotanical survey and ecological approach of medicinal and aromatic plants in Algeria

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Ethnobotany Research and Applications 32:05 (2025) - http://dx.doi.org/10.32859/era.32.5.1-31
Manuscript received: 09/08/2025 - Revised manuscript received: 01/09/2025 - Published: 05/09/2025

Research

Abstract

Background: Herbal medicine remains widely used globally, often preferred due to concerns over pharmaceutical side effects. In Algeria, where 80% of the population relies on traditional medicine, this study aimed to document medicinal and aromatic plants (MAPs) used in a semi-arid region of northeastern Algeria.

Methods: Conducted from 2017 to 2020, the ethnobotanical survey involved 300 participants. The data were evaluated using a range of botanical citation indexes. In addition, for each plant species identified, ethnobotanical features were assigned, including the plant part used in herbal medicine, preparation modes, medication routes of administration, and diseases treated. Furthermore, ecological characteristics such as plant morphological types, IUCN Red List status, and geographic origins were recorded.

Results: All participants reported using MAPs for treatment. Data analysis using Multiple Component Analysis revealed that married, urban housewives aged 36 to 61 years were the primary users. Additionally, 158 species were identified from 62 families, with Asteraceae, Lamiaceae, and Apiaceae being the most represented. Leaves were the most commonly used plant part, with infusion and decoction as the main preparation methods. Ecological data included IUCN status, with some species listed as Vulnerable or Endangered. Several species showed high Informant Consensus Factor (ICF) and Fidelity Level (FL), notably *Prunus dulcis* (Mill.) D.A.Webb, *Olea europaea* L., and *Lavandula angustifolia* Mill.

Conclusion: This study underscores the significant role of MAPs in traditional healthcare practices in northeastern Algeria, offering key insights into their use for the treatment of various diseases. The findings contribute to the body of knowledge in alternative medicine and provide a valuable ethnobotanical database that could be leveraged for pharmaceutical applications.

Keywords: Herbal medicine, Medicinal and aromatic plants, Semi-arid regions, Ethnobotanical survey, Botanical citation indexes, Montane habitats.

Background

As we explore the historical landscape of treatments, plants have consistently played a significant role (Boutabia *et al.* 2020). Initially, humans turned to these botanical resources to alleviate their ailments (Boullard 2001). Globally, plants have been used as medicinal remedies, valued for their relatively low toxicity and gentle nature compared to pharmaceutical drugs. Nowadays, pharmaceutical industries are increasingly interested in the ethnobotanical study of plants (Tahri *et al.* 2012, López-Rodríguez *et al.* 2024). Despite the substantial growth of the pharmaceutical sector, approximately 80% of the world's population still relies on traditional medicine, recognizing the empirical wisdom of their ancestors (El Rhaffari & Zaid 2004). The medicinal and aromatic plants (MAPs) continue to be a crucial source of medical care in developing countries where modern medical systems are often lacking (Tabuti *et al.* 2003). Today, the effectiveness of herbal medicine is well-established, and its undeniable health benefits have allowed natural medicine to become integrated into our daily routines (Lousse *et al.* 2017, Kasilo *et al.* 2019). This trend is evident even in the most developed countries (Pastor 2006). Also, MAPs contribute to the history of all continents (Wang *et al.* 2018, Kasilo *et al.* 2019). In China and India, knowledge about plants has been meticulously organized, documented, and passed down through generations for centuries. In Western countries, there is a renewed interest in herbal medicine, particularly for addressing imbalances induced by modern lifestyles, such as stress or weight issues. Herbal medicine is increasingly embraced as a preventive measure rather than solely reserved for treating diseases (Wang *et al.* 2018, Kasilo *et al.* 2019, Li *et al.* 2024, Mazzei *et al.* 2024).

In Africa, a significant number of individuals, primarily and sometimes exclusively, depend on traditional medicine as their primary healthcare option due to its affordability and perceived effectiveness (Kasilo *et al.* 2019, Prinsloo *et al.* 2023). In Algeria, as in other African countries where 80% of the population relies on traditional medicine, the use of MAPs is widespread (WHO 2022, Prinsloo *et al.* 2023). Algeria, with its vast and diverse ecosystems, concealing a significant wealth of nearly 4,000 taxa from various botanical families (Miara *et al.* 2013), has a long-standing tradition of utilizing plants in phytotherapy (Boutabia *et al.* 2020, Lazli *et al.* 2019). However, despite the rich medical tradition in Algeria, the study of medicinal flora in the country, as well as in other Maghreb countries, is insufficient. Unfortunately, these diverse plant species face considerable anthropogenic and climatic pressures, leading to an irreversible decline and potential extinction of several species, particularly those known for their medicinal properties (Ouadeh 2022). Furthermore, the lack of knowledge transmission regarding the uses and healing attributes of MAPs puts the preservation of this valuable natural resource at risk for future generations. The urban population, lacking trust in traditional healing resources, poses a particular threat (Akabassi *et al.* 2017). Given Algeria's extensive landscapes, including the renowned Aures region in northeastern Algeria, which is known for its diverse flora (Benmessaoud 2009), it is crucial to emphasize the importance of preserving and supporting this valuable knowledge, especially with the advancement of the pharmaceutical industry (Khemili *et al.* 2024). Therefore, there is a pressing need for the advancement of ethnobotany and ethnopharmacology studies (Beldi *et al.* 2021, Aouir *et al.* 2025).

Khenchela province, located in northeastern Algeria, benefits from a strategically advantageous geographical position and diverse climatic and soil conditions. These conditions create ideal circumstances for the proliferation of a rich and diverse flora consisting of MAPs (ANDI 2021). Despite being one of Algeria's most important regions in terms of its favorable geographical location and pristine natural environment (Benabadji *et al.* 2007, Véla & Benhouhou 2007), no previous ethnobotanical study has been conducted in this area. In light of this, a comprehensive study was undertaken to examine the flora and ethnobotany of the region, aiming to create the most comprehensive inventory of MAPs in northeastern Algeria at the Khenchela province, with particular attention to usage patterns and sociodemographic influences. A structured questionnaire was utilized to gather data on prevailing therapeutic practices. Specifically, this study aims to: (i) identify and classify MAP species present in the region; (ii) document their ethnomedicinal applications; (iii) analyze how sociodemographic factors influence the use of MAPs; (iv) assess their ecological status; and (v) quantify the relative importance of each species using standardized ethnobotanical indices. The overarching goals of this research are to preserve traditional knowledge, support conservation strategies, and contribute to the scientific foundation for potential pharmacological development.1

Materials and Methods

Study area

The region of Khenchela is located in northeastern of Algeria, between 06°32'E and 07°34'E longitude and 35°07’N and 35°38’N latitude, at an elevation of 830-1100 m. It covers an area of 9,715 km² and is bordered by the provinces of Oum El Bouaghi to the north, El Oued and Biskra to the south, Tebessa to the east, and Batna to the west (Figure 1). The study was carried out in eight municipalities distributed from the northern to the southern regions of the Khenchela province: Kais, El Hamma, Khenchela, Ain Touila, Bouhmama, Ouled Rechache, Chechar, and Babar. Khenchela is a mountainous area situated at the base of the Aures regions, belonging to the Atlas Mountains (Bouzekri *et al.* 2023).

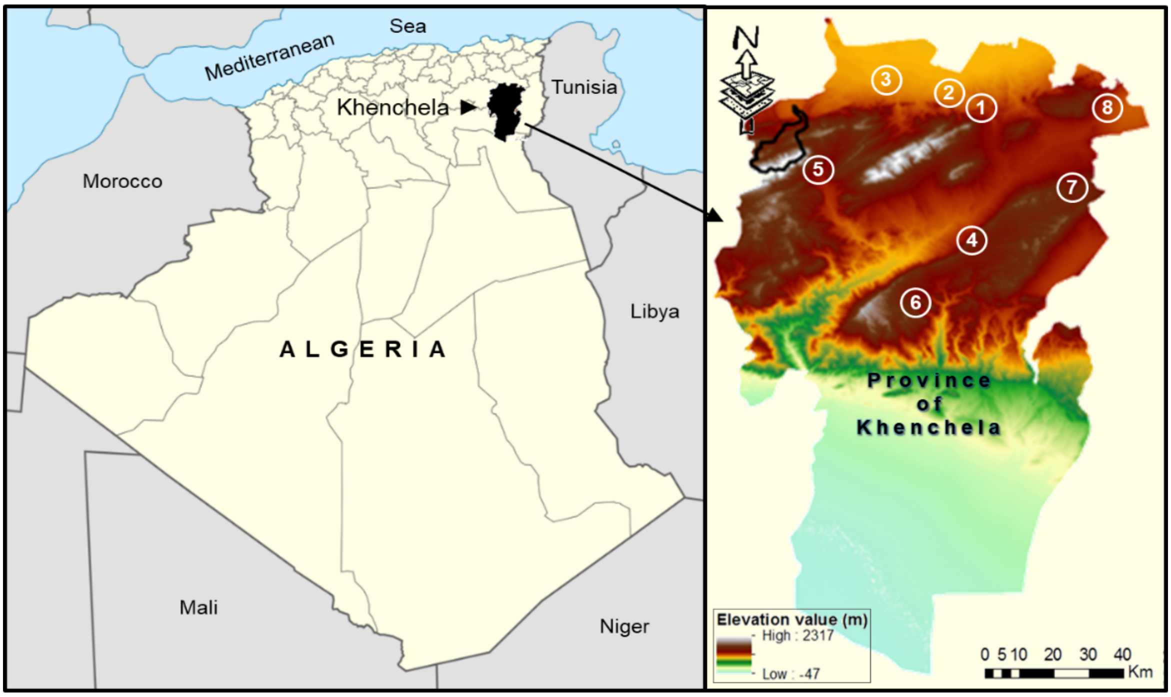

Figure 1. Geographical location of the studied area in northeastern Algeria. (Surveyed regions: 1: Khenchela, 2: El Hamma, 3: Kais, 4: Babar, 5: Bouhmama, 6: Chechar, 7: Ouled Rechache, 8: Ain Touila)

The area is characterized by an agro-sylvo-pastoral vocation due to its highly diverse natural environments. Classified as a semi-arid region, with scorching and dry summers registering a mean maximum temperature of 34.9 °C in July, and cold winters, with a mean minimum temperature of 1.85 °C in January, 509 mm of rainfall is averaged annually (Drouai *et al.* 2018).

Data collection

The data collection period extended from November 2017 to June 2020. This investigation consisted of two parts. The first part involved the identification and enumeration of spontaneous and cultivated MAP species in the selected study areas. Taxonomic identification was performed using available flora guides (Chevallier 2017, Lousse *et al.* 2017), with the assistance of experts of the local flora. All binomial names of identified medicinal species were verified using the online resources *World Flora Online* (https://worldfloraonline.org) and *Tela Botanica* (https://www.tela-botanica.org/). Herbarium specimens are available at Laboratory of Biotechnology, Water, Environment and Health (University of Khenchela, Algeria). The second part comprised an ethnobotanical survey on the use and virtues of MAPs, following standard methods (Martin, 1995). The survey was initially prepared in Arabic, the native language of the local population, and later translated into English (Figure 2). A total of 300 local people, of different intellectual levels, aged 19-85 years old, comprised up of 212 women and 88 men. During each interview, we collected personal information to detect variations in the informants' backgrounds (Mechaala *et al.* 2022). These respondents were also asked to provide pertinent knowledge about MAPs they were familiar with and their therapeutic uses. It is important to ensure that these activities are conducted in a responsible and sustainable manner to protect both natural resources and local cultures, as there is a significant risk that traditional knowledge about MAPs may be lost in the future. Therefore, these residents play a crucial role in preserving traditional medical knowledge and discovering potential new sources of natural medicines (Numpulsuksant *et al.* 2021).

Ethnobotanical data analysis

Ethnobotanical and ethnopharmacological data were analyzed using quantitative ethnobotanical indices including Relative Frequency of Citations (RFC), Family Importance Value (FIV), Fidelity Level (FL), Plant Part Value (PPV), and Informant Consensus Factor (ICF).

Relative Frequency of Citations (RFC)

This index exposes the importance of each plant species in a given community (Benamar *et al.* 2023, Rahim *et al.* 2023). RFC was calculated by dividing the Frequency of citation (FC) and the total number of survey participants (N) with this formula (1) (Tardio & Pardo-de-Santayana 2008):

$$RFC = FC/N \qquad (1)$$

As part of the preparation for an ethnobotanical study, we kindly ask you to participate in this questionnaire, which aims to collect as much information as possible about medicinal plants from the region of Khenchela, northeastern Algeria. Thank you for your valuable collaboration.
Gender: Female / Male
Age: ....
Education: ....
Profession: ....
Marital status: ....
Municipality: ....
Locality: ....
Do you know any medicinal plant used in your region? If so, which one(s)?
Do you know its vernacular and/or local name?
Does this (these) medicinal plant(s) have therapeutic use(s)?
Which part of the plant do you use? Leaf / Flower / Seed / Aerial Parts / Fruit / Root / Bark / Bulb / Steam / Peel / Whole plant
How do you use this (these) plant(s) in treatment? Infusion / Decoction / Powder / Cooked / Oil / Fresh / Poultice or Pad
Which diagnosing method do you choose to use this (these) plant(s): by herbalist / by yourself / by doctor
Does the treatment result in healing or relieving?

