



Ethnobotanical knowledge and medicinal plant use in Khenchela Province (Northeastern Algeria)

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Research

Abstract

Background: Alongside the development of modern healthcare systems, medicinal plants continue to play an important role in local therapeutic practices. Their sustained and growing use is largely associated with their therapeutic value and the relatively low risk of undesirable effects. In this context, the documentation of traditional plant-based knowledge is essential to prevent its gradual disappearance and to ensure its continuity over time.

Methods: This ethnobotanical study was conducted to document the medicinal plant species used by inhabitants of the Khenchela region and to record their associated therapeutic uses. Data collection was carried out through structured interviews using 488 questionnaires.

Results: The study recorded 85 medicinal plant species belonging to 39 botanical families. The most cited species was *Artemisia herba-alba* (RFC = 0.096). Asteraceae was the most represented family (15%), followed by Lamiaceae (14%) and Apiaceae (8%). Leaves were the most frequently used plant part (36%), while decoction was the dominant method of preparation (38%). The majority of reported uses targeted digestive disorders (21%), followed by respiratory and dermatological diseases (12% each).

Conclusions: By providing detailed insight into local medicinal plant practices, this study contributes to the preservation of ethnobotanical knowledge and offers a reliable reference framework for future research in phytochemistry and pharmacology.

Keywords: Ethnobotanical Surveys; Khenchela; Medicinal Plants; Methods of Preparation; Uses.

Background

For centuries, human societies have progressively developed medical and technological knowledge, often accompanied by a gradual distancing from natural environments. In recent decades, however, the recognized limitations of modern medicine

have prompted a renewed interest in traditional healthcare systems, particularly phytotherapy, which emphasizes the use of plant-based remedies generally perceived as safer and associated with fewer adverse effects (Béné *et al.* 2016).

The increasing prevalence of infectious, degenerative, and metabolic diseases, combined with environmental degradation and changes in dietary habits, has led to an extensive reliance on synthetic substances such as antibiotics, anticancer drugs, and pesticides. Although these compounds have significantly improved public health, their widespread use has raised concerns related to toxicity, side effects, and the growing problem of antimicrobial resistance. Consequently, scientific research has increasingly focused on natural alternatives derived from medicinal plants, which are considered promising sources of bioactive compounds with potential therapeutic value and improved safety profiles (Bouyahyaoui 2017, Ghedadba 2018).

In Algeria, the traditional medicine use remains deeply rooted in cultural practices and has experienced renewed momentum, particularly during the COVID-19 pandemic, when the absence of specific treatments reinforced public confidence in natural remedies. Medicinal plants continue to be widely utilized owing to their availability, affordability, and perceived effectiveness, especially in rural and semi-rural communities.

Due to its strategic location at the crossroads of the Mediterranean and sub-Saharan Africa, Algeria is characterized by remarkable floristic diversity, with approximately 3,000 plant species, of which nearly 15% are endemic (Daroui-Mokaddem 2012). This exceptional botanical richness is closely linked to a long-standing ethnobotanical knowledge system, transmitted across generations and reflecting a strong interaction between local populations and their natural environment.

Although ethnobotanical studies are increasing in Algeria, the province of Khenchela remains underrepresented. Previous investigations have mainly focused on general inventories of medicinal plants, with limited application of quantitative ethnobotanical indices such as the Relative Frequency of Citation (RFC), and insufficient detail regarding preparation methods and patterns of use. Moreover, there is a lack of recent data on traditional knowledge in this region, which is increasingly threatened by rapid socio-cultural changes. Therefore, conducting an in-depth and quantitative assessment of the ethnobotanical heritage of this area is essential to ensure its proper documentation, preservation, and scientific valorization.

To address these gaps, the present study aims to:

- (i) document the diversity of medicinal plants used by the local population in Khenchela Province;
- (ii) analyze their modes of preparation and therapeutic applications;
- (iii) quantify their cultural importance using ethnobotanical indices such as RFC; and
- (iv) contribute to the preservation of traditional knowledge and its potential valorization in pharmacological research.

Materials and Methods

Study area

Located in northeastern Algeria within the Aurès mountain range, the Khenchela area occupies a contact zone between the steppe belt and the high plateaus (Fig. 1). This distinctive setting gives rise to a heterogeneous landscape combining forest formations, agro-pastoral environments, and elements characteristic of Saharan ecosystems (Fig. 1). Climatically, the area is marked by a gradual transition, with semi-arid conditions prevailing in the northern highlands, continental influences dominating the central mountainous sector, and arid desert conditions characterizing the southern part of the region.

Covering 9,715 km², the Khenchela landscape is characterized by a remarkable extent of vegetation, estimated at around 128,898 hectares, which hosts a mosaic of natural plant communities. The forested areas are dominated by species such as Aleppo pine (*Pinus halepensis*), Atlas cedar (*Cedrus atlantica*), Holm oak (*Quercus ilex*), Phoenician juniper (*Juniperus phoenicea*), and Prickly juniper (*Juniperus oxycedrus*) (Bouafia, 2015). In addition, the region supports other ecologically and economically important flora, including Wormwood (*Artemisia herba-alba*), various *Atriplex* species, and jujube (*Ziziphus* spp.), contributing to the diversity and resilience of the local ecosystems.

Administratively, the area is organized into eight districts comprising 21 municipalities and hosts an estimated population of about 510,000 residents.

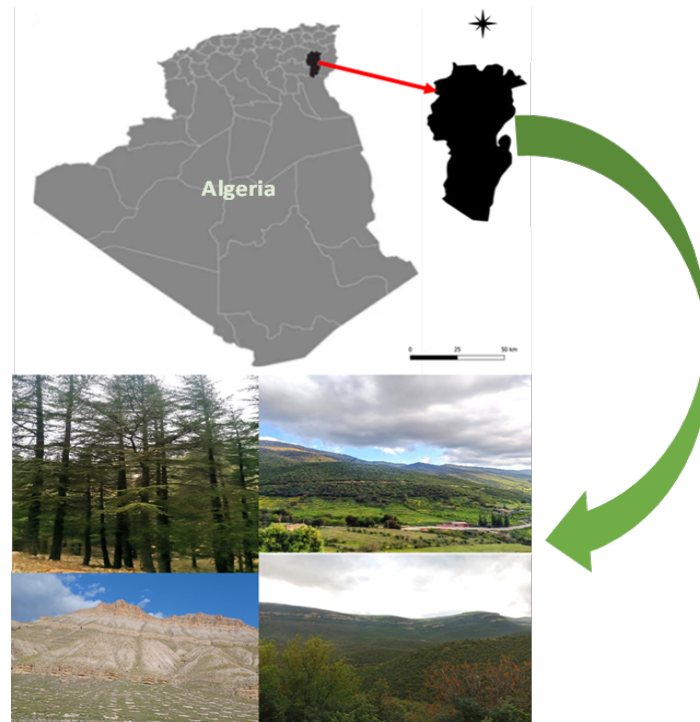


Figure 1. Location of the study area and overview of the main landscapes in the study area (Seraoui H. 2025)

Data collection

The survey was conducted from March to December 2022. Data were collected through structured interviews using a bilingual questionnaire (Arabic and French) designed to record respondents' socio-demographic information (age, gender, educational level, family status) as well as detailed information on medicinal plants, including vernacular names, plant parts used, preparation methods, and associated therapeutic applications. The study targeted local residents of Khenchela Province aged 16 years or older with knowledge or experience in traditional medicinal practices. Individuals not meeting these criteria were excluded from participation.

Plant Identification and Voucher Specimens

Medicinal plants cited by respondents were collected in the field with the assistance of informants whenever possible. Specimens were carefully harvested, pressed, and air-dried following standard herbarium techniques. The dried samples were subsequently mounted and preserved for further analysis.

Plant identification was carried out using standard floras and taxonomic references relevant to Algerian flora (Maire 1957, Quézel & Santa 1962, 1963, Baba Aïssa 1991), as well as recognized botanical databases such as the African Plant Database and The Plant List. Scientific names were verified by a qualified botanist.

All voucher specimens were deposited in the herbarium of the Laboratory of Environmental Sciences and Agroecology, University Chadli Bendjedid, El Tarf, Algeria, where they are available for future reference. Each specimen was assigned a unique voucher number to ensure traceability and reproducibility of the study.

Legal aspects

Participants were clearly informed that the questionnaires constituted a component of a scientific study, and all interviews were conducted openly and freely, without any constraints or obligations (Fig. 2).

Data analysis

Data were analyzed using both Principal Component Analysis (PCA) and Multiple Correspondence Analysis (MCA), following the approaches outlined by Borgatti (1997) and Legendre & Legendre (2012). To quantify the cultural importance of medicinal plants, several ethnobotanical indices were calculated as follows:



Figure 2. Photos of people interviewed during surveys (Seraoui H. 2025).

Relative Frequency of Citation (RFC)

Relative frequency citation was used to assess the relative frequency of citation or mention from the informants who participated in the study using the formula:

$$RFC = FC / N$$

Where, FC is the number of informants who mentioned a given species; N is the total number of informants participating in the survey (Tardío & Pardo-de-Santayana, 2008).

Family Importance Value (FIV)

Family Importance Value measures the relative importance of plant families based on the proportion of informants citing them.

$$FIV = (FC_family / N) \times 100$$

Where, FC_family is the number of informants mentioning at least one species within a given family; N is the total number of informants (Vitalini *et al.*, 2013).

Use Value (UV)

Use Value (UV) was used to determine the relative importance of the medicinal plants using the formula:

$$UV = \Sigma U / N$$

Where, ΣU is the total number of use-reports for a given species; N is the total number of informants (Phillips & Gentry, 1993).

Chi-squared tests were applied to test difference among Sociodemographic characteristics of respondents. Pearson correlation analyses were conducted to explore the relationships among key ethnobotanical indices. The study examined how the Family Importance Value (FIV) relates to the number of species per family and additionally, how the Use Value (UV) associates the number of ailments addressed by the most frequently cited species. Significance was evaluated at $p < 0.05$.

Statistical analyses and graphical outputs were performed using R3.6.1software (R Development Core Team, 2019).

Results and Discussion

Sociodemographic characteristics of respondents

The study concerned 488 informants with different sociocultural profiles.

Age and gender

Analysis of the survey data showed that the ages of our informants spanned a wide range, from 16 to 105 years. The majority (40.5%) were in the 40-60 age group, followed with those aged 20-40 (30.5%), those under 20 and those over 60, with 15% and 14% respectively (Table 1).

According to Hamdani and Houari (2020), individuals over 30 years of age are generally more inclined to share information regarding their experiences with medicinal plants.

During our investigations, we noted that older participants possessed extensive expertise of medicinal plants, their names and their uses. They have significant experience in using these plants for therapeutic purposes, whereas younger people, although well-informed about medicinal plants, often lack practical experience in their use.

In this study, women accounted for the majority of respondents (61%), while men accounted for 39% (Table 1). Oliveira *et al.* (2012) highlighted the predominance of women in the composition of samples during surveys. Several studies have shown that women hold more traditional knowledge of herbal medicine (Lazli *et al.* 2019, Beldi *et al.* 2021, Hadjadj *et al.* 2020, Meddour *et al.* 2022, Gherib *et al.* 2024, Merouane *et al.* 2025, Radjai *et al.* 2025). The findings of this study suggest women's increased interest in medicinal plants due to their family responsibilities as mothers, where they have experience in the use of medicinal plants. They take charge of preparing medicinal remedies and a variety of potions to care for their family members. In rural areas, both women and men contribute to gathering, drying, and carefully preserving medicinal plants, but collection in areas considered dangerous is carried out only by men (Rhattas *et al.* 2016).

