Phytotherapeutic uses of edible plant species in Erissani (Morocco)

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Research

Abstract

Background: In many cultures, the medicinal and food uses of natural resources are so closely linked that it is difficult to determine where one ends and the other begins. The aim of this study is therefore to promote and document species with dual therapeutic and food uses.

Methods: An ethnobotanical survey using a questionnaire based on closed and semi-closed questions was conducted among traditional practitioners in the south-eastern Sahara region of Morocco. A total of 128 medicinal plants species were documented, with particular attention to those with both therapeutic and food properties.

Results: Among the medicinal plants inventoried, 48 species were food plants grown mainly as subsistence crops in vegetable gardens or as cash crops in oases. These were mainly dicotyledons, belonging to 24 families. Herbaceous plants predominated. The Apiaceae and Fabaceae families were the most represented. According to their culinary use, the species were divided into 54.17% used as food, 31.25% as condiments, 8.33% as both food and condiments, and 6.25% infused as herbal teas. Seeds, leaves, and fruits were the most commonly used parts. In addition, for 33 species, the same part of the plant was used for nutritional and therapeutic purposes. Ethnobotanical analysis identified *Trigonella foenum-graecum* L. and *Salvia rosmarinus* Spenn. as the most frequently cited spices in local traditional therapy. 85% of species were used to treat digestive disorders, 17 species showed a fidelity level of 100%.

Conclusions: These results offer promising prospects for the exploitation of ethnomedical knowledge for the benefit of medicine and nutrition.

Keywords: Medicinal plants; Condiments; Ethnobotany; Food; Phytotherapy; Morocco.

Background

Over the centuries, humans have relied on nature to meet their basic needs in terms of food production, shelter, clothing, transport, fertilizers, aromas and perfumes, not to mention medicines (Ayyanar & Ignacimuthu 2013).

In many cultures, the medicinal and food uses of natural resources are so closely linked that it is difficult to determine where one ends and the other begins (de Medeiros *et al.* 2021). Although many plant species are exclusively medicinal or exclusively edible, ethnopharmacological investigations have confirmed that local populations who gathered various wild species for food were aware of their therapeutic properties. Indeed, in several socio-ecological systems, certain foods go beyond nutritional aspects, thanks to their health-promoting phytochemicals, their high fiber and polyphenol content, and their superior antioxidant power, which have been shown to be effective in the prevention or treatment of several diseases (Sansanelli *et al.* 2017). On the other hand, several medicinal plants are frequently used as condiments or spices (Najem *et al.* 2024a, Najem *et al.* 2024b). This observation reflects the overlap between medicinal and edible uses (de Medeiros *et al.* 2021) and supports the concept of a continuum between food and medicine (Esakkimuthu *et al.* 2018).

Traditional dietary habits are generally considered holistic, healthy and medicinal (Cencic & Chingwaru 2010). Thus, in many regions, medicinal plants are not only a medicinal practice or a socio-cultural ethnobotanical heritage, but are also at the heart of traditional cuisine (Alrhmoun *et al.* 2025, Dop *et al.* 2020, Yao *et al.* 2023), particularly in Morocco, in the Rissani district of the Errachidia province, which is distinguished by its strategic location at the crossroads between northern Morocco and the Sahara. This region is home to a population attached to traditional and diverse practices, including Amazighs, Arab Muslims, Jews and Saharans (Ben Brahim 2021, El Ansari *et al.* 2025). This human and cultural mix has contributed to a wealth of knowledge in phytotherapy and nutrition, passed down orally from generation to generation (El Mansouri *et al.* 2011).

Despite the wealth of traditional knowledge and plant resources in the Rissani circle, medicinal plants used for food or condiments remain poorly studied. In this context, the present study aims to document and promote these dual-use species and to identify species with nutraceutical potential among those of ethnobotanical importance in the local pharmacopoeia.

Materials and Methods

Study area

This ethnobotanical study was conducted in the rural commune of Rissani in the south-eastern Sahara of Morocco (Fig. 1). In this area, ancestral medicine is deeply rooted in the lives of the local population, and traditional healthcare systems encompass empirical phytotherapy and magical-religious medicine (talismans, exorcism, etc.), in addition to certain specialties, notably cauterization, fracture reduction, bloodletting and dentistry.

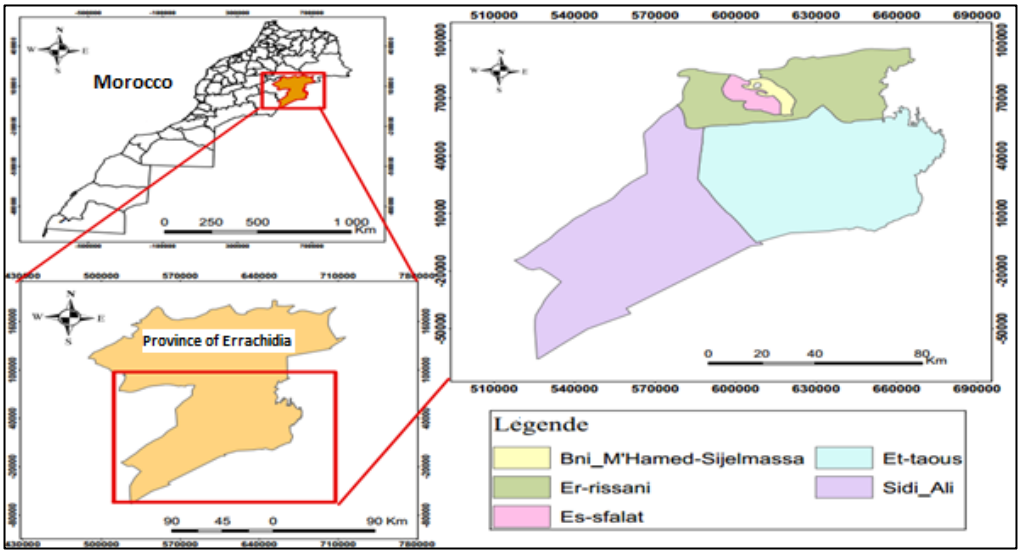


Figure 1. Map of the study area

Tools and procedures

Respondents

For this study, the informants chosen are local traditional practitioners; they are professionals or occasional practitioners who carry on the oral tradition of healthcare and disease control. They make diagnoses, administer care and may issue prescriptions based solely on herbal remedies or in combination with magical-religious medicine (talismans, etc.).

Sampling and saturation criteria

The sampling method chosen was snowball sampling (Vignigbé *et al.* 2024). This approach was initiated through a leading traditional healer, widely recognized in the region for her knowledge and practice of traditional medicine. She referred us to other locally recognized traditional practitioners, who in turn recommended other practitioners working in the region. Traditional practitioners were eligible for the study if they were actively practicing traditional medicine and were recognized for their practice and knowledge in this field. No predefined criteria regarding age or number of years' experience were applied. Exclusion criteria applied to individuals who did not practice traditional medicine, those who were not locally recognized for their knowledge and practice of traditional care, and those who did not consent to participate in the study. The interviews continued until data saturation was reached, i.e. when the interviews no longer yielded any significant new information (Aribou & Amrani 2023). At this stage, twenty-seven traditional practitioners had been interviewed.

A questionnaire comprising closed and semi-closed questions was developed in line with the study's objectives and based on ethnobotanical questionnaires published in the literature, notably those previously used by our research team during ethnobotanical surveys conducted in this same region and in other regions of Morocco (El Ansari *et al.* 2025, Najem *et al*. 2020, Najem *et al*. 2019). This approach ensured that the questionnaire covered the information required to carry out this study, whilst allowing informants the opportunity to express themselves freely within a predefined thematic framework.

The questionnaire included: socio-demographic information on the respondents (age, gender, occupation, level of education, etc.). information on the aromatic and medicinal plants traditionally used in the region, and details on the uses and methods of preparation of the recommended and/or administered medicinal recipes (parts used, therapeutic indications, dosages, possible toxic or undesirable effects).

The survey was conducted over a period of four months, as follows: August and September 2023, then February and March 2024. The interviews were conducted in Arabic dialect ('Darija').

Taxonomic identification of species

The species used by the local traditional practitioners interviewed were collected, dried, numbered and preserved in accordance with the standard method (Jain 1964). Taxonomic identification was carried out at the Laboratory for the Environment and valorization of microbial and plant resources Unit, using the vascular plant identification guides 'Flore pratique du Maroc' (Fennane *et al.* 1999, Fennane *et al.* 2007, Fennane *et al.* 2014). The names of species and families were revised in accordance with the 'Plants of the World Online' website (http://plantsoftheworldonline.org/).

All specimens have been deposited for future reference in the herbarium of the Environment and valorization of microbial and plant resources Unit, Faculty of Sciences, Moulay Ismail University of Meknes, Meknes, Morocco.

Presentation and analysis of data

The results were tabulated and presented in graph form. The ethnobotanical data collected were used to calculate two quantitative indices: the relative frequency of citation (RFC) and the fidelity level (FL).

The fidelity level (FL) is used to determine the ideal species used to treat a specific disease; it is calculated using the following formula (Najem *et al.* 2022):

$$\mathbf{FL\ (\%) = (Np / N) \times 100}$$

Where:

Np: the number of informants who reported using a given species to treat a disease;

N: the number of informants who mentioned the species for any use.

Relative frequency of citation of species (RFC): shows the local importance of each species and is given by the following formula (Najem *et al.* 2021):

$$\mathbf{RFC = FC / N}$$

Where:

- FC = the number of informants using a given species;
- N = the total number of informants interviewed.

The value of the relative frequency of citation varies from 0 to 1 (Tardio & Pardo-de Santayana 2008).

Statistical and multivariate analyses

Multivariate statistical analyses were conducted to study the relationships between plant biological types, parts used, food use categories, and conditions treated by edible medicinal plants. Prior to analysis, data were organised into contingency and presence-absence matrices according to the objective of each analysis.

Heat maps were used to visualise (i) associations between plant biological types and plant organs used, and (ii) relationships between plant parts and conditions treated. The matrices were based on binary presence-absence data. Hierarchical clustering of rows and columns was performed using Euclidean distance and the complete linkage method. Heat maps were generated using the pheatmap package implemented in RStudio software (version 2025.05.1+513).