Figure 2. Ethnobotanical survey form distributed to the 300 of interviewees residents in the study area

Family importance value

Family importance value (FIV) is utilized to emphasize the significance of plant families, aiming to estimate their biological taxonomic value (Benamar *et al.* 2023). It was calculated according to Sreekeesoon and Mahomoodally (2014) formula (2):

$$FIV = (FC\ family)/Ns \qquad (2)$$

Where, FC family is TFC applied for families, which represents the number of informants mentioned the family, and Ns refers to the total number of cited species within each family.

Fidelity level

Fidelity level (FL) reveals which species prefers to treat a specific sickness over the others, calculated using the formula (3) provided by Friedman *et al.* (1986):

$$FL = (IP/Lu) \times 100 \qquad (3)$$

Where: Ip is the citations number of a particular plant used for a specific sickness, and Lu is the total number of citations of this plant used for the treatment to any use.

A higher FL (>60%) suggests that the plant is recognized for single-use purposes. Whilst, a lower FL (<40%) indicates that the plant is recognized for multiple-use purposes (Friedman *et al.* 1986, Jeddi *et al.* 2024).

Value of the plant part

Plant part value (PPV) signifies the usage frequency of each plant part, determined following this equation (4) (Gomez-Beloz 2002):

$$PPV = (RU\ plant\ part/RU) \times 100 \qquad (4)$$

In which, RU plant part indicates the total number of uses per a particular plant part, while RU the total number of uses of all plant parts

Informant census factor (ICF)

The ICF index was determined by applying the formula (5) given by Trotter and Logan (2019), for each group of illness, to determine the agreement of the indigenous people regarding the proposed diseases treated with various medicinal plants (Bahadur *et al.* 2023, Jeddi *et al.* 2024).

$$ICF = (Nur - Nt) / (Nur - 1) \qquad (5)$$

Where, Nur denotes the number of citations of a particular illness category, and Nt denotes the number of medicinal plants used to treat that category of illness. ICF value should fall within the range of 0.0 to 1.0. A low ICF value, nearing 0, suggests that informants consider the plant not highly useful and less know. Conversely, a high ICF value, approaching 1, indicates that informants consider the plant highly effective for treating the disease (Tedjani *et al.* 2024).

Ecological characterization

Geographic origin

According to Quézel (1978), the study area belongs to the North African region. The biogeographical classification of the studied plants was determined based on the works of Quézel & Santa (1962, 1963) and Quézel (1965).

Morphological types

Morphological species were identified based on Quézel & Santa (1962, 1963) and Ozenda (2004). Plants were classified as trees, shrubs, or herbaceous based on the morphology of the aerial vegetative part (Wang *et al.* 2018, Bouallala *et al.* 2023).

IUCN Red List

The International Union for Conservation of Nature (IUCN) Red List of Threatened species is a system for classifying species at high risk of global extinction. It divides species into categories: Not Evaluated (NE), Data Deficient (DD), Least Concern (LC), Near Threatened (NT), Vulnerable (VU), Endangered (EN), and Critically Endangered (CR). The IUCN of plants was sourced from the IUCN Red List website (www.iucnredlist.org/).

Analysis of statistical data

The data collected on survey sheets were processed and analyzed using Microsoft Office Excel version 2016. The respondents' sociodemographic data were analyzed by simple descriptive statistics using percentages and their associations were examined using Multiple component analysis (MCA) performed with performed using the R Package {FactoMineR} version 1.34 (Le *et al.* 2008). Pearson's Chi-squared tests were applied to test difference among categories of the studies variables. Also, Pearson correlation tests were used to analyze the relationship between, FIV and number of plant species per family, RFC and the number of treated diseases, and between FL and the number of species used per disease. Graphics and statistical tests were carried out using R software version 4.4.2 (R Core Team 2024).

Results

Sociodemographic characteristics of interviewees

The study included 300 informants and the sociodemographic data is categorized by age, gender, education level, profession, family status, locality, and the surveyed municipality, as presented in Table 1. This categorization enabled the determination of the response rate of participants within each category in the region.

Age and gender

The ethnobotanical study carried out in the Khenchela region involved interviews with individuals aged from 19 years to 85 years. The majority of people surveyed fell within the age range of [36-61[years old, accounting for 41.7%, followed by the age groups of [19-36[and [61-85] years, with rates of 37.7% and 20.7%, respectively (Table 1). The distribution of respondents across the three age categories was significantly different (Chi-squared test: $\chi^2 = 7.46$, $p = 0.024$). Similarly, a highly significant difference (Chi-squared test: $\chi^2 = 17.08$, $p < 0.001$) was found between males and females, with more females (70.7%) participating in the survey than males (29.3%). This showed a gender-based disparity in engagement with MAP use, with women being more involved in traditional healthcare practices.

Education, profession and marital status

The respondents with a university level of education held 36.7% of the total, followed by 34.3% with a high school degree, and 29% illiterate. This distribution pattern differed sufficiently between education levels (Chi-squared test: $\chi^2 = 68.21$, $p < 0.001$), suggesting that education level affects the knowledge and use of MAPs (Table 1).

Regarding profession, the results indicated that different segments of society, each according to their occupation, showed significant interest in utilizing MAPs. Housewives indisputably ranked first, with a high rate of 50.3%, highlighting their prominent role in the use and knowledge of MAPs in this community (Table 1). They were followed by students, comprising 22.0% of the respondents, then job holders and herbalists, with rates of 13.7% and 11.3%, respectively. Shopkeepers had the lowest rate at 2.7%. Significant differences were observed among respondents' professions (Chi-squared test: $\chi^2 = 66.99$, $p < 0.001$). The survey revealed that married individuals significantly outnumbered single people in their reliance on the use of MAPs (Table 1), with percentages of 71.3% and 28.7%, respectively (Chi-squared test: $\chi^2 = 18.2$, $p < 0.001$). This suggests that marital status might play a role in engagement with traditional medicine, possibly due to family health responsibilities.

Table 1. Sociodemographic characteristics of interviewees (N = 300). Statistics of Pearson Chi square test (χ^2, degree of freedom '*df*', and *p*-value) are shown for each variable.

Sociodemographic characteristics	**Count of respondents**	
	n	**%**
Age (year) (χ^2 = 7.46, *df* = 2, p = 0.024)		
[19-36[	113	37.7
[36-61[	125	41.7
[61-85]	62	20.7
Gender (χ^2 = 17.08, *df* = 1, $p < 0.001$)		
Female	212	70.7
Male	88	29.3
Education level (χ^2 = 68.21, *df* = 4, $p < 0.001$)		
Illiterate	87	29.0
Primary and middle education	0	0.0
Secondary education	103	34.3
University	110	36.7
Profession (χ^2 = 66.99, *df* = 4, $p < 0.001$)		
Housewives	151	50.3
Sellers of MAPs	34	11.3
Job Holders	41	13.7
Shopkeepers	8	2.7
Students	66	22.0
Marital status (χ^2 = 18.2, *df* = 1, $p < 0.001$)		
Married	214	71.3
Single	86	28.7
Type of locality (χ^2 = 58.78, *df* = 1, $p < 0.001$)		
City	265	88.3
Village	35	11.7
Municipality (χ^2 = 106.68, *df* = 7, $p < 0.001$)		
Khenchela	139	46.3
El Hamma	29	9.7
Kais	22	7.3
Babar	16	5.3
Bouhmama	19	6.3
Chechar	33	11.0
Ouled Rechache	24	8.0
Ain Touila	18	6.0

Locality and municipality

A significant difference was found between urban and rural respondents (Chi-squared test: χ^2 = 58.78, $p < 0.001$). Urban dwellers were more represented in the survey (88.3% vs. 11.7 of villagers), indicating that locality influences participation, possibly due to better access to information or healthcare services in urban areas (Table 1). The interviewees distributed across various locations such as Khenchela (46.3%), Chechar (11.0%), El Hamma (9.7%), Ouled Rechache (8.0%), Kais (7.3%), Bouhmama (6.3%), Ain Touila (6.0%), and Babar (5.3%), with a significant difference (Chi-squared test: χ^2 = 106.68, $p < 0.001$).

Multiple component analysis (MCA)

The results of MCA are presented in Figure 3. Overall, the first two dimensions, Dim1 and Dim2, accounted for 30.34% of the total variance in the dataset. Dim1 explained 19.42% of the variance and revealed four groups of respondents based on their use of MAPs, considering factors such as gender, profession, and residence in one of the municipalities in the study area, whether in rural villages or urban cities (Figure 3a). The second dimension (Dim 2), accounted for 10.92% of the variance and differentiated survey-respondents according to their profession, marital status, educational level, and municipalities of residence. The MCA biplot demonstrated that the individuals represented along both axes share commonalities in their profession and municipalities of residence (Figure 3b).

The MCA identified four distinct groups of respondents based on their use of MAPs: Group 1 comprised respondents categorized by their jobs, while Group 2 included respondents based on their marital status. Group 3 consisted of respondents classified by their educational level, and Group 4 included those grouped by their municipalities of residence. All the studied variables were significantly correlated ($p < 0.05$) on the first two dimensions, while the projection of their categories differed from one dimension to another (Table 2).

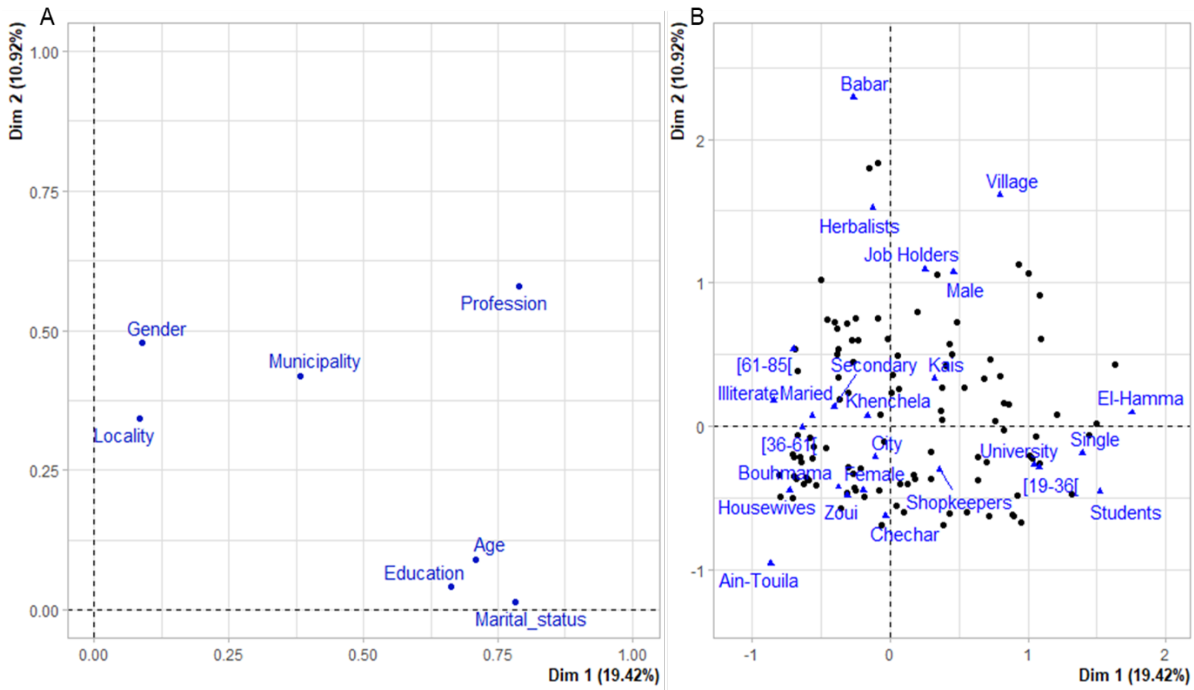

Figure 3. Biplot of MCA applied to different variables related to the survey respondents. A: projection of the main variables on the first two dimensions, B: projection of the categories of variables.

Table 2. Projections of different variables (age, gender, educational level, profession, marital status, locality, and municipality) and variable categories related to the respondents of the survey on MAPs on the first five dimensions of the multiple component analysis (MCA).