Table 1. Sociodemographic characteristics of informants (N=488). Statistical analyses are shown for each variable (Chi square test « χ^2 », degree of freedom « *df* », *p*-value).

Characteristics	Subgroup	Number	Percentage
Gender ($\chi^2=23.02$; <i>df</i> =1 ; <i>p</i> <0.0001)	Women	297	61%
	Men	191	39%
Age ($\chi^2=94.87$; <i>df</i> =3 ; <i>p</i> <0.0001)	≤ 20	74	15%
	20 à 40	149	30.5%
	40 à 60	197	40.5%
	≥ 60	68	14%
Educational level ($\chi^2=137.35$; <i>df</i> =4 ; <i>p</i> <0.0001)	Analphabetic	88	18%
	Primary	47	10%
	College	38	9%
	Secondary	154	30%
	University	161	33%
Profession ($\chi^2=108.05$; <i>df</i> =6 ; <i>p</i> <0.0001)	Self-employed	116	24%
	Teacher	82	17%
	Unemployed	92	19%
	Student	82	17%
	Medical field	71	14%
	Herbalist	24	5%
Marital status ($\chi^2=42.49$; <i>df</i> =1 ; <i>p</i> <0.0001)	Traditional healers	21	4%
	Married	316	65%
	Single	172	35%

The distribution of respondents across the for- age categories was significantly different (Chi-squared test: $\chi^2=94.87$; *p*<0.0001). Similarly, a highly significant difference (Chi-squared test: $\chi^2=23.02$; *p*<0.0001) was found between males and females, with more females (61%) participating in the survey than males(39%). 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

In terms of educational attainment, most respondents had attended university (33%). The others are divided between secondary education (30%) and illiteracy (18%). Moreover, nearly 9% of the informants have an intermediate level of education, compared with approximately 10% having a primary level of education (Table 1). This study reveals that university graduates represent a significant proportion, which differs from several ethnobotanical studies (Islam *et al.* 2014, Jdaïdi & Hasnaoui 2016, Kadri *et al.* 2018, Miara *et al.* 2018, Benderradji *et al.* 2021, Ismaili *et al.* 2021, Radjai *et al.* 2025) and is consistent with those of Helali *et al.* (2020) and Hamdani & Houari (2020). These results can be considered a consequence of COVID-19, where people have strongly resumed the use of medicinal plants due to increased awareness in this area.

The findings indicate that individuals with limited formal education appear more inclined to explore and experiment with plant-based remedies within traditional healthcare practices. However, those with a university education have considerable knowledge in this field. This paves the way for the development of phytotherapy, particularly by avoiding toxicity-related complications associated with certain medicinal plants and minimizing potential adverse effects.

According to the survey, the largest proportion of interviewees is self-employed (24%), followed by unemployed individuals (19%). Teachers and students each account for 17%, while 14% of respondents work in the medical field. The remaining 9% consist of herbalists and traditional healers. (Table 1). Significant differences were observed among respondents' education levels and professions: Chi-squared test: $\chi^2=137.35$, $p<0.0001$; $\chi^2=108.05$, $p<0.0001$, respectively.

In another context, our research showed that the use of herbal medicines is higher among married respondents (65%) than among single respondents (35%). Married people are considered responsible for their family's health (Table 1). This difference was statistically significant ($\chi^2=42.49$; $p<0.0001$), indicating a clear association between marital status and reliance on traditional herbal medicine. This pattern may reflect differences in health-related practices and responsibilities at the household level. These results agree with those obtained by Fedjer (2022) and Bensizerara *et al.* (2025).

Multiple component analysis (MCA)

The Multiple Correspondence Analysis (MCA) reveals a clear structuring of individuals according to their sociodemographic characteristics (sex, age class, education level and occupation) (Fig. 3). The first two axes explain a substantial proportion of total inertia, indicating that they effectively summarize relationships among categorical variables.

Axis 1 primarily represents a socio-professional and educational gradient, contrasting higher education levels and institutionalized occupations (teachers, medical field professionals) with lower education levels and traditional or informal occupations (herbalists, traditional healers). This pattern confirms the strong interdependence between education and occupation, widely documented in social sciences and ethnobotanical research (Quinlan & Quinlan 2007).

Axis 2 is mainly structured by age classes, with older individuals showing a stronger association with traditional occupations, supporting previous findings on the importance of age in the conservation and transfer of ancestral heritage. (Phillips & Gentry 1993, Voeks & Leony 2004, Lazli *et al.* 2019, Beldi *et al.* 2021).

The separation between Men and Women is moderate, suggesting that sex is not the dominant structuring factor but interacts with age, education and occupation, as reported in other studies (Howard 2003, Pfeiffer & Butz 2005). The partial overlap of group ellipses reflects internal heterogeneity within categories, a common feature of social data analyzed using MCA (Le Roux & Rouanet 2010).

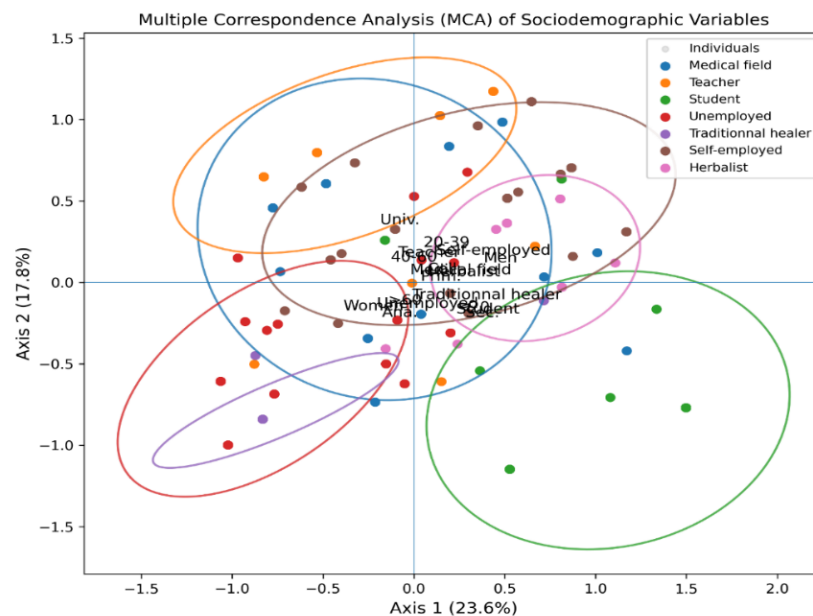


Figure 3. Multiple Correspondence Analysis (MCA) of sociodemographic variables (sex, age class, education level and occupation). Points represent individuals, labels correspond to variable modalities, and ellipses indicate concentration areas by occupation. Percentages on the axes refer to the proportion of explained inertia.

Taxonomic diversity

Survey analysis identified 85 medicinal plant species distributed among 39 families (Fig. 4, Table 2). Asteraceae accounted for the highest proportion (15%), followed by Lamiaceae (14%), Apiaceae (8%), and Rosaceae (5%), while all other families included between one and three species.

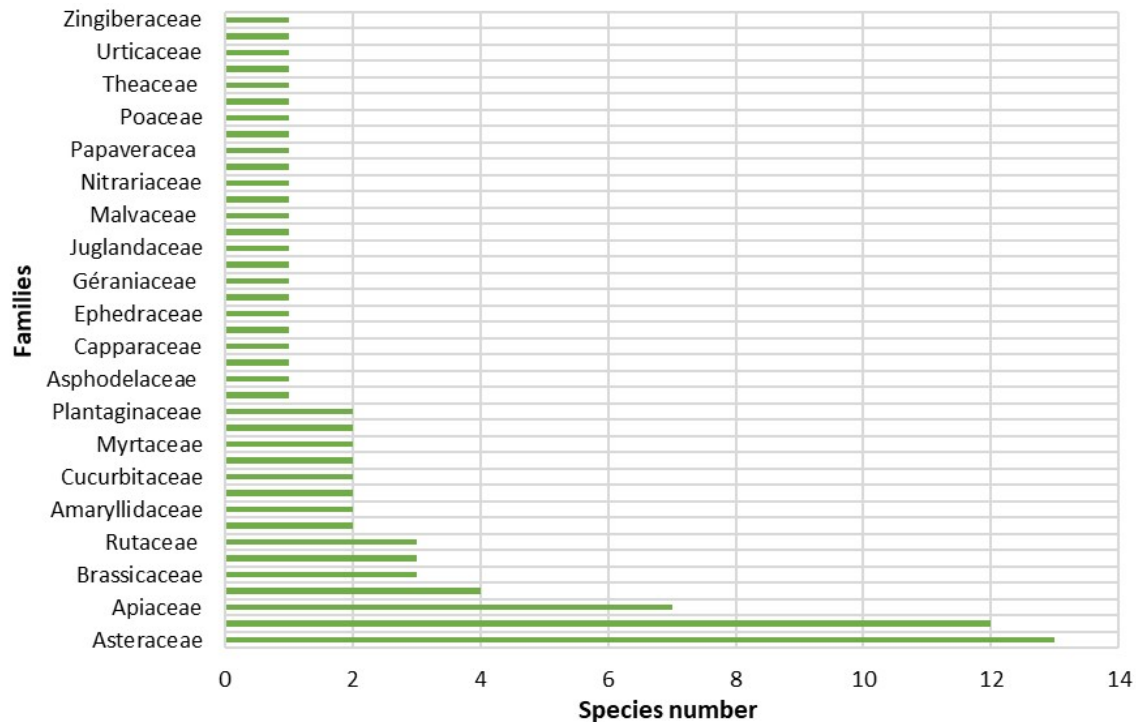


Figure 4. Botanical families of plants used in phytotherapy by rural communities in the study area.

Of the documented species, 48 were wild (56%), 31 cultivated (36%), and 6 obtained through purchase (7%) (Table 2).

The wide range of medicinal plants reported by the interviewees during this research illustrates the rich flora of the Khenchela area, which is known for its mosaic of landscapes composed of forest ecosystems, agro-pastoral zones, and Saharan traits. The regional distinctions found in Algeria illustrate the country's rich ecological and cultural landscape, highlighting the crucial role of local contexts in shaping ethnobotanical practices.

Several works conducted out in Algeria, especially in the north-eastern part of the country and the High Plateaus, have reported that medicinal plants from the Asteraceae and Lamiaceae families were the commonest used (Lazli *et al.* 2019, Belmouhoub *et al.* 2021, Zatout *et al.* 2021, Meddour *et al.* 2022, Belhacini *et al.* 2024, Aouir *et al.* 2025, Bensizerara *et al.* 2025). María de Cortes & Javier (2016) highlighted that, across the Mediterranean region, Lamiaceae, Asteraceae, and Apiaceae are the predominant families in phytotherapeutic applications.

Diversity of medicinal plants and their characteristics

Gathered data is summarized in Table 2 which comprises plant families, species with vernacular and local names, plant parts used, preparation modes, treated diseases, some ethnobotanical indices (UV, RFC) and Voucher No.

