# Ethnobotanical study of medicinal plants used in the rural area of the Western High Atlas (Morocco)

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**Ethnobotany Research and Applications 29:15 (2024)** - http://dx.doi.org/10.32859/era.29.15.1-26
Manuscript received: 21/03/2024 – Revised manuscript received: 01/06/2024 - Published: 03/06/2024

## Research

## Abstract

*Background:* This study aimed to address the lack of comprehensive research on the use of medicinal plants in the Western High Atlas, a landlocked region known for its rich plant biodiversity.

*Methods:* A survey was conducted among 150 participants, utilizing semi-structured interviews to collect socio-economic data and information on medicinal plants.

*Results:* Most respondents had limited education (76%). Approximately half of the population reported no income (49%), and a significant proportion lacked medical insurance (84%). The study documented the use of 101 plant species from 54 families. High Use Values were observed for *Argania spinosa, Opuntia ficus-indica, Tetraclinis articulata, Rosmarinus officinalis,* and *Trigonella foenum-graecum* (UVs 3.17 – 3.67). *Thymus broussonetii, Thymus satureoides, T. articulata,* and *Chenopodium ambrosioides* exhibited high Relative Frequencies of Citation (0.23 - 0.47). Notable Fidelity Levels (100%) were observed for *T. satureoides, Allium sativum,* and *Ephorbia officinarum* for respiratory diseases, *T. foenum-graecum* for urinary affections, *C. ambrosioides* for fever, and *Cuminum cyminum* for bloating. Digestive and respiratory disorders were the most treated, with respiratory ailments demonstrating the highest ICF (0.86). The study documented new uses, such *as Ononis natrix* for hepatic disorders, *Ammodaucus leucotrichus* for digestive and respiratory ailments, and *T. articulata* for diarrhea.

*Conclusion:* One hundred and one medicinal plants were listed. The remedies primarily aimed to treat respiratory, digestive, and urinary diseases that recorded high ICFs. New uses were noted for *O. natrix*, *A. leucotrichus*, and *T. articulata*.

*Keywords*: Ethnobotany; High Atlas; Morocco; Traditional Medicine

## Background

The global plant diversity comprises approximately 500,000 species, of which 80,000 possess medicinal properties, predominantly utilized in developing nations (Phillips et al. 1994; Tabuti et al. 2003). Factors such as perceived ineffectiveness or toxicity of conventional drugs and cultural preferences contribute to the reliance on medicinal plants (Greenwood 1981, Philips et al. 1994, Tabuti et al. 2003). Furthermore, poverty and limited access to conventional

healthcare, particularly in rural areas lacking medical infrastructure, drive communities to resort to medicinal plants, especially when herbs are readily accessible in their environments (Bodeker & Kronenberg 2006, Brandão et al. 2006).

Among Mediterranean countries, Morocco ranks second in terms of plant biodiversity after Turkey. It hosts over 160 sites of significant biodiversity, integrated into the national strategy for environmental preservation (Fennane 2004). The High Atlas Mountains, characterized by a high rate of endemism with 7 000 species from 130 families, contribute to the country's botanical richness (Taleb & Fennane 2011). However, the occidental High Atlas region faces poverty and subsistence challenges commonly observed among mountainous populations (Crawford 2003, Montanari 2014).

The High Atlas region possesses rich plant biodiversity due to its altitude and the influence of the Atlantic Ocean (Msanda et al. 2021). However, the population of this rural area remains landlocked and primarily resides in small villages called Douars, which lack medical infrastructure (MIDGCL 2019). Development policies in the region have favoured coastal areas along the Atlantic, resulting in neglect of rural zones (Boujrouf et al. 2003). Additionally, economic activities with low added value, primarily based on food agriculture, hinder the population's access to medical facilities located in cities and larger agglomerations (MIDGCL 2019). Consequently, the use of medicinal plants could serve as an alternative to conventional medical care. However, no ethnobotanical study has been conducted to assess the knowledge and usage of medicinal plants among the population of the Western High Atlas. This study aims to inventory the medicinal plants used, the diseases treated, and the preparation methods of remedies, taking into consideration the socio-economic factors such as education, income, and social coverage of the rural population in the study area.

## Materials and Methods

**Study area**

The study was conducted in the Imouzzer District, which is part of the Agadir province (Fig. 1). The province covers an area of 2297 km2 and is bordered by the Essaouira province to the north, Taroudannt province to the east, Inezgane Aït Melloul prefecture to the south, and the Atlantic Ocean to the west. It consists of an urban district (Agadir city) and 12 rural districts (Akesri, Aourir, Taghazout, Tamri, Aziar, Tadrart, Drarga, Amskroud, Idmine, Tiqqi, Imessouane, and Imouzzer). The region's topography is mainly characterized by the dominant western High Atlas massif, which covers approximately 85% of the total surface area and features rugged and diverse terrain. The climate of the region is semi-arid, with abundant sunshine of approximately 300 days per year. The region benefits from a sea breeze that moderates temperatures, while the Anti Atlas in the south acts as a barrier against Saharan winds.

The study area is known for its floristic diversity, encompassing Mediterranean, tropical, and endemic elements. Key species include cedar, argan, holm oak, thyme, or a combination of these species (Msanda *et al.* 2021). It is part of a Biosphere Reserve declared by UNESCO in 1998 to protect the endangered tree species *Argania spinosa*.

