An ethnobotanical inventory and therapeutic potential of medicinal plants used in traditional practices in northeastern Algeria

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Research

Abstract

Background: Medicinal plants are a precious heritage and a true wealth of humanity and are highly sought after all over the world, especially in developing countries where poorest communities need it to treat various diseases.

Objective: This floristic and ethnobotanical study was carried out with the aim of carrying out the most complete inventory possible of medicinal plants and gathering as much information as possible concerning the therapeutic practices practiced in the region of Setif, northeastern Algeria.

Methods: Using a semi-structured questionnaire and based on a simple stratified random approach, 250 selected local residents were directly interviewed. The collected data were examined using quantitative indices of ethnobotany.

Results: A total of 109 plant species belonging to 42 different families were recorded. Of these, the Asteraceae were the most represented with 15 taxa, followed by the Lamiaceae with 13 species. The analysis of relationships between medicinal species and the types of diseases treated showed that the plants commonly used were *Cuminum cyminum* L., *Vicia faba* L., *Mentha spicata* L., *Olea europaea* subsp. *europaea* L., *Citrus aurantium* L., *Citrus limon* (L.) Burm.f, and *Aloysia citrodora* Paláu, which were the most widespread in the area. Most of these taxa were used mainly in the care of the digestive system (19.75%) and metabolic disorders (14.88%) by the infusion of the leaves which represents the most dominant preparation recipe among the local population.

Conclusion: The ethnobotanical results obtained not only provide a very valuable source of information on the medicinal flora of the study area, but also show that it is possible to use certain plants in socio-economic development, particularly in Algerian rural areas.

Keywords: Ethnobotanical study, Medicinal plant, Traditional medicine, Therapeutic uses, Algeria.

Background

Medicinal plants are a precious heritage and a true wealth of humanity and are highly sought after all over the world, especially in developing countries, where the poorest communities need them to ensure access to primary health care in the absence of a modern medical system (Bouzid *et al.* 2007, Fitzgerald *et al.* 2020). The World Health Organization (WHO) has stated that about 80% of the populations in developing countries prefer traditional medicine to treat various diseases (Fitzgerald *et al.* 2020, Inkoto *et al.* 2020). Among 500,000 plant species in the world, around 80,000 have medicinal properties (Bendif *et al.* 2021) and are virtually non-toxic (Bruneton 1999). At present, plants still remain the primary source in the development of new drugs (Bendif *et al.* 2021, Enyew *et al.* 2014, Goodla *et al.* 2017, Şen *et al.* 2022). Algeria constitutes a real phylogenetic reservoir through its richness and floristic diversity, comprising 4,449 plant taxa, including 3,951 native and 498 introduced into Algeria (Aouadj *et al.* 2021, Bouzid *et al.* 2017, Degdag *et al.* 2022, Dobignard & Chatelain 2010, Lazli *et al.* 2023). However, only a part of these plant taxa is used by Algerians (humans and herbalists) to treat various diseases (Hani *et al.* 2023). In recent years, Algerians have increasingly turned to medicinal plants as therapeutic alternatives due to the high cost and limited effectiveness of conventional therapies (Khitri *et al.* 2016). Recently, ethnobotanical studies have attracted the attention of many researchers at the national level, highlighting the significance of documenting ethnomedicinal knowledge among local populations in various regions of Algeria (Senouci *et al.* 2023, Zatout *et al.* 2021).

The region of Setif, due to its location (semi-arid climate), its reliefs (high plateaus, mountains, plains), and its vegetation cover (Rouabhi *et al.* 2019), has a special position in terms of the richness of medicinal plant species, the majority of which are spontaneous. However, there is a significant gap in comprehensive ethnobotanical studies in this area. Only fragmentary studies have been carried out, and existing research has often lacked quantitative analyses using ethnobotanical indices such as use-value and informant consensus factor; these tools could provide a more objective assessment of the medicinal plants' importance (Boudjelal *et al.* 2013, Hani *et al.* 2023). Additionally, the conservation status of these plant species has not been thoroughly documented, raising concerns about overharvesting and environmental pressures threatening their availability. Studies are also needed to understand how socioeconomic factors influence the selection and use of these plants by local communities (Chermat & Gharzouli 2015).

Only a few ethnobotanical studies have been conducted, primarily limited to the work of Chermat and Gharzouli (2015), Hani *et al.* (2023), Madoui *et al.* (2017), and Mecheri *et al.* (2023). Given this context, this ethnopharmacological research was conducted for the first time in the region of El-Hamma (Setif Province, Algeria), part of the Boutaleb massif in the province of Setif. The study aims to provide a comprehensive floristic analysis, phytotherapeutic assessment, and taxonomic inventory of medicinal plants in this region. Furthermore, this research seeks to validate traditional uses through biochemical or pharmacological analyses and explore the transmission of ethnomedicinal knowledge among local populations.

Materials and Methods

Study area

The region of Setif (capital of the highlands) located 300 km south-east of the capital, Algiers. It is between 5°00' and 6°00' east longitudes and between 35°00' and 36°50' north latitudes (Hani *et al.* 2023, Rouabhi *et al.* 2019). It is located between two natural areas of Tell and the steppe. It presents a remarkable relief and contrast; they are practically limited to the Tellian Babords mountains in the north (2200m) and to the steppe area and Jebel Boutaleb (1886 m a.s.l.) in the south (Rouabhi *et al.* 2019). The Boutaleb forest, which extends over 28,427 ha, is located in the southern region of the Province '*Wilaya*' of Setif (north east of Algeria) located between the vast Setif Plains to the north and the Hodna Basin to the south (35°44'21.1"N, 05°19'47.9"E) (Moumeni *et al.* 2021).

It occupies the Djebel Boutaleb, one of the most important mountains on the eastern side of the Hodna ranges. Climatically, the region is characterized by a semi-arid bioclimatic phase (cool winters in the north, cold in the south) at low altitude, and at high altitude, a semi-humid phase (very cold winters). The wet season lasts longer at lower altitudes, lasting up to five months. However, it does not last more than three months in the high mountains (Bouchelouche *et al.* 2022). Annual

precipitation is 468 mm, and the average annual temperature is 13.3°C (Moumeni *et al.* 2021). The Boutaleb Forest is located between six communes of Setif: Rasfa, Ain Azel, Boutaleb, El-Hamma, and Saleh Bey and the commune of Gosbet in the province of Batna, as well as the commune of Magra in the province of M'Sila (Bouchelouche *et al.* 2022). This ethnobotanical survey was conducted in the commune of El-Hamma, at the southwestern limit of the high plains of Setif (Hadji *et al.* 2016, Zahri *et al.* 2016), about 80 km from the headquarters of the wilaya (35°40'50"N, 05°22'22"E, 1095 m a.s.l.). It is located between Djebel Boutaleb in the north and Djebel Belezma in the south, at an altitude of 1663 to 755 m a.s.l. It is known for its great forest richness, especially on the north side (Figure 1).