Table 2. Results of the ethnobotanical survey obtained in study area

Family	Species	Local name	Origin	Part used	Preparation Mode	Treated disease	UV	RFC	Voucher No.
Amaranthaceae	<i>Beta vulgaris</i> L.	Chamandar Ahmar	Wild	Fruits	Cooked	Intestinal diseases, Anaemia	0.0235	0.0020	KH-13
	<i>Atriplex halimus</i> L.	Katf	Wild	Leaves	Decoction	Urogenital diseases	0.0118	0.0102	KH-12
Amaryllidaceae	<i>Allium cepa</i> L.	Bassal	Cultivated	Stems, Bulbs	Raw Cataplasm	Neurological diseases, Fever, Endocrinological diseases, dental diseases, Ophthalmological diseases, Dermatological diseases	0.0706	0,0082	KH-02
	<i>Allium sativum</i> L.	Thoum	Cultivated	Bulbs	Oil maceration Cataplasm Cooked	Endocrinological diseases, Respiratory diseases, Intestinal diseases	0.0352	0,0082	KH-03
Anacardiaceae	<i>Pistacia lentiscus</i> L.	Dharou	Purchased	Leaves	Essential oil	Respiratory diseases, Dermatological diseases	0.0235	0,0020	KH-62
Asphodelaceae	<i>Aloe vera</i> (L.) Burm.f.	Şabbar al-Alwah	Cultivated	Leaves	Gel	Rheumatism, Dermatological diseases.	0.0235	0,0164	KH-04
Apiaceae	<i>Thapsia garganica</i> L.	Bounafaa	Wild	Roots Aerial Parts	Cooked Cataplasm	Rheumatism, Digestive diseases	0.0235	0,0225	KH-78
	<i>Bunium bulbocastanum</i> L.	Talghouda	Wild	Bulbs	Powder Raw	Endocrinological diseases, ENT diseases	0.0235	0,0225	KH-15
	<i>Eryngium campestre</i> L.	Tablouadha karsaana	Wild	Roots	Decoction	ENT diseases	0.0118	0,0102	KH-32
	<i>Petroselinum crispum</i> (Mill.) Fuss	Maadnous	Cultivated	Aerial Parts	Infusion Juice	Urogenital diseases, Endocrinological diseases	0.0235	0,0123	KH-59
	<i>Apium graveolens</i> L.	Krafes	Cultivated	Leaves	Decoction	Digestive diseases, Urogenital diseases.	0.0235	0,0102	KH-08
	<i>Thapsia villosa</i> L.	Toufalt	Wild	Roots	Cataplasm	Rheumatism	0.0118	0,0020	KH-78
	<i>Pimpinella anisum</i> L.	Yanssoun	Cultivated	Seeds	Decoction	Intestinal diseases	0.0118	0,0020	KH-60
Asteraceae	<i>Artemisia herba-alba</i> Asso	Chih	Wild	Aerial parts	Decoction, Powder, Maceration, Ointment	Digestive diseases, Intestinal diseases, Dental diseases, Fever, Ophthalmia.	0.0471	0,0963	KH-11
	<i>Artemisia campestris</i> L.	Tagueft	Wild	Leaves	Decoction, Cataplasm, Powder, Herbal fumigation	Digestive diseases, Intestinal diseases, Dental diseases, Fever, Ophthalmia.	0.0471	0,0123	KH-10
	<i>Matricaria chamomilla</i> L.	Baboundj	Wild	Flowers	Powder Decoction	Neurological diseases, Urogenital diseases,	0.0588	0,0225	KH-48

						Dermatological diseases, Respiratory diseases, Body care			
	<i>Scolymus hispanicus</i> L.	Guernina	Wild	Aerial parts Roots	Raw Cooked	Digestive diseases, Hepatic diseases	0.0235	0,0041	KH-73
	<i>Notobasis syriaca</i> (L.) Cass.	Guernina chouk soury	Wild	Leaves	Cooked	Hepatic diseases, digestive diseases	0.0235	0,0020	KH-53
	<i>Calendula officinalis</i> L.	Atheyoun	Wild	Leaves Flowers	Infusion	Dermatological diseases, Urogenital diseases	0.0235	0,0123	KH-16
	<i>Artemisia absinthium</i> L.	Chajret meriem	Wild	Leaves	Decoction	Digestive diseases, Urogenital diseases, ENT diseases	0.0353	0,0041	KH-09
	<i>Silybum marianum</i> (L.) Gaertn.	Chouk el jamal	Wild	Seeds	Decoction Powder Cooked	Respiratory diseases, Reproductive and sexual health diseases	0.0235	0,0020	KH-74
	<i>Sonchus oleraceus</i> L.	Telfaf	Wild	Leaves Stems	Raw	Digestive diseases	0.0118	0,0020	KH-75
	<i>Hertia cheirifolia</i> L.	El haffar	Wild	Aerial parts	Decoction Infusion	Digestive diseases	0.0118	0,0020	KH-36
	<i>Inula viscosa</i> (L.) Aiton	Amokrane	Wild	Aerial parts	Decoction Infusion Catapasm	Rheumatism	0.0118	0,0020	KH-38
	<i>Anacyclus perethrum</i> (L.) Lag.	El kountes	Wild	Roots	Powder Raw	Respiratory diseases	0.0118	0,0020	KH-07
	<i>Cynara scolymus</i> L.	Karnoun	Cultivated	Leaves	Cooked	Digestive diseases	0.0118	0,0020	KH-28
Brassicaceae	<i>Eruca sativa</i> Mill.	Jarjir	Wild	Leaves	Raw Cooked	Digestive diseases, Anemia	0.0235	0,0082	KH-31
	<i>Lepidium sativum</i> L.	Hab rched	Purchased	Seeds	Powder	Rheumatism, Dermatological diseases	0.0235	0,0082	KH-44
	<i>Brassica rapa</i> L.	Khardel	Cultivated	Roots	Raw	Respiratory diseases	0.0118	0,0020	KH-14
Cactaceae	<i>Opuntia ficus-indica</i> (L.) Mill.	Tine chaouki	Cultivated	Fruits	Cooked	Intestinal diseases	0.0118	0,0041	KH-55
Capparaceae	<i>Capparis spinosa</i> L.	Kabbar	Wild	Roots Leaves Fruits	Powder Raw Cooked	Dermatological diseases, Urogenital diseases, Anemia, Digestive diseases	0.0471	0,0164	KH-18
Cupressaceae	<i>Juniperus phoenicea</i> L.	Arraar finiki	Wild	Leaves Fruits	Decoction Powder Raw Catapasm	Digestive diseases, Urogenital diseases, Endocrinological diseases, Dermatological diseases, Rheumatism	0.0588	0,0717	KH-40
	<i>Cupressus sempervirens</i> L.	Sarouw	Wild	Fruits Barks	Maceration	Respiratory diseases	0.0118	0,0061	KH-27

Cucurbitaceae	<i>Citrullus colocynthis</i> (L.) Schrad.	Handhal	Wild	Roots Fruits	Raw Poultice Decoction	Rheumatism, Dermatological diseases, Endocrinological diseases, Digestive diseases.	0.0471	0,0102	KH-21
	<i>Cucurbita pepo</i> L.	Yaktine	Cultivated	Seeds	Cooked Powder	Intestinal parasitic diseases	0.0118	0,0020	KH-26
Dryopteridaceae	<i>Dryopteris filix-mas</i> (L.) Schott	Sarkhes	Wild	Leaves	Cooked	Intestinal parasitic diseases	0.0118	0,0020	KH-29
Ephedraceae	<i>Ephedra alata</i> Decne.	Alynda	Wild	Aerial parts	Decoction Infusion	Cancer	0.0118	0,0102	KH-30
Fabaceae	<i>Ceratonia siliqua</i> L.	Kharoub	Cultivated	Leaves Fruits	Raw Cooked Powder	Digestive diseases, Intestinal diseases	0.0235	0,0184	KH-20
	<i>Trigonella foenum-graecum</i> L.	Helba	Purchased	Seeds	Decoction, poultice, powder, cooked, ointment	Urogenital diseases, Anaemia, Dermatological diseases, Endocrinological diseases, Digestive diseases	0.0588	0,0061	KH-82
	<i>Vicia faba</i> L.	Foul	Cultivated	Fruits	Powder	Digestive diseases	0.0118	0,0020	KH-84
Fagaceae	<i>Quercus ilex</i> L.	Balout akhdar	Wild	Leaves Fruits	Raw Decoction	Digestive diseases, Urogenital diseases, Dermatological diseases	0.0353	0,0061	KH-68
Geraniaceae	<i>Pelargonium graveolens</i> (L.) L'Hér.	Aatercha	Cultivated	Leaves	Decoction, fumigation Maceration	Respiratory diseases, Urogenital diseases, Endocrinological diseases	0.0353	0,0041	KH-58
Iridaceae	<i>Crocus sativus</i> L.	Zaafan	Cultivated	Stigmata	Maceration	Digestive diseases, Dental diseases	0.0235	0,0020	KH-25
Juglandaceae	<i>Juglans regia</i> L.	Jouz	Cultivated	Leaves Barks	Decoction	Urogenital diseases, Endocrinological diseases, ENT diseases	0.0353	0,0061	KH-39
Lamiaceae	<i>Lavandula stoechas</i> L.	Khouzama	Purchased	Aerial parts Flowers	Infusion, decoction, Maceration Powder	Neurological diseases, Genital diseases, Dental diseases, Rheumatism	0.0471	0,0164	KH-42
	<i>Rosmarinus officinalis</i> L.	Eklil el jabal	Wild	Aerial parts	Infusion, decoction, Cooked, Poultice	Urogenital diseases, Digestive problems, Neurological diseases, Dermatological diseases	0.0471	0,0512	KH-70
	<i>Thymus vulgaris</i> L.	Zaatar	Cultivated	Aerial parts	Decoction Infusion	Respiratory diseases, Digestive diseases	0.0235	0,0615	KH-81
	<i>Thymus serpyllum</i> L.	Zaatar berri	Wild	Aerial parts	Decoction Infusion	Respiratory diseases	0.0118	0,0061	KH-80

	<i>Marrubium vulgare</i> L.	Meriouta	Wild	Aerial parts	Powder, Maceration Infusion	Endocrinological diseases, Dermatological diseases, Fever.	0.0353	0,0471	KH-47
	<i>Marrubium deserti</i> Boiss.	Jaada	Wild	Aerial parts	Infusion	Endocrinological diseases	0.0118	0,0020	KH-46
	<i>Mentha pulegium</i> L.	Fleyou	Cultivated	Leaves	Decoction	Respiratory diseases, Digestive diseases, Intestinal diseases, ENT diseases	0.0353	0,0061	KH-49
	<i>Mentha spicata</i> L.	Naanaa	Cultivated	Leaves	Decoction Infusion Raw, Poultice	Respiratory diseases, Dental diseases, Endocrinological diseases	0.0353	0,0471	KH-51
	<i>Teucrium polium</i> L.	Khayata	Wild	Aerial parts	Powder, Infusion Decoction	Dermatological diseases, Digestive diseases	0.0235	0,0471	KH-76
	<i>Mentha rotundifolia</i> (L.) Huds.	Makl essayf	Wild	Leaves	Decoction Infusion Cooked	Fever, Digestive diseases, Rheumatism, Urogenital diseases, Neurological diseases	0.0588	0,0082	KH-50
	<i>Ajuga iva</i> (L.) Schreb	Chendgoura	Wild	Leaves Flowers	Powder, Decoction Infusion	Urogenital diseases	0.0118	0,0041	KH-01
	<i>Salvia officinalis</i> L.	Myramia	Cultivated	Leaves	Raw Powder Decoction Infusion	Urogenital diseases, Digestive diseases, Reproductive and sexual health disorders, Dental diseases, Dermatological diseases	0.0588	0,0082	KH-72
Lauraceae	<i>Laurus nobilis</i> L.	Rand	Cultivated	Leaves	Infusion, Powder Fumigation, Poultice Oily maceration	Respiratory diseases, Neurological diseases, Rheumatism	0.0353	0,0184	KH-41
Lythraceae	<i>Punica granatum</i> L.	Romane	Cultivated	Fruit peel	Maceration Powder	Gastrointestinal disorders, Rheumatism	0.0235	0,0061	KH-67
	<i>Lawsonia inermis</i> L.	Henna	Purchased	Leaves	Powder Poultice	Neurological diseases, Dermatological diseases	0.0235	0,0061	KH-43
Malvaceae	<i>Malva sylvestris</i> L.	Khobiza	Wild	Leaves	Cooked, Poultice Infusion	Digestive diseases	0.0118	0,0102	KH-45
Moraceae	<i>Ficus carica</i> L.	Tine	Cultivated	Fruits	Oily maceration Raw	Respiratory diseases, Digestive diseases, Anaemia	0.0353	0,0020	KH-34
Myrtaceae	<i>Eucalyptus globulus</i> Labill.	Kalitous	Wild	Leaves	Infusion	Respiratory diseases, Fever, Rheumatism.	0.0353	0,0102	KH-33
	<i>Myrtus communis</i> L.	Rihane	Wild	Aerial parts	Decoction, infusion	Dental diseases, Respiratory diseases	0.0235	0,0082	KH-52