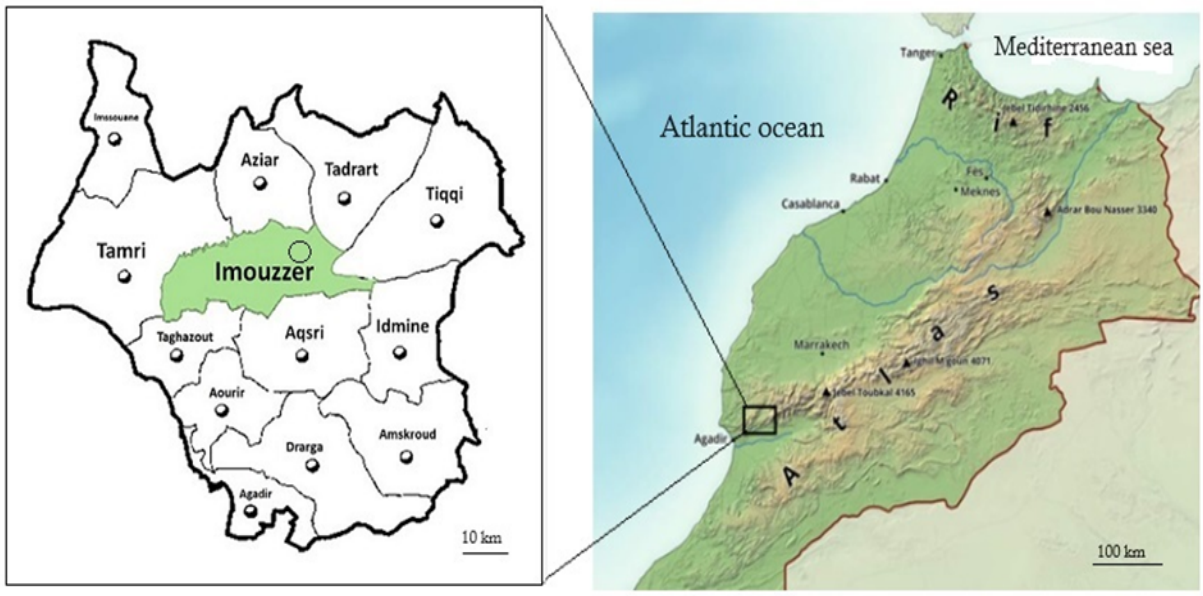


Figure 1. Study area

The rural commune of Imouzzer

**Data collection**

An ethnobotanical survey was conducted in the rural area of the Imouzzer district from May to October 2019. Ethical approval was obtained from the Bioethics Advisory Committee of the Faculty of Sciences of Agadir (approval number AE-2019-0001). Two interviewers were trained to have a good understanding of the research protocol, including study objectives, sampling strategy, interview format and ethical guidelines, through the organization of practice sessions. They were trained to use data collection tools and plant specimens effectively and correctly while respecting participants' cultural norms, beliefs and practices. Throughout the survey, a supervisor ensured consistency of approach during the interviews.

Simple random sampling was used. Participants were contacted at their homes. They are recruited considering the inclusion and exclusion criteria. This method helps to minimize selection and recruitment bias. The inclusion criteria for the study were individuals aged 18 years or older, residing in the study area, and signing the informed consent form. Individuals who did not meet these criteria were excluded from participation. Before commencing the research, an exclusive session was held to explain the ethical considerations to the participants, present the nature and mode of cooperation for the study, and provide them with the option to withdraw from participation at any stage.

A total of 150 respondents were individually interviewed using a semi-structured face-to-face interview approach and a questionnaire form administered through oral questioning in the Amazigh and Arabic languages. Each interview lasted approximately two hours. The questionnaire form consisted of two parts: the first focused on the socio-economic profile of the participants, while the second inquired about the medicinal plants used, diseases treated, and the methods of preparation and administration of remedies.

The taxonomic identification of plant species was conducted using "The traditional Moroccan pharmacopoeia" book (Bellakhdar 1997). Scientific names of plant species were cross-checked and updated using the website "www.catalogueoflife.org". Voucher specimens of each plant species were deposited in the herbarium of the Department of Biology at the Faculty of Sciences of Agadir.

**Data processing**

The collected data were processed to determine the following parameters: relative frequency of citation (RFC), use value (UV), fidelity level (FL), and informant consensus factor (ICF).

***Relative Frequency of Citation***

The RFC indicates the local importance of a specific plant species. It is calculated by dividing the number of informants who mentioned the use of the species (FC) by the total number of informants in the survey (N) (Phillips *et al.* 1994).

$$RFC = FC / N$$

If 50 informants are interviewed, and 10 of them mention the use of Plant A, RFC for this plant = 10 / 50 = 0.2.

***Use Value***

The UV assesses the significance of a plant species in traditional medicine within a particular community. It is calculated using the formula:

$$UV = \Sigma U / N.$$

U represents the number of reports of use mentioned by each informant for a given plant species, and N is the total number of informants interviewed for that plant (Phillips *et al.* 1994).

If Plant B is cited for medicinal, culinary, and ritual purposes by 10, 5, and 2 informants, respectively, UV for this plant = (10 + 5 + 2) / 50 = 17 / 50 = 0.34.

***Fidelity Level***

The FL indicates the percentage of informants who declared the use of a specific plant species for the same therapeutic objective. This parameter is calculated using the formula:

$$FL (\%) = (NP / N) \times 100$$

NP is the number of informants mentioning the use of a plant species for a particular purpose, and N is the total number of informants who mentioned the species for any use (Friedman *et al.* 1986).
If out of 50 informants, 30 mentioned plant C for treating fever, FL for treating fever using plant C = (30 / 50) * 100 = 60%.

***Informant Consensus Factor***

The ICF reflects the degree of agreement among informants regarding ethnobotanical information (Trotter & Logan 1986).

$$ICF = (Nur - Nt) / (Nur – 1)$$

Nur is the number of times an ailment was mentioned, and Nt is the number of plants mentioned to treat that ailment.
For example, three plant species (A, B, and C) are used for a particular disease, and these plants are respectively cited 20, 15, and 10 times. The total number of use reports is the sum of all use reports: Nu=20 + 15 + 10 = 45. The number of taxa ($Nt$) used is 3 (A, B, and C). ICF = 45−1/45−3 = 0.95.

## Results

**Socio-cultural aspects of informants**

Table 1 presents the results of the socio-cultural aspects of the informants. The age group with the highest representation was 40-60 years (46%), followed by 20-40 years (42%) and over 60 years (12%). Both women and men participated in the study, but women were more represented, accounting for 85 out of 150 respondents (57%). Most informants were married (64%). In terms of education, the highest percentage was found among individuals with no education (48%), followed by those with primary (28%), secondary (21%), and university education (3%). Regarding income, 49% of informants reported having no income, while 33% had a monthly income of less than $200, and 18% had a monthly income of more than $200. Medical insurance coverage was lacking for the majority of informants (84%). Most informants acquired their knowledge of medicinal plants from the experience of others (71%). A smaller percentage relied on personal experience (16%) or obtained information through reading (13%). The primary reasons for using medicinal plants were their perceived effectiveness (32%), easy accessibility (30%), low cost (26%), and lack of side effects (12%).