A correspondence factor analysis (CFA) was applied to assess the relationships between food use categories and treated conditions. This ordination method was chosen because it is well suited to analysing associations between categorical variables in contingency tables. The correspondence analysis was performed using the FactoMineR package, and the graphical results were generated with the factoextra package.

The overall statistical significance of the correspondence analysis was assessed using the chi-square independence test. The eigenvalues and the percentage of total inertia explained by each dimension were calculated to assess the contribution of the ordination axes. Statistical significance was assessed at a threshold of $\alpha = 0.05$. These statistical analyses and graphical representations were performed using RStudio software (version 2025.05.1+513).

Results and Discussion

Socioeconomic characteristics of respondents

Four independent variables—gender, age, level of education, and years of experience—were used to study the socioeconomic characteristics of respondents (Fig. 2). The results illustrated in the heat map reveal a predominance of women practising traditional medicine (85.19%) among the respondents. This finding can be explained by the fact that men in the study region are mainly involved in the sale of plants in souks and herbalism. Furthermore, women are responsible for healthcare, making them the preservers of traditional ancestral knowledge. These results are consistent with those obtained by other researchers in the Tafilalet region (El Rhaffari & Zaid 2002) and in the Saharan province of Tata (Abouri *et al.* 2012).

In terms of age, young people under 20 are completely absent. On the other hand, the most represented age group is 40-60 (59.3%), followed by respondents over 60 (37%), indicating that the profession of traditional practitioners is exclusively held by mature adults and elderly people who have accumulated knowledge and expertise over time, thus confirming that a better understanding of the virtues of medicinal plants and their properties is generally acquired after long experience. Unfortunately, the absence of young people in this field suggests a recent decline in intergenerational transmission.

The level of education of those surveyed is generally low; 77.78% of respondents have no formal education, compared to 3.70% who have attained university education. This result highlights that the acquisition of ethnobotanical knowledge relies more on oral tradition and experience than on academic training (Najem *et al.* 2021).

In terms of experience, the most represented groups are those with 10-20 years of experience (40.74%) and 20-30 years (22.22%). These figures testify to the richness and durability of the knowledge and expertise accumulated by these practitioners over the years. When these holders of ethnobotanical practices disappear, it is as if a library were burning down, and unfortunately, a great deal of knowledge would be lost (Najem *et al.* 2019).

Botanical data

At the end of the ethnobotanical investigation, a total of 128 medicinal plants were collected, of which 48 (38%) have dual uses: therapeutic and culinary (Fig. 3). These plants belong solely to the angiosperm subphylum and are dominated by dicotyledons (Fig. 4).

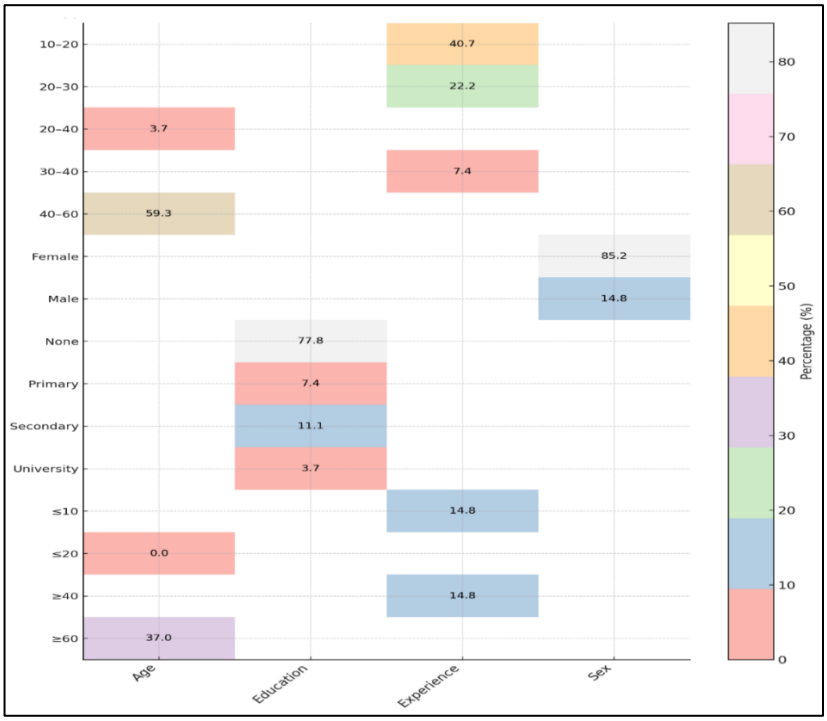


Figure 2. Heatmap of the socioeconomic variables of the respondents

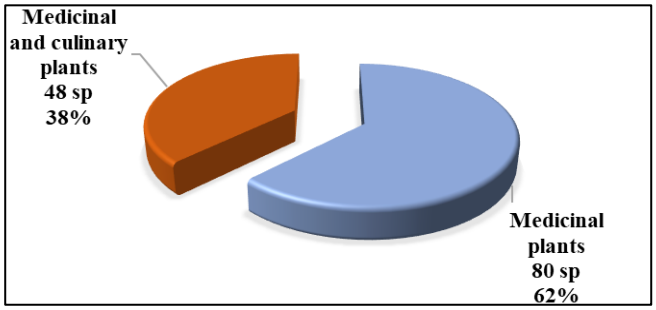


Figure 3. Distribution of medicinal species and dual-use species (medicinal and culinary)

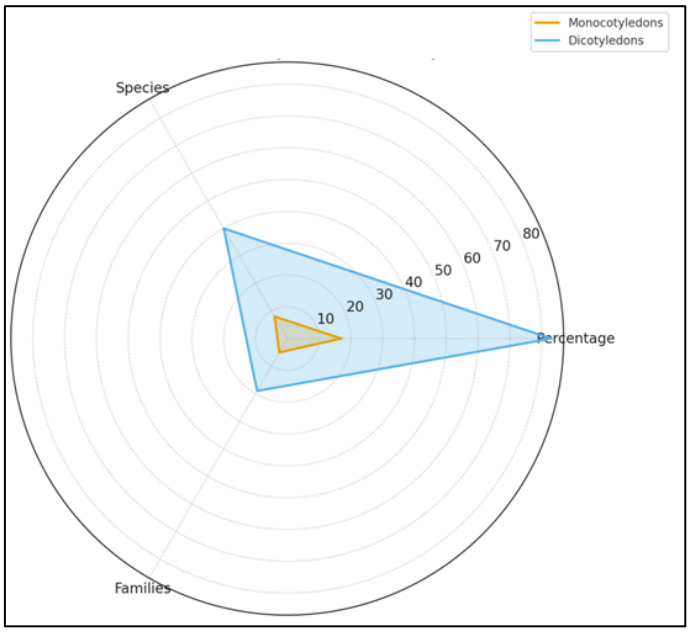


Figure 4. Distribution of culinary medicinal plants between monocotyledons and dicotyledons

Analysis of the biological spectrum (Fig. 5 and Table 1) shows a clear dominance of herbaceous plants (thirty-three species) over woody plants, accounting for 69% of the total; these are divided into eighteen therophytes, nine hemicryptophytes, four geophytes and two giant herbaceous plants. These results highlight that despite the difficult environmental conditions, marked by drought in the study area, the diversity of plant life forms remains remarkable. This biodiversity offers considerable potential for applications, thus underlining the crucial importance of preserving these natural resources for their potential food and medicinal properties.

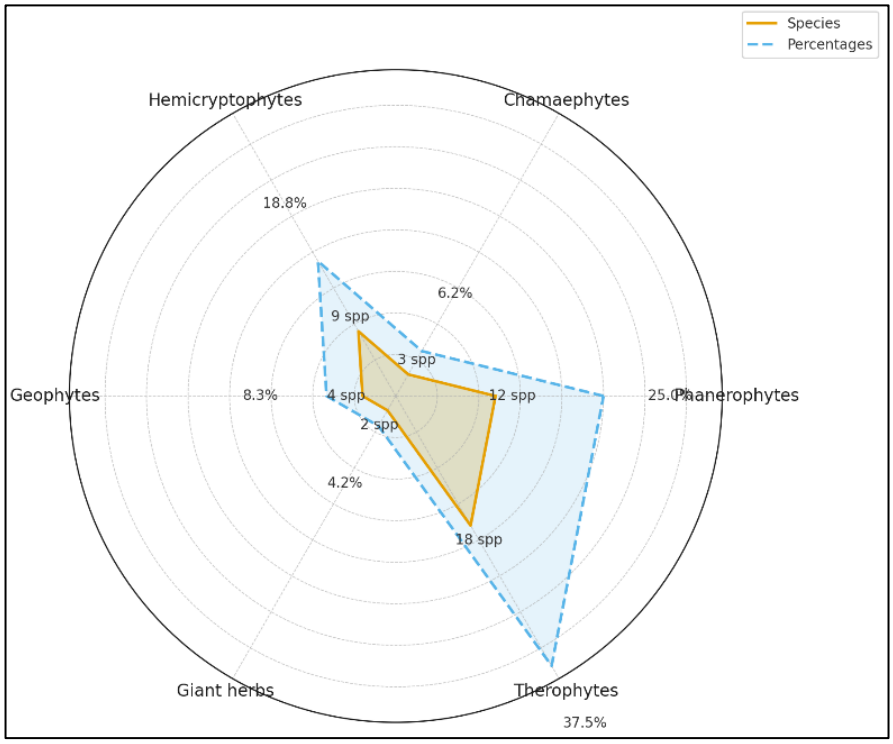


Figure 5. Biological spectrum of the inventoried culinary medicinal plants

Furthermore, the results reveal a clear dominance of cultivated species both inside and outside the study area (Fig. 6 and Table 1). This predominance reflects the high demand for these taxa for food and medicinal use by the population, as well as their integration into different types of production systems. Furthermore, the population partly relies on external supplies of therapeutic and food plants, as reflected in the use of plants cultivated outside the study area (CE = 29%). Strictly local species are rare, indicating open use and connections with other regions. Thus, the origin of the species used reveals a dynamic system adapted to food and therapeutic needs.