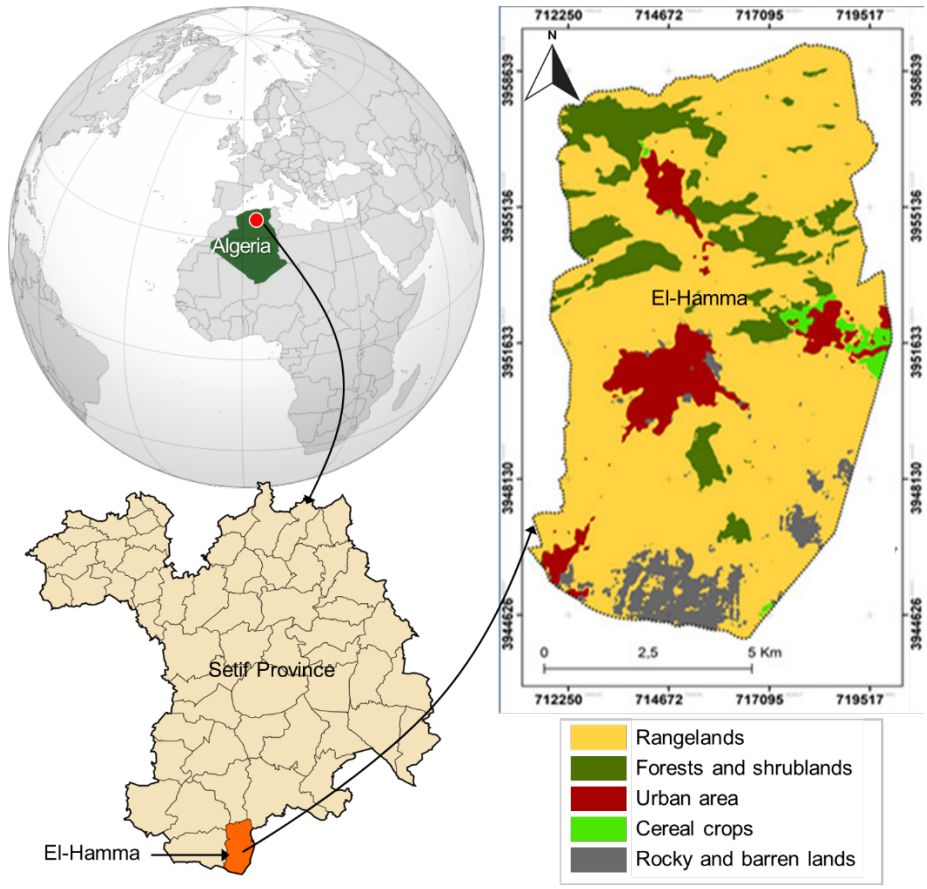

Figure 1. Location and vegetation cover in the El-Hamma region (Setif Province, Algeria).

Collection of ethnobotanical data

This study was carried out using an ethnopharmacological survey conducted during the period between May 2021 and April 2022 in the six villages of the commune of El-Hamma (Addaoua, Bouhlel, Badjrou, Al Hamma, L'Hammam and Oum Laadam), using 250 questionnaire sheets with the local informants (villagers and herbalists). During this study, we organized a number of field visits to the research areas, where we were accompanied by guides who elderly (traditherapists) are considered the most knowledgeable, with expertise in local medicinal plants that directly identified the plant taxa; we also consulted the Boutaleb forest management study. The questionnaire consists of two parts, the first part concerns the informant on traditional medicine (age, gender, academic level, origin of information, and the choice between traditional medicine and modern medicine), and the second part was designed to obtain information about medicinal plants (the local name and French name of the plant, the form, the parts of the plant used, the prescription, the method of preparation, the treated diseases and the type of plant (spontaneous or cultivated). Plant identification was carried out using the works of Maire (1957), Quézel and Santa (1962, 1963), Baba Aissa (1991), Dobignard and Chatelain (2010), and the Tela-botanica website (http://www.tela-botanica.org).

Quantitative data analysis

The collected data were analyzed using the following quantitative indices: Frequency Citation (FC) and Relative Frequency Citation (RFC).

Frequency Citation (FC)

The frequency index or frequency of citation is calculated by the formula used by Phillips & Gentry (1993).

$$FC = (n/N) \times 100$$

Where "n" is the number of persons citing the species, and "N" is the total number of persons interviewed
The frequency index is high when many informants mention a particular plant and low when there were few reports (Sulaiman *et al.* 2022).

Relative Frequency Citation (RFC)

It is used to assess the local therapeutic significance of each plant taxa. It is calculated according to the formula of Tardío & Pardo-De-Santayana (2008).

$$RFC = FC / N \ (0 < RFC < 1).$$

Where "FC" is the number of informants who cited the use of the species, and "N" is the total number of persons interviewed

Results and Discussion

Sociodemographic profile of informants

During this study, 250 people were interviewed in the El-Hamma region (Table 1). Women (64%) are more identified by traditional medicine than men (36%); the majority of those concerned are in the age group between 30 and 40 years (29%). However, people in the age group over 70 and under 20 have low percentages (<5%). Comparing our results with previous studies, Bouasla & Bouasla (2017), Miara *et al.* (2019) and Vinagre *et al.* (2019) showed that the use of medicinal plants was higher in the 60 age group. While Mechaala *et al.* (2022) find that the 40-49 age group is the most dominant with a predominance of women (64.21%). Furthermore, Jouad *et al.* (2001) explained this predominance that women are more attached than men to anything traditional, as well as the ease of transmission of this information between women.

Most of the informants (23%) have a secondary education level (23%), (42%) of them preferred herbal medicine (Table 1). These results are consistent with those previously published by Akbulut *et al.* (2019), who found in their study that 33.3% of informants had a secondary education. However, Şen *et al.* (2022), Karaköse (2022) and Karaköse *et al.* (2019) reported that 53.8, 47.9 and 53.7%, respectively, of informants had a primary education. Moreover, most previous ethnobotanical studies revealed the predominance of illiterate informants such as the reports of Aribi (2013), Benlamdini *et al.* (2014), Islam *et al.* (2014) and Miara *et al.* (2018).

Table 1. Sociodemographic profile of informants.

Variables	Categories	Number of informants	Frequency (%)
Gender	Female	160	64.0
	Male	90	36.0
Age (years)	18-20	12	4.8
	20-30	35	14.0
	30-40	73	29.2
	40-50	50	20.0
	50-60	35	14.0
	60-70	33	13.2
	>70	12	4.8
Education level	Illiterate	55	22.0
	Primary	37	14.8
	Middle	53	21.2
	Secondary	58	23.2
	University	47	18.8
Origin of the information	Healers	33	13.2
	Experiences of others	174	69.6
	Herbalist	10	4.0
	Reading	33	13.2
Therapeutic practice	Modern medicine	80	32.0
	Phytotherapy	105	42.0
	Both	65	26.0

Variety of therapeutic plants used in the study area

Inventory of botanical families

The inventory carried out in this study allowed us to identify 109 plant taxa divided into 97 genera and 42 botanical families. The medicinal plants listed and their properties (their family name, scientific name, local name, origin, part used, method of preparation, therapeutic uses, FC, RFC) are grouped in Table 2. In addition, the botanical identification showed that among the 42 families recorded, Asteraceae is the most represented with 15 plant taxa (13.76%), then Lamiaceae with 13 taxa (11.92%), Apiaceae with 11 taxa (10.09%), Liliaceae and Rosaceae with six taxa (5.5% for each), Poaceae with five taxa (4.58%), Fabaceae with four taxa (3.66%). The remaining 35 families are represented by one, two or three taxon/taxa (Figure 2). These results show the enormous diversity of medicinal plants in the El-Hamma region, as well as the extent of the plant known to the local population to use medicinal plants to cure many diseases.

Recent ethnobotanical research in different regions of Algeria has revealed differences between regions. Meddour *et al.* (2022) in the province of Bouira have identified 136 medicinal plant taxa, they belong to 54 families of which the most represented are Asteraceae (18 taxa) and Lamiaceae (16 taxa). Meddour & Sahar (2023) in Djurdjura, reported 121 plant taxa belonging to 108 genera and 56 families with a dominance mainly of Lamiaceae (10.7%) and Asteraceae (9.1%). Zatout *et al.* (2021) in Tlemcen National Park reported 109 taxa belonging to 54 families whose most frequent families were Lamiaceae (15.5%) and Asteraceae (11.9%). However, Djelaila *et al.* (2022) in El Bayadh recorded only 40 plant taxa belonging to 23 families, the most important of which is Lamiaceae (17.5%) and Fabaceae (12.5%). In previous research carried out in various regions of the world, Lamiaceae and Asteraceae families were identified as the most common ones as well: Morocco (Taïbi *et al.* 2023), Pakistan (Rehman *et al.* 2023a), Nepal (Karki *et al.* 2023), Spain (Rigat *et al.* 2015), Cameroon (Bruno *et al.* 2023), while, Rosaceae was the most used family in different regions of Turkey (Güler *et al.* 2021, Karaköse 2022, Karaköse *et al.* 2019, Şen *et al.* 2022).