Table 1. General data of the respondents (%)

| | | | | | |
|---|---|---|---|---|---|
| **Age (years)** | 20-40 | 42 | **Gender** | Women | 57 |
| | 41-60 | 46 | | Men | 43 |
| | > 60 | 12 | **Marital status** | Married | 64 |
| **Education** | Illiterate | 48 | | Single | 36 |
| | Primary | 28 | **Monthly income** | Without | 49 |
| | Secondary | 31 | | < $200 | 33 |
| | University | 3 | | > $200 | 18 |
| **Origin of information** | Reading | 13 | **Reason for choosing herbal medicine** | No side effects | 12 |
| | Personal experience | 16 | | Efficacy | 32 |
| | Experience of others | 71 | | Low cost | 26 |
| **Medical insurance** | | 16 | | Easy access | 30 |

**Medicinal plants**

A total of 101 plant species belonging to 54 families and 90 genera were identified in this study (Table 2). The most represented families were Lamiaceae (14 species), Asteraceae (9 species), Apiaceae (7 species), Fabaceae (4 species), and several other families with three species each, including Brassicaceae, Myrtaceae, Anacardiaceae, and Oleaceae (Fig. 2). Among these plants, approximately 59.45% were spontaneous species such as *Argania spinosa*, *Thymus satureioides, Pistacia lentiscus*, and *Lavandula dentata* (results not shown). Cultivated plants accounted for 29% of the species, including *Coriandrum sativum, Artemisia absinthium,* and *Carum carvi*, while the remaining 11.55% were sourced from other regions or countries, such as *Crocus sativus, Lepidium sativum,* and *Myristica fragrans*.

The highest UVs were recorded for *A. spinosa* (3.67), *Opuntia ficus-indica* (3.57), *Tetraclinis articulata* (3.27), *Rosmarinus officinalis* (3.25), *Trigonella foenum-graecum* (3.17), *Artemisia inculta* (3.15), *Globularia alypum* (3.14), *Thymus satureioides* (3.02), and *Thymus broussonetii* (3.01). Plants with lower UVs were *Pinus halepensis* and *Citrus aurantium* (1.0) (Table 2).

Table 2. Ailments, plant parts used, mode of preparation, Use Value (UV) and Relative Frequency of Citation (RFC)

| Family | Species (voucher code) | local name | Ailments | Part used | Preparation | UV | RFC |
|---|---|---|---|---|---|---|---|
| Alliaceae | *Allium cepa* L. (Imaac) | Azalim, Basla | Urinary disorders, Respiratory disorders, Intestinal disorders, Kidney disorders, Pharyngitis, Skin affections, Back pain, Insect bites, Cosmetic care, Bone fractures, Fever, Joint disorders, Bloating, Flu. | Bulb | Poultice, Decoction | 2,48 | 0,17 |
| | *Allium sativum* L. (imaas) | Touma Tiskert | Urinary Disorders, Respiratory Disorders, Intestinal Disorders, Kidney Disorders, Dental Ailments, Pharyngitis, Skin affections, Back Pain, Cosmetic Care, Hepatic Disorders, Cough, Flu | Bulb | Cooked, Decoction | 2,81 | 0,18 |
| Aloeaceae | *Aloe vera* (L.) Burm. f. (Imaav) | Alouivera | Skin affections, Diabetes, Fungal infections, Cosmetic care | Aerial part | Infusion, Decoction | 2,50 | 0,01 |
| Anacardiaceae | *Pistacia atlantica* Desf *(imipa)* | Igg, Lebtam | Digestive disorders, Bloating | Leaves, Seeds | Powder | 2,00 | 0,01 |
| | *Pistacia lentiscus* L. (Imapl) | Titkt | Diarrhea, Urinary disorders, Respiratory disorders, Intestinal disorders, Skin affections, Digestive disorders, Nervous disorders, Bone fractures, Sciatica | Leaves, Roots | Decoction, Powder | 2,80 | 0,03 |
| | *Rhus pentaphylla* Jacq (Imapp) | Azad, Tazzad | Intestinal disorders, Digestive disorders, Bloating, Diarrhea | Roots | Decoction | 2,50 | 0,03 |
| Apiaceae | *Ammodaucus leucotrichus* Coss (imaal) | Kamoun sofi | Bloating, Digestion difficulties, Digestive disorders, Intestinal disorders, Respiratory disorders | Seeds | Powder | 3,00 | 0,02 |
| | *Carum carvi* L. (Imaac) | Karwia | Bloating, Digestion difficulties, Large intestine, Digestive disorders, Intestinal disorders, Respiratory disorders | Seeds | Powder | 2,00 | 0,06 |
| | *Coriandrum sativum L.* (imacs) | Lkzbour | Diarrhea, Bloating, Nervous disorders, Large intestine, Digestive disorders, Intestinal disorders, Urinary disorders | Seeds, Leaves, Stems | Decoction, Infusion | 2,38 | 0,09 |