	Dimensions of MCA									
	MCA dim 1 (EV = 19.42%)		MCA dim 2 (EV = 10.92%)		MCA dim 3 (EV = 9.25%)		MCA dim 4 (EV = 8.00%)		MCA dim 5 (EV = 6.70%)	
Main variables										
	***R*²**	***p*-value**	***R*²**	***p*-value**	***R*²**	***p*-value**	***R*²**	***p*-value**	***R*²**	***p*-value**
Age	0.708	<0.001	0.091	<0.001	0.062	<0.001	0.491	<0.001	0.079	<0.001
Gender	0.088	<0.001	0.477	<0.001	0.228	<0.001	0.016	0.026	NS	NS
Education	0.662	<0.001	0.041	0.002	0.023	0.032	0.602	<0.001	0.038	0.003
Profession	0.789	<0.001	0.580	<0.001	0.406	<0.001	0.076	<0.001	0.654	<0.001
Marital status	0.783	<0.001	0.014	0.041	NS	NS	NS	NS	NS	NS
Locality	0.084	<0.001	0.343	<0.001	0.355	<0.001	NS	NS	0.035	0.001
Municipality	0.382	<0.001	0.419	<0.001	0.584	<0.001	0.249	<0.001	0.388	<0.001
Variable categories										
	Est.	***p*-value**	**Est.**	***p*-value**	**Est.**	***p*-value**	**Est.**	***p*-value**	**Est.**	***p*-value**
Age class = [19-36[	0.823	<0.001	-0.195	<0.001	NS	NS	NS	NS	NS	NS
Age class = [36-61[	-0.389	<0.001	NS	NS	-0.130	0.006	0.379	<0.001	-0.148	<0.001
Age class = [61-85[	-0.435	<0.001	0.243	<0.001	0.193	<0.001	-0.476	<0.001	0.162	<0.001
Gender=Male	0.230	<0.001	0.402	<0.001	-0.256	<0.001	0.064	0.026	NS	NS
Gender=Female	-0.230	<0.001	-0.402	<0.001	0.256	<0.001	-0.064	0.026	NS	NS
Education=Illiterate	-0.548	<0.001	0.086	0.049	-0.107	0.010	-0.434	<0.001	-0.114	0.001
Education=Secondary	-0.238	<0.001	NS	NS	NS	NS	0.450	<0.001	NS	NS
Education=University	0.786	<0.001	-0.149	<0.001	NS	NS	NS	NS	0.084	0.016
Profession=Herbalists	NS	NS	0.655	<0.001	-0.593	<0.001	NS	NS	-0.672	<0.001

Profession=Housewives	-0.695	<0.001	-0.385	<0.001	0.346	<0.001	NS	NS	-0.307	0.008
Profession=Job Holders	NS	NS	0.431	<0.001	0.431	0.001	0.257	<0.001	0.371	<0.001
Profession=Shopkeepers	NS	NS	NS	NS	-0.392	0.002	NS	NS	1.000	<0.001
Profession=Students	0.895	<0.001	-0.391	<0.001	NS	NS	-0.114	0.019	-0.392	0.001
Marital status=Single	0.692	<0.001	-0.069	0.041	NS	NS	NS	NS	NS	NS
Marital status=Married	-0.692	<0.001	0.069	0.041	NS	NS	NS	NS	NS	NS
Locality=City	-0.319	<0.001	-0.483	<0.001	-0.452	<0.001	NS	NS	0.121	0.001
Locality=Village	0.319	<0.001	0.483	<0.001	0.452	<0.001	NS	NS	-0.121	0.001
Municipality=Ain-Touila	-0.616	<0.001	-0.527	<0.001	0.038	0.019	0.534	<0.001	-0.430	<0.001
Municipality=Babar	NS	NS	1.193	<0.001	0.572	<0.001	-0.272	0.032	-0.214	0.004
Municipality=Bouhmama	NS	NS	NS	NS	NS	NS	-0.399	<0.001	-0.237	0.001
Municipality=Chechar	NS	NS	-0.353	<0.001	NS	NS	0.281	<0.001	0.295	0.001
Municipality=El Hamma	1.233	<0.001	NS	NS	NS	NS	NS	NS	-0.258	<0.001
Municipality=Kais	NS	NS	NS	NS	0.671	<0.001	0.224	0.005	NS	NS
Municipality=Khenchela	-0.122	0.009	NS	NS	-0.518	<0.001	-0.112	0.006	0.143	0.010
Municipality=Zoui	NS	NS	-0.276	0.014	NS	NS	NS	NS	0.609	<0.001

EV: explained variance, NS: not significant ($p > 0.05$)

Diversity of MAPs and their characteristics

After identifying the plant species reported by the participants, the gathered data is presented and summarized in Table 3, comprises plant families, species with local and vernacular names, geographic origins, morphological types, IUCN red list status, plant parts used, preparation modes, treated diseases, and ethnobotanical indices (FIV, FC, and RFC).

Plant families with their FIV and geographical origin

The study area exhibited considerable floristic richness, comprising 158 species distributed across 62 botanical families. The Asteraceae family dominated with 20 species (4 exotics and 16 natives), followed by Lamiaceae with 16 species (5 exotics and 11 natives), Apiaceae family with 13 species (5 exotics and 8 natives), and Rosaceae with eight species (6 exotics and 2 natives). The Fabaceae and Myrtaceae families were both represented by five species, while the Malvaceae and Zingiberaceae families each had four species. Additionally, the Amaranthaceae, Brassicaceae, Cucurbitaceae, Cyperaceae, Iridaceae, Oleaceae, Poaceae, and Rutaceae families were represented by three species each. The Amaryllidaceae, Araliaceae, Burseraceae, Caprifoliaceae, Caryophyllaceae, Lauraceae, Lythraceae, Moraceae, Pinaceae, Plantaginaceae, Solanaceae, Verbanaceae, and Violaceae families each had two species. Finally, the remaining families were represented by only one species each.

The FIV index was found to be significant (> 0.01) in the following families: Amaryllidaceae, Aspleniaceae, Capparaceae, Equisetaceae, Lamiaceae, Ranunculaceae, Rutaceae, Poaceae, and Lauraceae. Conversely, the remaining families had an FIV of less than 0.01. The results of geographical origin showed that the plants used by indigenous people for treatment were in equal proportions between exotic and native species, 50% each (Figure 4). Pearson correlation tests revealed a significant correlation ($r = 0.26$, $p = 0.035$) between FIV and the number of plant species per family. However, the correlation was not significant ($p > 0.05$) in both exotic ($r = 0.22$) and native ($r = 0.23$) plants taken separately.

Morphological types

As shown in Figure 5, herbs, shrubs, and trees were the preferred morphological growth forms of MAPs used in the study area. Herbs had the highest proportion, with 93 species (59%), followed by shrubs with 36 species (23%), and trees with 29 species (18%). The distribution of plant species among these morphological growth forms was significantly different ($\chi^2 = 46.8$, $df = 2$, $p<0.001$).

Table 3. The ethnobotanical data of medicinal and aromatic plants reported in study area.

Plant family and species binomial name	Vernacular name	Local name	IUCN Status	Part used	Diseases with FL%	Preparation mode	Indices	
							FC	RFC
Acanthaceae (FIV = 0.0033)								
Adhatoda vasica Nees	Malabar Nut	-	LC	Leaf	-B 100% -F 100%	Infusion	1	0.0033
Aceraceae (FIV = 0.0033)								
Acer palmatum Thunb.	Japanese Maple	Alkikab	LC	Aerial parts	-A 100% -R 100%	Decoction Infusion	1	0.0033
Acoraceae (FIV = 0.0033)								
Acorus calamus L.	Calamus	Alwij	LC	Leaf	-SA 100%	Infusion	1	0.0033
Amaranthaceae (FIV = 0.0044)								
Amaranthus retroflexus L.	Redroot Pigweed	Oref Dik	NE	Leaf Stem	-DI 100%	Infusion Powder	1	0.0033
Atriplex rosea L.	Tumbling Saltweed	Gtaf	NE	Leaf	-UD 100%	Infusion	2	0.0067
Hammada scoparia (Pomel)	Saxaul	Remth	LC	Leaf	-DI 100%	Infusion	1	0.0033
Amaryllidaceae (FIV = 0.0117)								
Allium cepa L.	Onion	Basal	NE	Bulb Leaf	-F 66.67% -RI 33.33%	Cooked Infusion Powder	3	0.01
Allium sativum L.	Garlic	Thoom	NE	Bulb Leaf	-CR 25% -F 50% -IWT 25%	Cooked Infusion Powder	4	0.0133
Anacardiaceae (FIV = 0.0067)								
Pistacia lentiscus L.	Lentisk	Dharw	LC	Leaf Seed	-BT 50% -SD 50%	Infusion	2	0.0067
Apiaceae (FIV = 0.0062)								
Anethum graveolens L.	Dill	Chebet	NE	Seed	-SA 100%	Decoction	2	0.0067
Angelica archangelica L.	Garden Angelica	Karfas Barri / Hchichat Malak	LC	Flower	-DI 100% -T 100%	Infusion	1	0.0033
Apium graveolens L.	Wild Celery	Karfas	LC	Root	-IS 100%	Infusion	2	0.0067
Bunium fontanesii (Pers.) Maire	Great Pignut	Talghouda	LC	Aerial parts	-HR 100%	Cooked Powder	2	0.0067
Carum carvi L.	Caraway	Karwiya	LC	Seed	-DI 100%	Infusion Oil	1	0.0033

Centella asiatica (L.) Urb.	Asiatic Pennywort	Sorat Alared Asyawiya	LC	Flower	-BT 50% -DI 50%	Decoction	2	0.0067
Coriandrum sativum L.	Coriander	Kosbor	NE	Leaf	-DI 100%	Infusion	4	0.0133
Cuminum cyminum L.	Cumin	Kamoon	NE	Seed	-DI 100%	Infusion	2	0.0067
Foeniculum vulgare Mill.	Fennel	Shamar/ Basbas	LC	Leaf	-R 100%	Infusion	1	0.0033
Petroselinum crispum (Mill.) Nyman ex A.W.Hill	Parsley	Bakdones	NE	Leaf	-GI 100%	Cooked Infusion	3	0.01
Pimpinella anisum L.	Anise Burnet-Saxifrage	Yansoon / Habit Hlawa	NE	Seed	-DI 100%	Infusion Oil	1	0.0033
Thapsia garganica L.	Deadly Carrots	Boonafea	NE	Aerial parts	-DI 100%	Infusion	2	0.0067
Visnaga daucoides Gaertn.	Toothpick-Plant	Alkhala	LC	Leaf	-AD 100% -KD 100%	Infusion	1	0.0033
Apocynaceae (FIV = 0.0033)								
Nerium oleander L.	Oleander	Defla	LC	Leaf	-SA 100%	Infusion	1	0.0033
Araliaceae (FIV = 0.0033)								
Eleutherococcus senticosus (Rupr. & Maxim.) Maxim.	Siberian Ginseng	Ginseng Lasiia	NE	Leaf	-NSD 100%	Infusion	1	0.0033
Panax ginseng C.A.Mey.	Ginseng	Ginseng	NE	Leaf	-HR 100%	Infusion	1	0.0033
Asphodelaceae (FIV = 0.0067)								
Aloe vera (L.) Burm.f.	Aloe Vera	Sabar	NE	Leaf	-BT 100%	Fresh Infusion	2	0.0067
Aspleniaceae (FIV = 0.01)								
Asplenium ceterach subsp. bivalens (D.E.Mey.) Greuter & Burdet	Rustyback Fern	Kassarit Alhajar	LC	Flower Leaf	-GI 100%	Decoction Infusion	3	0.01
Asteraceae (FIV = 0.006)								
Arctium lappa L.	Greater Burdock	-	LC	Leaf	-H 100%	Infusion	1	0.0033
Artemisia absinthium L.	Absinth Wormwood	Chiba	LC	Leaf	-DI 100%	Infusion	2	0.0067
Artemisia annua L.	Sweet Wormwood	Chih Hawli	NE	Leaf	-RI 100%	Infusion	1	0.0033
Artemisia campestris L.	Field Wormwood	Dgofet	NT	Flower	-AD 100% -F 100% -SA 100%	Infusion	1	0.0033
Artemisia herba-alba Asso	White Wormwood	Chih	NE	Leaf	-DI 33.33% -IWT 66.67%	Decoction	3	0.01
Artemisia vulgaris L.	Common Wormwood	-	LC	Flower	-HR 100%	Infusion	1	0.0033
Chamaemelum nobile (L.) All.	Roman Chamomile	Baboonej Romani	LC	Flower	-RI 100%	Infusion	4	0.0133
Cichorium intybus L.	Chicory	Handibaa	LC	Whole plant	-DI 75%	Decoction	4	0.0133