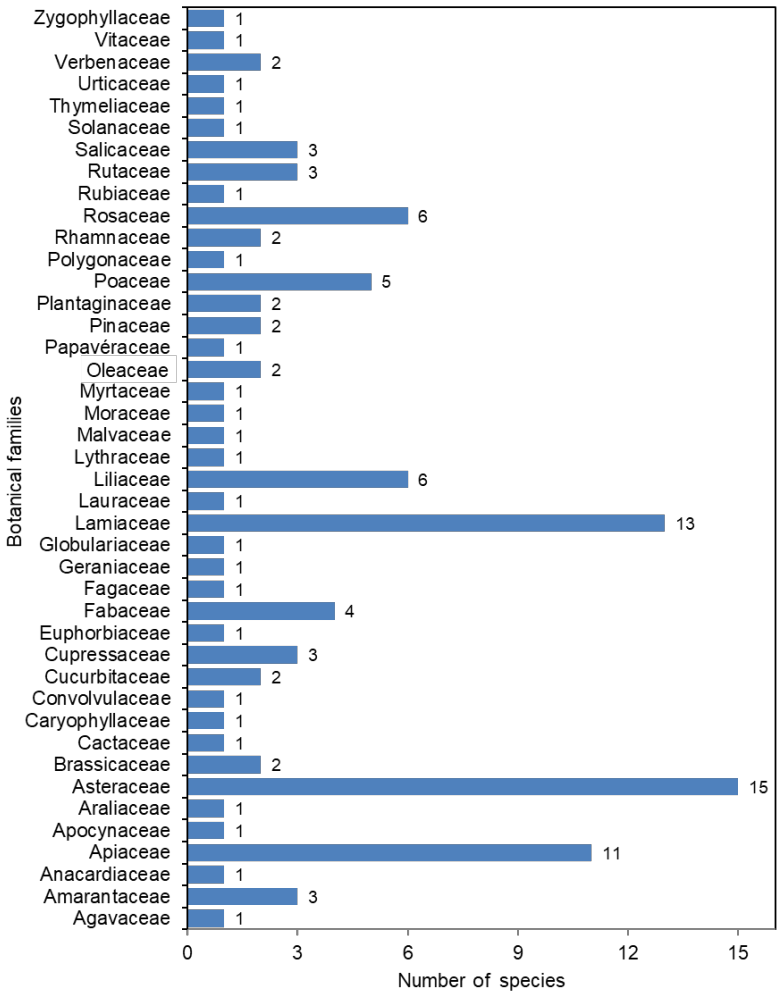

Figure 2. Distribution of plant species by botanical family.

Table 2. Classification of plants listed according to their families, local name, origins, parts used, preparation, diseases treated, FC and RFC.

Family name	Scientific name	Vernacular Arabic name	Origin	Part used	Method of Preparation	Disease treated	FC
Asparagaceae	*Agave americana* L.	*Nadjma*	Wild, Cultivated	Sap	Poultice	NE, CO, DE, DS	10.8
Amaranthaceae	*Spinacia oleracea* L.	*Salk*	Wild, Cultivated	Leaves	Raw, Cooked	ME, CV, DE, DS	70.0
	Atriplex halimus L.	*Gtaf*	Wild	Leaves	Infusion, Powder, Decoction	GU, ME, OA	20.0
	Haloxylon scoparium Pomel	*Remth*	Wild	Leaves	Powder, Decoction	OA, DS, ME, NE, DE	12.0
Anacardiaceae	*Pistacia terebinthus* L.	*Darow*	Wild	Seeds, Leaves	Oils, Powder, Infusion	DS, OA, RE, GU, CO, DE	72.8
Apiaceae	*Petroselinum sativum* L.	*Maadnous*	Cultivated	Whole plant	Infusion, Decoction	GU, ME, DS, RE	78.0
	Bunium bulbocastanum L.	*Talghouda*	Wild	Fruits	Powder, Decoction	RE, ME	36.8
	Thapsia garganica L.	*Bounafae*	Wild	Roots, Leaves	Powder, Poultice	OA, GU	24.8
	Ferula communis L.	*Kalkha*	Wild	Fruits, Leaves	Decoction	ME, NE, RE	2.0
	Ammi visnaga (L.) Lam.	*Kol Bliya*	Wild	Aerial part	Infusion	DS, ME, GU	21.6
	Pimpinella anisum L.	*Habet Hlawa*	Wild	Seeds	Infusion	DS, GU, RE, ME	64.0
	Daucus carota L.	*Zroudia baria*	Wild	Seeds, Leaves	Infusion, Decoction	CV, GU	16.0
	Apium graveolens L.	*Krafs*	Cultivated	Aerial part	Raw, Decoction, Maceration	DS, RE, ME	78.8
	Coriandrum sativum L.	*Dabcha*	Cultivated	Leaves, Seeds	Raw, Infusion	ME, RE, OA, DS, NE	86.0
	Cuminum cyminum L.	*Kamoun*	Cultivated	Seeds	Powder, Poultice, Decoction, Infusion	DS, ME, RE, GU	90.0
	Foeniculum vulgare Mill	*Besbes*	Wild, Cultivated	Bulbs, Roots, Seeds	Cooked, Raw, Decoction	DS	88.0
Apocynaceae	*Nerium oleander* L.	*Dafla*	Wild	Leaves	Infusion, Decoction	OA, ME, GU, NE	22.4
Araliaceae	*Hedera helix* L.	*Louay*	Wild Cultivated	Leaves	Poultice, Infusion	RE	12.0
Asteraceae	*Artemisia absinthium* L.	*Chadjrat Meryem*	Cultivated	Aerial part	Powder, Decoction, Maceration	DS, GU, ME, DE	52.8
	Artemisia herba-alba Asso	*Chih*	Wild	Aerial part	Powder, Maceration, Decoction, Infusion, Fumigation	DS, RE, NE, CV, DE, GU, OA	70.8
	Launaea resedifolia (L.) Kuntze	*Rokaym*	Wild	Leaves	Infusion	ME	16.0
	Artemisia campestris L.	*Tgouft*	Wild	Whole plant	Powder, Maceration, Decoction	DS, RE, DE, GU, ME	24.0
	Chamaemelum nobile (L.) All	*Babounj*	Wild	Flowers	Infusion	DS, CO, RE, NE, OA, DE	67.2
	Anacyclus clavatus (Desf.) Pers.	*Boubicha*	Wild	Flowers	Infusion	DS, OA, RE, CO, DE, NE	66.8
	Silybum marianum (L.) Gaertn.	*Bounagar*	Wild	Roots	Decoction	ME	14.0
	Pallenis spinosa (L.) Cass.	*Ribyan*	Wild	Flowers	Infusion	DS, ME	2.0