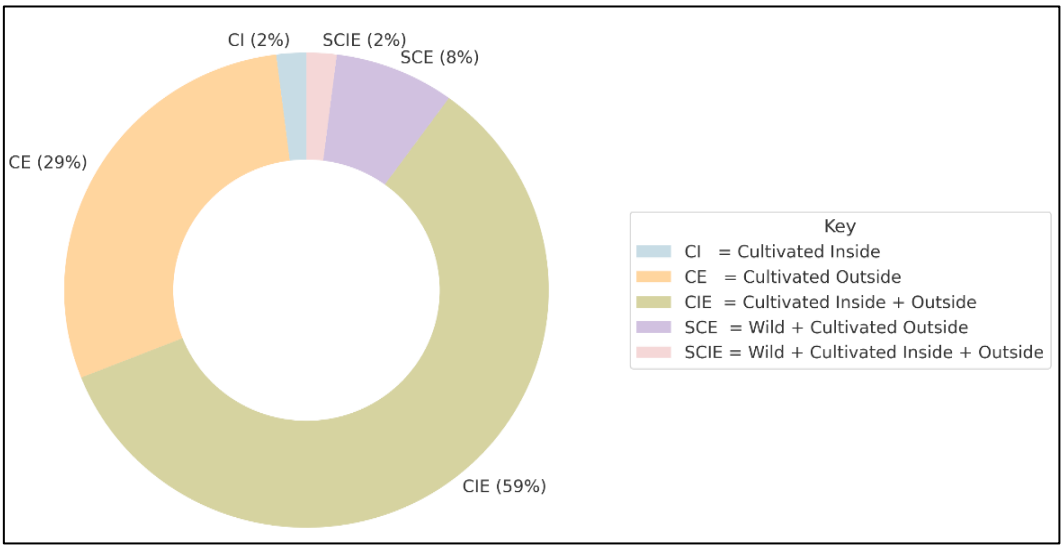


Figure 6. Origin of the inventoried culinary medicinal plants

Plants with dual medicinal and food uses in the Rissani circle are divided into twenty-four families, the most represented of which are: Apiaceae (eight species), Fabaceae (six species), Lamiaceae (five plants), Brassicaceae and Poaceae (three species each), Solanaceae, Rutaceae, Amaryllidaceae and Cucurbitaceae, each containing two species. The remaining fifteen families are each represented by a single species (Fig. 7 and Table 1).

The botanical families Apiaceae, Lamiaceae and Fabaceae are among the most represented families in Morocco, with 153, 202 and 424 species present in Morocco, respectively (Fennane & Ibn Tattou 2012). Within these families, most plants are commonly used in herbal medicine in the study region and are also among the most frequently used in Mediterranean countries (Najem *et al.* 2019, Nassiri *et al.* 2016).

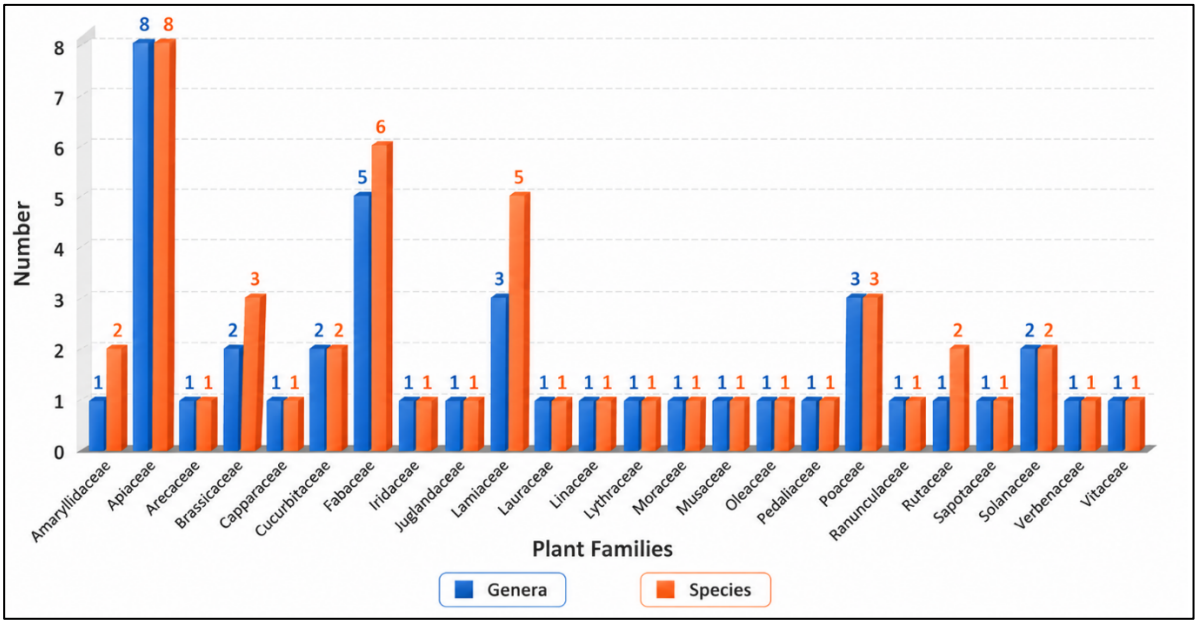


Figure 7. Genus and species richness of the families of the inventoried culinary medicinal plants

Plants listed for culinary and therapeutic use

The results shown in the figure indicate that twenty-six species (54%) are edible, fifteen (31%) are used as condiments, four (9%) have dual uses, and three are used to make herbal tea (Fig. 8).

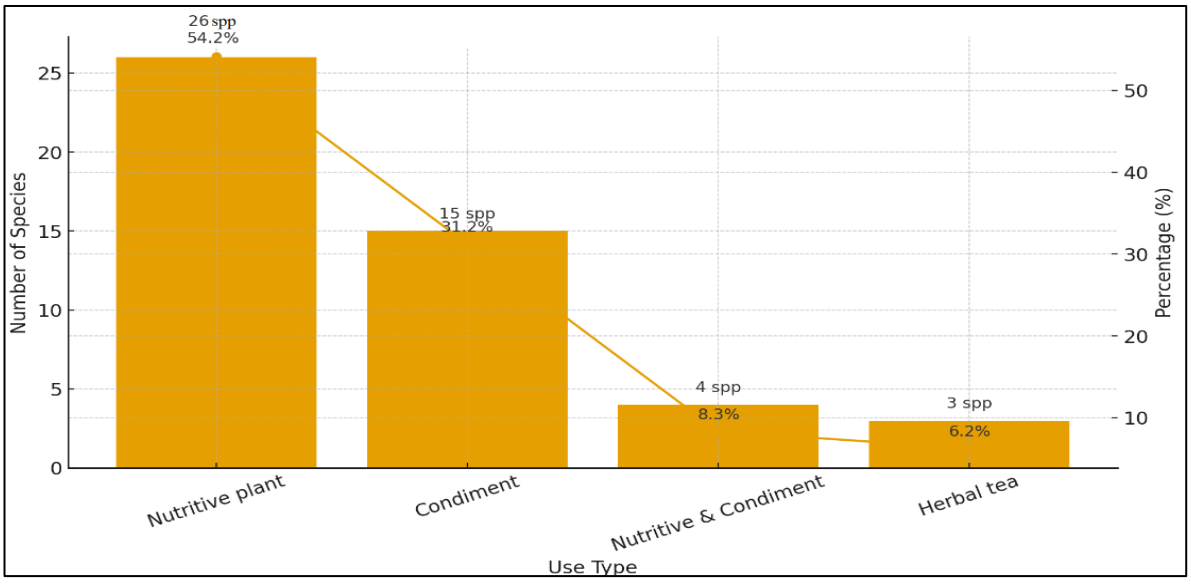


Figure 8. Number and percentage of species according to use type

Most plants with nutritional value are consumed as vegetables, cooked or raw, and as fresh or dried fruit; the rest are used to make flour, semolina, oil, etc. It should be noted that five species, including barley and maize, can also be used as animal feed. Condiments are divided into spices, seasonings, accompaniments, marinades, herbs, etc. (Fig. 9 and Table 1).

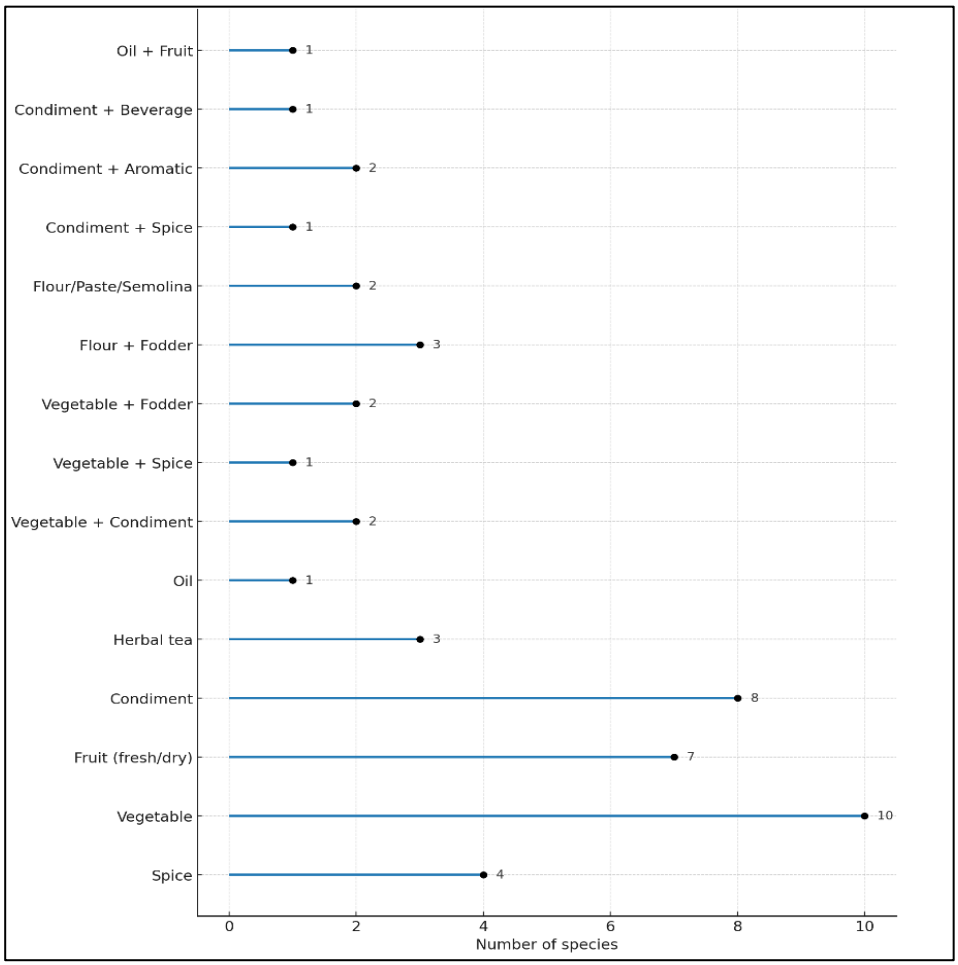


Figure 9. Details on the uses of the inventoried culinary medicinal plants

For most of the plants listed, the part used as food or condiment is the aerial part (Fig. 10-A). In terms of organs, seeds are used most frequently, followed by fruits, leaves and bulbs, while other organs such as flower buds (in the case of capers) or stigmas for saffron are rarely used (Fig. 10-B).