					-GI 25%	Infusion		
Cynara cardunculus L.	Cardoon Artichoke	Khorchof Chawki	LC	Leaf	-DI 100%	Infusion	1	0.0033
Cynara scolymus L.	Globe Artichoke	Khorchof	NE	Leaf	-LD 66.67%	Decoction	3	0.01
					-GI 33.33%	Infusion		
Dolomiaea costus (Falc.) Kasana & A.K.Pandey	Indian Costus	Kist Alhindi	NE	Steam	-AB 100%	Decoction	1	0.0033
Grindelia camporum Greene	Great Valley Gumweed	Samegh	NE	Leaf	-RI 100%	Infusion	1	0.0033
Gundelia tournefortii L.	Tumble Thistle	Kaoob	NE	Leaf	-DI 100%	Infusion	2	0.0067
Hertia cheirifolia (L.) Kuntze	Barbary Ragwort	Kherchoon	NE	Flower	-FV 50%	Infusion	2	0.0067
					-SD 50%			
Matricaria chamomilla L.	German Chamomile	Baboonej Almani	LC	Leaf	-DI 100%	Decoction	2	0.0067
Silybum marianum (L.) Gaertn.	Milk Thistle	Chook Djmal	LC	Flower	-LD 100%	Infusion	3	0.01
Stevia rebaudiana (Bertoni) Bertoni	Candyleaf	Warak Socari	NE	Leaf	-MD 100%	Infusion	1	0.0033
Tanacetum parthenium (L.) Sch.Bip.	Feverfew	Baboonej Bari	LC	Leaf	-FV 100%	Infusion	1	0.0033
					-H 100%			
					-M 100%			
Taraxacum officinale F. H. Wigg.	Common Dandelion	Tarkhachkon	LC	Flower	-CR 100%	Decoction	1	0.0033
Tussilago farfara L.	Coltsfoot	Hachichat Soal	LC	Leaf	-A 100%	Infusion	1	0.0033
Brassicaceae (FIV = 0.0033)								
Capsella bursa-pastoris (L.) Medik.	Shepherd's Purse	Kis Raai	LC	Flower	-H 100%	Decoction	1	0.0033
					-HR 100%	Infusion		
Eruca sativa Mill.	Garden Rocket	Jerjir	LC	Leaf	-TT 100%	Infusion	1	0.0033
Lepidium sativum L.	Cress	Hab Rechad	NE	Seed	-A 100%	Infusion	1	0.0033
					-M 100%			
Burseraceae (FIV = 0.0083)								
Boswellia sacra Flueck.	Olibanum Tree	Looban	NT	Seed	-MU 100%	Infusion	4	0.0133
Commiphora myrrha (T. Nees) Engl.	Myrrh	-	NE	Leaf	-MU 100%	Decoction	1	0.0033
Cactaceae (FIV = 0.0033)								
Opuntia ficus-indica (L.) Mill.	Prickly pear	Tine Chawki / Hendi	NE	Bark	-SD 100%	Decoction	1	0.0033
						Oil		
Capparaceae(FIV = 0.01)								
Capparis spinosa L.	Caper	Kobar	LC	Leaf	-DI 100%	Infusion	3	0.01
Caprifoliaceae (FIV = 0.0033)								
Lonicera caprifolium L.	Caprifoyle	Chahmit Alatroos	NE	Leaf	-CR 100%	Decoction	1	0.0033
Valeriana officinalis L.	Valerian	-	LC	Leaf	-NSD 100%	Infusion	1	0.0033
Caryophyllaceae (FIV = 0.0033)								

Paronychia argentea Lam.	Algerian Tea	Fotat Alhajar	NE	Aerial parts	-KD 100% -RI 100% -GI 100%	Decoction Infusion	1	0.0033
Saponaria officinalis L.	Bouncing Bet	Sabooniya	LC	Flower	-SD 100%	Infusion	1	0.0033
Cucurbitaceae (FIV = 0.0044)								
Citrullus colocynthis (L.) Schrad.	Colocynth	Handal / H'daj	NE	Aerial parts	-F 50% -GI 50%	Infusion	2	0.0067
Cucurbita pepo L.	Pumpkin	Yaktin	LC	Leaf	-GI 100%	Infusion	1	0.0033
Ecballium elaterium (L.) A.Rich.	Squirting Cucumber	Fagos Hmir	NE	Fruit	-LD 100%	Infusion	1	0.0033
Cupressaceae (FIV = 0.0078)								
Cupressus sempervirens L.	Mediterranean Cypress	Sarou	LC	Leaf	-DI 100%	Decoction	2	0.0067
Juniperus oxycedrus L.	Cade	Araar	LC	Leaf	-DI 100%	Infusion	3	0.01
Thuja plicata Donn ex D.Don	Western Redcedar	Debagha	LC	Aerial parts	-SA 100%	Infusion Powder	2	0.0067
Cyperaceae (FIV = 0.0033)								
Cyperus rotundus L.	Nut Grass	Hab Aziz	LC	Seed	-IS 100%	Infusion	1	0.0033
Ephedraceae (FIV = 0.0033)								
Ephedra sinica Stapf	Chinese Ephedra / Ma Huang	Alanda	LC	Leaf	-C 100%	Decoction	1	0.0033
Equisetaceae (FIV = 0.01)								
Equisetum arvense L.	Field Horsetail	Dil Alhisan	LC	Leaf	-UD 100%	Infusion	3	0.01
Euphorbiaceae (FIV = 0.0033)								
Codiaeum variegatum (L.) Rumph. ex A.Juss.	Fire Croton	Kartoon	LC	Leaf	-FV 100%	Infusion	1	0.0033
Fabaceae (FIV = 0.0047)								
Ceratonia siliqua L.	Carob	Kharob	LC	Fruit	-SD 100%	Infusion	1	0.0033
Glycyrrhiza glabra L.	Liquorice	Irq Soos	LC	Flower Root	-RI 100%	Infusion	2	0.0067
Senna alexandrina Mill.	Alexandrian Senna	Achrak / Achraj	LC	Flower	-SA 100%	Infusion	1	0.0033
Senna occidentalis (L.) Link	Coffee Senna	Senaa Maki	LC	Leaf	-SA 100%	Infusion	2	0.0067
Trigonella foenum-graecum L.	Fenugreek	Helba	NE	Seed	-SA 100%	Infusion	1	0.0033
Gentianaceae (FIV = 0.0033)								
Centaurium erythraea Rafn	Common Centaury	Morarit Hnech	LC	Leaf	-UD 100%	Infusion	1	0.0033
Ginkgoaceae (FIV = 0.0033)								
Ginkgo biloba L.	Ginkgo	Ganka	EN	Leaf	-CVI 100%	Infusion	1	0.0033
Grossulariaceae (FIV = 0.0033)								
Ribes nigrum L.	Black Currant	Alkichmich Alaswad	LC	Flower	-RI 100%	Infusion	1	0.0033

Iridaceae (FIV = 0.0044)								
Crocus sativus L.	Saffron	Zaafran	NE	Flower	-DI 50% -LD 50%	Infusion	2	0.0067
Iris domestica (L.) Goldblatt & Mabb.	Tiger Flower	Onsol	NE	Leaf	-MD 100% -SA 100%	Infusion	1	0.0033
Iris haynei Baker	Gilboa Iris	Saosan	VU	Flower	-UD 100%	Cooked	1	0.0033
Lamiaceae (FIV = 0.0125)								
Ajuga iva (L.) Schreb.	Southern Bugle	Chandgoura	NE	Leaf	-AD 100%	Infusion	2	0.0067
Ajuga reptans L.	Bugle	-	NE	Leaf	-AG 100%	Infusion	1	0.0033
Ballota nigra L.	Black Horehound	Ballota	LC	Flower	-NSD 100%	Decoction	1	0.0033
Clinopodium nepeta (L.) Kuntze	Lesser Calamint	-	NE	Flower	-DI 100%	Decoction	1	0.0033
Lavandula angustifolia Mill.	Lavender	Khezama	LC	Leaf	-A 14.29% -R 14.29% -UD 71.43%	Infusion Oil	7	0.0233
Marrubium vulgare L.	White Horehound	Meriwa	NT	Leaf	-B 50% -C 50%	Infusion	2	0.0067
Melissa officinalis L.	Lemon Balm	Meliles	LC	Leaf	-F 100%	Infusion	4	0.0133
Mentha piperita L.	Mentha	Naanaa	NE	Leaf	-DI 44.44% -RI 55.56%	Infusion Oil	9	0.03
Ocimum basilicum L.	Basil	Rihan / Hebaq	NE	Leaf	-SA 100%	Infusion	3	0.01
Ocimum tenuiflorum L.	Holy Basil / Telsi	Rihan Mokadas	NE	Leaf	-AD 50% -FV 50%	Infusion	2	0.0067
Origanum majorana L.	Marjoram	Mardakouch	NE	Flower	-UD 100%	Infusion	3	0.01
Salvia officinalis L.	Sage	Miramiya	LC	Flower	-HR 25% -RI 25% -UD 50%	Decoction Infusion	4	0.0133
Salvia rosmarinus Spenn. (syn. *Rosmarinus officinalis* L.)	Rosemary	Iklil Jabal	LC	Aerial parts	-DI 42.86% -LD 57.14%	Infusion	7	0.0233
Teucrium polium L.	Felty Germander	Khayata	NE	Leaf	-SA 100%	Infusion Powder	5	0.0167
Thymus vulgaris L.	Common Thyme	Zaatar	LC	Leaf	-DI 28.57% -RI 71.43%	Infusion Oil	7	0.0233
Vitex agnus-castus L.	Chaste Tree	Ochbit Meriem	DD	Aerial parts	-UD 100%	Infusion	2	0.0067
Lauraceae (FIV = 0.01)								
Cinnamomum verum J. Presl	Cinnamon	Korfa	NE	Bark	-A 50%	Infusion	4	0.0133

Laurus nobilis L.	Bay Laurel	Rand	LC	Leaf	-UD 50% -GI 100%	Decoction Infusion	2	0.0067
Linaceae (FIV = 0.0033)								
Linum usitatissimum L.	Common Flax	Bodor Alkitan	NE	Seed	-DI 100%	Infusion	1	0.0033
Lythraceae (FIV = 0.0067)								
Lawsonia inermis L.	Henna	Henna	LC	Leaf	-DI 100%	Powder Poultice/Pad	1	0.0033
Punica granatum L.	Pomegranate	Roman	LC	Fruit Leaf Peel	-SA 100%	Infusion	3	0.01
Malvaceae (FIV = 0.0042)								
Abelmoschus esculentus (L.) Moench	Okra	Bamia / Genawiya / Molokhiya	NE	Bark	-AD 100%	Cooked	1	0.0033
Althaea officinalis L.	Common Marshmallow	Khotami	LC	Leaf	-F 50% -RI 50%	Infusion	2	0.0067
Hibiscus sabdariffa L.	Roselle	Karkadiya	NE	Aerial parts	-DI 100%	Infusion	1	0.0033
Malva sylvestris L.	Blue Mallow	Khobiz	LC	Flower	-DI 100%	Decoction	1	0.0033
Monimiaceae								
Peumus boldus Molina	Boldo	-	LC	Flower	-DI 100%	Decoction	1	0.0033
Moraceae (FIV = 0.005)								
Ficus religiosa L.	Sacred fig	Lsan Osfour	LC	Flower	-F 100%	Infusion	1	0.0033
Morus alba L.	Mulberry	Tout	LC	Flower Fruit	-MU 50% -MD 50%	Decoction	2	0.0067
Myristicaceae (FIV = 0.0033)								
Myristica fragrans Houtt.	Nutmeg	Tib	DD	Seed	-MD 100%	Infusion	1	0.0033
Myrtaceae (FIV = 0.006)								
Eucalyptus globulus L.	Eucalyptus	Kalitoos	LC	Leaf	-F 100%	Infusion	4	0.0133
Melaleuca alternifolia (Maiden & Betche) Cheel	Tea Tree	Chajarit Chay	NE	Leaf	-RI 100% -GI 100%	Infusion	1	0.0033
Myrtus communis L.	Common Myrtle	Misk Almadina	LC	Leaf	-DI 100%	Infusion	2	0.0067
Psidium guajava L.	Guava	Jawafa	LC	Leaf	-F 100%	Cooked Decoction	1	0.0033
Syzygium aromaticum (L.) Merr. & L. M. Perry	Clove	Kronfol	NE	Flower	-F 100% -MU 100%	Infusion Oil Powder	1	0.0033

Nitrariaceae (FIV = 0.0067)								
Peganum harmala L.	African Rue	Harmal	NE	Aerial parts	-IS 100%	Infusion	2	0.0067
Oleaceae (FIV = 0.008)								
Fraxinus excelsior L.	Ash	-	NT	Leaf	-GI 100%	Infusion	1	0.0033
Jasminum officinale L.	Jasmine	Yasmine	NE	Flower	-SA 100%	Infusion	2	0.0067
Olea europaea L.	Olive	Zitoun	DD	Leaf Fruit	-CVI 75% -DI 25%	Infusion Cooked	4	0.0133
Papaveraceae (FIV = 0.0033)								
Papaver rhoeas L.	Common Poppy	AlKhachkhach	LC	Flower	-RI 100%	Infusion	1	0.0033
Pinaceae (FIV = 0.005)								
Pinus halepensis Mill.	Aleppo Pine	Sanawbar	LC	Seed	-SA 100%	Infusion	2	0.0067
Pinus sylvestris L.	Scotch Pine	Sanawbar barri	LC	Flower	-RI 100%	Infusion	1	0.0033
Plantaginaceae (FIV = 0.0033)								
Globularia alypum L.	Shrubby Globularia	Taselgha	LC	Aerial parts	-DI 100%	Decoction Powder	1	0.0033
Plantago lanceolata L.	Narrowleaf Plantain	Lisan Hamel	VU	Flower	-LD 100%	Infusion	1	0.0033
Poaceae (FIV = 0.01)								
Avena sativa L.	Oat	Chofan	LC	Aerial parts	-CVI 100%	Cooked Infusion	2	0.0067
Panicum virgatum L.	Switchgrass	Thamam / Bachna	LC	Stem	-SA 100%	Infusion	2	0.0067
Macrochloa tenacissima (L.) Kunth (syn. *Stipa tenacissima* L.)	Alfa	Halfa	VU	Stem	-GI 100%	Decoction	5	0.0167
Polygonaceae (FIV = 0.0033)								
Fallopia multiflora (Thunb.) Haraldson	Tuber Fleeceflower	-	NE	Leaf	-DI 100%	Infusion	1	0.0033
Primulaceae (FIV = 0.0033)								
Primula veris L.	Cowslip	-	LC	Flower	-DI 100%	Infusion	1	0.0033
Ranunculaceae (FIV = 0.0133)								
Nigella sativa L.	Black Cumin	Haba Sawda	NE	Seed	-AG 50% -RI 50%	Decoction Infusion	4	0.0133
Rhamnaceae (FIV = 0.0033)								
Frangula alnus Mill.	Alder Buckthorn	Sider	LC	Leaf	-DI 100%	Infusion	1	0.0033
Rosaceae (FIV = 0.005)								
Agrimonia eupatoria L.	Common Agrimony	Ghafith	LC	Flower	-TT 100%	Decoction	1	0.0033
Alchemilla acutiloba Opiz	Lady's Mantle	Rejil Assad	LC	Leaf	-UD 100%	Decoction Powder	1	0.0033