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|---|---|---|---|---|---|---|---|
| | *Cuminum cyminum* L. (Imacc1) | Lcamon | Bloating, Appetite, Cough, Digestion difficulties, Dizziness, Diabetes, Digestive disorders, Intestinal disorders | Seeds | Powder | 2,36 | 0,09 |
| | *Foeniculum vulgare* Mill (imafv) | Nafaa | Urinary disorders, Intestinal disorders, Large intestine, Digestive disorders, Nervous disorders, Digestion difficulties, Bloating | Seeds, Fruits | Infusion, Decoction | 1,88 | 0,05 |
| | *Petroselinum crispum* Mill (imapc) | Maadnous | Urinary disorders, Respiratory disorders, Intestinal disorders, Kidney disorders, Dental pain, Back pain, Digestive disorders, Large intestine, Nervous disorders, Fever, Asthma, Prostate, Liver disorders, Diarrhea, Sexual impotence, Bloating | Leaves, Stems | Decoction | 2,47 | 0,23 |
| | *Pimpinella anisum* L (imapa | Hbat hlawa | Bloating, Digestion difficulties | Seeds | Powder | 2,00 | 0,01 |
| Apocynaceae | *Nerium oleander* L. (imana) | Alili, Dafla | Nervous disorders, Fatigue, Skin affections, Kidney disorders, Urinary disorders | Leaves | Powder, Infusion | 2,00 | 0,03 |
| | *Periploca laevigata* Aiton. (imapl) | Aslif | Bone fractures, Joint disorders | Leaves, Roots | Poultice | 2,00 | 0,01 |
| Arecaceae | *Chamaerops humilis* L. (imach) | taznirt Doum | Large intestine, Digestive disorders, Intestinal disorders, Urinary disorders | Seeds | Powder | 2,00 | 0,01 |
| Aristolochiaceae | *Aristolochia baetica* L. (imacb) | Azlak | Intestinal disorders, Respiratory disorders, Urinary disorders | Leaves | Decoction,Powder | 1,67 | 0,02 |
| Asclepiadaceae | *Ceropegia europaea* Guss (imace) | Igougan | Influenza, Diabetes, Respiratory Diseases | Leaves | Decoction, Powder | 2,00 | 0,02 |
| Asparagaceae | *Asparagus altissimus* Munby (imaci) | Tikragan | Nervous disorders, Sunstroke, Fatigue, Headaches | Leaves | Powder | 2,00 | 0,01 |
| | *Asparagus officinalis* L. (imaae) | Azzwi sekoum | Sexual Impotence, Diabetes, Nervous Disorders, Respiratory Disorders | Leaves, Stems | Infusion, Decoction | 2,25 | 0,03 |
| Asphodelaceae | *Asphodelus tenuifolius* Cav (imaat) | Lberwag Iguri | Respiratory disorders, Intestinal disorders, Skin affections, Digestive disorders, Influenza, Bloating, | Roots | Decoction | 2,63 | 0,05 |

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|---|---|---|---|---|---|---|---|
| | | | Diarrhea, Liver disorders, Fungal infections | | | | |
| Asteraceae | *Artemisia absinthium* L. (imaaa) | Chiba | Bloating, Nervous disorders, Large intestine, Fatigue, Digestive disorders, Headaches, Intestinal disorders, Urinary disorders | Leaves | Infusion, Decoction | 1,80 | 0,07 |
| | *Artemisia inculta* Delile (imaai) | Izri Chih | Urinary disorders, Conditions, Various pains, Vertigo, Bone fractures, Digestive and Respiratory disorders, Intestinal disorders, Pharyngitis, Genital disorders, Skin affections, Burns, Diarrhea, Injuries, Bloating, | Leaves | Decoction, Infusion, Powder | 3,15 | 0,18 |
| | *Chamaeleon gummifer* L. (imacg) | Addad | Urinary disorders, Intestinal disorders, Genital disorders, Skin affections, Burns, Injuries, Digestive disorders, Fungal infections, Large intestine | Roots | Decoction, poultice | 1,91 | 0,07 |
| | *Carlina racemosa* L. (imacr) | Achekja | Digestive disorders, Skin affections, Respiratory disorders | Leaves, Roots | Decoction, Infusion | 3,00 | 0,03 |
| | *Cladanthus mixtus* L (imacm). | Babounje | Cosmetic care, Fungal infections, Intestinal disorders, Skin affections, Vertigo, Fatigue, Digestive disorders | flower heads | Infusion, Friction | 2,60 | 0,07 |
| | *Dittrichia viscosa* L. Greuter (imadv) | Terhala Tin arine | Joint disorders, Bone fractures, Digestive disorders, Injuries, Skin affections, Intestinal disorders | Leaves, Roots | Decoction, Powder | 2,40 | 0,03 |
| | *Kleinia anteuphorbium* L (imaka) | Achebardau | Liver disorders, Joint disorders, Bone fractures, Injuries, Burns, Skin affections, Respiratory disorders, Urinary disorders | Rods | Powder, Decoction, Poultice | 2,86 | 0,05 |
| | *Launaea arborescens* Batt (imala) | Iferskel | Diarrhea, Bloating, Urinary disorders, Intestinal disorders, Skin affections, Injuries, Digestive disorders | Roots | Decoction, Infusion | 2,60 | 0,03 |
| | *Pulicaria mauritanica* Coss (imapm) | Bamghar | Heart failure, Urinary disorders, Intestinal disorders, Digestive disorders, Large intestine, Diarrhea, Bloating, Vertigo | Flowers, Leaves | Powder, Infusion | 2,21 | 0,16 |