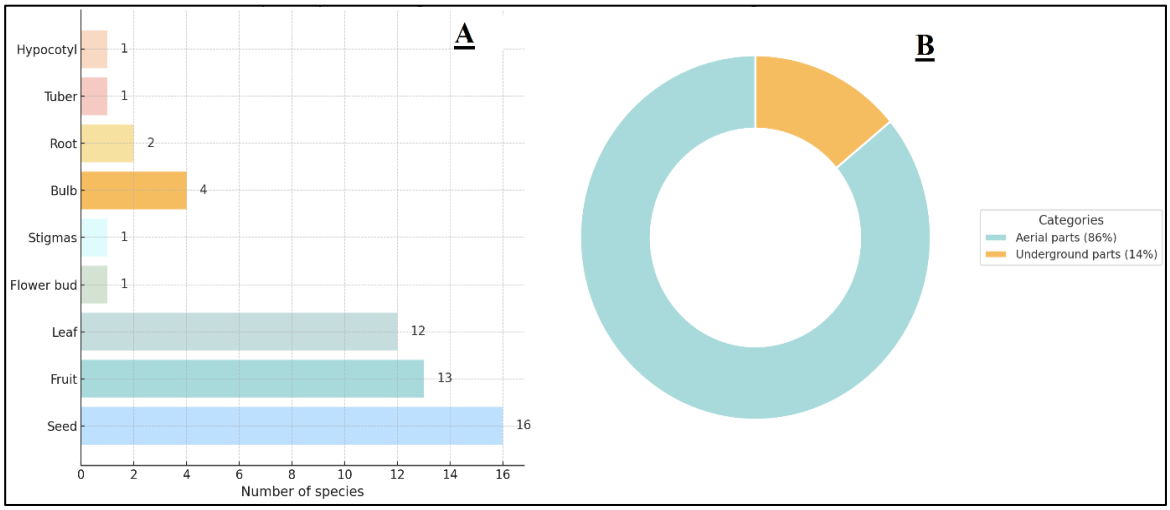


Figure 10. (A) Plant parts used for nutrition and as condiments; (B) Detailed distribution of the plant organs used

Table 1. Ethnobotanical data on medicinal plants used for food purposes

Families	Scientific names	Vernacular names	Specimen number	RFC	Biological types	Treated ailments	Parts used	Category	Specificities
Amaryllidaceae	*Allium cepa* L.	Lbassla - Azalim	EVMPRU-16	0.37	Geophyte	TD, SR, O, D, IM, SN, CV, SORL, EM	Bulb Seed	CW, CO	Vegetable (Bulb) and condiment (Bulb)
Amaryllidaceae	*Allium sativum* L.	Touma	EVMPRU-28	0.44	Geophyte	TD, SR, O, D, UG, OA, IM, CV, SORL	Bulb	CW, CO	Condiment
Apiaceae	*Apium graveolens* L. var. *rapaceum* (Mill.) Gaudin *Apium graveolens* L. var. *secalinum* Alef.	Krafes	EVMPRU-35	0.26	Hemicryptophyte (biennial)	TD, SR, O, UG, OA, SN	Seed	CW, CO	Vegetable (hypocotyl) Condiment (leaves)
Apiaceae	*Carum carvi* L.	Kerwiya	EVMPRU-02	0.59	Hemicryptophyte	TD, SR, UG, OA, IM, SN, CV, EM	Seed	CW, CO	Condiment
Apiaceae	*Coriandrum sativum* L.	kesbour	EVMPRU-36	0.26	Therophyte	TD, UG, SN, EM	Seed Leaves	CW, CO	Condiment and Spice (seed)
Apiaceae	*Cuminum cyminum* L.	Kamoun	EVMPRU-15	0.48	Therophyte	TD, SR, D, UG, OA, IM, SN, CV, SORL, EM	Seed	CW, CO	Spice (seed)
Apiaceae	*Daucus carota* L.= *Daucus carota* L.var. *sativa* L.	Khizzou	EVMPRU-27	0.07	Often Therophyte / Hemicryptophyte (biennial)	TD, UG, EM	Seed	CW, CO	Vegetable (Tuberous root)
Apiaceae	*Foeniculum vulgare* Mill. var. *dulce* (P. Mill.) = *Foeniculum dulce* DC.	Besbas	EVMPRU-42	0.59	Hemicryptophyte, sometimes biennial	TD, SR, UG, OA, IM, SN, CV, SORL, EM	Seed	CW, CO	Legume (fleshy swelling of the basal leaves: interlocking) = bulb
Apiaceae	*Petroselinum crispum* (Mill.) Fuss	Maadnous	EVMPRU-37	0.07	Hemicryptophyte	TD, UG, EM	Stem Leaves	CW, CO	Condiment
Apiaceae	*Pimpinella anisum* L.	Habat hlawa	EVMPRU-41	0.15	Therophyte or Hemicryptophyte	TD, UG, OA, IM, CV, EM	Seed	CO	Condiment (seeds and fresh leaves)
Arecaceae	*Phoenix dactylifera* L.	Nekhla	EVMPRU-17	0.37	Giant grass 'not a phanerophyte in the botanical sense'	TD, SR, O, UG, OA, IM, SN, EM	Seed Pollen Fruit Leaves	CW	Fruit 'dates'
Brassicaceae	*Brassica napus* L. subsp. *rapifera* Metzg.	Left fajli	EVMPRU-08	0.11	hemicryptophyte	SR, IM, SN, SORL	Root	CW, CO	Feed for grazing cattle and sheep (foliage and above-ground part of the root) Legume (tuberous root)
Brassicaceae	*Brassica oleracea* var. *viridis* L. =	lwarguia /Elkhadra Zegzaw	EVMPRU-01	0.15	Therophyte or Hemicryptophyte	TD, SR, D, UG OA, SN, SORL, EM	Root Stem Leaf	CW, CO	Leafy vegetable

	Brassica oleracea subsp *acephala* DC.								
Brassicaceae	*Lepidium sativum* L.	Hab erchad	EVMPRU-14	0.52	Therophyte	TD, SR, D, UG, OA, IM, SN, CV, EM	Seed	CW, CO	Salad vegetable (the leaves and flowers are added raw to salads) young shoots
Cucurbitaceae	*Capparis spinosa* L. subsp. *spinosa*	Kabar	EVMPRU-26	0.04	Nanophanerophyte	TD, UG, CV	Flower bud	CO, W	Condiment Flower bud (caper) and Fruit (caper berry)
Cucurbitaceae	*Cucurbita maxima* Duchesne	Geraa hemra	EVMPRU-03	0.04	Therophyte	TD, IM	Seed	CW, CO	Legume (the fruit)
Cucurbitaceae	*Lagenaria siceraria* (molina) Standl.	Slawi	EVMPRU-38	0.07	Therophyte	TD, SR, IM, SN	Fruit	CW, CO	Legume (the fruit)
Fabaceae	*Ceratonia siliqua* L.	Elkharoub	EVMPRU-40	0.15	Phanerophyte	TD, EM	Fruit	CO, W	Flour (carob pulp and skin, excluding seeds), Human consumption. Animal feed. Fruit (carob)
Fabaceae	*Cicer arietinum* L.	Hammas	EVMPRU-39	0.11	Therophyte	TD, SR, UG, OA, IM, EM	Seed	CO	Legume (Seed: chickpea)
Fabaceae	*Medicago sativa* L. subsp *sativa*	Fassa	EVMPRU-07	0.30	Hemicryptophyte	TD, SR, D, UG, OA, IM, EM	Leaves Stem Seed	CW, CO	Livestock feed (fodder) Human consumption Sprouted seeds Vegetable (leafy stems)
Fabaceae	*Trigonella foenum-graecum* L.	Halba	EVMPRU-04	0.74	Therophyte	TD, SR, D, UG, OA, IM, SN, CV, EM	Seed	CW, CO	Spice (Seed)
Fabaceae	*Vicia faba* L.	Foul	EVMPRU-18	0.15	Therophyte	TD, SR, UG, OA, IM, SN, CV	Seed	CW, CO	Legume (Seed)
Fabaceae	*Vicia lens* (L.) Coss. & Germ.	La'dass -	EVMPRU-43	0.26	Therophyte	TD, SR, UG, OA, IM, SN, CV	Seed	CW, CO	Legume (Seed)
Iridaceae	*Crocus sativus* L.	Zaafrane hor	EVMPRU-44	0.26	Geophyte	TD, SR, O, D, UG, OA, IM, EM	Stigmata	CO	Spice (Stigmata)
Juglandaceae	*Juglans regia* L.	Swak/ Guergaa	EVMPRU-29	0.04	Phanerophyte	D, EM	Bark	CO	Fresh and dried fruit (walnut kernels)
Lamiaceae	*Origanum majorana* L. = *Majorana hortensis* Moench	Mardadouch	EVMPRU-19	0.07	Hemicryptophyte/ Chamephyte sufrutescent	TD, SR, UG, OA, IM, SN, CV, EM	Stem Leaves	CO	Condiment (fresh or dried leaves) Beverage flavouring (tea)
Lamiaceae	*Mentha × piperita* L.	Na'na' lhror -	EVMPRU-05	0.04	Hemicryptophyte	TD, SR, IM	Stem Leaves	CW, CO	Flavoured drink (herbal tea and infusion made from leafy stems)