Nitrariaceae	<i>Peganum harmala</i> L.	Harmal	Wild	Seeds	Powder, Decoction Fumigation	Rheumatism, Respiratory diseases	0.0235	0,0204	KH-57
Oleaceae	<i>Olea europaea</i> L.	Zeitoune	Cultivated	Leaves Fruits	Decoction Oil	Endocrinological diseases, Digestive diseases, Dermatological diseases, Intestinal diseases, Rheumatism, Respiratory diseases	0.0588	0,0204	KH-54
Papaveraceae	<i>Papaver rhoeas</i> L.	Chakayek enoamane	Wild	Flowers	Infusion	Dermatological diseases, Dental diseases	0.0235	0,0061	KH-56
Pinaceae	<i>Cedrus atlantica</i> (Endl.) Manetti ex Carrière	Arz atlassi	Wild	Barks	Essential oil	Rheumatism, Respiratory diseases, Dermatological diseases, Neurological diseases	0.0471	0,0061	KH-19
	<i>Pinus sylvestris</i> L.	Snouber	Wild	Gum Barks	Powder	Respiratory diseases, Dermatological diseases.	0.0235	0,0041	KH-61
Plantaginaceae	<i>Globularia alypum</i> L.	Tasselgha	Wild	Leaves Flowers	Infusion, Powder Decoction, Poultice	Digestive diseases, Dermatological diseases, Urogenital diseases	0.0353	0,0205	KH-35
	<i>Plantago major</i> L.	Lissane el haml	Wild	Seeds Leaves	Powder	Respiratory diseases, Dermatological diseases.	0.0235	0,0020	KH-63
Portulacaceae	<i>Portulaca oleracea</i> L.	Bagla	Cultivated	Aerial parts	Raw Poultice	Anaemia, Dermatological diseases	0.0235	0,0020	KH-64
Poaceae	<i>Hordeum vulgare</i> L.	Cheir	Cultivated	Seeds	Cooked	Digestive diseases, Rheumatism	0.0235	0,0041	KH-37
Rhamnaceae	<i>Ziziphus lotus</i> (L.) Lam.	Sedra	Wild	Fruits	Raw	Intestinal diseases	0.0118	0,0020	KH-85
Rosaceae	<i>Crataegus oxyacantha</i> L.	Boumkhari	Wild	Fruits	Raw	Endocrinological diseases, Neurological diseases	0.0235	0,0020	KH-24
	<i>Prunus amygdalus</i> Batsch var. amara	Louz morr	Cultivated	Fruits	Oil Powder	Dermatological diseases, Intestinal parasitic diseases	0.0235	0,0020	KH-65
	<i>Prunus armeniaca</i> L.	Mechmech	Cultivated	Fruits	Dried	Digestive diseases, Anaemia	0.0235	0,0020	KH-66
	<i>Rosa gallica</i> L.	Ward ahmar	Cultivated	Flowers	Maceration	Dermatological diseases	0.0118	0,0020	KH-69
Rutaceae	<i>Citrus sinensis</i> (L.) Osbeck	Bortokal	Cultivated	Fruits Fruit peel	Powder, Juice Poultice, Raw	Respiratory diseases, Rheumatism	0.0235	0,0082	KH-23
	<i>Citrus limon</i> (L.) Burm. f.	Lemoun	Cultivated	Leaves Fruits	Juice, Maceration Poultice	Respiratory diseases, Fever, Dermatological diseases	0.0353	0,0020	KH-22
	<i>Ruta graveolens</i> L.	Figel	Wild	Leaves Roots	Powder, Decoction Maceration Poultice Fumigation	Respiratory diseases, ENT diseases, Urogenital diseases	0.0353	0,0082	KH-71

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Theaceae	<i>Camellia sinensis</i> (L.) Kuntze	Chay	Cultivated	Leaves	Decoction	Endocrinological diseases, Neurological diseases	0.0235	0,0020	KH-17
Thymeleaceae	<i>Thymelaea hirsuta</i> (L.) Endl.	Methnane	Wild	Leaves	Powder Poultice	Reproductive and sexual health diseases	0.0118	0,0041	KH-79
Urticaceae	<i>Urtica dioica</i> L.	Korass	Wild	Leaves Roots Flowers	Decoction, infusion, poultice, salad (raw), cooked	Respiratory diseases, Rheumatism, ENT diseases, Digestive diseases, Blood disorders, Anaemia	0.0706	0,0184	KH-83
Verbenaceae	<i>Aloysia citrodora</i> Palau	Tizana	Cultivated	Leaves	Decoction	Respiratory diseases, Neurological diseases, Digestive diseases.	0.0353	0,0102	KH-05
Zingiberaceae	<i>Alpinia officinarum</i> Hance	Khanjlene	Purchased	Roots	Decoction Fumigation	Endocrinological diseases, Rheumatism, Respiratory diseases, Neurological diseases	0.0471	0,0020	KH-06

Plant families with their FIV

The Family Importance Value (FIV) analysis highlighted Lamiaceae as the most important plant family cited by informants (FIV=0.31), followed by Asteraceae (FIV = 0.17) (Fig. 5). These families accounted for the highest relative importance among all recorded taxa, indicating their prominent role in local traditional practices.

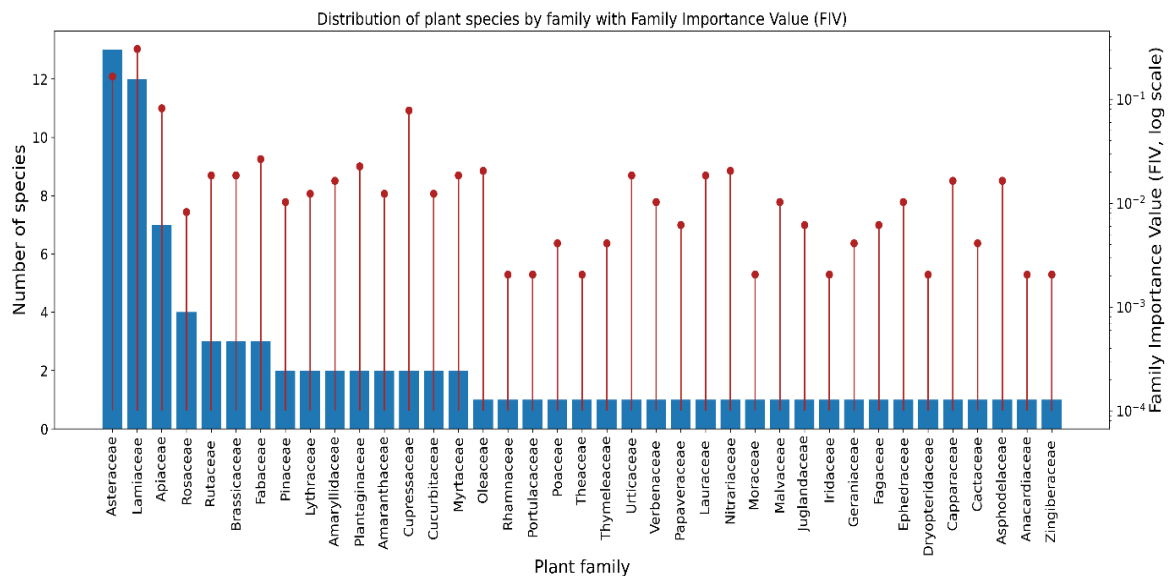


Figure 5. Distribution of plant species across families and their corresponding FIV. Bars represent the number of species per family, while brick-red points and vertical stems represent FIV values displayed on a logarithmic scale.

Figure 5 demonstrates that families with a higher number of species do not necessarily exhibit greater cultural importance. While Asteraceae are slightly richer in species, Lamiaceae exhibit the highest FIV, indicating stronger cultural salience.

The prominence of Lamiaceae suggests intensive and recurrent use of a limited number of highly valued taxa. This family is characterized by pronounced aromatic properties and a high concentration of bioactive compounds, and broad therapeutic applications, which explain its frequent citation by informants. Similar dominance of Lamiaceae has been reported in Mediterranean, North Africa, and Asian ethnobotanical studies (Vitalini *et al.* 2013, Polat *et al.* 2015, Rehman *et al.* 2023, Bensizerara *et al.* 2025, Yassara *et al.* 2025). In contrast, Asteraceae, despite higher species richness, show a lower FIV, suggesting that their uses are more dispersed across taxa and often restricted to specific ailments. Such patterns reflect a more fragmented or specialized role within local pharmacopeias (Leonti *et al.* 2003, Heinrich *et al.* 2009).

The logarithmic scale highlights that most plant families have low but non-zero FIV values, confirming an uneven distribution of ethnobotanical knowledge. Only a few families concentrate the majority of citations, notably Lamiaceae and Asteraceae, which display the highest FIV values and the greatest number of recorded species, reflecting their central role in local medicinal practices. In contrast, families such as Cucurbitaceae, Oleaceae, Malvaceae, and Rutaceae exhibit low FIV values despite the presence of one or more species, indicating limited citation frequency and a more marginal or specialized use within the traditional pharmacopeia in the considered region. Overall, the results confirm that frequency and intensity of use, rather than species richness, drive cultural importance, reflecting long-term knowledge transmission and empirical selection (Begossi 1996, Albuquerque *et al.* 2019, Yassara *et al.* 2025).

Pearson correlation analysis showed a strong and statistically significant positive association between the family Importance Value (FIV) and the number of species per family ($r=0.89$, $p < 0.001$), indicating that plant families with higher species richness generally display greater cultural importance. Nevertheless, deviations from strict proportionality were observed, suggesting that intensive use of a limited number of species can also lead to high FIV values.

Plant species and RFC

Relative Frequency of Citation (RFC) analysis showed that a limited number of plant species concentrate the highest citation frequencies, reflecting their strong cultural salience and widespread use within the local medicinal system. The species with the highest RFC values were *Artemisia herba-alba* (RFC = 0.096), *Juniperus phoenicea* (RFC= 0.072), *Thymus vulgaris* (RFC =

0.061), and *Rosmarinus officinalis* (RFC = 0.051), followed by *Marrubium vulgare*, *Mentha spicata*, and *Teucrium polium* (RFC \approx 0.007) (Fig. 6). These species therefore represent the most culturally prominent elements of the local pharmacopeia.