Dryas octopetala L.	Mountain Avens	Deryas	NE	Flower	-DI 100%	Infusion	3	0.01
Eriobotrya japonica (Thunb.) Lindl.	Loquat	Bachmala/ Zaaror yaban	NE	Fruit	-MD 100%	Fresh	1	0.0033
				Leaf		Infusion		
Filipendula ulmaria (L.) Maxim.	Meadowsweet	Lehyat Altis	LC	Leaf	-C 100%	Decoction	1	0.0033
					-A 100%			
Prunus cerasus L.	Sour Cherry	Karaz Barri	LC	Leaf	-DI 100%	Infusion	1	0.0033
Prunus dulcis (Mill.) D.A.Webb	Almond	Louz	NE	Leaf	-CR 100%	Infusion	3	0.01
Rubus fruticosus L.	Shrubby Blackberry	Tout Alik	LC	Flower	-RI 100%	Decoction	1	0.0033
Rutaceae (FIV = 0.0111)								
Citrus aurantium L.	Orange	Bortokal	NE	Leaf	-H 100%	Infusion	3	0.01
Citrus limon (L.) Burm.f.	Lemon	Laymoon	LC	Fruit	-C 50%	Decoction	4	0.0133
				Leaf	-F 50%	Infusion		
Ruta graveolens L.	Common Rue	Fijel	LC	Fruit	-SA 100%	Decoction	3	0.01
Salicaceae (FIV = 0.0067)								
Salix alba L.	White Willow	Weraq Safsaf	LC	Flower	-DI 50%	Infusion	2	0.0067
				Leaf	-GI 50%			
Salvadoraceae (FIV = 0.0033)								
Salvadora persica L.	Toothbrush Tree	Siwaq	LC	Leaf	-MU 100%	Infusion	1	0.0033
				Stem				
Santalaceae (FIV = 0.0033)								
Viscum album L.	Mistletoe	-	LC	Leaf	-MD 100%	Infusion	1	0.0033
Sapindaceae (FIV = 0.0033)								
Paullinia cupana Kunth	Guarana	-	NE	Leaf	-DI 100%	Infusion	1	0.0033
Schisandraceae (FIV = 0.0033)								
Illicium verum Hook. f.	Star Anise	Yanson Najmi	NE	Flower	-DI 100%	Infusion	1	0.0033
Smilacaceae (FIV = 0.0033)								
Smilax aspera L.	Salsaparilla	-	LC	Flower	-HR 100%	Decoction	1	0.0033
Solanaceae (FIV = 0.0033)								
Atropa belladonna L.	Belladonna	Set Hosen	NE	Leaf	-SD 100%	Infusion	1	0.0033
Capsicum annuum L.	Cayenne Pepper	-	LC	Leaf	-AS 100%	Infusion	1	0.0033
Tropaeolaceae (FIV = 0.0033)								
Tropaeolum majus L.	Garden Nasturtium	Om Droua	NE	Flower	-IS 100%	Decoction	1	0.0033
Verbenaceae (FIV = 0.005)								
Aloysia citrodora Palau	Lemon Verbena	Louiza Limoniya	NE	Flower	-NSD 100%	Infusion	1	0.0033
Verbena officinalis L.	Common Verbena	Louiza	LC	Leaf	-SA 50%	Decoction	2	0.0067

					-NSD 50%	Infusion		
Violaceae (FIV = 0.0033)								
Viola odorata L.	Sweet Violet	Banafsaj Itri	LC	Flower	-GI 100%	Infusion	1	0.0033
Viola tricolor L.	Wild Pansy	Banafsaj Molawan	LC	Leaf	-DI 100%	Infusion	1	0.0033
Vitaceae (FIV = 0.0067)								
Vitis vinifera L.	Domestic Grape	Waraq Inab	LC	Leaf	-DI 100%	Infusion	2	0.0067
Zingiberaceae (FIV = 0.0067)								
Alpinia officinarum Hance	Lesser Galangal	Kholanjan	NE	Leaf	-DI 100%	Infusion	1	0.0033
Curcuma longa L.	Curcuma	Korkom	DD	Root	-DI 66.67%	Infusion	3	0.01
					-SA 33.33%			
Elettaria cardamomum (L.) Maton	Cardamom	Hil	NE	Seed	-DI 100%	Infusion	1	0.0033
Zingiber officinale Roscoe	Ginger	Zanjabil	DD	Root	-DI 100%	Decoction	3	0.01

IUCN status (**LC**: least concern, **NE**: not evaluated, **NT**: near threatened, **EN**: endangered, **VU**: vulnerable, **DD**: data deficient),

Codes of diseases (**A:** Arthralgia, **AB:** Antibiotic, **AD:** Antidiabetic, **AG:** Analgesic, **AS:** Antiseptic, **B:** Bronchitis, **BT:** Burn treatment, **C:** Colds, **CR:** Cholesterol regulation, **CVI:** Cardiovascular illnesses, **DI:** Digestive illnesses, **F:** Flu, **FV:** Fever, **GI:** Genitourinary infections, **H:** Headache, **HD:** Hormone disorder, **ISD:** Immune system dysfunction, **IWI:** Intestinal worm infection, **KD:** Kidney disorders, **LD:** Liver diseases, **M:** Migraine, **MD:** Metabolic dysfunction, **MU:** Mouth ulcer, **NSD:** Nervous system diseases, **R:** Rheumatism, **RI:** Respiratory infections, **SA:** Stomach ache, **SD:** Skin diseases, **T:** Tonsillitis, **TT:** Toothache, **UD:** Uterine disorders),

Botanical citation indices (**FC**: frequency of citation, **FIV**: family importance value, **FL**: fidelity level, **RFC**: relative frequency of citations)

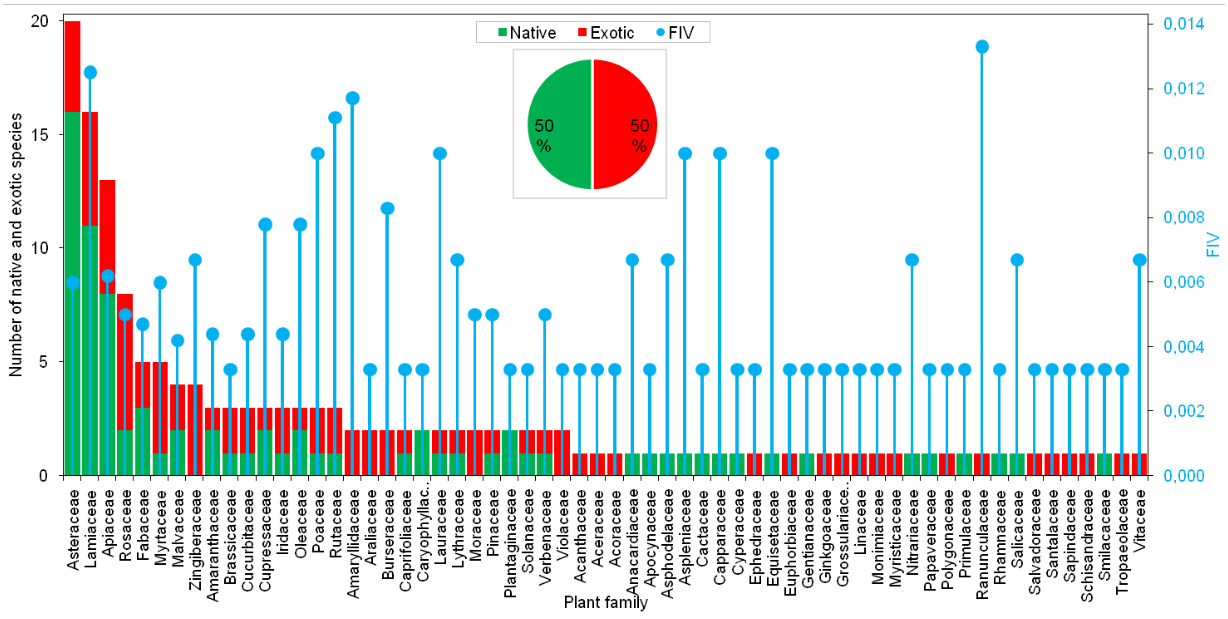

Figure 4. Distribution of the plant species following listed families with FIV and geographical origin.

Plant species with their RFC

The Khenchela region, with its eight municipalities, revealed the presence of 158 species. Based on the RFC index, which indicates the most frequently mentioned plants by respondents, *Mentha piperita* (Lamiaceae) was the most cited plant with an RFC of 0.03. This was followed by three species from the Lamiaceae family: *Lavandula angustifolia*, *Salvia rosmarinus*, *Thymus vulgaris*, each with an RFC of 0.0233. *Macrochloa tenacissima* (Poaceae) and *Teucrium polium* (Lamiaceae) had an RFC of 0.0167. Then, *Allium sativum* (Amaryllidaceae), *Boswellia sacra* (Burseraceae), *Chamaemelum nobile* (Asteraceae), *Cichorium intybus* (Asteraceae), *Cinnamomum verum* (Lauraceae), *Citrus limon* (Rutaceae), *Coriandrum sativum* (Apiaceae), *Eucalyptus globulus* (Myrtaceae), *Melissa officinalis* (Lamiaceae), *Nigella sativa* (Ranunculaceae), *Olea europaea* (Oleaceae), and *Salvia officinalis* (Lamiaceae), each had an RFC of 0.0133. The most frequently cited plants by the respondents belonged to the Lamiaceae family. *L. angustifolia*, *A. sativum*, and *S. rosmarinus* were the most mentioned plants with the highest number of diseases treated (Figure 6). According to Pearson test, the correlation was not significant (r = 0.24, p > 0.05) between RFC and the number of treated diseases counted at the level of each plant species.

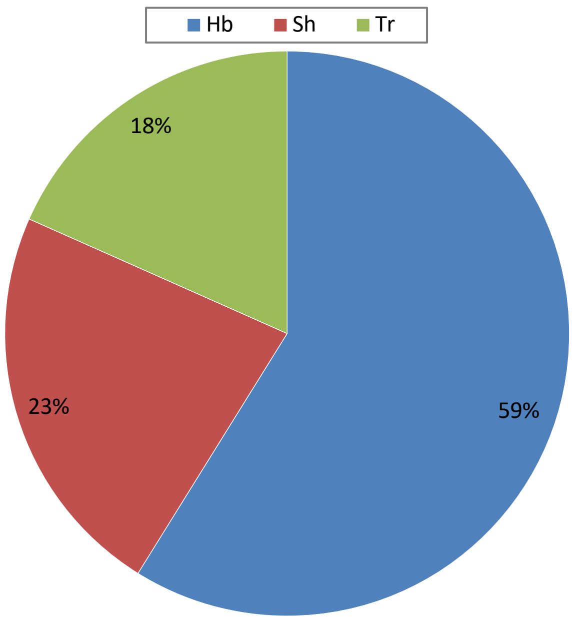

Figure 5. Morphological types of MAPs used in the study area. (Hb: herbs, Sh: shrubs, Tr: trees)

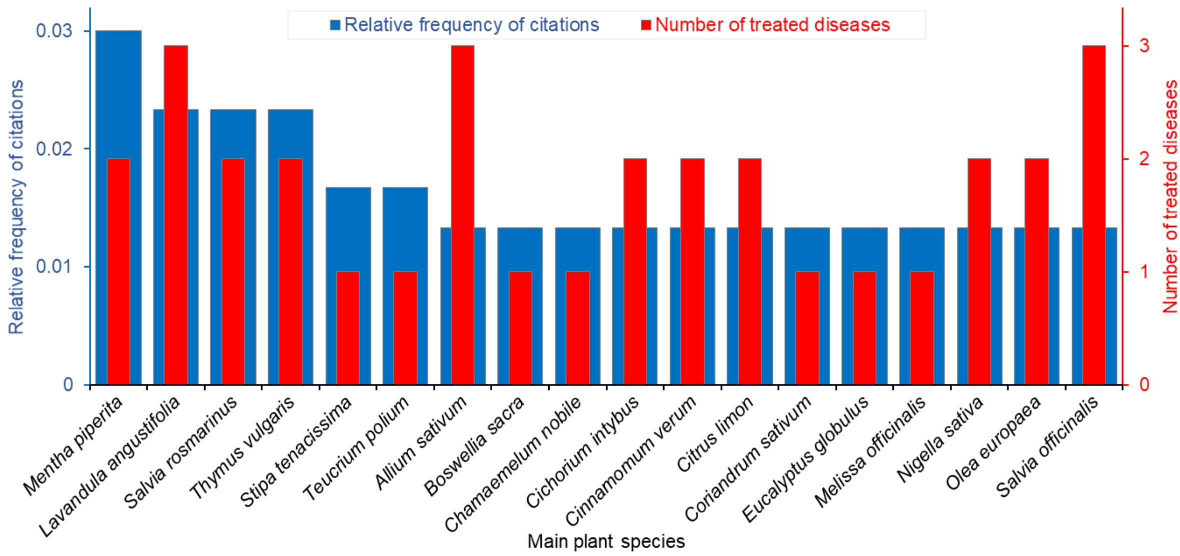

Figure 6. Distribution of the most mentioned plant species with their RFC and number of diseases treated.