Lamiaceae	*Mentha spicata* L.	Naanaa'	EVMPRU-45	0.04	Hemicryptophyte	TD, UG, SN, CV, SORL	Stem Leaves	CW, CO	Flavoured drink (herbal tea and infusion made from leafy stems)
Lamiaceae	*Salvia rosmarinus* Spenn. = *Rosmarinus officinalis* L.	Azir	EVMPRU-21	0.74	Chamephyte (frutescent - Nanophanerophyte)	TD, SR, O, D, UG, OA, IM, SN, CV, SORL, EM	Stem Leaves	CW, CO	Seasoning for sauces, infusion (fresh or dried leafy branches) Condiment for grilled meats (fresh or dried leaves)
Lamiaceae	*Salvia officinalis* L.	Salmia	EVMPRU-30	0.07	Chamephyte (frutescent)	TD, SR, D, UG, IM, SN, SORL, EM	Leaves	CO	Condiment (fresh or dried leaves)
Lauraceae	*Laurus nobilis* L.	werket sidna moussa	EVMPRU-06	0.11	Nano-phanerophyte	TD, SR, UG, OA, IM	Leaves	CW, W	Condiment (Dried leaf)
Linaceae	*Linum usitatissimum* L.	Zeriat el ketan	EVMPRU-20	0.11	Therophyte	TD, EM, SORL, EM	Seed	CW, CO	Condiment (whole seeds added to barley soups)
Lythraceae	*Punica granatum* L.	Rommane	EVMPRU-31	0.48	Phanerophyte	TD, D	Peel Fruit	CW, CO	Fruit (pomegranate)
Moraceae	*Ficus carica* L.	Karmous	EVMPRU-48	0.04	Phanerophyte	SR, D, UG, IM	Fruit Latex	CW, CO	Fruit (fresh or dried figs)
Musaceae	*Musa acuminata* Colla	Banane	EVMPRU-13	0.04	Giant grass 'Nano-Phanerophyte'	D	Peel Fruit	CO	Fruit (banana)
Oleaceae	*Olea europaea* L. subsp. *europaea* var. *europaea*	Zitoune	EVMPRU-25	0.48	Phanerophyte	TD, SR, O, D, UG, OA, IM, SN, CV, SORL, EM	Fruit Leaves Seed	CW, CO	Fruit (olive) and olive oil
Pedaliaceae	*Sesamum indicum* L.	zenjlane	EVMPRU-34	0.04	Therophyte	TD	Seed	CO	Roasted seeds (cakes)
Poaceae	*Hordeum vulgare* L.	Cheir	EVMPRU-47	0.33	Therophyte	TD, SR, UG, OA, IM, EM	Barley grain (caryopsis: both fruit and seed)	CW, CO	Barley grain (caryopsis: both fruit and seed) Human consumption: Barley flour Animal feed: Grains
Poaceae	*Pennisetum typhoides* (Burn.) Stapf et Hubb.	Illane	EVMPRU-22	0.26	Therophyte	TD, OA, EM	Seed	CO	Seed (Flour and semolina)
Poaceae	*Zea mays* L. subsp. *mays*	Lakbale/ Amazgour/ Dra	EVMPRU-32	0.11	Therophyte	UG, SORL	Seed and Styles (bristles)	CW, CO	Ground corn kernels Flour, semolina, starch (corn flour) Boiled whole kernels (salad) Roasted or boiled corn cobs The entire plant can be consumed by livestock as fresh or dry fodder.

Ranunculaceae	*Nigella sativa* L.	Sanouj	EVMPRU-11	0.33	Therophyte	TD, UG, OA, EM	Seed	CO	Seed Spice (used in the composition of Ras el hanout, a traditional spice blend with many ingredients) Sprinkled on bread
Rutaceae	*Citrus sinensis* (L.) Osbeck	Limoun	EVMPRU-23	0.15	Nano-Phanerophyte	TD, UG, IM, SN	Fruit	CO	Fruit (orange) consumed directly, or pressed (juice), jam
Rutaceae	*Citrus × limon* (L.) Osbeck =*Citrus limon* (L.) Burm.	Lhamed	EVMPRU-46	0.15	Nano-Phanerophyte	SR, D, UG, IM, SN, SORL	Fruit	CW, CO	Fruit (Lemon) Drink Jam Condiment (juice)
Sapotaceae	*Sideroxylon spinosum* L. = *Argania spinosa* (L.) Skeels	Argane	EVMPRU-09	0.04	Phanerophyte	TD, UG, OA	Seed (Almond)	CO, W	Seed Argan oil
Solanaceae	*Capsicum frutescens* L.	Felfla harra/ Assoudania	EVMPRU-33	0.04	Chamephyte frutescens	TD, SR, IM, D	Fruit	CW, CO	Spice (dried fruit reduced to powder: hot chilli pepper) Vegetable (fruit preserved in water and salt and covered with olive oil)
Solanaceae	*Solanum tuberosum* L.	Batata	EVMPRU-24	0.04	Geophyte	D	Tuber (underground storage stem) Tuber (underground storage stem)	CO	Tuber (culinary vegetable) Human consumption Boiled, fried, mashed, au gratin, etc.
Verbenaceae	*Aloysia citrodora* Palau = *Lippia citrodora* (Paláu) Kunth	Lwiza	EVMPRU-10	0.04	Nano-phanerophyte or shrubby chamephyte	TD, SN, CV	Leaves	CO	Herbal tea (Infusion of green or dried leaves)
Vitaceae	*Vitis vinifera* L. *Vitis vinifera* subsp. *vinifera* = *Vitis vinifera* var. *sativa*	Alînab	EVMPRU-12	0.04	Nano-phanerophyte	TD, O, D	Leaves	CO	Fresh fruit (table grapes) Dried fruit (raisins)

Furthermore, if we compare the parts of plants used in medicine with those used in cooking (Table 1), we see that for thirty-three species (69% of the total inventoried), the part consumed is also used in phytotherapy, plus eight species (17%) where another organ is also used in therapy, such as the pomegranate, where the part consumed is the pomegranate seeds and the part used for therapeutic purposes is the pomegranate seeds plus its peel (Fig. 11). This offers the advantage of having plants with culinary value supplemented by medicinal properties, thus ensuring both nutrition and self-medication. Finally, for seven species, one organ or part is used for food while another different organ is used for therapy; one example is the vine, where the organ consumed is the fruit (fresh or dried grapes), while it is the leaf that has therapeutic properties, particularly the red vine, whose infused leaves have beneficial properties for blood circulation and the reduction of varicose veins and skin rashes; Similarly, a decoction of vine leaves is generally used to treat eye inflammation and, when taken internally, heavy periods and varicose veins.

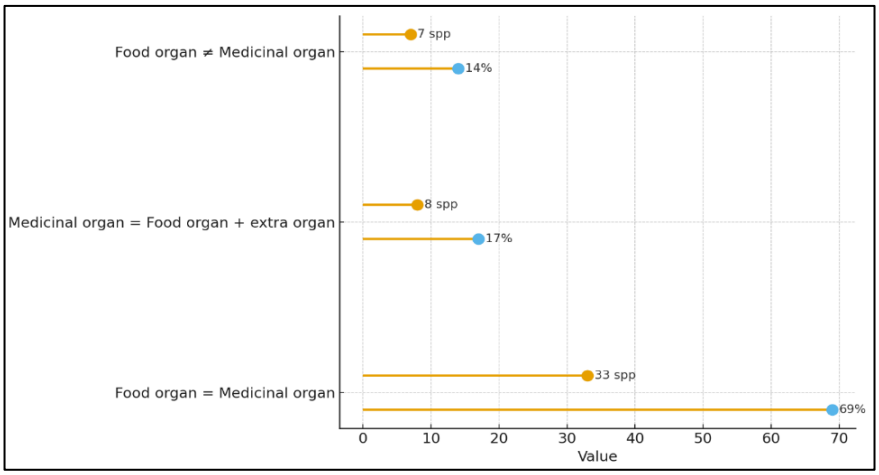


Figure 11. Comparison between the culinary and therapeutic uses of the inventoried plants

In socio-ecological systems, different forms of interaction between food and medicine can emerge, which can be summarized in three possible contexts: (1) a given plant is used both as medicine and as food, but with no other association between the two (for example, the part of the plant used for medicinal purposes is different from the part consumed as food); (2) a food plant is considered healthy, but without a single or specific medicinal target (known as a 'functional food' according to some definitions); and (3) a plant is consumed to obtain a specific medicinal effect (a medicinal food or food medicine) (Pieroni & Quave 2006).

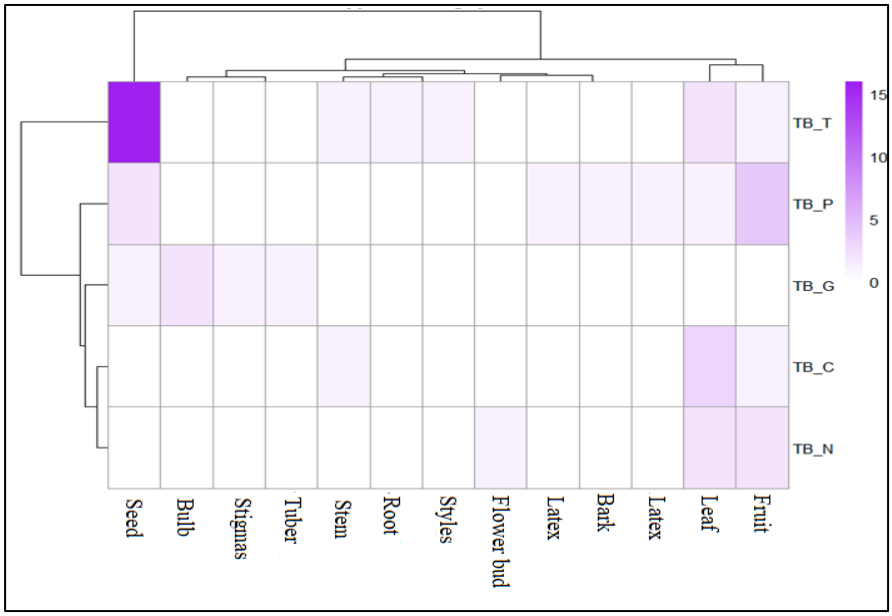


Figure 12. Heatmap showing associations between plant biological types and utilized plant organs

Biological types include chamaephytes (TB_C), geophytes (TB_G), therophytes (TB_T), phanerophytes (TB_P), and nanophanerophytes (TB_N). Hierarchical clustering was performed using Euclidean distance and Ward's method.