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|---|---|---|---|---|---|---|---|
| Boraginaceae | *Echium horridum* Batt (imbeh). | Tanasat | Prostate, Urinary Disorders, Bone fractures, Kidney Disorders, Respiratory Disorders | Leaves | Decoction | 2,67 | 0,02 |
| Brassicaceae | *Brassica rapa* L (imbbr). | Tirkmin, Laft lbaldi | Diabetes, Large intestine, Digestive disorders, Ear disorders | Seeds | Powder | 1,50 | 0,03 |
| | *Lepidium sativum* L. (imbls) | Hab rchad | Bloating, Urinary Disorders, Large Intestine, Digestive Disorders, Pharyngitis, Respiratory Disorders | Seeds | Powder, Decoction | 2,00 | 0,03 |
| | *Sinapis alba* L. (imbsa) | Kalkas | Urinary Disorders, Genital Disorders | Seeds | Powder | 1,00 | 0,01 |
| Burseraceae | *Boswellia sacra* Flueck (imbbs) | Salaban | Injuries, Skin affections, Respiratory Disorders | Roots | Fumigation, Powder, Poultice | 1,60 | 0,03 |
| Cactaceae | *Opuntia ficus-indica* (L.) Mill (imcofi) | Acnari,Karmous | Diarrhea, Diabetes, Urinary disorders, Respiratory disorders, Intestinal disorders, Skin affections, Injuries, Digestive disorders, Large intestine, Bone fractures | Aerial part | Decoction, Powder | 3,57 | 0,05 |
| Capparaceae | *Capparis spinosa* L (imccs) | Kabbar | Joint disorders, Sciatica, Bone fractures, Nerve disorders, Skin affections, Urinary disorders | Leaves, Roots | Decoction, Poultice | 2,00 | 0,05 |
| Caprifoliaceae | *Lonicera biflora* Desf . (imclb) | Irifi | Hepatic disorders, Respiratory disorders, Intestinal disorders, Bloating, Diarrhea | Leaves, Fruit | Decoction, Infusion | 2,67 | 0,02 |
| Caryophyllaceae | *Herniaria cinerea* DC (imghc) | Tawzrout Hrast lhjer | Urinary Disorders | Leaves | Decoction | 2,00 | 0,01 |
| | *Silene vulgaris* Moench (imcsv) | Tighercht | Diarrhea, Large intestine, Digestive disorders, Injuries, Skin affections, Genital disorders, Intestinal disorders, Respiratory disorders, Urinary disorders | Roots | Decoction, Infusion | 2,60 | 0,03 |
| Chenopodiaceae | *Chenopodium ambrosioides* L. (imcca) | Mkhinza | Heart failure, Urinary disorders, Respiratory disorders, Intestinal disorders, Skin affections, Headaches, Digestive disorders, Fatigue, Sunstroke, Joint disorders, Diarrhea, Bloating, Appetite, Difficulties digestion, Period | Leaves, Stems | Infusion, Decoction, Poultice | 2,89 | 0,23 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | pain, Various pains, Flu, Disorders nervous, Bone fractures, Fever | | | | |
| Cistaceae | *Cistus creticus* L. (imccc) | Irguel | Urinary disorders, Respiratory disorders, Intestinal disorders, Digestive disorders, Large intestine, Dizziness, Appetite, Sexual impotence, Diarrhea, Joint disorders | Seeds, Leaves | Powder, Decoction, Infusion | 2,63 | 0,13 |
| Rutaceae | *Citrus aurantium* L. (imrca) | Hamed beldi | Flu | Fruits | Juice, Decoction | 1,00 | 0,01 |
| Cucurbitaceae | *Citrullus colocynthis* L. (imccc) | Hadja Aferziz | Respiratory disorders, Intestinal disorders, Skin affections, Fatigue, Bone fractures, Diabetes, Vertigo, Sciatica, Joint disorders, Diarrhea | Fruits, Pulps | Poultice, Decoction, Infusion | 2,75 | 0,05 |
| Cupressaceae | *Juniperus oxycedrus* L. (imcjo) | Katran | Insect bites, Burns, Skin affections, Kidney disorders | Fruits | Decoction | 2,00 | 0,03 |
| | *Tetraclinis articulata* Vahl (imcta) | Azouka Aarar | Diarrhea, Impotence, Bloating, Dizziness, Diabetes, Sunstroke, Digestive disorders, Injuries, Burns, Skin affections, Intestinal disorders, Urinary disorders | Leaves | Powder, Poultice, | 3,27 | 0,27 |
| Euphorbiaceae | *Euphorbia officinarum* L. (imeeo) | Tikiout Daghmous | Joint disorders, Influenza, Urinary disorders, Respiratory disorders, Kidney disorders, Skin affections, Bone fractures, Diabetes, Asthma | Aerial part | Decoction | 2,50 | 0,09 |
| Fabaceae | *Ceratonia siliqua* L. (imfcs) | Tikida | Diarrhea, Impotence, Bloating, Digestion difficulties, Diabetes , Nervous disorders, Large intestine, Digestive disorders, Intestinal disorders, Urinary disorders | Seeds, Fruits | Powder, Decoction | 2,60 | 0,13 |
| | *Genista ifniensis* A. (imfgi) | Azi | Bone fractures, Insect bites, Injuries, Skin affections | Leaves | Powder, poultice | 2,33 | 0,02 |
| | *Ononis natrix* L. (imfon) | Afezdad | Hepatic disorders, Respiratory disorders, Intestinal disorders, Bloating | Leaves, Roots | Decoction, Infusion | 2,25 | 0,03 |
| | *Trigonella foenum- graecum* L. (imftfg) | Tifidasse Halba | Heart failure, Joint disorders, Fever, Sexual impotence, Bloating, Urinary | Seeds | Powder, Decoction, Infusion | 3,17 | 0,12 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | disorders, Respiratory disorders, Intestinal disorders, Kidney disorders, Various pains, Bone fractures, Large intestine, Digestive disorders, Skin affections | | | | |
| Fagaceae | *Quercus ilex* L. (imfqi) | Tassaft Balout | Urinary Disorders, Respiratory Disorders, Intestinal Disorders, Difficulties Digestion | Leaves, Fruit | Decoction, Powder | 2,33 | 0,02 |
| Geraniaceae | *pelargonium hederaefolium* Salisb (imgph) | Aatercha | Sexual impotence, Urinary disorders, Intestinal disorders, Fatigue, Sunstroke, Large intestine | Leaves | Infusion | 2,50 | 0,04 |