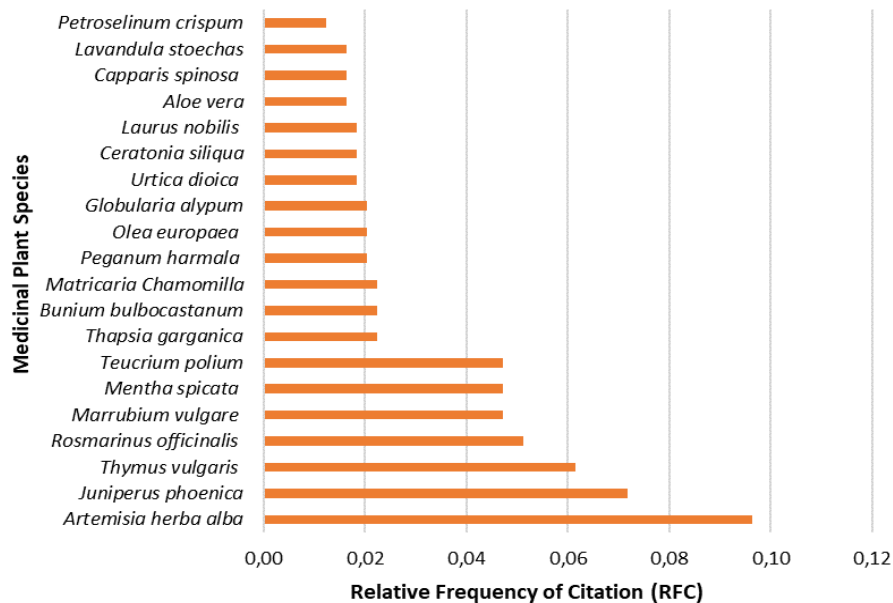


Figure 6. Distribution of the Relative Frequency of Citation (RFC) for the 20 medicinal plant species with the highest cultural importance.

These species are consistently cited by a large proportion of informants and are widely employed in the treatment of multiple health conditions, particularly those affecting the digestive, respiratory, and dermatological systems. Their prominence is likely related to their strong perceived therapeutic effectiveness, aromatic properties, availability, and long-standing integration into traditional healthcare practices. Similar patterns have been documented in ethnobotanical studies from Algeria and other Mediterranean and North African regions, where *Artemisia herba-alba*, *Thymus spp.*, *Rosmarinus officinalis*, and *Mentha spp.* consistently rank among the most frequently cited medicinal plants (Vitalini *et al.* 2013, Polat *et al.* 2015, Benarba 2015, Bensizerara *et al.* 2025).

The results show that among the most frequently cited plants by informants, five belong the Lamiaceae family. This observation is consistent with those recorded by Bensizerara *et al.* (2025) in the same region. The high RFC values may be attributed to their widespread use, recognized therapeutic efficacy, easy availability, or to the local knowledge and long-established practices within the studied communities.

Analysis of the ethnobotanical survey data reveals that several plant species were cited by only single informant, including *Beta vulgaris*, *Eryngium campestre*, *Sonchus oleraceus*, *Inula viscosa*, *Brassica rapa* subsp. *rapa*, *Rosa gallica* and *Dryopteris filix-mas*.

Nonetheless, a low number of citations should not be interpreted as indicating limited value; it may rather reflect the gradual decline of traditional knowledge (Akerrata *et al.* 2007, Aouir *et al.* 2025). Such a decline could be attributed to the modernization of lifestyles, reduced intergenerational transmission of oral knowledge, diminishing interest among younger generation in traditional medicine, and the increasing rarity of certain species.

Plant species and use value

Among the medicinal plants recorded, *Urtica dioica* (UV= 0.071), *Allium cepa* (UV= 0.071), *Juniperus phoenicea* (UV=0.059), *Matricaria chamomilla* (UV= 0.059), *Olea europaea* (UV= 0.059), *Salvia officinalis* (UV= 0.059) and *Artemisia herba-alba* (UV= 0.047) exhibited the highest Use Values (UV), highlighting their prominent role in local traditional medicine (Fig. 7). These species are indeed among the most widely known and commonly used at the national level and have been frequently reported for their broad range of application in several studies. These species are among the most widely known and commonly used taxa at the national level and have been frequently reported for their broad range of therapeutic applications in previous ethnobotanical studies.

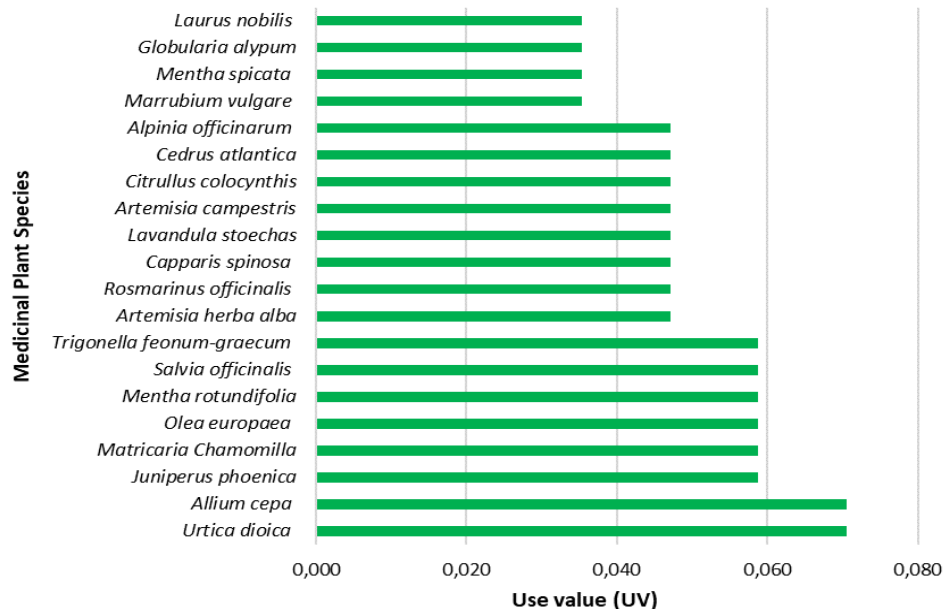


Figure 7. Distribution of Use value (UV) among the 20 most culturally important medicinal plant species.

The distribution of UV values shows a clear asymmetry, with only a limited number of taxa presenting elevated UV, while the majority display low values (Fig. 7), a pattern commonly observed in ethnobotanical surveys. Species such as *Urtica dioica*, *Allium cepa*, *Juniperus phoenica*, *Matricaria chamomilla*, *Olea europea*, *Salvia officinalis*, *Artemisia herba alba*... occupy the highest positions, reflecting their importance in local tradition medicine, a trend also observed in other ethnobotanical surveys carried out in Algeria and Mediterranean region (Benarba *et al.* 2015, Bouasla & Bouasla 2017, Bouafia *et al.* 2021).

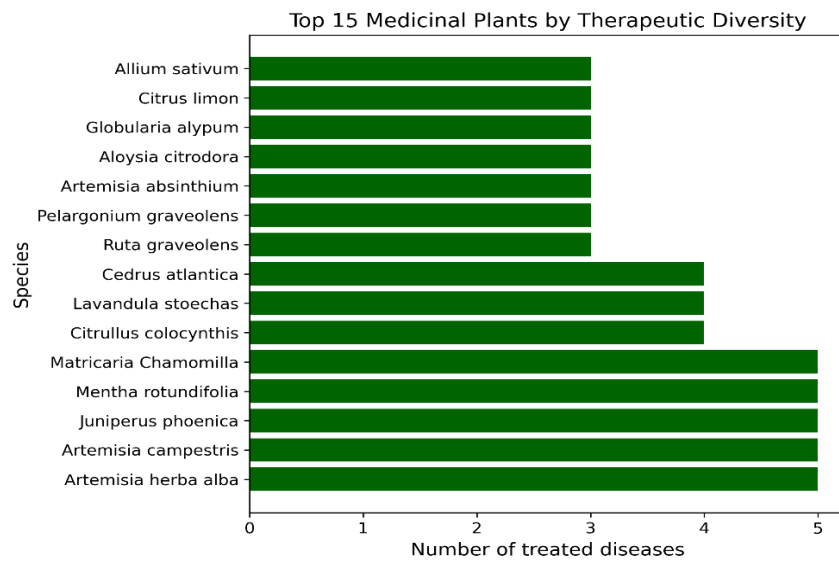


Figure 8. Number of disease categories treated by the most therapeutically versatile medicinal plant species.

Figure 8 illustrates the therapeutic diversity of each species, measured as the number of disorder categories treated per species. This metric provides complementary information to the Use Value (UV), particularly in cases where Fidelity Level (FL) indices are non-discriminatory due to the data structure (e.g., when a species is reported by a single informant). The diversity of uses reflects the breadth of traditional knowledge associated with each taxon. Comparable findings have been reported in Algerian and Mediterranean surveys where medicinal plant inventories reveal multiple ailment categories treated by some taxa, especially for species belonging to the Asteraceae and Lamiaceae families (Soltani *et al.* 2025). This suggests that, beyond citation frequency, traditional practice often incorporates plant species in diverse therapeutic contexts.

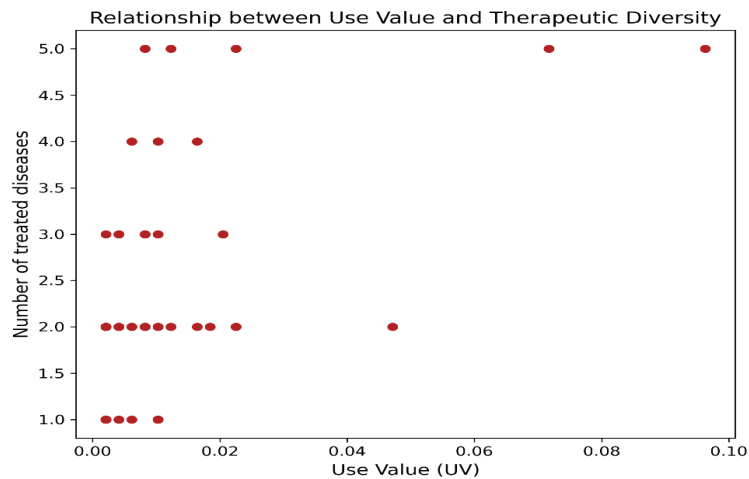


Figure 9. Relationship between Use Value (UV) and therapeutic diversity of medicinal plant species.

Figure 9 examines the quantitative relationship between cultural prominence (UV) and therapeutic diversity. Data analysis showed a significant positive correlation (Pearson's $r = 0.52$, $p < 0.001$), suggesting that the most frequently cited species tend to be associated with a greater number of therapeutic categories. However, the correlation is moderate, signifying that high cultural importance does not necessarily predict extensive therapeutic versatility. Similar patterns have been noted in multiregional Algerian studies employing quantitative indices, where species with high UV and fidelity values are common but not exclusively linked to a broad range of uses (Belhouala & Benarba 2021, Radjai *et al.* 2025).

Parts used

According to the results, leaves represent the majority of plant parts used (36%), with aerial parts constituting the second most used category (33%). Fruits and flowers account for 11% and 5%, respectively. Other parts such as roots, seeds, bulbs, bark, stigmas, and gum collectively make up approximately 15% of total uses (Fig. 10).