The heat map illustrating the correlation between biological types and plant organs used (Fig. 12) shows a predominance of phanerophytes associated with seeds and fruits. This pattern can be explained by the marked availability of these organs in woody species and their central role in local food and therapeutic practices. Other biological types contribute moderately, mainly through underground organs such as bulbs, roots, and tubers, reflecting a well-developed ecological and functional logic in ethnobotany.

The dual food and therapeutic use of certain organs is not only linked to their availability but also to their nutritional and medicinal value. Their richness in essential micronutrients (vitamins, minerals, trace elements) and secondary metabolites (antioxidants, phenolic compounds, unsaturated lipids) provides both nutritional benefits and protection or treatment against various diseases (Petersen *et al.* 2024, Slavin & Lloyd 2012).

Ethnopharmacological data

Relative frequency of citation (RFC)

The relative frequency of citation value ranges from 0 to 1; when it is close to 0, it means that none of the respondents referred to this plant as useful, and when it is close to 1, it indicates that this plant is considered useful by almost all respondents (Tardio & Pardo-de Santayana 2008).

According to the statements collected, *Salvia rosmarinus* Spenn. and *Trigonella foenum* graecum L. are widely used in traditional local medicine, with an RFC of 0.74 for each species; these are followed by *Carum carvi* L. and *Foeniculum vulgare* Mill., with an RFC of 0.59 each. In contrast, 18 species have an index very close to zero (between 0.04 and 0.07) (Table 1), probably because these species are little known to the informants or because they do not consider them useful for certain ailments. Furthermore, several categories of traditional practitioners were identified amongst those interviewed. The *fquihs* and *tolbas* are traditional healers who practice a wide range of therapeutic and medico-religious practices, which generally gives them in-depth knowledge of medicinal plants and a diverse therapeutic repertoire. In contrast, tooth extractors and cauterizers are more specialized practitioners whose activities are limited to specific therapeutic procedures; consequently, they rely on a more restricted selection of plant species suited to their field of practice.

Such heterogeneity among practitioners profiles may partly influence RFC values, as this index reflects the proportion of respondents citing a given species. Plants used in a variety of therapeutic contexts and by different categories of practitioners are more likely to be mentioned by a larger number of respondents and therefore tend to have higher RFC values. Conversely, species associated with specialized or less widespread practices are generally cited by a smaller number of informants and tend to have lower RFC values. Although the RFC was calculated by pooling all informants rather than separately for each category of practitioner, the diversity of practitioners' areas of expertise is a plausible factor contributing to the observed variation in citation frequencies between species.

Pathologies treated

According to the ethnobotanical data collected, it appears that several pathologies are treated by the traditional practitioners surveyed and that the majority of the medicinal plants inventoried are used to treat gastrointestinal disorders (Fig. 13 and Table 1). Thus, forty-one plant species (85%) are used to treat digestive tract conditions, followed by urogenital conditions with thirty-two species (67%). In contrast, ophthalmic disorders were treated with only eight medicinal plant species, representing the lowest number of species recorded among all therapeutic categories. Furthermore, the large number of species involved in each type of condition is likely due to the fact that the traditional practitioners surveyed often use mixtures of plants.

Fidelity index

The fidelity index (FI) is an extremely valuable tool for identifying the species most commonly used to treat a given disease (Najem *et al.* 2021). In this study, FI values range from 5% to 100% (Table 2). A high-fidelity index indicates high use of the plant species for a particular condition, while a low fidelity index indicates a wide range of medicinal uses but with low frequency for each condition (Yaseen *et al.* 2015).

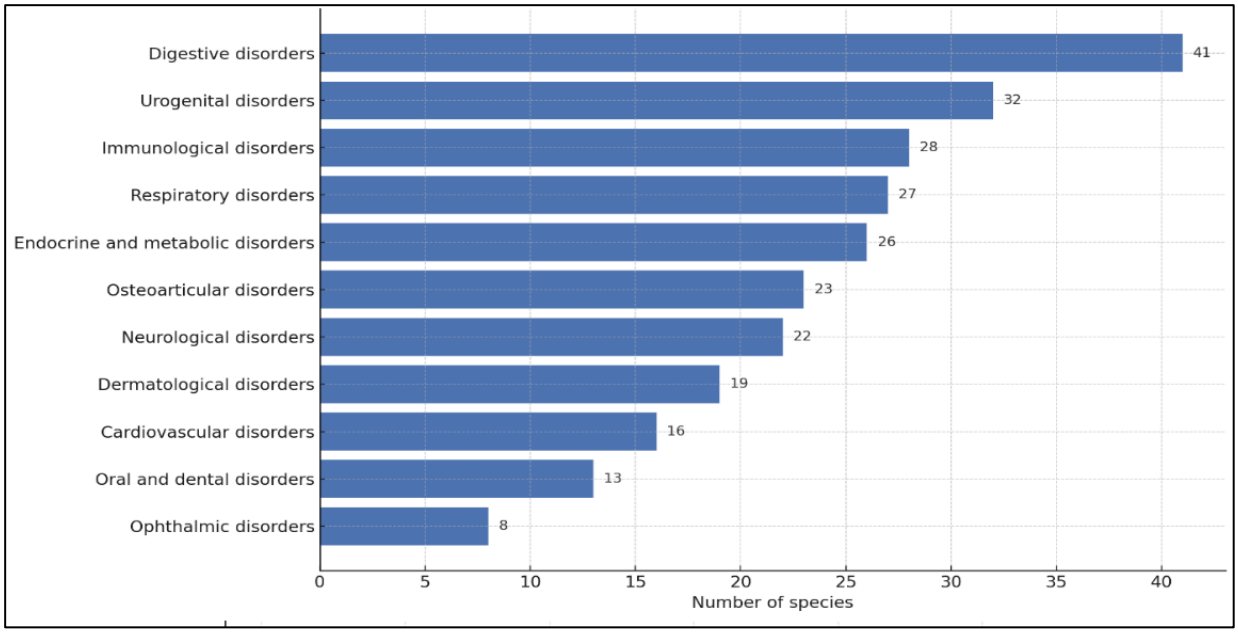


Figure 13. Number of medicinal plants used by type of pathology

Table 2. List of plant species with a 100% fidelity level by type of treated pathologies

Disorders	**Fidelity Index (%)**
Digestive (17 species)	*Apium graveolens* L., *Argania spinosa* (L.) Skeels, *Capsicum frutescens* L., *Ceratonia siliqua* L., *Cicer arietinum* L., *Cucurbita maxima* Duchesne, *Ficus carica* L., *Linum usitatissimum* L., *Lippia citrodora* (Paláu) Kunth, *Mentha spicata* L., *Mentha piperita* L., *Musa acuminata* Colla, *Origanum majorana* L., *Salvia officinalis* L., *Sesamum indicum* L., *Solanum tuberosum* L., *Vitis vinifera* L.
Urogenital (5 species)	*Lippia citrodora* (Paláu) Kunth, *Argania spinosa* (L.) Skeels, *Capparis spinosa* L., *Petroselinum crispum* (Mill.) Nyman, *Zea mays* L.
Dermatological (5 species)	*Juglans regia* L., *Lippia citrodora* (Paláu) Kunth, *Musa acuminata* Colla, *Salvia officinalis* L., *Solanum tuberosum* L.
Endocrine and metabolic (2 species)	*Olea europaea* var. *sylvestris* (Mill.) Lehr., *Lippia citrodora* (Paláu) Kunth
Immunological (4 species)	*Lippia citrodora* (Paláu) Kunth, *Brassica napus* L. subsp. *rapifera* Metzg., *Capsicum frutescens* L., *Ficus carica* L.
Respiratory (3 species)	*Brassica napus* L. subsp. *rapifera* Metzg., *Capsicum frutescens* L., *Ficus carica* L.
Oral and dental (3 species)	*Brassica napus* L. subsp. *rapifera* Metzg., *Mentha spicata* L., *Olea europaea* var. *sylvestris* (Mill.) Lehr.
Musculoskeletal (2 species)	*Lippia citrodora* (Paláu) Kunth, *Argania spinosa* (L.) Skeels
Neurological (1 species)	*Lagenaria siceraria* (molina) Standl.
Cardiovascular (1 species)	*Origanum majorana* L.

Table 2 lists the species with a fidelity level (FI) of 100 per cent. These values indicate complete consensus amongst the informants, meaning that all respondents who mentioned a given species associated it with the same therapeutic use (Amsalu *et al.* 2025). However, a high FI reflects the consistency of traditional knowledge rather than the pharmacological efficacy of the species (Mir *et al.* 2024).

This table shows that digestive disorders, with seventeen species, have the highest number of plants with a FI of 100%, followed by urogenital and oral disorders, with five species each. It should be noted that only *Origanum majorana* L. (true marjoram) has a FL of 100% for cardiovascular diseases, and *Lagenaria siceraria* (molina) Standl. (bottle gourd) for neurological diseases, while no species reaches this level for ophthalmic conditions.

These results correlate with those relating to conditions treated in the Errissani circle by the traditional practitioners surveyed (Fig. 13); digestive conditions are the most common, while visual conditions are very rarely treated. However, it is crucial not to neglect plants with a low fidelity index, as this could lead to a gradual loss of traditional knowledge (Chaudhary *et al.* 2006).

Correlation between treated diseases and parts of plants used

The heat map reveals the strongest associations (dark colors) and the weakest associations (light colors) between the different parts used and the conditions treated (Fig. 14).