| Iridaceae | *Crocus sativus* L. (imics) | Zaafran | Urinary disorders, Respiratory disorders, Intestinal disorders, Kidney disorders, Genital disorders, Digestive disorders, Fatigue, Heart failure, Large intestine, Sexual impotence, Bloating, Prostate, Nervous disorders | Stigmas | Infusion, Decoction | 3,00 | 0,15 |
| Juncaceae | *Juncus rigidus* Desf . (imjjr) | Azmay | Nervous disorders, Respiratory disorders, Urinary disorders | Leaves, Stems | Decoction, Infusion | 2,00 | 0,02 |
| Lamiaceae | *Ajuga iva (*L*)* Shreb (imlai) | Chendgoura | Intestinal disorders, Skin affections, Bone fractures, Bloating, Diarrhea | Leaves, Seeds | Infusion, Powder | 2,50 | 0,03 |
| | *Lavandula dentata* L. (imlld) | Lhalhal Igersh | Fever, Urinary disorders, Respiratory disorders, Intestinal disorders, Diabetes, Pharyngitis, Genital disorders, Skin affections, Injuries, Digestive disorders, Fatigue, Sunstroke, Nervous disorders | Leaves, Stems, Seeds | Decoction, Powder | 3,00 | 0,13 |
| | *Lavandula maroccana* Murb. (imllm) | Lkhzama | Cosmetic care, Urinary disorders, Respiratory disorders, Intestinal disorders, Genital disorders, Skin affections, Back pain, Fever, Bloating, Hypertension, Digestive disorders, Nervous disorders | Leaves Flowers | Decoction, Infusion | 2,00 | 0,08 |
| | *Marrubium vulgare* L. (imlmv) | Merout Ifzi | Urinary Disorders, Respiratory Disorders, Intestinal Disorders, Skin | Leaves | Infusion, Decoction | 2,67 | 0,08 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | affections, Burns, Injuries, Bloating, Diarrhea, Hepatic Disorders | | | | |
| *Mentha pileguin* L. (imlmp) | Flio | Respiratory disorders, Intestinal disorders, Pharyngitis, Digestive disorders, Sunstroke | Leaves, Stems | Infusion, Decoction | 2,50 | 0,01 |
| *Mentha spicata* L. (imlms) | Naanaa Liqamt | Respiratory disorders, Intestinal disorders, Pharyngitis, Backaches, Headaches, Digestive disorders, Fatigue, Sunstroke, Flu, Cough | Leaves, Stems | Infusion | 2,53 | 0,13 |
| *Mentha suaveolens* Ehrh. (imlms2) | Timija | Respiratory disorders, Intestinal disorders, Burns, Headaches, Digestive disorders, Fatigue, Sunstroke, Nervous disorders, Flu, Bloating | Leaves | Infusion, Decoction | 2,67 | 0,06 |
| *Myristica fragrans* Houtt. (imlmf) | Gouza | Intestinal disorders | Seeds | Powder | 1,00 | 0,01 |
| *Ocimum basilicum* L. (imlob) | Hbak | Heart failure, bloating, insect bites, respiratory disorders | Leaves | Infusion, Decoction | 2,50 | 0,01 |
| *Rosmarinus officinalis* L. (imlro) | Azir | Urinary disorders, Respiratory disorders, Intestinal disorders, Gum disorders, Headaches, Digestive disorders, Fatigue, Large intestine, Nervous disorders, Diabetes, Vertigo, Digestion difficulties, Heart failure, Sexual impotence, Cough, Bloating, | Leaves, Stems | Infusion | 3,25 | 0,11 |
| *Salvia aegyptiaca* L. (imlsa) | Iderky | Heart failure, Influenza, Intestinal disorders, Respiratory disorders, Urinary disorders | Leaves, Roots | Infusion, Decoction | 2,00 | 0,01 |
| *Salvia officinalis* L. (imlso) | Salmia | Cough, Hypertension, Influenza, Vertigo, Nervous disorders, Sunstroke, Fatigue, Digestive disorders, Back pain, Intestinal disorders, Respiratory disorders, Urinary disorders | Leaves, Stems | Infusion, Decoction | 2,70 | 0,07 |
| *Thymus broussonetii* Boiss (imltb) | Zaitra Tazouknit | Urinary disorders, Respiratory disorders, Intestinal disorders, Pharyngitis, Gum disorders, Skin affections, Digestive | Leaves, Stems | Infusion, Decoction | 3,01 | 0,47 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | disorders, Liver disorders, Heart failure, Diarrhea, Bloating, Digestion difficulties, Flu, Fever, Dizziness, Diabetes, Nervous disorders, Large intestine, Insolation , Fatigue | | | | |
| | *Thymus pallidus* Coss. (imltp) | Ajllab | Urinary Disorders, Respiratory Disorders, Intestinal Disorders | Leaves, Flowers | Infusion, Decoction | 2,00 | 0,02 |
| | *Thymus satureoides* Coss. (imlts) | Zaater Azokni | Urinary Disorders, Respiratory Disorders, Intestinal Disorders, Dental Ailments, Pharyngitis, Gum Disorders, Skin affections, Injuries, Bloating, Sciatica, Influenza, Vertigo, Digestive Disorders | Leaves, Stems | Infusion, Fumigation | 3,02 | 0,39 |
| Lauraceae | *Cinnamomum verum* J. (imlcv) | Lkarfa | Diarrhea, Bloating, Asthma, Nervous disorders, Large intestine, Digestive disorders, Gum disorders, Intestinal disorders, Urinary disorders | rods | Powder, Decoction | 1,86 | 0,05 |
| Linaceae | *Linum usitatissimum* L. (imllu) | zriaat lktan | Joint disorders, Urinary disorders, Respiratory disorders, Intestinal disorders, Digestive disorders, Large intestine, Bloating, | Seeds | Powder | 2,40 | 0,07 |
| Lythraceae | *Lawsonia inermis* L. (imlli) | Henna | Joint disorders, Bone fractures, Skin affections | Leaves | Powder, poultice | 2,40 | 0,03 |
| Lythraceae | *Punica granatum* L. (imlpg) | Raman | Urinary disorders, Intestinal disorders, Digestive disorders, Large intestine, Digestion difficulties, Bloating, Fungal infections | Fruits, Pulps | Powder, Decoction | 2,40 | 0,03 |
| Malvaceae | *Malva parviflora* L. (immmp) | Igoudi | Respiratory Diseases | Leaves, Stems | Decoction | 2,00 | 0,01 |
| | *Malva sylvestris* L. (immms) | Tibi | Urinary Disorders, Respiratory Disorders, Digestive Disorders | Leaves, Stems | Decoction | 2,00 | 0,02 |