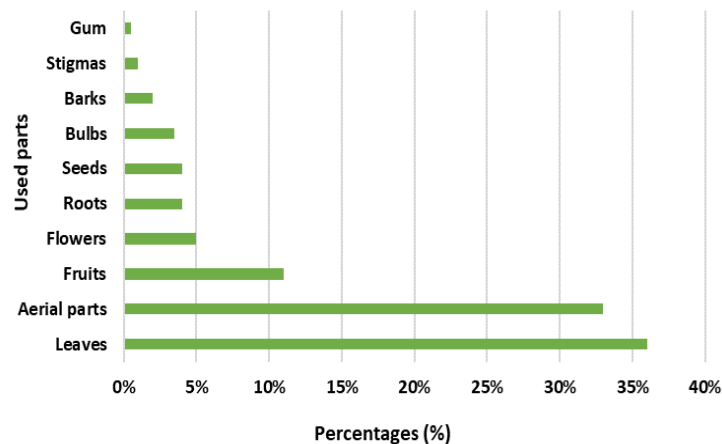


Figure 10. Percentage of medicinal plant parts used according to survey data.

The widespread use of leaves and aerial parts can be attributed to their function as a primary site of carbohydrate biosynthesis, amino acids, and other bioactive compounds. Similar results have been reported in previous ethnobotanical studies, where leaves were documented as the predominant plant part used (Kadri *et al.* 2018, Kemassi *et al.* 2014, Mecheri *et al.* 2023, Ouadeh *et al.* 2021, Dif *et al.* 2022, Komikoukoura *et al.* 2022, Radjai *et al.* 2025). However, it differs from the finding of El Hilah *et al.* (2015), who observed that the entire plant was the most commonly used, accounting for over 58% of uses. Additionally, Khitri *et al.* (2016) emphasized that the preference of leaves is not only due to their high concentration of active compounds, resulting from their central role in phytochemical process, but also because they are more accessible and easier to harvest.

The predominance of certain plant parts in therapeutic application is primarily explained by variations in the concentration and distribution of bioactive compounds among different plant organs, such as leaves, flowers, roots, bark, fruits, seeds, and rhizomes. These organs are known to contain diverse classes of secondary metabolites, including alkaloids, flavonoids,

essential oils, tannins, and bitter compounds, which collectively contribute to their medicinal effectiveness (Bammou *et al.* 2015, Chaachouay 2021). Kadri *et al.* (2018) also highlighted that certain fruits and seeds are employed either as primary sources of active ingredients or as complementary additives in traditional medicinal formulations.

Modes of preparation

The local population employs a wide range of therapeutic preparation methods, including decoction, infusion, powder, maceration, and others. Among the remedies reported by informants, decoction was the commonest method of preparation (38%), with infusion coming next (21%). These data are in line with other ethnobotanical investigations, which also identified decoction as the predominant form of preparation. These findings are in line with previous reports, which also identified decoction as the predominant method of preparation (Tahri *et al.* 2012, Hachi *et al.* 2015, Bouzid *et al.* 2017, Ouadeh *et al.* 2021, Dif *et al.* 2022, Radjai *et al.* 2025). Other methods, such as the use powdered forms, maceration, raw or cooked plant material, poultices, and fumigation were reported at varying frequencies (Fig. 11).

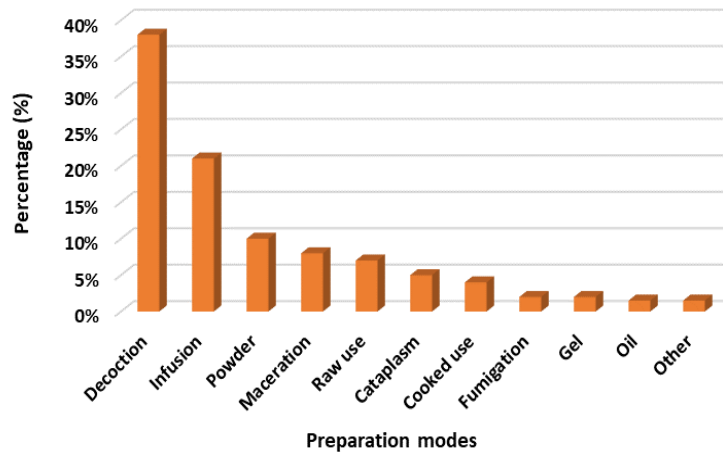


Figure 11. Percentage of administration modes in the study region

Decoction is widely regarded as one of the most effective preparation methods for extracting and assimilating active compounds in medicinal plants. In the multiregional ethnobotanical study in Algeria by Belhouala & Benarba (2021), decoction was the commonest used method (35%) among traditional practitioners, followed by raw usage (24%) and infusion (19%). Nevertheless, high temperatures or extended boiling times during decoction may lead to the degradation of bioactive constituents, such as volatile oils and specific flavonoids (Mecheri *et al.* 2023).

In northwestern Tunisia, Jdaïdi & Hasnaoui (2016) reported the same finding concerning preparation forms: decoction with approximately 40%, followed by infusion (20%), then powder (15%); while other methods, including maceration, poultice, raw application, and fumigation, accounted for the remaining 25%. Their finding suggests that decoction not only recovers a wide range of active constituents but may also attenuate or eliminate certain toxic effects present in raw plant material.

Infusion, by contrast, allows for effective extraction of water-soluble bioactive compounds, including those with limited solubility in their pure form. This observation is supported by Bentabet *et al.* (2022), who reported similar findings in their survey of medicinal plants used to treat dermatological conditions in the Aïn Témouchent region of Algeria.

Treated diseases

According to the questionnaire data, a single plant may be used to prevent or treat multiple conditions, whereas some condition may be managed through the use of various plant species. For example, *Artemisia herba-alba* (Mugwort) was reported to treat stomach pain, gum pain, fever, diarrhoea and intestinal worms, while flu can be treated with Mint, Thyme, Eucalyptus, etc.

Several thousand plants are used around the world. Their action scope is vast and their effectiveness varies. Most have specific effects on certain parts of the body and are known for their ability to treat various conditions (Hachi *et al.*, 2015). The ethnobotanical analysis carried out in the Khenchela region allowed us to highlight the diseases treated using herbal medicine. Among which we recorded: digestive (21%), respiratory and Dermatological diseases (12% each), ENT diseases with a percentage of 11%, and Musculoskeletal diseases (9%). In addition, all other diseases account for $\leq 8\%$ (Fig. 12).

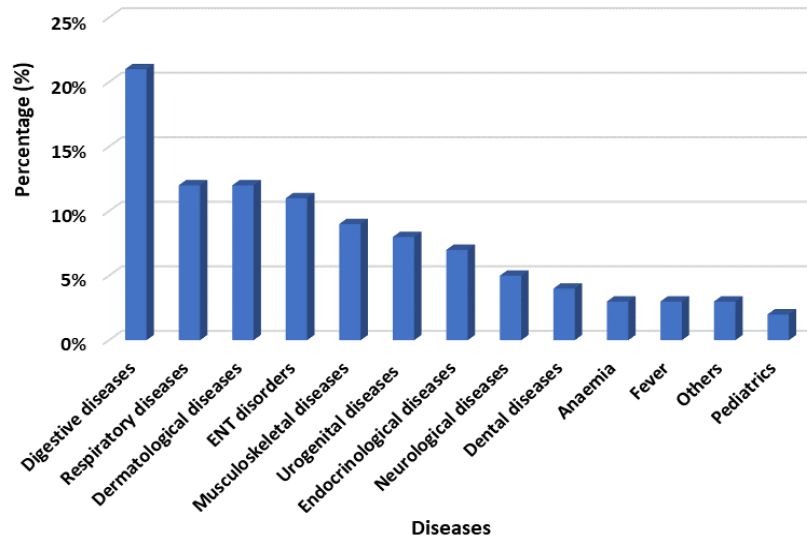


Figure 12. Treated diseases reported in the survey at the study region.

The finding of this study aligns with those reported by Lazli *et al.* (2019) in northeastern Algeria, Hadjadj *et al.* (2019) in southwestern Algeria, and Jdai & Hasnaoui (2016) in northwestern Tunisia, who all noted that digestive disorders represent the primary indication for medicinal plant use.

To further explore the relationship between cultural prominence and therapeutic versatility, a Pearson correlation test was performed between RFC and the number of treated diseases per species. The analysis revealed a positive and statistically significant correlation ($r = 0.37$, $p < 0.001$), indicating that species cited by a larger proportion of information tend to be used for a broader range of ailments. However, the moderate strength of this correlation suggests that high citation frequency does not always imply high therapeutic diversity, as some widely cited species may be specialized in treating a limited number of diseases, while less frequently cited species can exhibit notable polyvalence. This relationship suggests that culturally salient species often develop polyvalent medicinal roles within traditional knowledge systems, as also reported in comparable quantitative ethnobotanical studies (Tardío & Pardo-de-Santayana 2008, Vitalini *et al.* 2013).

Overall, these results highlight that RFC effectively captures the cultural prominence of individual plant species, while its relationship with therapeutic diversity reflects a balance between specialization and polyvalence within traditional medicinal knowledge systems.

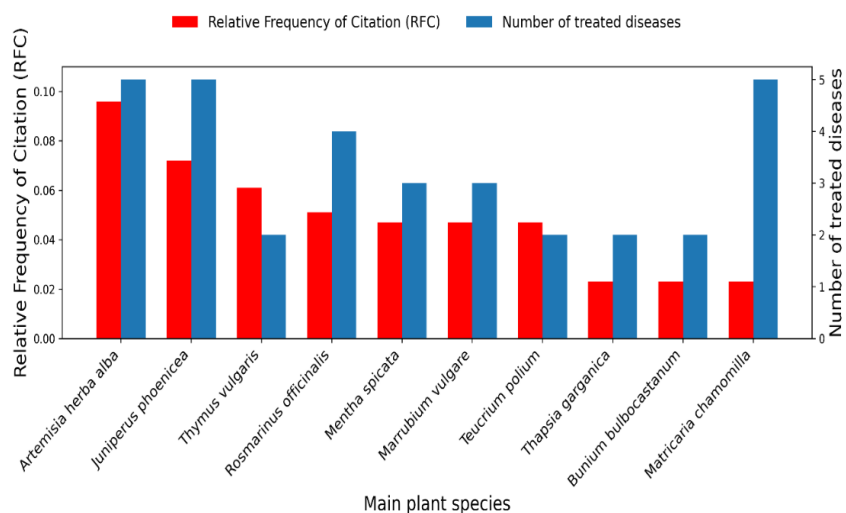


Figure 13. Most cited medicinal plant species: relationship between Relative Frequency of Citation (RFC) and number of treated diseases.

The figure above illustrates the relative frequency and prevalence of the most cited medicinal plant species based on their Relative Frequency of Citation (RFC) and the number of diseases treated (Fig. 13). Species such as *Artemisia herba-alba*,

The second principal component (Axis 2) discriminates species and practices related to chronic or systemic diseases (e.g., metabolic categories) from those associated with acute, localized, or external condition, such dermatological complaints and pain. Species positioned near the center of the PCA space exhibit polyvalent medicinal roles, being associated with multiple plant parts, preparation modes, and therapeutic categories. In contrast, species located toward the periphery of the ordination space display specialized use patterns, reflecting more targeted therapeutic applications. This balance between polyvalence and specialization has been widely reported in ethnobotanical literature, particularly in studies from the Maghreb and Mediterranean regions, where taxa such as *Artemisia*, *Thymus*, and *Rosmarinus* consistently emerge as polyvalent cornerstone species of local medicinal systems (Benarba *et al.* 2015, Vitalini *et al.* 2013).

Overall, the PCA demonstrates that ethnomedicinal practices in the study region are not randomly structured but rather organized around coherent functional relationships between plant organs, preparation techniques, and therapeutic objectives. This integrative structure closely mirrors patterns observed in ethnobotanical studies from Algeria, the Mediterranean basin, and other biocultural regions worldwide, supporting the hypothesis that traditional medical systems are shaped by long-term empirical optimization and cultural transmission of knowledge (Hammiche & Maiza 2006, González-Tejero *et al.* 2008, Teixidor-Toneu *et al.* 2016).