	Scorzonera laciniata L.	*Talma*	Wild	Leaves	Infusion	DS	20.0
	Calendula officinalis L.	*Ward Tchini*	Wild	Flowers	Infusion, Poultice	ME, OA, NE, GU, DE	16.0
	Helianthus annuus L.	*Achak Echams*	Cultivated	Seeds	Oils, Infusion	DE, CO, ME	24.0
	Echinops spinosus L.	*Chouk*	Wild	Whole plant	Decoction	ME, GU	1.6.0
	Onopordum macracanthum Schousb.	*Khorchof*	Wild	Aerial part	Cooked	DS, RE, ME	80.0
	Anvillea radiata Coss. & Durieu	*Nagd*	Wild	Aerial part	Powder, Infusion	DS, DE, RE	2.0
	Scolymus hispanicus L.	*Khodra*	Wild	Rhizome, Shoots	Infusion	DS	70.0
Brassicaceae	*Lepidium sativum* L.	*Hab Rchad*	Wild	Seeds	Powder Maceration	OA, RE	47.2
	Brassica rapa L.	*Laft*	Cultivated	Roots	Raw	RE	70.0
Cactaceae	*Opuntia ficus-indica* (L.) Mill.	*Handi*	Wild, Cultivated	Leaves, Fruits, Sap	Poultice, Raw	CV, RE, DS	16.8
Caryophyllaceae	*Paronychia argentea* Lam.	*Kassar Lahdjar*	Wild	Leaves, Flowers	Infusion, Decoction	GU, DS	30.0
Convolvulaceae	*Convolvulus cantabrica* L.	*Louay*	Wild, Cultivated	Whole plant	Infusion, Decoction	GU, DS	12.0
Cucurbitaceae	*Colocynthis vulgaris* Schrad.	*Handhal*	Wild	Fruits	Decoction, Poultice, Powder	ME, OA	6.0
	Ecballium elaterium (L.) A.Rich.	*Fagous Lahmir*	Wild	Fruits	Raw	ME	1.6
Cupressaceae	*Cupressus sempervirens* L.	*Saroual*	Wild	Fruits, Leaves	Oils, Infusion	DS, CO, DE, CV	25.2
	Juniperus phoenicea L.	*Arar*	Wild	Leaves, Shoots, Fruits	Powder, Maceration, Decoction, Infusion, Fumigation	NE, ME, DS, GU, DE, RE, OA	46.4
	Juniperus oxycedrus L.	*Taga*	Wild	Bark, Shoots, Leaves	Decoction, Oils, Powder, Infusion	RE, GU, DS, CV, ME, CO	40.0
Euphorbiaceae	*Ricinus communis* L.	*Kharouaa*	Cultivated	Seeds, Leaves	Oils, Infusion	CO, DE	64.0
Fabaceae	*Astragalus armatus* Willd.	*Lekded*	Wild	Aerial part	Decoction	ME	1.6
	Vicia faba L.	*Foul*	Cultivated	Seeds	Cooked	RE, ME	94.0
	Retama raetam (Forssk.) Webb & Berthel.	*Ratma*	Wild	Aerial part	Powder, Decoction, Maceration	CO, NE, RE, DS, ME, OA, DE	17.6
	Calicotome spinosa (L.) Link	*Guendoul*	Wild	Seeds, Aerial part	Powder	DE, CV	1.6
Fagaceae	*Quercus rotundifolia* Lam.	*Balout*	Wild	Fruits, Bark, Roots	Decoction	DS, DE	23.6
Geraniaceae	*Geranium robertianum* L.	*Rekmaya*	Wild	Leaves	Powder, Oils, Cooked	CV, ME, NE	16.0
Globulariaceae	*Globularia alypum* L.	*Tasalgha*	Wild	Whole plant	Decoction, Powder, Infusion, Maceration	NE, DS, CV, CO	12.8
Lamiaceae	*Ocimum basilicum* L.	*Hbak*	Cultivated, Wild	Aerial part	Powder, Infusion, Decoction	ME, DS, DE	72.8
	Salvia verbenaca L.	*Khayata*	Wild	Aerial part	Decoction, Powder, Infusion	OA, DE, DS	40.4
	Ajuga iva (L.) Schreb.	*Chandgoura*	Wild	Aerial part	Decoction, Powder	DS, ME, CV, GU, OA, DE	5.6
	Lavandula officinalis Mill.	*Khezama*	Cultivated	Flowers, Leaves	Decoction, Oils, Infusion	RE, GU, NE, ME, DE	46.0
	Marrubium alysson L.	*Tameriwt*	Wild	Aerial part	Decoction, Powder, Poultice	RE, NE, ME, GU, DS	57.6

	Marrubium vulgare L.	*Tameriwt*	Wild	Aerial part	Infusion, Poultice, Powder	RE, NE, ME, GU, DS	57.6
	Mentha pulegium L.	*Fliyo*	Cultivated, Wild	Aerial part	Infusion, Maceration	DS, RE, NE, GU	47.2
	Mentha spicata L.	*Naenae*	Cultivated, Wild	Aerial part	Infusion, Decoction, Maceration	DS, RE, NE	90.8
	Teucrium polium L.	*Jaeda*	Wild	Leaves	Infusion, Powder, Decoction	DS, ME, OA, DE	33.6
	Rosmarinus officinalis L.	*Iklil Djabel*	Wild	Aerial part	Powder, Poultice, Infusion, Decoction	DS, RE, ME, GU, OA, DE	65.2
	Salvia officinalis L.	*Miramiya*	Cultivated, Wild	Leaves	Infusion, Decoction, Maceration	RE, GU, ME, DS, NE, DE, CO	30.0
	Thymus vulgaris L.	*Zaatar*	Wild	Aerial part	Infusion, Powder, Decoction, Poultice	DS, RE, GU, ME, CO, CV, DE	84.4
	Thymus serpyllum L.	*Zaitra*	Wild	Aerial part	Infusion, Powder, Decoction, Poultice	DS, RE, GU, ME	71.6
Lauraceae	*Laurus nobilis* L.	*Rand*	Cultivated, Wild	Leaves	Decoction, Powder, Infusion	CV, ME, DS, OA	84.4
Liliaceae	*Asparagus albus* L.	*sekoum*	Wild	Leaves	Decoction, Infusion	DS, RE	24.0
	Asphodelus microcarpus Viv.	*Berwaga*	Wild	Whole plant	Poultice	DE	2.0
	Urginea maritima (L.) Baker	*Aunsal*	Wild	Bulbs	Infusion	RE, CV, OA	12.4
	Allium sativum L.	*Thoum*	Cultivated	Whole plant	Infusion, Powder, Cooked	RE, CV, OA, DE, DS, GU	88.0
	Aloe vera **(**L) Burm.f.	*Nadjma*	Cultivated, Wild	Sap	Poultice	NE, CO, DE	10.8
	Allium cepa L.	*Basla*	Cultivated	Bulbs	Raw, Infusion, Poultice, Maceration	RE, CV, NE, DE	88.8
Lythraceae	*Punica granatum* L.	*Roumen*	Cultivated	Bark, Fruits	Decoction, Infusion	DS, OA	58.0
Malvaceae	*Malva sylvestris* L.	*Belkhobayz*	Wild	Leaves, Flowers	Infusion, Powder, Poultice, Decoction, Maceration	DS, OA, DE, RE	28.8
Moraceae	*Ficus carica* L.	*Kartous*	Cultivated	Fruits, Leaves	Infusion, Jam	ME, DE, CV, DS	80.0
Myrtaceae	*Eucalyptus globulus* Labill.	*Kalitous*	Wild	Leaves	Decoction, Infusion, Poultice, Fumigation	RE, NE, ME	88.0
Oleaceae	*Olea europaea* subsp. *europaea* L.	*Zaytoun*	Cultivated, Wild	Whole plant	Chewing, Oils, Decoction, Infusion, Maceration, Fumigation	DS, RE, CO, DE, CV, ME, GU	94.0
	Fraxinus angustifolia Vahl.	*Dardar*	Wild	Shoots	Decoction	RE, OA, GU	0.8
Papaveraceae	*Papaver rhoeas* L.	*Kbabouch*	Wild	Flowers	Infusion, Poultice	DE, RE, NE	22.8
Pinaceae	*Pinus halepensis* Mill.	*Snobar*	Wild	Bark, Sap, Seeds	Powder, Oils, Infusion, Decoction	DE, DS, RE, OA	45.6
	*Cedrus atlantica (*Endl.)	*Snobar*	Wild	Leaves	Decoction	NE	80.8
Plantaginaceae	*Plantago albicans* L.	*Halma*	Wild	Leaves	Infusion	DS, RE	0.8
	Plantago coronopus L.	*Boudjnah*	Wild	Leaves	Infusion	DS, RE	0.8
Poaceae	*Stipa tenacissima* (L.) Salisb.	*Halfa*	Wild	Leaves	Decoction, Powder	DS, CV, OA, ME	16.0