Plant status following the IUCN Red List

According to the IUCN Red List of Threatened species, over half (85 species = 54%) of the MAPs mentioned by the respondents were of Least Concern (LC), followed by Not Evaluated plants (NE) (60 species = 38%). Plants for which sufficient data could not be obtained were categorized as Data Deficient (DD) (5 species = 3%), and the remaining plants were categorized as Near Threatened (NT) (2%), which included *Artemisia campestris* (Asteraceae), *B. sacra* (Burseraceae), *Marrubium vulgare* (Lamiaceae), and *Fraxinus excelsior* (Oleaceae). Vulnerable plants (VU) (2%) included *Iris haynei* (Iridaceae), *Plantago lanceolata* (Plantaginaceae), and *Macrochloa tenacissima* (Poaceae). One species, *Ginkgo biloba* (Ginkgoaceae), was categorized as Endangered (EN) (1%) (Figure 7).

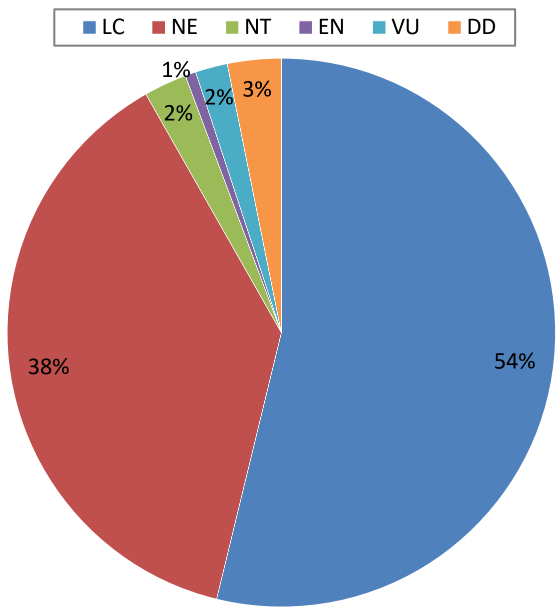

Figure 7. Status of plants studied based on the IUCN Red List of threatened species. (LC: least concern, NE: not evaluated, NT: near threatened, EN: endangered, VU: vulnerable, DD: data deficient)

Characteristics of MAPs uses

Methods of disease diagnosis and uses of MAPs in treatment

According to participant's responses, diagnosis results were most often obtained from herbalists (67%), followed by those who rely on self-diagnosis (30.33%). The percentage of those who visit a doctor was much lower (2.67%). The majority of MAPs seem to alleviate the symptoms of diseases; the percentage (63.33%) was higher compared to those that lead to complete recovery from the disease (36.67%).

Plant parts used with their PPV

The active substances can be found in different parts of the plant; however, the plant parts most commonly used by respondents of this study were the leaves (RU=83, PPV=49.40%), with geographic origins of 42 exotics and 41 native species, and morphological types of 45 herbs, 22 shrubs, and 16 trees. Flowers were also commonly used (RU=39, PPV=23.21%), with geographic origins of 18 exotics and 21 native species, and morphological types of 23 herbs, 9 shrubs, and 7 trees. Other plant parts were not extensively used by respondents: seeds, aerial parts, fruits, roots, bark, bulbs, stems, skin, and the entire plant, which had an RU of 14, 12, 8, 4, 3, 2, 1, 1, 1, respectively, each with a low PPV (PPV < 10%). The PPV values decreased significantly for seeds (8.33%), aerial parts (7.14%), fruits (4.76%), roots (2.38%), bark (1.79%), and bulbs (1.19%). Stem, peel, and whole plant parts had a similar PPV of 0.60% each (Figure 8).

Preparation modes

The most common methods of using MAPs mentioned by interviewees were infusion and decoction, with rates of 65.46% and 19.59% respectively; the geographic origins for these were 63 exotics and 64 native species, and 18 exotics and 20 native species, respectively. The morphological types included 75 herbs, 28 shrubs, and 24 trees for infusion, and 22 herbs, 8 shrubs, and 8 trees for decoction. There was then a sharp decline in the percentages of other methods, which were as follows: powder 5.15%, cooked 4.64%, oil 3.61%, fresh 1.03%, and poultice/pad 0.52% (Figure 9).

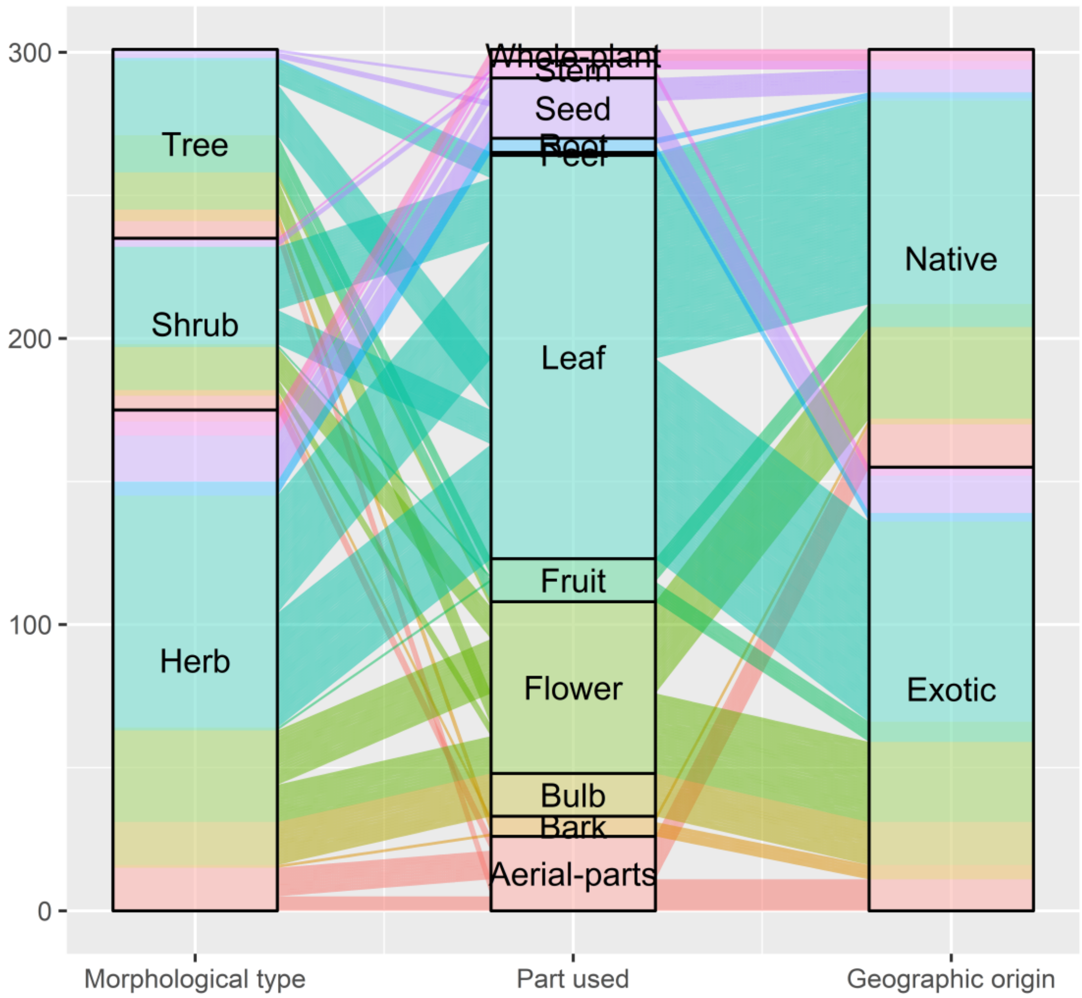

Figure 8. Distribution of plant parts used with their geographic origins and morphological types.

Diseases treated according to ICF

According to the ICF index, the plants *Prunus dulcis* (0.67), *O. europaea* (0.6), *L. angustifolia* (0.57), *S. rosmarinus* (0.55), *Artemisia herba-alba* (0.5), and *N. sativa* (0.5) showed moderate effectiveness against cholesterol regulation, cardiovascular illnesses, uterine disorders, liver diseases, intestinal worm infection, and analgesic, respectively. *T. polium* (0.48), *M. piperita* (0.46), *T. vulgaris* (0.46), *B. sacra* (0.43), *M. tenacissima* (0.43), *Apium graveolens* (0.40), *Peganum harmala* (0.40), *C. sativum* (0.39), *M. piperita* (0.39), *E. globulus* (0.38), and *M. officinalis* (0.38) showed below average effectiveness against stomach ache, respiratory infections, mouth ulcer, genitourinary infections, immune system dysfunction, digestive illnesses, and flu, respectively. The other plants had low effectiveness against the diseases mentioned by the respondents (Table 4).

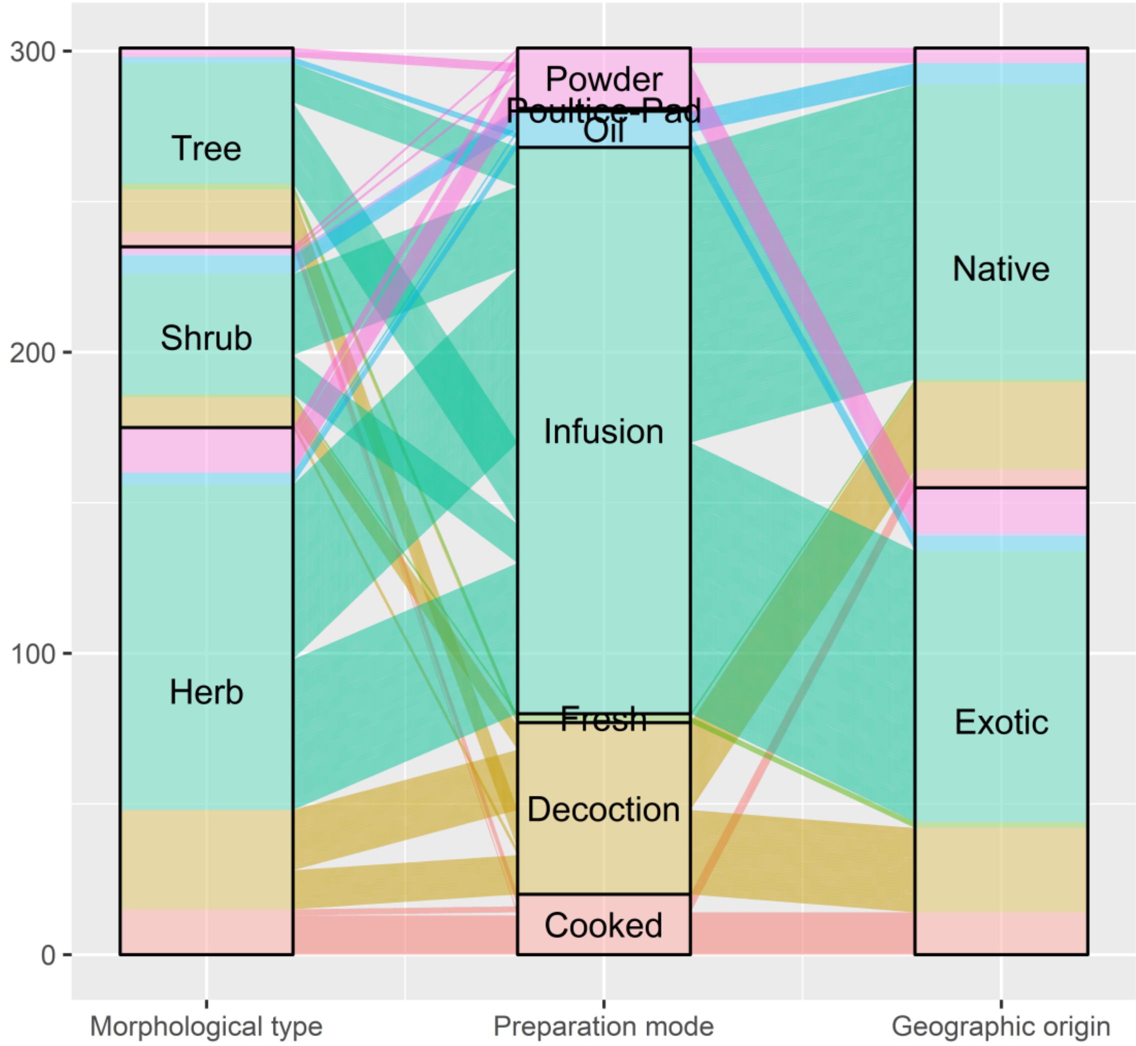

Figure 9. Distribution of preparation modes of herbal formulations used by respondents with their geographic origins and morphological types.