| Myrtaceae | *Eucalyptus globulus* L. (immeg) | Caliptous | Nervous disorders, Fatigue, Skin affections, Intestinal disorders, Respiratory disorders | Leaves | Fumigation, Decoction, Infusion | 2,14 | 0,05 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | *Myrtus communis* L. (immmc) | Rayhan | Heart failure, Bloating, Intestinal disorders, Back pain, Injuries, Digestive disorders, Sunstroke, Diabetes, Hypertension | Leaves | Infusion, Decoction, Poultice | 2,17 | 0,04 |
| | *Syzygium aromaticum* L. (immsa) | Kronfel | Urinary Disorders, Dental Ailments, Gum Disorders, Digestive Disorders | Nail | Decoction, Infusion | 3,00 | 0,01 |
| Nitrariaceae | *Peganum harmala* L. (imnph) | Harmel | Respiratory disorders, Skin affections, Headaches, Fatigue, Nervous disorders | Seeds | Fumigation | 1,83 | 0,04 |
| Oleaceae | *Olea europaea* L. (imooe) | Zitoun | Urinary Disorders, Respiratory Disorders, Intestinal Disorders, Kidney Disorders, Gum Disorders, Ear Disorders, Digestive Disorders, Bloating | Leaves | Decoction | 2,75 | 0,05 |
| | *Olea europaea* subsp *Europaea* (imooese) | Zebbouj Azemour | Urinary disorders, Respiratory disorders, Intestinal disorders, Kidney disorders, Gum disorders, Injuries, Digestive disorders | Leaves, Fruit | Oil, Decoction, Infusion | 2,62 | 0,09 |
| | *Phillyrea angustifolia* L. (imopa) | Tamtoula | Nervous disorders, Headaches | Leaves | Decoction | 2,00 | 0,01 |
| Papaveraceae | *Papaver rhoeas* L. (imppr) | Belaaman | Cough, Respiratory Disorders, Intestinal Disorders, Skin affections, Burns, Wounds | Leaves, Stems | Decoction, Infusion | 2,25 | 0,03 |
| Pinaceae | *Pinus halepensis* Mill. (impph) | Iguenguem | large intestine | Bark | Decoction | 1,00 | 0,01 |
| Plantaginaceae | *Globularia alypum* L. (impga) | Tasselgha | Joint disorders, Diarrhea, Prostate, Bone fractures, Urinary disorders, Respiratory disorders, Intestinal disorders, Genital disorders, Digestive disorders, Injuries, Burns, Skin affections | Leaves, Stems | Infusion, Decoction, Powder, | 3,14 | 0,15 |
| Poaceae | *Cymbopogon schoenanthus* L. (impcs) | Tibermt | Joint disorders, Kidney disorders, Urinary disorders | Leaves | Infusion | 2,00 | 0,02 |
| | *Cenchrus americanus L.* (impca) | Ilan | Urinary Disorders, Respiratory Disorders, Large Intestine, Asthma, Digestion Difficulties, Bloating, Joint Disorders | Seeds | Powder, Decoction | 2,13 | 0,05 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | *Hordeum vulgare* L. (imphv) | Tomzine Mrisse | Digestive disorders, Bloating, Intestinal disorders, Difficulties in digestion, Vertigo, Large intestine, | Seeds | Friction | 2,67 | 0,02 |
| Ranunculaceae | *Nigella sativa* L. (imrns) | Sanouj habba saouda | Urinary disorders, Respiratory disorders, Intestinal disorders, Injuries, Digestive disorders, Large intestine, Asthma, Cough, Heart failure | Seeds | Powder | 2,69 | 0,09 |
| Rhamnaceae | *Ziziphus lotus (*L*)* Lam (imrzl) | Sedra Azegar | Digestion difficulties, Urinary disorders, Digestive disorders, Large intestine | Fruit, Leaves | Powder, poultice | 2,25 | 0,03 |
| Rosaceae | *Rosa centifolia* L. (imrrc) | Ward Tihfert | Bloating, Intestinal disorders, Digestive disorders | Flowers, Leaves | Infusion | 2,50 | 0,01 |
| Rubiaceae | *Rubia peregrina* L. (imrrp) | Tarouba | Fungal infections, Intestinal disorders, Diarrhea, Large intestine, Digestive disorders | Roots, Leaves | Decoction, Powder | 2,14 | 0,05 |
| Rutaceae | *Ruta montana* L. (imrrm) | Awermi Lfijel | Respiratory disorders, Digestive disorders, Large intestine, Joint disorders | Aerial part | Infusion | 2,00 | 0,01 |
| Sapotaceae | *Argania spinosa (*L) Skeels (imsas) | Argan | Urinary disorders, Respiratory disorders, Intestinal disorders, Genital disorders, Skin affections, Digestive disorders, Bone fractures, Bloating, Sexual impotence, Heart failure, Cosmetic care | Seeds, Leaves | Friction, Infusion | 3,67 | 0,10 |
| Urticaceae | *Urtica urens* L. (imuuu) | Harriga Tazentakt | Urinary disorders, Respiratory Disorders, Skin affections | Leaves | Decoction | 1,67 | 0,02 |
| Verbenaceae | *Aloysia citrodora* Palau (imvac) | Louisa | Urinary disorders, Intestinal disorders, Backaches, Headaches, Digestive disorders, Fatigue, Sunstroke, Diarrhea, Nervous disorders, Vertigo, Fever, Bloating, Hypertension, Period pains, Various pains | Leaves, Stems | Infusion | 2,87 | 0,21 |
| | *Vitex agnus-castus,*L. (imvvac) | Kherwaa | Intestinal disorders, Skin affections, Digestive disorders, Joint disorders | Leaves | Decoction, Powder, Poultice | 1,50 | 0,03 |
| Zingiberaceae | *Alpinia officinarum* Hance (imzao) | Khoudanjal | Joint disorders, Sexual impotence, Bloating, Urinary disorders | Roots | Decoction, Powder | 2,00 | 0,01 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | *Zingiber officinale* Roscoe (imzzo) | Skinjbir | Urinary Disorders, Respiratory disorders, Joint disorders, Appetite, Cough, Digestion disorders, Influenza, Back Pain, Pharyngitis, Intestinal Disorders | Rhizomes | Decoction, Infusion | 2,08 | 0,08 |
| Zygophyllaceae | *Fagonia cretica* L. (imzfc) | Timchekla | Diarrhea, Respiratory disorders, Intestinal disorders, Digestive disorders, Vertigo | Leaves, Stems | Infusion, Powder | 2,25 | 0,03 |