	Triticum vulgare L.	*Gamh*	Cultivated	Seeds	Powder	DS, ME, DE, GU, OA, CO	72.4
	Zea mays L.	*Lekboub*	Cultivated	Seeds	Decoction, Oils	DS, GU, CV, ME	71.6
	Hordeum vulgare L.	*shaeir*	Cultivated	Seeds	Powder	DS, GU, CV, ME	74.0
	Avena sativa L.	*Khartal*	Cultivated	Fruits, Seeds	Powder, Decoction	ME, NE, DE	6.0
Polygonaceae	*Rumex bucephalophorus* L.	*Hdjel*	Wild	Leaves	Infusion	DS, DE	0.8
Rhamnaceae	*Ziziphus lotus* (L.) Lam.	*Sedra*	Wild	Fruits	Powder, Decoction, Infusion, Fumigation	DS, ME, OA, GU	42.8
	Rhamnus alaternus L.	*Mlilis*	Wild	Leaves	Infusion, Decoction	DS, ME,	2.0
Rosaceae	*Prunus amygdalus* L.	*Louz*	Cultivated	Fruits	Oils, Cooked	CO, NE, CV, OA	49.6
	Crataegus laevigata (Poir.) DC.	*Zuerura*	Wild	Flowers, Leaves	Powder, Maceration, Decoction	CV, OA	12.0
	Eriobotrya japonica (Thunb.) Lindl.	*Mchimcha*	Cultivated	Leaves	Decoction	DS	28.0
	Rosa micrantha Borrer ex Sm.	*Ward*	Wild	Leaves	Decoction	NE, GU	16.0
	Rosa canina L.	*Ward Ezarb*	Wild	Leaves	Decoction	NE, GU	4.8
	Prunus armeniaca L.	*Mechmach*	Cultivated	Leaves, Fruits	Infusion, Raw	DS, ME	18.0
Rubiaceae	*Galium aparine* L.	*Foua*	Wild	Leaves	Infusion	CV, DS, OA	0.8
Rutaceae	*Citrus aurantium* L.	*Randj*	Cultivated	Fruits, Leaves	Infusion, Maceration, Juice	RE, GU, DS, ME	92.0
	Citrus limon (L.) Burm.f.	*Karas*	Cultivated	Fruits, Leaves	Infusion, Maceration, Juice	RE, GU, DS, DE, CV, NE, CO	92.8
	Ruta montana (L.) L.	*Fidjel*	Cultivated, Wild	Aerial part	Decoction, Infusion, Powder	DS, OA, GU, NE, ME	41.2
Salicaceae	*Populus alba* L.	*Safsaf*	Wild	Leaves	Decoction	DS	4.0
	Populus nigra L.	*Safsaf*	Wild	Leaves	Decoction	DS	4.0
Solanaceae	*Capsicum annuum* L.	*Felfel*	Cultivated	Fruits	Poultice	DE, RE, GU, DS, CV	83.2
Thymelaeaceae	*Thymelaea hirsuta* (L.) Endl.	*Mathnen*	Wild	Leaves, Flowers	Poultice, Powder, Infusion, Fumigation	DS, DE, CO	23.6
Urticaceae	*Urtica dioica* L.	*houryg*	Wild	Roots, Leaves	Poultice, Maceration, Decoction	GU, OA, NE, CO	30.4
Verbenaceae	*Aloysia citrodora* Paláu	*Tizana*	Cultivated	Leaves	Infusion	DS, RE, NE	92.4
	Lantana camara L.	*Oum kalthoum*	Cultivated	Leaves	Decoction	DS	1.6
Vitaceae	*Vitis vinifera* L.	*Dalya*	Cultivated	Fruits, Leaves	Dried, Infusion	DS, ME, GU	20.0
Zygophyllaceae	*Peganum harmala* L.	*Harmel*	Wild	Aerial part	Poultice, Powder, Decoction	OA, DS, DE, GU, ME, RE	28.0

DS: Digestive system diseases, ME: Metabolic diseases, OA: Osteoarticular diseases, CV: Cardiovascular diseases, RE: Respiratory diseases, GU: Genitourinary diseases, NE: Neurological diseases, DE: Dermatological diseases, CO: Cosmetic.

Review of ethnobotanical studies conducted in Algeria

The great geographical extension of Algeria, from east to west (1644 km) and from north to south (1900 km), resulted a diversity of climatic regions and, therefore, a diversity of vegetation, which was confirmed by many previous studies. Consequently, a comparative summary of the main ethnobotanical research projects carried out throughout Algeria is given in Table 3, emphasizing the variation in regional knowledge of therapeutic plants. Asteraceae and Lamiaceae are consistently among the most represented families, as seen in table 3, which shows significant variance in the number of species documented (ranging from 40 to 136 taxa). This pattern is also shown in the current El-Hamma research (109 species, 42 families). As previously noted by Meddour *et al.* (2022) and Zatout *et al.* (2021), this regional variety reflects Algeria's ecological and cultural diversity and emphasizes the significance of local context in forming ethnobotanical traditions (Benchohra *et al.* 2024). Furthermore, methodological variations—like the current study's use of quantitative indices—improve the findings' comparability and scientific rigor

Table 3. Summary table of the different ethnobotanical studies carried out in Algeria.

Region	Location in Algeria	Number of informants	Number of taxa	Number of genera	Number of families	References
Tizi-Ouzou (Djurdjura)	North	64	121	108	56	Meddour & Sahar (2023)
Annaba (Edough)	Northeast	100	80	77	41	Hamel *et al.* (2018)
M'sila (12 regions)	North	250	41	37	24	Sarri *et al.* (2015)
M'sila (Berhoum)	North	76	29	29	12	Sarri *et al.* (2017)
M'sila	North	83	58	50	27	Boudjelal *et al.* (2013)
M'sila (Sidi Aissa)	North	ND	17	ND	09	Boubekeur *et al.* (2023)
Skikda	Northeast	89	90	ND	42	Bouasla & Bouasla (2017)
Bordj Bou Arreridj (El Mansourah)	North	200	75	67	39	Bendif *et al.* (2018)
Bordj Bou Arreridj (El-Hammadia)	North	149	78	ND	36	Bendif *et al.* (2021)
Chlef	North	74	33	ND	22	Senouci *et al.* (2023)
Adrar and Bechar	Southwest	22	83	ND	38	Benarba (2016).
Laghouat	South	200	58	ND	30	Benlarbi *et al.* (2023)
Constantine and Mila	Northeast	79	102	90	53	Ouelbani *et al.* (2016)
Tassili N'Ajjer	Southeast	ND	80	ND	33	Hammiche & Maiza (2006)
Bouira (Haizer and El Asnam)	North	69	136	123	54	Meddour *et al.* (2022)
El Bayadh	Southwest	40	40	ND	23	Djelaila *et al.* (2022)
El-Oued	Southeast	100	40	ND	16	Djahra *et al.* (2023)
Naama(Ain Sefra)	Southwest	ND	47	ND	27	Benamara *et al.* (2022)
Illizi	Southeast	120	118	ND	43	Miara *et al.* (2019)
Sidi Bel Abbes	Northwest	400	ND	ND	ND	Bouzid *et al.* (2017)
Tlemcen	Northwest	254	109	ND	54	Zatout *et al.* (2021)
Biskra	Southeast	95	60	ND	29	Mechaala *et al.* (2022)
El Kala (Bougous)	Northeast	237	164	124	58	Lazli *et al.* (2023)

(ND: not determined)

Origin and morphological types of medicinal plants

Wild (spontaneous) taxa represent (62%), (25%) cultivated and (13%) are mixed (Figure 3). Our results are consistent with those obtained by Meddour & Sahar (2023) and Zank & Hanazaki (2012).

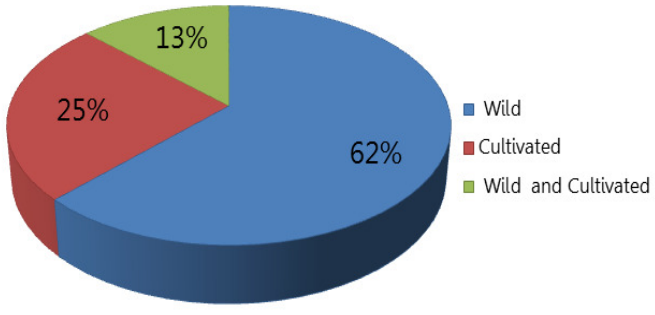

Figure 3. Origin of documented species in El-Hamma region.