Conclusion

This study highlights the vital role of medicinal plants in the ethnomedicinal practices of local communities in the Khenchela province (High Plateaus, Algeria). The surveys revealed a remarkable flora diversity, reflecting the area's mosaic of ecosystems. Traditional knowledge was found to be primarily held by women, underscoring their central role as household caregivers responsible for the health and well-being of family members.

While such knowledge was historically concentrated among illiterate individuals, the study shows that today, those with higher levels of education are better able to provide detailed and precise information on medicinal plants, including the parts used, dosages, methods of preparation, modes of administration, and treated ailments. This knowledge is transmitted through multiple channels, including family traditions, written sources, and social networks. Interest in herbal medicine notably increased during the COVID-19 pandemic, when the lack of safe and effective treatments led many people worldwide to rely on phytotherapy.

By compiling data on medicinal flora diversity, the plant parts used, their modes of use, and associated therapeutic practices, this survey provides a valuable contribution to the conservation and enhancement of traditional knowledge systems, while providing a scientific foundation for future investigations. The findings highlight the importance of exploring and validating the pharmacological potential of underutilized medicinal plants through advanced phytochemical and pharmacological studies. Integrating ethnobotanical data with modern analytical and biological techniques may facilitate the discovery of new bioactive compounds with significant therapeutic value.

Beyond its scientific contribution, this work emphasizes the need to conserve plant biodiversity and promote the sustainability of natural resources. Encouraging the responsible valorization of local medicinal flora can simultaneously support environmental preservation and empower local communities, particularly women, who remain central to the transmission and practice of traditional healing knowledge.

Declarations

List of abbreviations: COVID-19: Coronavirus Disease 2019; MAP: Medicinal and Aromatic Plants; ENT diseases: Ear, Nose, and Throat diseases.

Ethics approval and consent to participate: All interviewees gave their prior approval to take part in the ethnobotanical surveys.

Consent for publication: All individuals appearing in the photos gave their permission for these to be published.

Availability of data and materials: Most of the data used in this article are available upon request.

Competing interests: Authors declare no conflict of interest

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Authors' contributions: All authors participated to the preparation of the manuscript according to their respective roles. Hanane Sraoui conducted the field investigations, processed the survey forms, and drafted the first version of the manuscript. Amel Lazli supervised the study, conducted the formal analysis, and contributed to the writing of the original draft as well as to the review and editing of the manuscript. Faouzi Guenadil and Karim Loucif participated in data analysis

and manuscript revision. Imane Gherib was involved in the bibliographic research. All authors reviewed and approved the final manuscript.

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Literature cited

- Akerreta S, Caverro RY, Calvo MI. 2007. First comprehensive contribution to medical ethnobotany of Western Pyrenees. *Journal of Ethnobiology and Ethnomedicine* 3: 26. doi: 10.1186/1746-4269-3-2.
- Albuquerque UP, Nascimento ALB, Soldati GT, Feitosa IS, Campos JLA, Hurrell JA, Hanazaki N, de Medeiros PM, da Silva RRV, Ludwinsky RH, Ferreira Júnior WS, Reyes-García V. 2019. Ten important questions/issues for ethnobotanical research. *Acta Botanica Brasilica* 33: 376-385. doi: 10.1590/0102-33062018abb0331
- Aouir F, Chaibi R, Benhamza AEH, Benchettouh A, Gouzi H, Benaceur F, Chenchouni H. 2025. An ethnobotanical inventory and therapeutic potential of medicinal plants used in traditional practices in northeastern Algeria. *Ethnobotany Research and Applications* 31:1-19. doi: 10.32859/era.31.50.1-19
- Baba Aïssa F. 1991. Les plantes médicinales en Algérie. In: Bouchéne et Ad Diwan (Co-Ed), Alger.
- Bammou M, Daoudi A, Sellam KH, El Rehaffari L, Ibijen J, Nassiri L. 2015. Étude ethnobotanique des Astéracées dans la région Meknès-Tafilalet (Maroc). *International Journal of Innovation and Applied Studies* 13: 789-815.
- Belhacini F, Anteur D, Zohra R. 2024. Ethnobotanical study of the therapeutic plants of the Beni Haoua region in the wilaya of Chlef (Algeria). *Ethnobotany Research and Applications* 29:1-15. doi: 10.32859/era.29.49.1-15
- Belhouala K, Benarba B. 2021. Medicinal plants used by traditional healers in Algeria: A multiregional ethnobotanical study. *Frontiers in Pharmacology* 12. doi: 10.3389/fphar.2021.760492
- Beldi M, Merzougui H, Lazli, A. 2021. Ethnobotanical study of *Pistacia lentiscus* L. in El Tarf region (Northeastern Algeria). *Ethnobotany Research and Applications* 21:1-18. doi: 10.32859/era.21.09.1-18
- Belmouhoub M, Aberkane B, Tacherfiout M, Boukhalfa F, Khodja YZ, Bachir-bey M. 2024. Ethnobotanical survey of medicinal plants used by people cured of SARS-CoV-2 in the center of Algeria. *Ethnobotany Research and Applications* 28:1-26. doi: 10.32859/era.28.42.1-26
- Belmouhoub M, Aberkane B, Bachir-bey M. 2021. Ethnopharmacological survey on medicinal plants used by Algerian population to prevent SARS-CoV-2 infection. *Ethnobotany Research and Applications* 22:1-13. doi: 10.32859/era.22.38.1-13
- Benarba B. 2015. Use of medicinal plants by breast cancer patients in Algeria. *EXCLI Journal* 14: 1164-1166.
- Benarba B, Belabid L, Righi K, Bekkar AA, Elouissi M, Khaldi A, Hamimed A. 2015. Ethnobotanical study of medicinal plants used by traditional healers in Mascara (North West of Algeria). *Journal of Ethnopharmacology* 175: 626-637. doi: [10.1016/j.jep.2015.09.030](https://doi.org/10.1016/j.jep.2015.09.030)
- Benderradji L, Bounar R, Ghadbane M, Rebbas K. 2021. Étude ethnobotanique comparative et utilisation thérapeutique de plantes médicinales de Djebel Djedoug (Hammam Dhalaa) et du milieu oasien (oasis de Boussaâda). *Journal of Oasis Agriculture and Sustainable Development* 3(1):1-12. doi: 10.56027/JOASD.012021
- Bene K, Camara DJ, Fofie NBY, Kanga Y, Yapi AB, Yapo YC, Ambe SA, Zirih GN. 2016. Étude ethnobotanique des plantes médicinales utilisées dans le Département de Transua, District du Zanzan (Côte d'Ivoire). *Journal of Animal & Plant Sciences* 27(2):4230-4250.
- Benkhigui O, Zidane L, Fadli M, Elyacoubi H, Rochdi A, Douira A. 2011. Ethnobotanical study of medicinal plants in the Mechraâ Bel Ksiri region (Gharb region of Morocco). *Acta Botanica Barcinonensia* 53: 191-216.
- Bensizerara D, Khemili A, Hassad R, Aroua K, Mellal H, Chenchouni H. 2025. Ethnobotanical survey and ecological approach of medicinal and aromatic plants in Algeria. *Ethnobotany Research and Applications* 32:1-31. doi: 10.32859/era.32.5.1-31

- Bentabet N, Rahal R, Nassour S. 2022. Enquête ethnobotanique et inventaire des plantes médicinales utilisées dans le traitement des maladies dermatologiques dans la ville d'Ain Temouchent. *Journal of Applied Biosciences* 170:17704-17719. doi: 10.35759/JABs.170.4
- Borgatti SP. 1997. Structural holes: Unpacking Burt's redundancy measures. *Connections* 20:35-38.
- Bouafia H. 2015. Hydrodynamique souterraine et transfert des réservoirs profonds (couplage architecture stratigraphique vulnérabilité et risque de pollution) dans la région de Khenchela. PhD dissertation, Université Badji Mokhtar- Annaba.
- Bouafia M, Amamou F, Gherib M, Benaissa M, Azzi R, Nemmiche S. 2021. Ethnobotanical and ethnomedicinal analysis of wild medicinal plants traditionally used in Naâma, southwest Algeria. *Vegetos* 34:654-662. doi: 10.1007/s42535-021-00229-7
- Bouasla A, Bouasla I. 2017. Ethnobotanical Survey of Medicinal Plants in Northeastern of Algeria. *Phytomedicine* 36 :68-81. doi: 10.1016/j.phymed.2017.09.007
- Bouyahyaoui A. 2017. Contribution à la valorisation des substances naturelles: Étude des huiles essentielles des cupressacées de la région de l'Atlas algérien. PhD dissertation, Université Abdelhamid Ibn Badis de Mostaganem, Faculté des Sciences de la Nature et de la Vie.
- Bouzid A, Chadli R, Bouzid K. 2017. Étude ethnobotanique de la plante médicinale *Arbutus unedo* L. dans la région de Sidi Bel Abbés en Algérie occidentale. *Phytothérapie* 15:373-378. doi: 10.1007/s10298-016-1027-6
- Chaachouay N. 2021. Étude floristique et ethnomédicinale des plantes aromatiques et médicinales dans le Rif (Nord du Maroc). PhD dissertation, Université Tofail, Faculté des Sciences de la Vie et de l'Environnement.
- Daroui-Mokaddem H. 2012. Étude phytochimique et biologique des espèces *Eucalyptus globulus* (*Myrtaceae*), *Smyrniololus* (*Apiaceae*), *Asteriscus maritimus* et *Chrysanthemum trifurcatum* (*Asteraceae*). PhD dissertation, Université Badji Mokhtar-Annaba, Faculté des Sciences.
- Dif MM, Benchohra HA, Dellal A, Nasrallah K, Gherabi, A. 2022. Ethnobotanical study of medicinal plants in the Lagarmi zone (Wilaya of El Bayadh, Algeria, West). *Egyptian Academic Journal of Biological Sciences, C. Physiology and Molecular Biology* 14(1):165-174. doi: 10.21608/EAJBSC.2022.223362
- El Hilah F, Ben Akka F, Dahmani J, Belahbib N, Zidane L. 2015. Étude ethnobotanique des plantes médicinales utilisées dans le traitement des infections du système respiratoire dans le plateau central marocain. *Journal of Animal & Plant Sciences* 25(2):3886-3897.
- Fedjer Z, Mazari A, Blama Meraia A. 2022. Étude ethnobotanique auprès de la population riveraine de Souk-Ahras: Cas du romarin à Taoura et du figuier de Barbarie à Sidi-Fredj. *Recherche Agronomique* 20(1):43-60.
- Ghedadba N. 2018. Contribution à l'étude de l'activité biologique des deux espèces de *Marrubium vulgare* L. et *Marrubium deserti* de Noé in vitro et in vivo. PhD dissertation, Université Mustapha Ben-Boulaïd, Batna 2, Faculté des Sciences de la Nature et de la Vie.
- Gherib I, Lazli A, Guenadil F, Seraoui H. 2024. Ethnobotanical knowledge of *Achillea ligustica* All. in El Tarf region (Northeastern Algeria). *Ethnobotany Research and Applications* 29:1-16. doi: 10.32859/era.29.73.1-16
- González Tejero MR, Casares Porcel M, Sánchez Rojas CP, Ramiro Gutiérrez JM, Molero Mesa J, Pieroni A, Giusti ME, Censorii E, De Pasquale C, Della A, Paraskeva Hadjichambi D, Hadjichambis A, Houmani Z, El Demerdash M, El Zayat M, Hmamouchi M, El Johrig S. 2008. Medicinal plants in the Mediterranean area: Synthesis of the results of the project RUBIA. *Journal of Ethnopharmacology* 116(2): 341-357. doi: 10.1016/j.jep.2007.11.045
- Hachi M, Hachi T, Belahbib N, Dahmani J, Zidane L. 2015. Contribution à l'étude floristique et ethnobotanique de la flore médicinale utilisée au niveau de la ville de Khenifra (Maroc). *International Journal of Innovation and Applied Studies* 11:754-770.
- Hadjadj K, Benaissa M, Mahammedi M, Ouragh A, Rahmoué A. 2019. Importance des plantes médicinales pour la population rurale du Parc National de Djebel Aïssa (Sud-ouest algérien). *Lejeunia, Revue de Botanique, Nouvelle série* 199:1-12. doi: 10.25518/0457-4184.1864