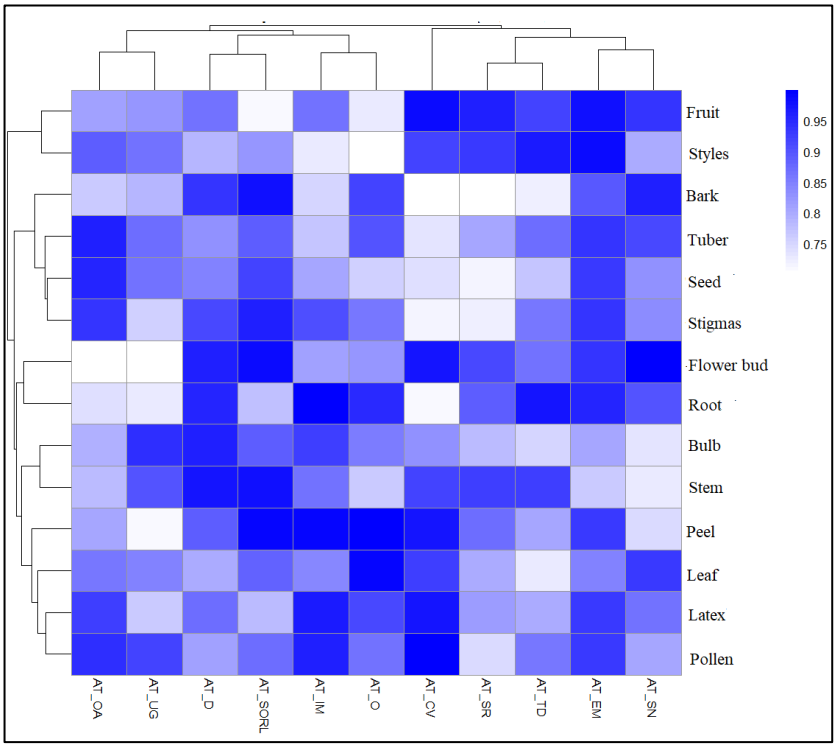


Figure 14. Heatmap illustrating the relationships between plant parts and treated ailments

Treated ailments include osteoarticular disorders (AT_OA), urogenital disorders (AT_UG), dermatological disorders (AT_D), oral disorders (AT_SORL), immunological disorders (AT_IM), ophthalmic disorders (AT_O), cardiovascular disorders (AT_CV), respiratory disorders (AT_SR), digestive disorders (AT_TD), endocrine-metabolic disorders (AT_EM), and neurological disorders (AT_SN). Hierarchical clustering was based on Euclidean distance and Ward's method.

Indeed, the leaves, stem, bark and latex have high values for several conditions, particularly digestive, dermatological and respiratory disorders. This suggests that these organs are easily accessible, rich in secondary metabolites with pharmacological properties and often recommended by traditional practitioners in traditional recipes (Bammou *et al.* 2015).

Furthermore, the seeds and fruit have moderate intensities for neurological, cardiovascular, endocrine and metabolic conditions thanks to their biochemical composition rich in saturated lipids, antioxidants and phenolic compounds that improve blood sugar regulation and reduce cholesterol (Haminiuk *et al.* 2012, Jia *et al.* 2024).

In addition, certain organs are rarely used, indicating specificity or limited availability. This is the case with the floral parts, the stigmas recommended for immunological conditions and the flower buds, which have significant value for respiratory and dermatological disorders.

Analysis of the relationships between dietary specificities and the conditions treated

Studies on the dietary habits of a population are a useful tool for better understanding the health and disease profiles observed within that population (Alarcón *et al.* 2015). In this regard, a correspondence factor analysis (CFA) was performed to explore the relationships between the specific dietary properties of plants and the conditions they are used to treat.

The first two factor axes explain 72.4% of the total inertia, with 40.3% for dimension 1 and 32.1% for dimension 2, indicating an interpretable structure of the cloud of modalities (Fig. 15). However, the overall χ^2 test associated with CFA is not significant ($\chi^2 \approx 0.16$; ddl = 1128; p = 1), suggesting the absence of a statistically significant dependence between the categories of conditions treated and the dietary specificities considered as a whole.

The projection of the modalities on the factorial plane shows that the majority of them are close to the origin, reflecting a low level of dietary specialization for most conditions. Cardiovascular and osteoarticular conditions are located on the negative side of dimension 1, mainly in association with fruit and sweet preparations. Conversely, vegetables and condiments are projected on the positive side of this axis, close to urogenital conditions. Furthermore, nervous system and immune system conditions occupy a central position on the factorial plane, indicating that the plants used in these contexts have varied and non-discriminatory dietary profiles. The species associated with endocrine and metabolic disorders appear relatively distinct from other food categories, suggesting a certain specificity in their uses.

Overall, despite the partial structure highlighted by the first two dimensions of the CFA, the non-significance of the χ^2 test and the dispersion of modalities indicate that the relationships between the disorders treated and dietary specificities remain diffuse. This reflects the versatility of plant species within the local food pharmacopoeia, where plants are perceived simultaneously as nutritional and therapeutic resources rather than as foods strictly specialized by type of condition.

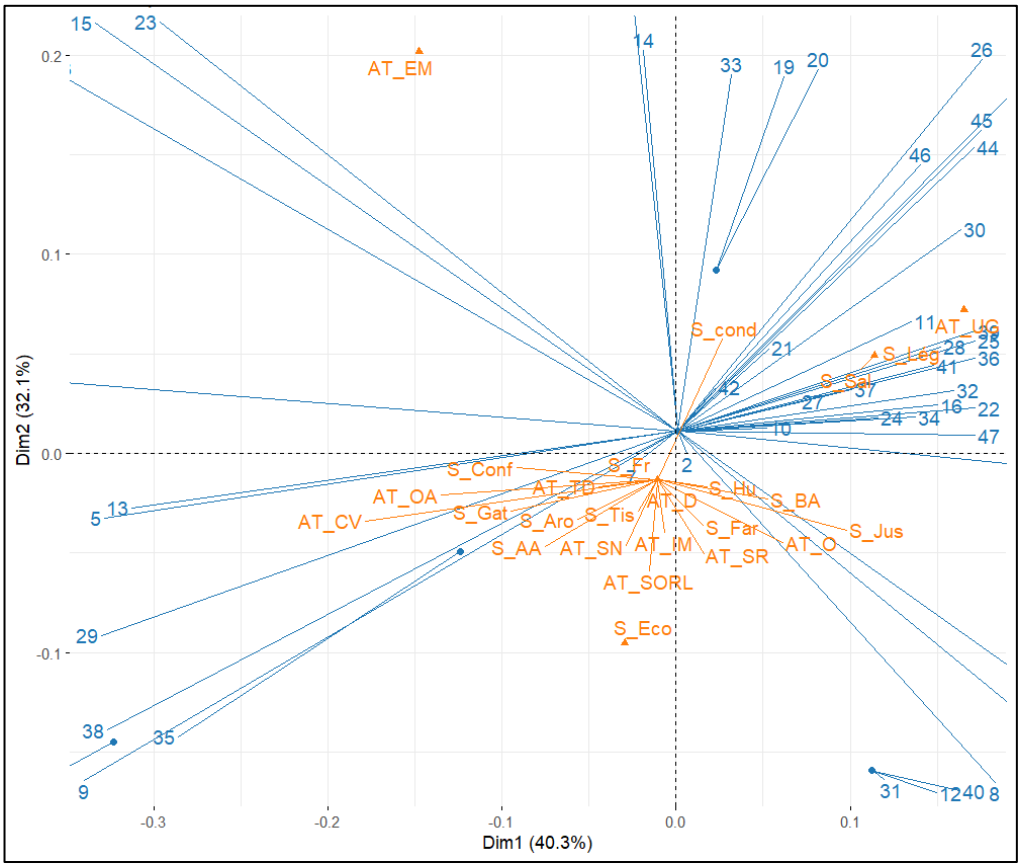


Figure 15. Corresponding factor analysis (CFA) illustrating the relationships between food use categories and treated conditions

Treated conditions include digestive disorders (AT_D), respiratory disorders (AT_SR), dermatological disorders (AT_TD), osteoarticular disorders (AT_OA), immune disorders (AT_IM), cardiovascular disorders (AT_CV), urogenital disorders (AT_UG), endocrine and metabolic disorders (AT_EM), and nervous system disorders (AT_SN). The categories of food use include fruit (S_Fr), vegetables (S_Lég), condiments (S_Cond), juices (S_Jus), herbs (S_Aro), herbal teas (S_Tis), cakes and sweet preparations (S_Gat), jams (S_Conf), spices (S_Eco), animal feed (S_AA), flour (S_Far), oil (S_Hui) and flavored drinks (S_BA)

Conclusion

This ethnobotanical study in the Errissani region highlights ethnomedical knowledge, the diversity of plants with medicinal properties in general, and those combining both food and medicinal properties in particular. Of 128 medicinal species, 48 (38 per cent) have dual uses: therapeutic and food. These species are generally cultivated and belong to 24 botanical families, the most common of which are the Apiaceae and Fabaceae. Their culinary use generally involves being used as food, as a condiment, or as both food and a condiment, as well as, in some cases, as herbs added to tea. In the majority of cases, the same part of the plant is used for both nutritional and therapeutic purposes, with digestive and urogenital disorders being the most commonly treated conditions. This empirical knowledge contributes to the promotion of ethnomedical heritage and illustrates the continuity between food and medicine; it deserves to be preserved and promoted. Similarly, this study makes a scientific contribution to the documentation of ethnobotanical knowledge by providing an inventory of species with dual medicinal and food uses. Further research into the phytochemical characterization, the assessment of biological activities and the nutritional quality of these species, as well as their safety and toxicity, is required to validate their traditional use. Ultimately, these studies could provide a scientific basis for the development of these species and for exploring their potential in the medical and agri-food sectors with a view to developing value-added products.

Declarations

List of abbreviations: Not applicable

Ethics approval and consent to participate: All participants provided informed consent after being fully informed of the purpose of the study.

Consent for publication: Not applicable

Availability of data and materials: Not applicable

Competing interests: Not applicable

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Literature cited

Abouri M, El Mousadik A, Msanda F, Boubaker H, Saadi B, Cherifi K. 2012. An ethnobotanical survey of medicinal plants used in the Tata Province, Morocco. International Journal of Medicinal Plant Research 1:99-123.