Concerning the growth form of plants, herbs are the predominant with (58 plant taxa), followed by shrubs (31 taxa), trees (17 taxa) and small shrubs (3 taxa) (Figure 4). Our result is close to that of Karki *et al.* (2023), Karaköse (2022) and Karaköse *et al.* (2019). Shrubs are overrepresented in the inventory of medicinal plants compared to annual or biennial taxa that disappear during the summer months, which is probably linked to their year-round accessibility. This could explain, at least partially, why species in some families have become so commonly used in medicine because they are more readily available or abundant locally (Gras *et al.* 2021).

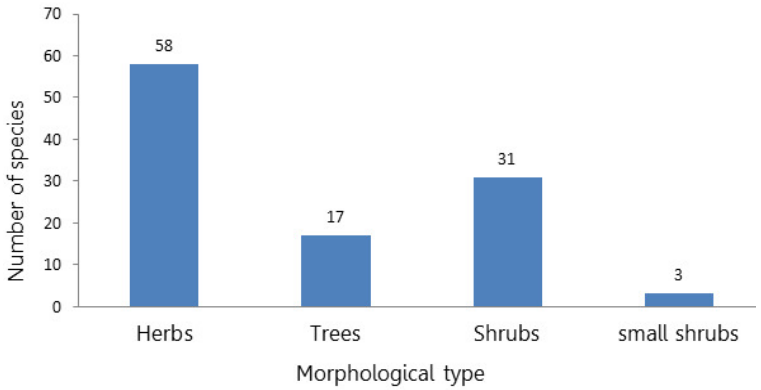

Figure 4. Different morphological types of therapeutic plants at El-Hamma region.

Frequently cited plant taxa

The plant taxa most frequently cited by informants with the highest RFC value (≥ 0.9) are *Cuminum cyminum* L., *Vicia faba* L., *Mentha spicata* L., *Olea europaea* L., *Citrus aurantium* L., *Citrus limon* (L.) Burm.f and *Aloysia citrodora* Paláu. Twenty-three taxa of all plants recorded, are mentioned with an RFC value ≥ 0.7, of which 11 have an RFC value ≥ 0.8 (Figure 5). However, a large number of taxa (50.45%) are cited with the lower RFC value (<0.3), of which 15 have an RFC value < 0.09. Some aromatic and medicinal plants have higher RFC values; this can be attributed to their therapeutic properties, probably due to their effectiveness, local pharmacopoeia or its availability (Bouasla & Bouasla 2017, Kefifa *et al.* 2019). On the other hand, a taxon mentioned by only one informant does not mean that it is worthless but may simply reflect the loss of specific knowledge (Akerreta *et al.* 2007).

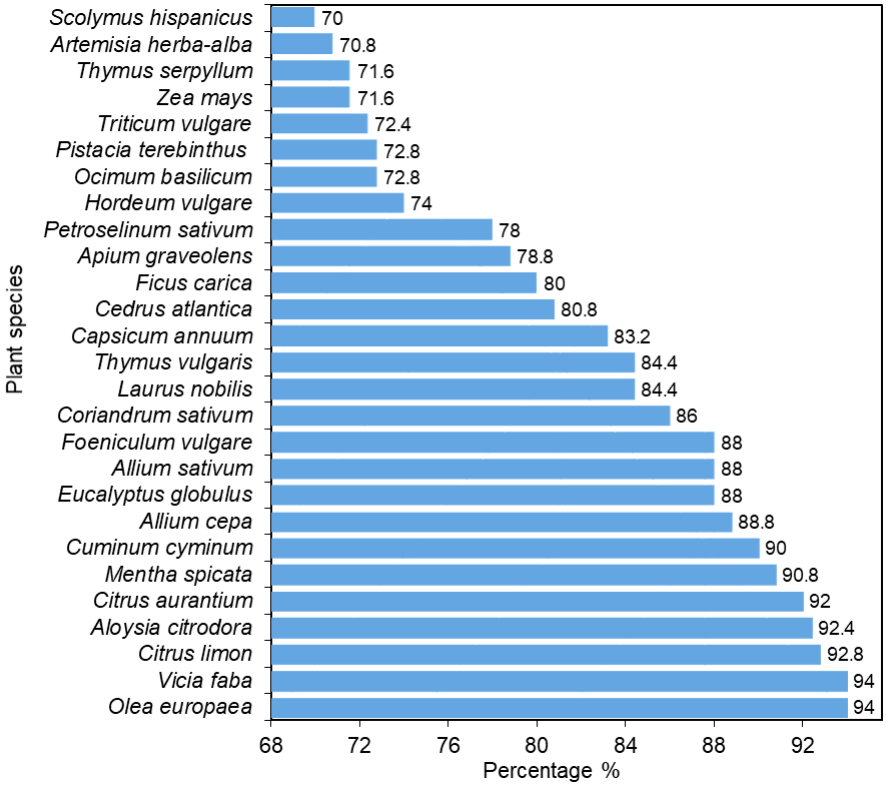

Figure 5. Plant taxa with the highest ethno-medicinal use by the local population of El-Hamma region (Setif, Algeria).

Parts of plants used

The leaves were the most used part, accounting for 33.1% of all plant parts (Figure 6). The aerial part and fruits, with 14.48% and 12.41% of cases are the second and third most used organ groups respectively, while the roots represent only 4.82%. This extensive use of leaves is consistent with many other ethnobotanical studies, such as in Algeria: (35.30%) (Bendif *et al.* 2018), (46.4%) (Benlarbi *et al.* 2023). Morocco: (39.65%) (Afrokh *et al.* 2023), (18.6%) (Benkhnigue *et al.* 2023), (48%) (Taïbi *et al.* 2023), (41.6%) (Tlemcani *et al.* 2023), (35%) (Aftab *et al.* 2023), (24.22%) (Rehman *et al.* 2023a), (28.57%) (Rehman *et al.* 2023b). Cameroon: (Bruno *et al.* 2023) (68.18%). Mexico: (39.8%) (Torres-León *et al.* 2023). India: (25%) (Singh *et al.* 2023), Ivory Coast: (Rouabhi *et al.* 2019) (96%) (Kouadio *et al.* 2016) and Turkey: (61.95%) (Şen *et al.* 2022), (37.03 %) (Güler *et al.* 2021). The high frequency of leaf use can be explained by the availability and ease of leaf collection (Nasution *et al.* 2018) and leaf collection, does not damage or affect plant growth (Brito *et al.* 2017). In addition, leaves are the site of photosynthesis and storage of secondary metabolites responsible for medicinal effects (Slimani *et al.* 2016, Susanti & Zuhud 2019). However, Zareef *et al.* (2023) revealed that the aerial part was the most widely used. Rehman *et al.* (2023c) found that the study population preferred the use of the whole plant. Belhaj & Zidane (2023), Bouzid *et al.* (2017) and Karki *et al.* (2023) demonstrated that the roots were the most used part. Indeed, root removal affects the plant's nutrition, reducing its metabolite reserves as well as its physiological functions.

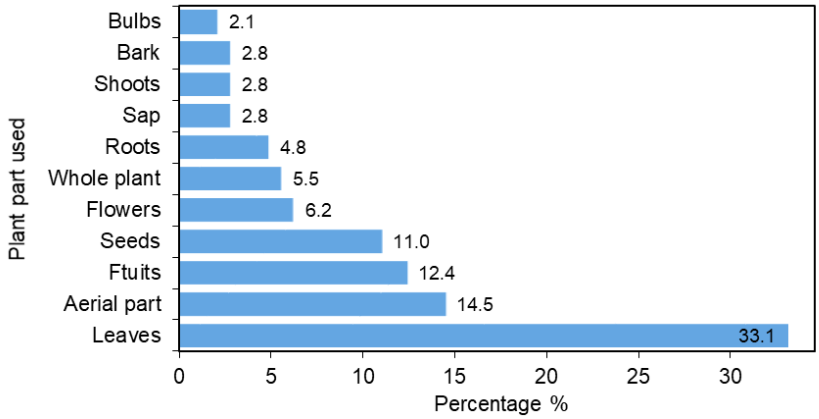

Figure 6. Part of the plants used by the local population of El-Hamma region (Setif, Algeria).