- Hadjadj K, Daoudi BB, Guérine L. 2020. Importance thérapeutique de la plante *Ephedra alata* subsp. *Alenda* dans la médecine traditionnelle pour la population de la région de Guettara (Djelfa, Algérie). *Lejeunia, Revue de Botanique, Nouvelle série* 201. doi: 10.25518/0457-4184.1956
- Hamdani FZ, Houari N. 2020. Phytothérapie et Covid-19: Une étude fondée sur une enquête dans le nord de l'Algérie. *Phytothérapie* 18:248-254. doi: 10.3166/phyto-2020-0241
- Hammiche V, Maiza K. 2006. Traditional medicine in Central Sahara: Pharmacopoeia of Tassili N'Ajjer. *Journal of Ethnopharmacology* 105(3): 358-367. doi: 10.1016/j.jep.2005.11.028
- Heinrich M, Ankli A, Frei B, Weimann C, Sticher O. 1998. Medicinal plants in Mexico: Healers' consensus and cultural importance. *Social Science & Medicine* 47(11):1859-1871. doi: 10.1016/S0277-9536(98)00181-6
- Helali A, Mokhtaria C, Ghoula M, Belhadef M. 2020. Prévenir l'infection par le COVID-19: Quelle place pour les plantes médicinales selon la population algérienne? *Algerian Journal of Pharmacy* 3(1):47-57.
- Howard PL. 2003. *Women and plants: Gender relations in biodiversity management and conservation*. London: Zed Books.
- Islam MK, Saha S, Mahmud I, Mohamad K, Awang K, Uddin SJ, Shilpi JA. 2014. An ethnobotanical study of medicinal plants used by tribal and native people of Madhupur Forest Area, Bangladesh. *Journal of Ethnopharmacology* 151(2):921-930. doi: 10.1016/j.jep.2013.11.056
- Ismaili R, Lanouari S, Lamiri A, Moustaid K. 2021. Étude ethnobotanique de plantes aromatiques et médicinales marocaines. *International Journal of Innovation and Applied Studies* 34:403-413.
- Jdaïdi N, Hasnaoui B. 2016. Étude floristique et ethnobotanique des plantes médicinales au nord-ouest de la Tunisie: Cas de la communauté d'Ouled Sedra. *Journal of Advanced Research in Science and Technology* 3(1):281-291.
- Kadri Y, Moussaoui A, & Benmebarek A. 2018. Étude ethnobotanique de quelques plantes médicinales dans une région hyperaride du Sud-ouest Algérien: Cas du Touat dans la wilaya d'Adrar. *Journal of Animal & Plant Sciences* 36(2):5844-5857.
- Kemassi A, Darem S, Cherif R, Boual Z, Sadine S, Aggoune M, Ould el Hadj-Khelil A, Ould el Hadj M. D. 2014. Recherche et identification de quelques plantes médicinales à caractère hypoglycémiant de la pharmacopée traditionnelle des communautés de la vallée du M'Zab (Sahara septentrional Est Algérien). *Journal of Advanced Research in Science and Technology* 1(1):1-5.
- Khitri W, Lachgueur N, Tasfaout A, Lardjam A, Khalf A. 2016. Plantes antilithiasiques utilisées en médecine traditionnelle dans la ville d'Oran, Algérie. *Revue d'Ethnoécologie* 9:2267-2419. doi: 10.4000/ethnoecologie.251
- Komi Koukoura K, Salifou TS, Gbekley EH, Pissang P, Effoe S, Tchacondo T, Batawila K. 2022. Enquête ethnobotanique des plantes médicinales utilisées dans le traitement des infections vaginales et intestinales dans la région maritime au Togo. *International Journal of Biological and Chemical Sciences* 16(5):1906-1918. doi: 10.4314/ijbcs.v16i5.8
- Lazli A, Beldi M, Ghouri L, Nouri N. 2019. Étude ethnobotanique et inventaire des plantes médicinales dans la région de Bougous (Parc National d'El Kala, Nord-est algérien). *Bulletin de la Société Royale des Sciences de Liège* 88:22-43. doi: 10.25518/0037-9565.8429
- Legendre P, Legendre L. 2012. *Numerical ecology*. 3rd ed. Amsterdam: Elsevier.
- Leonti M, Sticher O, Heinrich M. 2003. Antiquity of medicinal plant usage in two macro Mayan ethnic groups (México). *Journal of Ethnopharmacology* 88(2-3):119-124. doi: 10.1016/S0378-8741(03)00188-0
- Le Roux B, Rouanet H. 2010. *Multiple Correspondence Analysis*. Thousand Oaks: Sage.
- Maire R. 1957. *Flore de l'Afrique du Nord*. Paris: Paul Lechevalier. Vol. IV.
- Mecheri R, Smati D, Boutefnouchet A, Daudon M 2023. Étude ethnobotanique des plantes médicinales utilisées dans le traitement de la lithiase rénale dans le Nord-Est algérien. HAL Id: hal-04064327.
- Meddour R, Sahar O, Babkar A. 2022. Savoirs locaux sur les plantes spontanées chez les populations de la wilaya de Tamanrasset (Sahara Central, Algérie). *Vertigo - la revue électronique en sciences de l'environnement* 22(1): 1-30. doi: 10.4000/vertigo.35315

- Merouane A, Cheurfa M, Noui A, Benbeskri A. 2025. The value of wild edible plants among rural communities in Chlef province (Algeria): A quantitative ethnobotanical survey. *Ethnobotany Research and Applications* 30:1-18. doi: 10.32859/era.30.63.1-18
- Miara MD, Bendif H, Ait Hammou M, Teixidor-Toneu I. 2018. Ethnobotanical survey of medicinal plants used by nomadic peoples in the Algerian steppe. *Journal of Ethnopharmacology* 219:248-256. doi: 10.1016/j.jep.2018.03.011
- Oliveira SGD, de Moura FRR, Demarco FF, Nascente Pda S, Pino FA, Lund RG. 2012. An ethnomedicinal survey on phytotherapy with professionals and patients from basic care units in the Brazilian Unified Health System. *Journal of Ethnopharmacology* 140:428-437. doi: 10.1016/j.jep.2012.01.054
- Ouadeh N, Benhissen S, Belkassam A, Bendif H, Rebbas K. 2021. Ethnobotanical study and inventory of medicinal plants in the Dréat region (M'Sila, Algeria). *Geo-Eco-Trop* 45(4):617-633.
- Pfeiffer JM, Butz RJ. 2005. Assessing cultural and ecological variation in ethnobiological research: The importance of gender. *Journal of Ethnobiology* 25(2):240-278.
- Phillips O, Gentry A. H. 1993. The useful plants of Tambopata, Peru: I. Statistical hypotheses tests with a new quantitative technique. *Economic Botany* 47(1):15-32.
- Polat R, Çakılcıoğlu U, Kaltaloğlu K, Ulaşan MD, Türkmen Z. 2015. An ethnobotanical study on medicinal plants in Espiye and its surrounding (Giresun Turkey). *Journal of Ethnopharmacology* 163:1-11. doi: 10.1016/j.jep.2015.01.008
- Quézel P, Santa S. 1962-1963. Nouvelle flore de l'Algérie et des régions désertiques méridionales. Paris: Centre National de la Recherche Scientifique (CNRS). 2 vols. (Tome I: 1962; Tome II: 1963).
- Quinlan MB, Quinlan RJ. 2007. Modernization and medicinal plant knowledge in a Caribbean horticultural village. *Medical Anthropology Quarterly* 21:169-192. doi: 10.1525/maq.2007.21.2.169
- Radjai A, Sarri D, Zedam A. 2025. Knowledge and medicinal plants in El Ach region (Algeria). *Ethnobotany Research and Applications* 32:1-16. doi: 10.32859/era.32.13.1-16
- Rhattas M, Douira A, Zidane L. 2016. Étude ethnobotanique des plantes médicinales dans le Parc National de Talassemrane (Rif occidental du Maroc). *Journal of Applied Biosciences* 97:9187-9211.
- Rehman S, Sabith Rehman¹, Iqbal Z, Qureshi R, Shah GM. 2023. Quantitative ethnobotanical study of medicinal plants used by the indigenous communities of Shawal Valley, District North Waziristan, Pakistan. *Ethnobotany Research and Applications* 25:1-24. doi: 10.32859/era.248.5.1-24
- Sánchez Mata M de C, Tardío J. 2016. Mediterranean wild edible plants: Ethnobotany and food composition tables, Berlin, Springer (Eds.).
- Soltani Y, Benyamina A, Toumi MN, Mansouri A, Bouzidi MA, Toumi F. 2025. Medicinal plants used in the treatment of asthma in western Algeria: An ethnobotanical survey in Sidi Bel Abbès, Oran, and Mascara. *Ethnobotany Research and Applications* 32:1-21. doi: 10.32859/era.32.18.1-21
- Tahri N, El Basti A, Zidane L, Rochdi A, Douira A. 2012. Étude ethnobotanique des plantes médicinales dans la province de Settat (Maroc). *Kastamonu University Journal of Forestry Faculty*, 12(2): 192-208. doi: 10.17475/KUOFD.87650
- Teixidor Toneu I, Martin GJ, Ouhammou A, Puri RK, Hawkins JA 2016. An ethnomedicinal survey of a Tashelhit speaking community in the High Atlas, Morocco. *Journal of Ethnopharmacology* 188: 96-110. doi: 10.1016/j.jep.2016.05.009
- Tardío J, Pardo-de-Santayana M, Morales R 2006. Ethnobotanical review of wild edible plants in Spain. *Botanical Journal of the Linnean Society* 152:27-71. doi: 10.1111/j.1095-8339.2006.00549.x
- Vitalini S, Iriti M, Puricelli C, Ciuchi D, & Segale A. 2013. Traditional knowledge on medicinal and food plants used in Val San Giacomo (Sondrio, Italy)—An alpine ethnobotanical study. *Journal of Ethnopharmacology* 145(2):517-529. doi: 10.1016/j.jep.2012.11.024
- Voeks RA, Leony A. 2004. Forgetting the forest: Assessing medicinal plant erosion in Eastern Brazil. *Economic Botany* 58 (Suppl 1), S294-S306. doi: 10.1663/0013-0001

Yassara S, Jaouhar S, Zeouk I, Bekhti K. 2025. Ethnobotanical study of medicinal plants used to treat microbial infections in the Fez Meknes region, Morocco. *Ethnobotany Research and Applications* 31:1-19. doi: 10.32859/era.31.46.1-19

Zatout F, Benarba B, Bouazza A, Babali B, Nacer Bey N, Morsli, A. 2021. Ethnobotanical investigation on medicinal plants used by local populations in Tlemcen National Park (extreme North West Algeria). *Mediterranean Botany* 42 e69396:1-12. doi: 10.5209/mbot.69396