Alarcón R, Pardo-de-Santayana M, Priestley C, Morales R, Heinrich M. 2015. Medicinal and local food plants in the south of Alava (Basque Country, Spain). Journal of Ethnopharmacology 176:207-224. doi: 10.1016/j.jep.2015.10.022

Alrhmoun M, Sulaiman N, Pieroni A. 2025. Phylogenetic perspectives and ethnobotanical insights on wild edible plants of the Mediterranean, Middle East, and North Africa. Foods 14:1-23. doi: 10.3390/foods14030465

Amsalu N, Mengiste, Birhanu, Awoke, Getnet GT. 2025. Ethnobotanical investigation of traditionally used phytomedicines in Jabitehnan district, West Gojjam Zone, Ethiopia. Scientific Reports 15: 1-33. doi: 10.1038/s41598-025-29297-4

Aribou ML, Amrani BE. 2023. Rôle des pratiques du Management de la qualité totale dans la réussite du processus de Knowledge Management et d'innovation: Une étude de cas multiple appliquée au secteur marocain d'automobile. Alternatives Managériales Economiques 5:296-317. doi: 10.48374/IMIST.PRSM/ame-v5i4.44243

Ayyanar M, Ignacimuthu S. 2013. Plants as food and medicine: An ethnobotanical survey among Kanikaran community in Southern India. European Journal of Nutrition & Food Safety 3:123-133.

Bammou M, Daoudi A, Sellam K, El Rhaffari L, Ibijbijen J, Nassiri L. 2015. Étude ethnobotanique des Astéracées dans la région Meknès-Tafilalet (Maroc). International Journal of Innovation and Applied Studies 13:789-815.

Ben Brahim M. 2021. Les rapports à l'eau dans les oasis présahariennes du Maroc. UNESCO, Paris, France.

Cencic A, Chingwaru W. 2010. The role of functional foods, nutraceuticals, and food supplements in intestinal health. Nutrients 2:611-625. doi: 10.3390/nu2060611

Chaudhary NI, Schnapp A, Park JE. 2006. Pharmacologic differentiation of inflammation and fibrosis in the rat bleomycin model. American Journal of Respiratory and Critical Care Medicine 173:769-776. doi: 10.1164/rccm.200505-717OC

de Medeiros PM, Figueiredo KF, Gonçalves PHS, Caetano RDA, Santos ÉMDC, Dos Santos GMC, Barbosa DM, de Paula M, Mapeli AM. 2021. Wild plants and the food-medicine continuum—an ethnobotanical survey in Chapada Diamantina (Northeastern Brazil). Journal of Ethnobiology Ethnomedicine 17:1-10. doi: 10.1186/s13002-021-00463-y

Dop MC, Kefi F, Karous O, Verger EO, Bahrini A, Ghrabi Z, El Ati J, Kennedy G, Termote C, MEDINA Study Group. 2020. Identification and frequency of consumption of wild edible plants over a year in central Tunisia: a mixed-methods approach. Public Health Nutrition 23:782-794. doi: 10.1017/S1368980019003409

El Ansari M, Najem M, Ibijbijen J, Bouraada K, Nassiri L. 2025. Qualitative and quantitative ethnobotanical assessment of *Zygophyllum gaetulum* Emb. & Maire: An emblematic medicinal plant of Saharan heritage. Ethnobotany Research and Applications 32: 1-21. doi: 10.32859/era.32.35.1-21

El Mansouri L, Ennabili A, Bousta D. 2011. Socioeconomic interest and valorization of medicinal plants from the Rissani oasis (SE of Morocco). Boletin Latinoamericano y del Caribe de Plantas Medicinales y Aromáticas 10:30-45.

El Rhaffari L, Zaid A. 2002. Pratique de la phytothérapie dans le sud-est du Maroc (Tafilalet) : un savoir empirique pour une pharmacopée rénovée. In: Des sources du savoir aux médicaments du futur: actes du 4e congrès européen d'ethnopharmacologie. Paris (FRA); Metz: IRD; SFE, Pp. 293-318.

Esakkimuthu S, Sylvester Darvin S, Mutheeswaran S, Gabriel Paulraj M, Pandikumar P, Ignacimuthu S, Al-Dhabi NA. 2018. A study on food-medicine continuum among the non-institutionally trained siddha practitioners of Tiruvallur district, Tamil Nadu, India. Journal of Ethnobiology and Ethnomedicine 14:1-29. doi: 10.1186/s13002-018-0240-9

Fennane M, Ibn Tattou M. 2012. Statistiques et commentaires sur l'inventaire actuel de la flore vasculaire du Maroc. Bulletin de l'Institut Scientifique, Rabat, section Sciences de la Vie 34:1-9.

Fennane M, Ibn Tattou M, El Oulaidi J. 2014. Flore pratique du Maroc Vol. 3. Travaux Institut Scientifique, Série Botanique N° 40, Rabat, Maroc.

Fennane M, Ibn Tattou M, Mathez J, Ouyahya A, El Oulaidi J. 1999. Flore pratique du Maroc vol 1. Travaux Institut Scientifique, Série Botanique N° 36, Rabat, Maroc.

Fennane M, Ibn Tattou M, Ouyahya A, El Oulaidi, J. 2007. Flore pratique du Maroc Vol. 2. Travaux Institut Scientifique, Série Botanique N° 38, Rabat, Maroc.

Haminiuk CW, Maciel GM, Plata-Oviedo MS, Peralta RM. 2012. Phenolic compounds in fruits - an overview. International Journal of Food Science and Technology 47:2023-2044. doi: 10.1111/j.1365-2621.2012.03067.x

Jain SK. 1964. The role of botanist in folklore research. Folklore 5:145-150.

Jia Y, Wang H, Fan W, Lv J, Niu Q, Zhu R, Zhang Q. 2024. Effects of polyphenol-rich seed foods on lipid and inflammatory markers in patients with coronary heart disease: a systematic review. Frontiers in Nutrition 11:1-13. doi: 10.3389/fnut.2024.1493410

Mir AM, Mir BA, Peer LA. 2024. Medicinal plants of the Himalayan Tral region of Kashmir, India: an ethnobotanical study of their diversity, use patterns, and health implications. Ethnobotany Research and Applications 27 :1-19. doi: 10.32859/era.27.33.1-19

Najem M, Bouiamrine EH, Ibijbijen J, Nassiri L. 2024a. Ras El Hanout: a theriac of therapeutic plants and spices-Qualitative and quantitative ethnobotanical investigation in the city of Meknes (Morocco). Ethnobotany Research and Applications 29:1-32. doi: 10.32859/era.29.51.1-32

Najem M, Daoudi A, Bouiamrine EH, Ibijbijen J, Nassiri L. 2019. Biodiversity of poisonous medicinal plants solicited in the traditional phytotherapy of the central Middle Atlas-Morocco. Ethnobotany Research & Applications 18:1-23. doi: 10.32859/era.18.19.1-22

Najem M, Harouak H, Ibijbijen J, Nassiri L. 2020. Oral disorders and ethnobotanical treatments: A field study in the central Middle Atlas (Morocco). Heliyon 6:1-11. doi: 10.1016/j.heliyon.2020.e04707

Najem M, Ibijbijen J, Nassiri L. 2019. Quantitative Ethnobotanical Study of Poisonous Medicinal Plants used in the Traditional Pharmacopoeia of the Central Middle Atlas Region: Morocco. Ethnobotany Research & Applications 18:1-17. doi: 10.32859/era.18.36.1-17

Najem M, Ibijbijen J, Nassiri L. 2021. Ethnobotanical treatment of respiratory diseases in the central Middle Atlas (Morocco): Qualitative and quantitative approach. European Journal of Integrative Medicine 46:1-15. doi: 10.1016/j.eujim.2021.101358

Najem M, Ibijbijen J, Nassiri L. 2022. Phytotherapy in response to COVID-19 and risks of intoxication: A field study in the city of Meknes (Morocco). Journal of Pharmacy & Pharmacognosy Research 10:357-386. doi: 10.56499/jppres21.1257_10.3.357

Najem M, Nassiri L, Ibijbijen J. 2021. Origin of vernacular names of plants: case of toxic plants for medicinal use in the central Middle Atlas-Morocco. Interdisciplinary Science Reviews :1-22. doi: 10.1080/03080188.2021.1918371

Najem M, Ouadjane Y, Ibijbijen J, Nassiri L. 2024b. Ras El Hanout: Traditional blend of medicinal plants and spices-toxic compounds and poisoning risks. Ethnobotany Research and Applications 29:1-22. doi: 10.32859/era.29.72.1-22

Nassiri L, Zarkani S, Daoudi A, Bammou M, Bouiamrine EH, Ibijbijen J. 2016. Contribution to the establishment of ethno botanical catalog of Aguelmous (Khenifra, Morocco). International Journal of Innovation and Applied Studies 17:373-387.

Petersen KS, Maki KC, Calder PC, Belury MA, Messina M, Kirkpatrick CF, Harris WS. 2024. Perspective on the health effects of unsaturated fatty acids and commonly consumed plant oils high in unsaturated fat. British Journal of Nutrition 132:1-12. doi: 10.1017/S0007114524002459

Pieroni A, Quave CL. 2006. Functional foods or food medicines? On the consumption of wild plants among Albanians and Southern Italians in Lucania. In: Pieroni A, Price LL (Eds.), Eating and healing: traditional food as medicine. Food Products Press, Binghamton, USA, 101-129.

Sansanelli S, Ferri M, Salinitro M, Tassoni A. 2017. Ethnobotanical survey of wild food plants traditionally collected and consumed in the Middle Agri Valley (Basilicata region, southern Italy). Journal of Ethnobiology and Ethnomedicine 13:1-10. doi: 10.1186/s13002-017-0177-4

Slavin JL, Lloyd B. 2012. Health benefits of fruits and vegetables. Advances in Nutrition 3:506-516. doi: 10.3945/an.112.002154

Tardio J, Pardo-de Santayana M. 2008. Cultural importance indices: a comparative analysis based on the useful wild plants of southern Cantabria (Northern Spain). Economic Botany 62:24-39.

Vignigbé M, Maccaro A, Checa Rifà P, Piaggio D, Pecchia L. 2024. Précaution ou prévention? Des responsabilités de la politique et de la société pendant la gestion de la pandémie de COVID-19 au Bénin. Canadian Journal of Development Studies 45:332-347. doi: 10.1080/02255189.2023.2268794

Yao R, He C, Xiao P. 2023. 'Food and medicine continuum' in the East and West: Old tradition and current regulation. Chinese Herbal Medicines 15:6-14. doi: 10.1016/j.chmed.2022.12.002

Yaseen G, Ahmad M, Sultana S, Suleiman Alharrasi A, Hussain J, Zafar M, Shafiq-Ur-Rehman. 2015. Ethnobotany of medicinal plants in the Thar Desert (Sindh) of Pakistan. Journal of Ethnopharmacology 163:43-59. doi: 10.1016/j.jep.2014.12.053