Recipe preparation techniques

Infusion (31.96%), decoction (22.97%), poultice (11.61%) and maceration (7.96%) are the most used methods of preparation. The other preparation methods (raw, oil, chewing, cooked, juice, powder, fumigation, jam) are cited with quantities of less than 5% each (Figure 7). The works of Bendif *et al.* (2018) (41%), Benlarbi *et al.* (2023) (38.8%) and Madani *et al.* (2017) (45%) confirm our result. However, these results contradicted many other studies, which revealed that decoction is the most used technique, such as Benarba (2016) (49%), Benarba *et al.* (2015) (48%), Bouasla & Bouasla (2017) (41%), Meddour & Sahar (2023) (36%), Sarri *et al.* (2015, 2017) (59%), Şen *et al.* (2022) (59.78 %) and Güler *et al.* (2021) (29.06 %). According to Benlamdini *et al.* (2014), decoction remains the most effective way of extracting and assimilating the most active ingredients and cancelling out the toxic effect of certain recipes, but it can destroy some of the active ingredients of the species used.

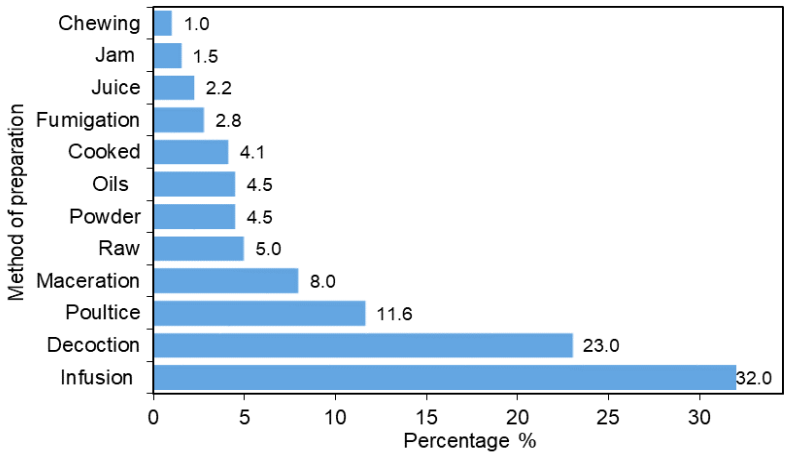

Figure 7. Method of preparation used by the local population of El-Hamma region (Setif, Algeria).

Therapeutic indications

The local population uses the different medicinal plants identified to treat various diseases, which have been grouped into nine disease groups (Table 4), in particular: digestive system disorders (gastric ulcer, diarrhea, constipation, etc.) with a total of 73 plant taxa, followed by 55 species for metabolic disorders (anemia, diabetes, hypercholesterolemia, etc.) and only 19 taxa for cosmetic purposes, namely digestive system disorders (19.7%), metabolic disorders (14.9%), respiratory diseases (12.97%), genito-urinary diseases (11.62%), dermatological diseases (11.35%) and the remaining four groups were treated with less than 10% of the plants identified (Table 4). According to Meddour & Sahar (2023) 63 of the 121 plant taxa recorded are used to treat digestive diseases, 35 taxa for skin diseases, 27 for cardiovascular diseases and 23 for respiratory diseases. Bendif *et al.* (2018) reported that 43 taxa among the 75 plant taxa identified are used to treat digestive diseases, 36 taxa for skin diseases, 26 for cardiovascular diseases, 12 for respiratory diseases. Rehman *et al.* (2023a), in a study they did in the Kakar region of Pakistan, they found that the highest number of 19 plant taxa are used to treat children's gastrointestinal disorders. Digestive system problems have spread to most parts of the world due to poor nutrition in humans since childhood, especially in children who are not breastfed but rather fed milk powder full of food colorings (Nasab & Khosravi 2014).

Table 4. Number of plant taxa by group of diseases treated in the El-Hamma region

Groups of diseases treated	Diseases treated (Use Report: UR)	Total UR	Number of species
Digestive system diseases (DS)	Gastric and Duodenal Ulcer (UR: 16), Diarrhea (UR: 10), Constipation (UR: 7), Biliary stone (UR: 3), Nausea (UR: 5), Vomiting (UR: 3), Hemorrhoids (UR: 2), Colon (UR: 12).	58	73 (19.7%)
Metabolic diseases (ME)	Diabetes (UR: 7), Anemia (UR: 9), Obesity (UR: 5), Hypercholesterolemia (UR: 4), Hyperthyroidism (UR: 1).	26	55 (14.9%)
Osteoarticular diseases (OA)	Rheumatism (UR: 8), Osteoporosis (UR: 9), Osteoarthritis (UR: 5), Toothache (UR: 10).	32	33 (8.9%)
Cardiovascular diseases (CV)	Cardiac Arrhythmia (UR: 2), Angina (UR: 7), Blood Pressure (UR: 3).	12	25 (6.8%)
Respiratory diseases (RE)	Asthma (UR: 5), Cold (UR: 5), Cough (UR: 5), Covid 19 Bronchitis (UR: 9), Tuberculosis (UR: 2).	26	48 (13.0%)
Genitourinary diseases (GU)	Bacterial vaginosis (UR: 2), Kidney stones (UR: 3), Chronic renal failure (UR: 2), Uterine diseases (UR: 1).	8	43 (11.6%)
Neurological diseases (NE)	Epilepsy (UR: 1), Headache (UR: 1), Sciatica (UR: 1), Meningitis (UR: 1), Insomnia (UR: 7), Migraine (UR: 3).	14	32 (8.6%)
Dermatological diseases (DE)	Skin wound (UR: 4),, Eczema (UR: 8), Herpes (UR: 1), Periodontopathy (UR: 1).	14	42 (11.4%)
Cosmetic (CO)	Manufacturing of masks and creams(UR: 4), Hair (UR: 14).	18	19 (5.1%)

(UR: Use Report)

Patterns of uses of inventoried plants

The alluvial plot in Figure 8 illustrates the total plant incidences of plant organs used in interaction with plant origins and preparation methods. Leaves represented the dominant category among plant organs used, accounting for 30.9% of total plant incidences, followed by aerial parts (18.1%) and fruits (11.2%). Notably, leaves from wild plants showed the highest interaction percentage at 21.8%, underscoring their prominence in plant use. Similarly, aerial parts of wild plants contributed significantly, at 13.6%. Fruits were evenly distributed between wild and cultivated origins, each contributing 5.6%, highlighting their balanced use across both origins. The higher interaction percentages for plant leaves and aerial parts of wild-grown plants reflect local harvesting practices and the perceived efficacy of wild flora compared to cultivated varieties. Regarding preparation method, infusion of wild plants represented a high interaction percentage of 16.2%, emphasizing its prevalence. Decoction also contributed significantly, with 17.3% for wild plants. Additionally, powder from wild plants displayed a prominent percentage at 12.2%, highlighting its notable application among the preparation methods. Such practices are consistent with findings from other regions, where boiling or steeping leaves is favored to maximize the therapeutic benefits. As for the interaction between plant preparation methods and plant organs, infusion of leaves showed the highest combined percentage at 9.3%, underscoring their frequent pairing. Decoction of leaves displayed a significant interaction at 7.4%. Additionally, powder was commonly associated with leaves, contributing 3.7%, highlighting leaves as a versatile component across multiple preparation methods. This versatility may explain the continued reliance on leaves in traditional medicine, as they can be adapted for different ailments and preferences, thus sustaining their cultural relevance in the region.