Figure 10 illustrates a heatmap and hierarchical clustering of four key factors: parts used of the plant, preparation modes, Geographic origins, and morphological types, in relation to the diseases treated as mentioned in this investigation. Bright blue indicates the lowest values, while bright red indicates the highest values for each factor. Leaves were the most commonly used part plant for treating the majority of diseases, followed by flowers, with other plant parts used less frequently. Diseases were evenly treated by both exotic and native species. Herbs were the most plant type used for treating most diseases, followed by trees.

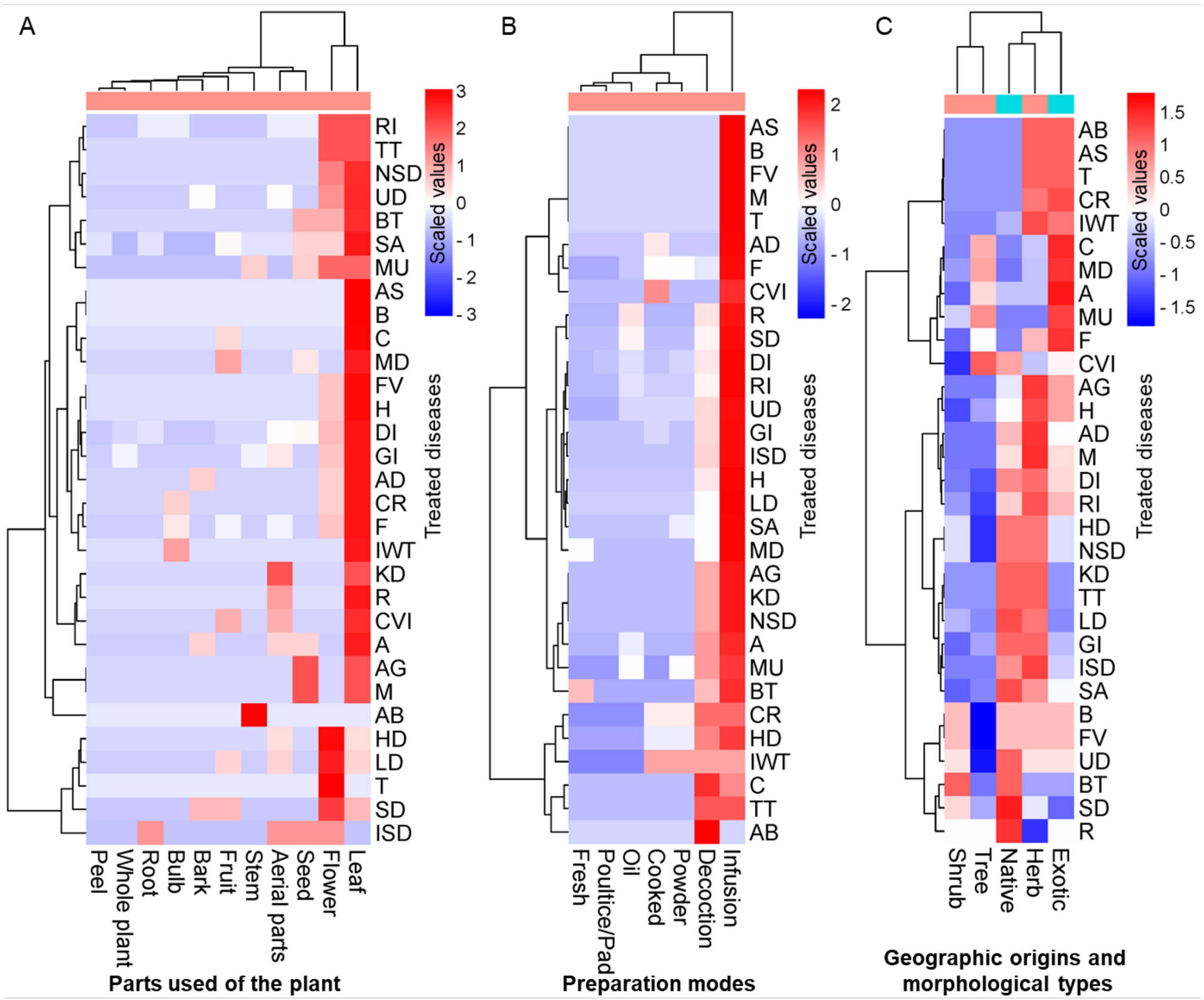

Figure 10. Heatmaps displaying the distribution of PAM uses by respondents based on plant parts used (A), preparation modes of herbal preparations (B), and geographical origins and morphological types (C) for different treated diseases. See Table 4 for the abbreviations of the treated diseases. Red and blue colors designate high and low values of the scaled data, respectively. The double clustering used the Ward's method, and Euclidian distance determined cluster distances.

Table 4. Values of informant consensus factor (ICF) by category for the treatment of different diseases

Category of diseases	N_{ur}	N_t	ICF	Important plant of this categories
Analgesic (AG)	3	2	0.50	*Nigella sativa* L.
Antibiotic (AB)	1	1	0	*Dolomia eacostus* (Falc.) Kasana & A.K.Pandey
Antidiabetic (AD)	6	5	0.20	*Ajuga iva* (L.) Schreb.
Antiseptic (AS)	1	1	0	*Capsicum annuum* L.
Arthralgia (A)	7	6	0.17	*Cinnamomum verum* J. Presl
Bronchitis (B)	2	2	0	*Adhatoda vasica* Nees
Burn treatment (BT)	4	3	0.33	*Aloe vera* (L.) Burm.f.
Cardiovascular illnesses (CVI)	6	3	0.60	*Olea europaea* L.
Cholesterol regulation (CR)	6	4	0.67	*Prunus dulcis* Mill.) D.A.Webb
Colds (C)	5	4	0.25	*Citrus limon* (L.) Burm.f.
Digestive illnesses (DI)	73	45	0.39	*Coriandrum sativum* L. *Mentha piperita* L.
Fever (FV)	4	4	0	*Codiaeum variegatum* (L.) A. Juss.
Flu (F)	25	16	0.38	*Eucalyptus globulus* L. *Melissa officinalis* L.
Genitourinary infections (GI)	22	13	0.43	*Macrochloa tenacissima* L.
Headache (H)	6	4	0.40	*Citrus aurantium* L.

Hormone disorder (HD)	7	6	0.17	*Bunium mauritanicum* (Boiss. & Reut.) Batt.
Immune system dysfunction (ISD)	6	4	0.40	*Apium graveolens* L.
				Peganum harmala L.
Intestinal worm infection (IWI)	3	2	0.5	*Artemisia herba-alba* Asso
Kidney disorders (KD)	2	2	0	*Paronychia argentea* Lam.
				Visnaga daucoides Gaertn.
Liver diseases (LD)	12	6	0.55	*Salvia rosmarinus* L.
Metabolic dysfunction (MD)	6	6	0	*Eriobotrya japonica* (Thunb.) Lindl.
				Myristica fragrans Houtt
				Stevia rebaudiana (Bertoni) Bertoni
				Viscum album L.
Migraine (M)	2	2	0	*Lepidium sativum* L.
				Tanacetum parthenium (L.) Sch.Bip.
Mouth ulcer (MU)	8	5	0.43	*Boswellia sacra* Flueck.
Nervous system diseases (NSD)	5	5	0	*Aloysia citrodora* Palau
				Ballota nigra L.
				Eleutherococcus senticosus (Rupr. & Maxim.) Maxim.
				Valeriana officinalis L.
Respiratory infections (RI)	29	16	0.46	*Mentha piperita* L.
				Thymus vulgaris L.
Rheumatism (R)	3	3	0	*Foeniculum vulgare* Mill.
Skin diseases (SD)	6	6	0	*Atropa belladonna* L.
				Ceratonia siliqua L.
				Opunita ficus-indica (L.) Mill.
				Saponaria officinalis L.
Stomach ache (SA)	34	18	0.48	*Teucrium polium* L.
Tonsillitis (T)	1	1	0	*Angelica archangelica* L.
Toothache (TT)	2	2	0	*Agrimonia eupatoria* L.
				Eruca sativa Mill.
Uterine disorders (UD)	22	10	0.57	*Lavandula angustifolia* Mill.

Fidelity level

The FL was used to evaluate the relative importance of MAPs within a disease or therapeutic class. The MAPs with the highest FL values, estimated at (100%), were the most mentioned for treating the following diseases: antibiotic, antiseptic, tonsillitis, analgesic, bronchitis, intestinal worm infection, kidney disorders, migraine, toothache, burn treatment, cardiovascular illnesses, rheumatism, colds, cholesterol regulation, fever, headache, and immune system dysfunction. The respective plants were: *Dolomiaea costus* (Asteraceae), *Capsicum annuum* (Solanaceae), *Angelica archangelica* (Apiaceae), *Ajuga reptans* (Lamiaceae), *Adhatoda vasica (*Acanthaceae), *A. sativum (*Amaryllidaceae*), Visnaga daucoides* (Apiaceae), *Lepidium sativum* (Brassicaceae), *Agrimonia eupatoria* (Rosaceae), *Centella asiatica* (Apiaceae), *Avena sativa* (Poaceae), *Acer palmatum* (Aceraceae), *C. limon* (Rutaceae)*, Taraxacum officinale* (Asteraceae), *Tanacetum parthenium* (Asteraceae)*,* and *Tropaeolum majus* (Tropaeolaceae).

The number of plant species used to treat only digestive illnesses reached 45 species, including *Curcuma longa* (Zingiberaceae)*, O. europaea* (Oleaceae), *C. asiatica* (Apiaceae), *C. intybus* (Asteraceae), *Salix alba* (Salicaceae), *S. rosmarinus* (Lamiaceae), *T. vulgaris* (Lamiaceae), *A. herba-alba* (Lamiaceae), and *M. piperita* (Lamiaceae), with an FL rate of 88%. This was followed by 18 species, such as *C. longa* (Zingiberaceae) and *Verbena officinalis* (Verbenaceae), used to treat stomach ache, with a rate of FL reached 93.5%. The plant species with the lowest FL value of 45.8% among MAPs were *A. herba-alba* and *C. longa,* which treat therapeutic classes like intestinal worm infection, digestive illnesses, and stomach ache (Figure 11). Pearson correlation test revealed a non-significant correlation (r = -0.002, p > 0.05) between FL and the number of plant species used per disease.

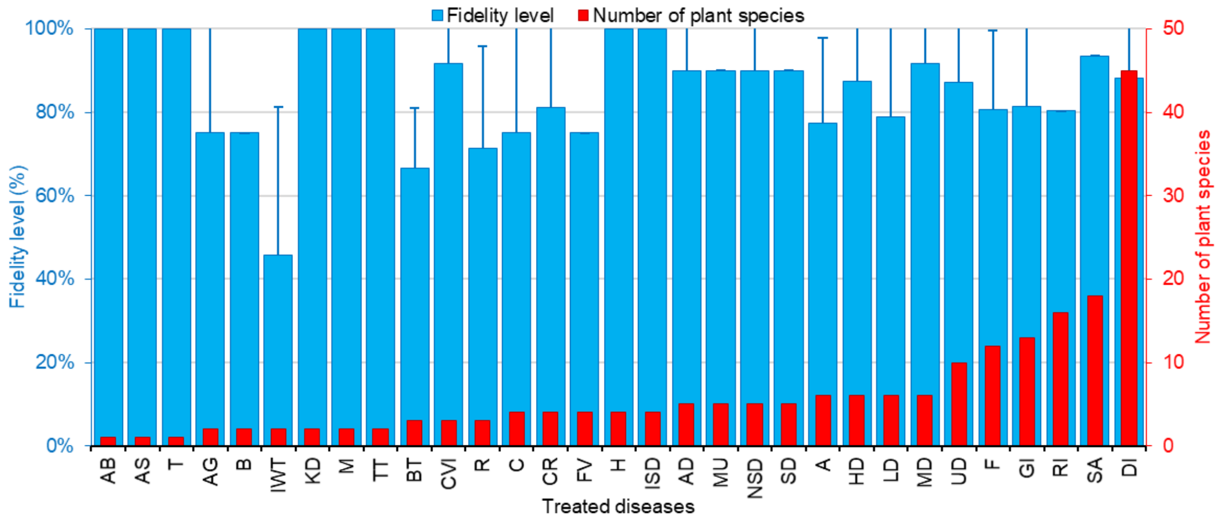

Figure 11. Values of fidelity level (FL) and number of plant species used for the treatment of different diseases. Vertical error bars represent standard deviations per diseases.