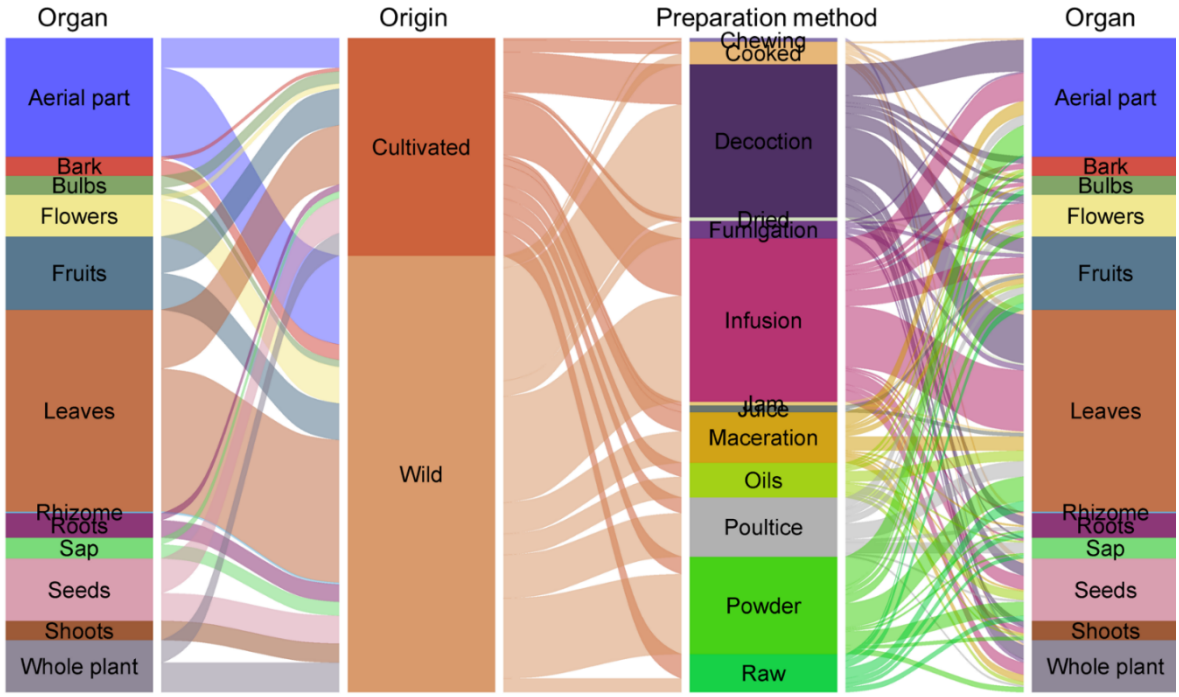

Figure 8. Alluvial plot displaying the distribution of plant incidences for different origins, plant organs used and preparation methods.

These observations align with previous ethnobotanical studies conducted in Algeria and other Mediterranean regions, where leaves and aerial parts are frequently reported as the most used plant organs due to their availability, ease of harvesting, and high concentration of bioactive compounds (Bendif *et al.* 2018, Meddour & Sahar 2023, Afrokh et al. 2023). Similarly, the predominance of infusion and decoction as preparation methods has been widely documented in North Africa (Bouasla & Bouasla 2017, Benlarbi *et al.* 2023) and in Mediterranean countries, where these methods are favored for their simplicity and effectiveness in extracting medicinal compounds (Şen *et al.* 2022, Güler *et al.* 2021). These findings confirm the continuity of ancestral practices and highlight the persistence of traditional knowledge among the local population, reflecting patterns reported in ethnobotanical literature from similar socio-cultural contexts.

Ethnobotanical implications and contribution to local health practices

The findings of this study provide valuable insights into the persistence and cultural relevance of traditional phytotherapy in the El-Hamma region. The dominance of wild plant use, the preference for simple preparation techniques such as infusion and decoction, and the frequent reliance on leaves reflect both the ecological availability of resources and the deeply rooted traditional knowledge of the local population. These practices demonstrate the resilience of ethnobotanical traditions in meeting healthcare needs, especially in rural communities where modern medical services are often limited or expensive. The results also emphasize the importance of preserving this intangible cultural heritage, which holds potential not only for local healthcare but also for future pharmacological research. In this context, integrating ethnobotanical knowledge into public health policies could support sustainable healthcare strategies while safeguarding biodiversity and cultural identity.

Conclusion

This ethnobotanical study provides the first comprehensive inventory of medicinal plants used by local communities in the El-Hamma region of Setif, northeastern Algeria. The results reveal remarkable floristic diversity, with 109 species across 42 families, and highlight the central role of herbs and wild taxa in traditional healthcare practices. The predominance of Asteraceae and Lamiaceae families is consistent with trends observed across Mediterranean and North African regions, reinforcing the strong biogeographical and cultural coherence in medicinal plant selection and use. Importantly, the study not only records plant species and their therapeutic indications but also provides detailed insights into the ethnobotanical practices of the local population, such as the preferred plant parts (leaves), preparation methods (infusion, decoction), and the major health concerns addressed, with digestive and metabolic disorders being the most cited. These findings reflect the persistence of plant-based therapies as a cornerstone of primary healthcare in rural and semi-arid environments, where access to modern healthcare can be limited. They also echo similar patterns in other traditional societies, where medicinal plant use remains an adaptive strategy to local ecological and socio-economic conditions. The quantitative approach,

employing use indices such as FC and RFC, enhances the scientific rigor of the findings and allows for meaningful comparisons with similar studies regionally and globally. Moreover, the identification of certain species with high citation values offers promising candidates for further pharmacological validation and bioactivity screening. This can contribute to the valorization of traditional knowledge and open new perspectives in the search for natural therapeutic agents.

Furthermore, the documentation of threatened and endemic species underscores the urgent need for conservation strategies to safeguard both biological and cultural heritage. Protecting these resources is essential not only for biodiversity preservation but also for maintaining the cultural identity and traditional knowledge of local populations. The integration of this traditional knowledge with pharmacological research could foster the discovery of novel bioactive compounds and contribute to sustainable rural development. Therefore, it is crucial to promote the rational use and conservation of these plant resources, encourage intergenerational transmission of ethnobotanical knowledge, and support collaborative research between local communities and scientists. Such interdisciplinary efforts can strengthen the links between biodiversity, cultural heritage, and health, offering valuable opportunities for sustainable development and bioprospecting in Algeria and beyond. This study not only enriches the ethnobotanical database of Algeria but also provides a valuable reference for future research, conservation planning, and the development of phytotherapeutic products. Ultimately, these findings highlight the global relevance of local knowledge systems and their potential contributions to health sciences, biodiversity conservation, and cultural sustainability.

Declarations

List of abbreviations: a.s.l.: above sea level, CO: Cosmetic, CV: Cardiovascular diseases, DE: Dermatological diseases, DS: Digestive system diseases, FC: Frequency Citation, GU: Genitourinary diseases, ME: Metabolic diseases, NE: Neurological diseases OA: Osteoarticular diseases, RE: Respiratory diseases, RFC: Relative Frequency Citation, UR: Use Report.

Ethics approval and consent to participate: Prior and informed verbal consent was obtained from each informant during the survey. Interviewees were fully informed of the importance of data and their contribution to research. All plants used by local population in the study area were inventoried. Field trips to the forest were carried out with the assistance of Dr. Abd Anaceur Azazga (Forest Directorate, Ain Oulmane, Setif, Algeria). Plant's identification was confirmed by Prof. Salim Zarrouk (Laboratory of Biological and Agricultural Sciences (LBAS), Amar Telidji University, Laghouat, Algeria).

Consent for publication: Not applicable

Availability of data and materials: The article contains figures and tables supporting the results of this study, and original datasets are available from the first author on request.

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CRediT Author contributions: Fatima Aouir: Conceptualization, Methodology, Investigation, Writing - Original Draft, Writing - Review & Editing. Rachid Chaibi: Supervision, Writing - Original Draft, Writing - Review & Editing. Abdelhakim Benhamza: Investigation. Ahmed Benchettouh: Visualization. Hicham Gouzi: Supervision. Farouk Benaceur: Supervision, Writing - Original Draft. Haroun Chenchouni: Formal Analysis, Visualization, Writing - Original Draft, Writing - Review & Editing. All authors reviewed and approved the final version of the manuscript.

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