Discussion

Sociodemographic characteristics of interviewees

The high utilization of MAPs for medicinal purposes by all study participants can be attributed to the Khenchela region's predominantly mountainous landscape, which offers significant environmental diversity and a rich ethnobotanical heritage. These easily accessible and affordable resources make plants an integral part of the population's daily therapeutic, social, and economic practices. This finding aligns closely with the research conducted by Eddouks *et al.* (2017), Benamar *et al.* (2023), and Jan *et al.* (2023). Several researchers have supported findings of this study, noting the prevalence of older individuals in the field of traditional plant therapy. This is attributed to their extensive experience compared to the younger generation, who often display less interest in indigenous knowledge (Benkhaira *et al.* 2021, Tahir *et al.* 2021, Prinsloo *et al.* 2023). The declining interest of the younger generation can be influenced by factors such as modernization, globalization, and changing living standards, especially in urban areas, which drive them towards pharmaceuticals (Heera *et al.* 2023, Mustafa *et al.* 2023). Consequently, this has resulted in the loss of traditional knowledge (Sargin 2015, da Silva *et al.* 2024). However, it is encouraging to observe that in the study area, continuous and mutual visits between young people and their elders help facilitate the transfer and preservation of traditional and local knowledge, as mentioned by Nkhabutane *et al.* (2019). The dominance of women in the field of MAPs can be attributed to their greater knowledge and expertise in the preparation and management of these plants compared to men. This is largely due to the broader responsibilities women often have in caring for themselves, their children, and even their male counterparts. Similar findings have been observed in other ethnobotanical studies (Alaoui & Laarbya 2017, Mohammadi *et al.* 2023). However, Bahadur *et al.* (2023) found that men are more knowledgeable and active in the field of MAPs than women. This disparity was explained by Yassin *et al.* (2015), who noted that in some patriarchal societies, cultural traditions restrict women's mobility, thereby limiting their contributions to the transmission and use of traditional knowledge of MAPs.

The results regarding education consistently demonstrated a relationship between indigenous knowledge and education level. This can be explained by the fact that individuals with a higher level of education are aware of the negative impact of chemically synthesized medicines, motivating them to return to their ancestral traditions. However, these findings contrast with the perspectives of Sharafatmandrad and Khosravi Mashizi (2020), Gebru *et al.* (2021), da Silva *et al.* (2024), and Rahim *et al.* (2023), who suggested that increased formal education leads to a decline in indigenous traditional knowledge. These authors argued that educational institutions and the urban environments associated with them contribute to a disconnection from nature, resulting in a loss of knowledge about MAPs. Similarly, Jan *et al.* (2022) observed that educated individuals tend to replace traditional treatment methods with modern approaches. Based on the responses of participants familiar with indigenous knowledge of MAPs, it became evident that different segments of society, according to their professions, showed significant interest in the use of MAPs. The majority agreed that housewives were the most interested group in using MAPs, with a high percentage of 50.33%. This can be attributed to the fact that this group plays multiple roles: mothers, caregivers, intellectuals, and elders who take care of all the household members, necessitating their familiarity with the hidden secrets of herbal medicine.

The findings pertaining to marital status align with several previous studies (El-Assri *et al.* 2021, Benamar *et al.* 2023, Jeddi *et al.* 2024), highlighting the prevalence of married individuals in the utilization and dissemination of knowledge about MAPs compared to their unmarried counterparts. This can be attributed to their close interactions with older family members who possess expertise in this domain, as well as the increased responsibilities that come with marriage, often involving the management of larger households. Consequently, married individuals are inclined to explore natural therapeutic resources as a means to reduce expenses associated with costly treatments in modern medical facilities, particularly among families with moderate to low incomes. The substantial number of interview participants from urban areas who exhibit familiarity with indigenous knowledge of MAPs may be indicative of a growing cultural reliance on traditional medicine. This reliance can be attributed to the abundance of MAPs in Khenchela and its surrounding regions, characterized by mountainous terrain, as well as the intergenerational transmission of knowledge about these plants. Additionally, the affordability and efficacy of MAPs in treating various ailments, such as abdominal pain, diarrhea, cough, and fever, further reinforce their significance. These findings are consistent with other studies (Demie *et al.* 2018, Tefera & Kim 2019). Conversely, research conducted by Hachlavi *et al.* (2022) and Febriyanti *et al.* (2024) suggests that traditional medicine holds more prominence in rural areas, attributable to limited access to healthcare facilities and constrained financial resources in these regions. Consequently, individuals in rural areas resort to natural remedies that have demonstrated effectiveness and have been passed down through generations.

The results of the MCA indicate a widespread interest in the utilization of MAPs across various segments of society. Housewives emerged as the most prominent group in this regard due to their multifaceted roles, necessitating knowledge of traditional herbal remedies to care for all household members under their responsibility. Furthermore, women exhibit a greater propensity for incorporating traditional knowledge and methods in the preparation of MAPs as part of their daily routines, not only for their personal well-being but also for the welfare of their children and male family members. Consequently, their contributions to the transmission of this knowledge are highly significant. There is a strong correlation between these factors and the social status of individuals, as married individuals tend to hold a dominant position in the utilization and transmission of knowledge regarding MAPs, as compared to their unmarried counterparts. This is likely attributed to the increased responsibilities that come with having dependents, which in turn necessitates seeking guidance from experienced individuals, particularly older men and women, and locating accessible and affordable natural treatment resources. Given the predominantly forested and mountainous nature of the study area, a significant majority of the population possesses extensive knowledge of MAPs and has passed down this knowledge through generations, thus creating a region-specific cultural tradition. The efficacy and cost-effectiveness of these remedies, combined with an escalating level of education, have further strengthened the significance of adhering to this cultural tradition, particularly in light of global concerns surrounding the adverse effects of modern medicines.

Diversity of MAPs

The study revealed a diverse range of plant species mentioned by participants, reflecting both their personal experiences and the environmental diversity of the region. The region encompasses cold mountainous areas, moderate steppe, and hot desert zones, all of which provide suitable habitats for various plant species. The dominant families among the mentioned MAPs were Lamiaceae and Asteraceae, likely due to their widespread distribution in the region and extensive traditional medicinal uses. These findings were consistent with the results reported in numerous studies (Hosseini *et al.* 2019, Sharafatmandrad and Khosravi Mashizi 2020, Zouaoui *et al.* 2020, Senoussi *et al.* 2021). The study also found an equal proportion of exotic and native species, which could be attributed to the local population's search for MAPs regardless of their origin. Traditional medicine, often transmitted by illiterate individuals who inherited treatments without knowledge of plant geographical origins, may contribute to this phenomenon. Furthermore, the acquisition of plant species extends beyond direct collection from nature, as plants can also be obtained from sources such as the elderly, who keep MAPs in their homes, herbalists, and healer shops. Therefore, the exploration of traditional medicine is essential for the development of novel pharmaceuticals (Mohtashami *et al.* 2021).

The study area is characterized by a diverse environment consisting of mountains, plains, and deserts, where herbaceous plants are plentiful. The local population engages in activities such as cultivation and reproduction of herbaceous plants, making their availability and use in various fields, including medicine, relatively easy. As a result, herbaceous plants were found to be the most frequently used, followed by shrubs, which are also relatively easy to harvest, grow, and utilize within the study environment. Trees, on the other hand, were less utilized due to their larger size and the challenges associated with harvesting their various parts. These findings align with the results reported by Li *et al.* (2024).

The highest RFC values indicated that the most frequently mentioned plants by participants belonged to the Lamiaceae family, which is consistent with the findings of Bekalo *et al.* (2009). This suggests that these species hold significant traditional value in the local area for treating various diseases. However, MAPs face significant pressures, both natural (such as climate change and forest fires) and human-induced (such as excessive harvesting and overgrazing). Therefore, effective measures are necessary to preserve these plants and enhance their resilience. In the study area, 158 documented MAP species used for treatment were assessed based on the IUCN red list categories. Among these, four species were classified as Near Threatened (NT), three as Vulnerable (VU), and one as Endangered (EN), while the majority, 85 species, were classified as Least Concern (LC). This suggests that most species are currently not at risk of extinction (IUCN 2021).

Characteristics of MAPs uses

Herbalists ranked first in terms of patient visits for disease diagnosis in the study area, accounting for 67% of visits, surpassing those who relied on self-diagnosis at 30.33%. Conversely, doctors had the lowest ranking, with only 2.67% of patients seeking their expertise. These findings underscored the population's strong preference for traditional medicine, their high level of trust in herbalists, and the perceived effectiveness and affordability of MAP-based treatments. This effectiveness has also encouraged self-treatment, as people share tried-and-true recipes. In contrast, the role of doctors in disease diagnosis has diminished, likely due to the high costs associated with medical care, limited financial resources among the population, and awareness of the side effects of chemically manufactured drugs. The study results indicated that the majority of MAP-based treatments (63.33%) were effective in alleviating disease symptoms, while only 36.67% led to a complete recovery. This may be attributed to an incomplete understanding of the active biological compounds responsible for treatment and the precise dosage needed, as most methods of preparing and consuming natural medicines are arbitrary and approximate.

The current study unveiled that the inhabitants of the region have utilized various parts of plants to prepare traditional medicines. Leaves were found to be the most commonly used part, representing 52.08% of plant parts utilized, according to the PPV values. The preference for leaves in traditional medicine preparation is advantageous for plant conservation, as it avoids uprooting plants or harvesting their flowers or entire aerial parts. Similar findings have been reported in other ethnobotanical studies (Agyare *et al.* 2018, Chaachouay *et al.* 2019, Tefera & Kim 2019, Uzun & Koca 2020). This preference for leaves has been attributed to their ease of collection, abundance, and the belief that they contain a high concentration of active natural compounds due to their role in photosynthesis, contributing to the plant's therapeutic effects (El Hachlafi *et al.* 2022).

The residents of the region utilized various methods to prepare treatments using MAPs. Infusion was the most commonly employed method, followed by decoction, with other methods being used to a lesser extent. Our findings are consistent with previous research conducted by Bulut *et al.* (2017) and Uzun and Koca (2020). The preference for infusion and decoction may be attributed to their simplicity in preparation and their effectiveness in extracting active ingredients that aid in alleviating various diseases (Jan *et al.* 2023).

Based on reports from study participants, a total of 31 disease categories were identified, with 158 plant species documented for treatment within the study area. High Informant Consensus Factor (ICF) values indicate that the majority of individuals used MAPs for common diseases, whereas low or no ICF values suggest disagreement among participants regarding which species should be used to treat specific diseases (Gazzagno *et al.* 2005, Mustafa *et al.* 2023). *P. dulcis* was the most popular plant used for regulating cholesterol, displaying the highest ICF value of 0.67. Osman and Al-Naggar (2023) have confirmed the significant impact of this plant on lipid reduction. *O. europaea*, with an ICF of 0.6, emerged as the most commonly used plant for cardiovascular diseases. Studies on *O. europaea* leaf extracts indicate that secoiridoids may possess advantageous effects on inflammatory markers associated with cardiovascular diseases (Filardo *et al.* 2024). *Lavandula angustifolia* exhibited an ICF of 0.57 for the treatment of uterine disorders, with Mazzei *et al.* (2024) noting its historical use in menstrual regulation.

High FL values indicate that each of the plants under investigation possesses specific activity against a particular type of disease. Our findings align with Ralte *et al.* (2024), who attribute this to the presence of active compounds in these plants that combat diseases, emphasizing the need for further extraction and study of these compounds in all plants with high FL values to confirm their effectiveness. Conversely, many plant species with lower FL values were often combined to treat a single disease, such as gastrointestinal disorders or stomach pain. Moreover, some plants with low FL values were employed to address broader disease categories, including digestive system issues like stomach pain and intestinal worm infection.

Conclusion

The use of MAPs plays a crucial role in treating various ailments that are prevalent among the population in the study area. These MAPs serve as alternatives to synthetic medicines. The collected data from the investigation showed that 100% of participants rely on MAPs for creating traditional remedies. In this study, 158 species from 62 plant families have been identified. In Algeria, especially in its northeastern regions, traditional knowledge of MAPs is primarily held by herbalists, traditional healers, and elderly individuals. While this knowledge is typically passed down within communities, there is an urgent need to document it to ensure its preservation. These traditional remedies, which have been validated by generations of use, now stand as viable alternatives to modern medicine. The field of plant medicine is influenced by social and demographic factors, as well as the condition of the mentioned plants in their natural habitat. This emphasizes the importance of integrating this knowledge into educational curricula. By doing so, we can enhance understanding, affirm its significance, and emphasize the necessity of teaching it in schools and passing it on to future generations.

Declarations

List of abbreviations: FC - frequency of citation, FIV - family importance value , FL - fidelity level, ICF - informant Consensus Factor, Ip - citations number of a particular plant used for a specific sickness**.,** IUCN - international union for conservation of nature, Lu - total number of citations of this plant used for the treatment to any use, MAPs - medicinal and aromatic plants, MCA - multiple component analysis, N - total number of survey participants, Ns - total number of cited species within each family, Nt - number of medicinal plants used to treat an illness., Nur - number of citations of a particular illness category, PPV - plant part value, RFC - relative frequency of citations, RU - total number of uses of plant part.

Ethics approval and consent to participate: Verbal informed consent was obtained from all participants prior to their involvement in the survey.

Competing Interests: The authors declare that there is no conflict of interest.

Availability of data and materials: The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Funding: This study was not funded by any source.

Consent for publication: Not applicable.

Author contributions: Djamel Bensizerara: Conceptualization, Methodology, Resources, Investigation, Writing - Original Draft, Writing - Review & Editing. Aicha Khemili: Methodology, Investigation, Writing - Original Draft. Rayen Hassad: Methodology, Investigation. Khaoula Aroua: Methodology, Writing - Original Draft. Hanane Mellal: Methodology. Haroun Chenchouni: Validation, Formal analysis, Visualization, Writing - Original Draft, Writing - Review & Editing.

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