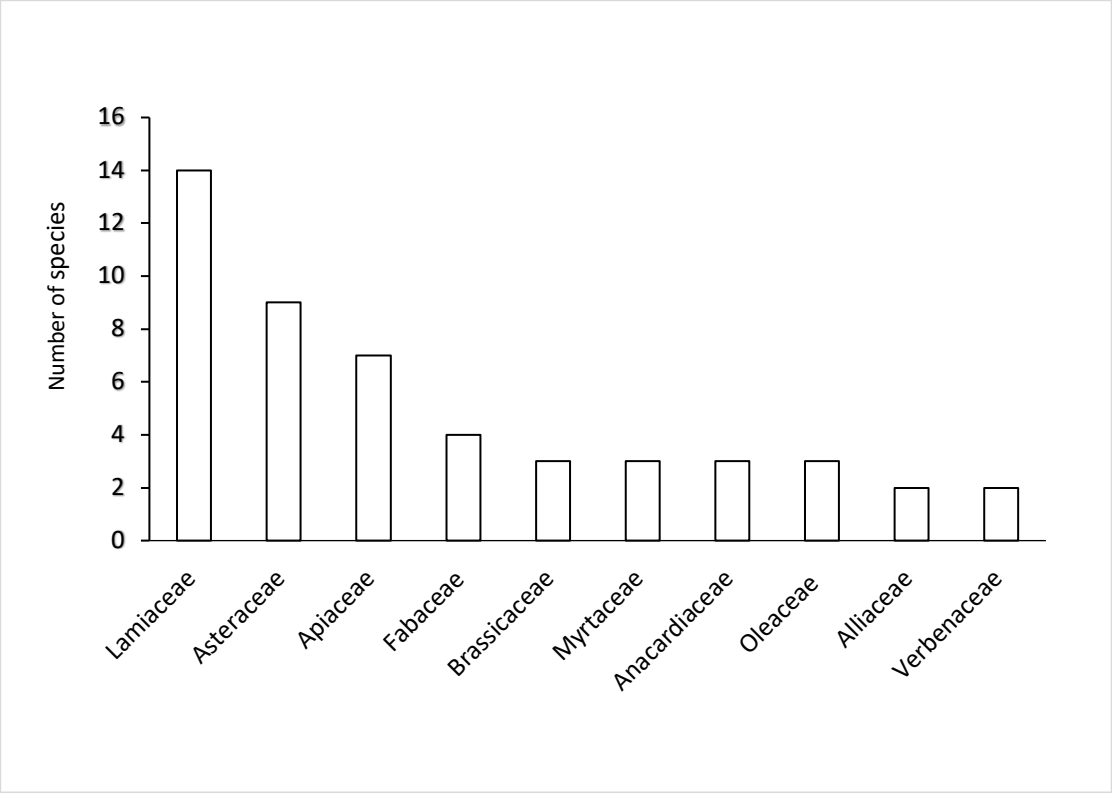


Figure 2. Number of species of the most represented families

The plant species with the highest RFC values were *Thymus broussonetii* (0.47), *Thymus satureioides* (0.39), *Tetraclinis articulata* (0.27), *Chenopodium ambrosioides* (0.23), *Petroselinum crispum* (0.22), *Artemisia citriodora* (0.21), *Allium sativum*, and *Artemisia inculta* (0.18). Plants with lower RFCs included *Phillyrea angustifolia* and *Citrus aurantium* (0.01).

Table 3 presents the FL values of the most cited plants, with a total of 48 plants. Among them, six plants had a value of 100%: *T. satureioides, Allium sativum,* and *Euphorbia foenum-graecum* for urinary disorders, *C. ambrosioides* for fever, and *Carum cyminum* for bloating. Four plants had a FL of 92%: *Allium cepa* and *Zingiber officinale* for respiratory conditions, *Marrubium vulgare* for digestive disorders, and *Pulicaria mauritanica* for diarrhea.

Table 3. Fidelity level for the most cited plants

| | **Plant species** | **FL (%)** | **Diseases** | **Plant species** | **FL (%)** |
|---|---|---|---|---|---|
| | *Marrubium vulgare* | 91.67 | | *Trigonella foenum-graecum* | 100.00 |
| | *Coriandrum sativum* | 84.62 | | *Olea europaea* | 87.50 |
| | *Asphodelus tenuifolius* | 75.00 | | *Crocus sativus* | 86.96 |
| | *Olea europaea* | 75.00 | | *Petroselinum crispum* | 85.29 |
| | *Artemisia inculta* | 74.07 | | *Nigella sativa*. | 84.62 |
| | *Cuminum cyminum* | 71.43 | | *Globularia alypum* | 81.82 |
| | *Rubia peregrina* | 71.43 | | *Argania spinosa* | 80.00 |
| | *Aloysia citriodora* | 70.97 | Urinary | *Lavandula dentata*. | 73.68 |
| Digestive disorders | *Foeniculum vulgare* | 62.50 | Disorders | *Cistus creticus* | 68.42 |
| | *Linum usitatissimum* | 60.00 | | *Pelargonium hederfolum* | 66.67 |
| | *Pulicaria mauritanica.* | 58.33 | | *Allium sativum* | 62.96 |
| | *Cinnamomum verum* | 57.14 | | *Allium cepa* L. | 60.00 |
| | *Carum carvi* | 55.56 | | *Opuntia ficus-indica* . | 57.14 |
| | *Ceratonia siliqua* | 50.00 | | *Olea europaea* | 53.85 |
| | *Myrtus communis* | 50.00 | | *Artemisia absinthium* | 50.00 |
| | *Lavandula maroccana* | 50.00 | | *Linum usitatissimum*. | 50.00 |
| | *Foeniculum vulgare* | 50.00 | Skin | *Carlina gummifera.* | 72.73 |
| Respiratory | *Allium sativum* | 100.00 | conditions | *Globularia alypum* | 59.09 |

| | | | | | |
|---|---|---|---|---|---|
| Diseases | *Thymus satureioides.* | 100.00 | | *Citrullus colocynthis* | 50.00 |
| | *Euphorbia officinarum* | 100.00 | Bloating | *Cuminum cyminum* | 100.00 |
| | *Allium cepa* | 92.00 | | *Cladanthus mixtus* | 90.00 |
| | *Zingiber officinale* | 91.67 | | *Rosmarinus officinalis* | 68.75 |
| | *Eucalyptus globulus* | 85.71 | | *Artemisia absinthium* | 50.00 |
| | *Nigella sativa* | 84.62 | Diarrhea | *Pulicaria mauritanica.* | 91.67 |
| | *Marrubium vulgare* | 75.00 | | *Ceratonia siliqua* | 75.00 |
| | *Salvia officinalis* | 70.00 | | *Opuntia ficus-indica .* | 71.43 |
| | *Lavandula dentata* | 63.16 | | *Cistus creticus* | 52.63 |
| | *Mentha spicata* | 63.16 | Fatigue | *Aloysia citriodora* | 77.42 |
| | *Pennisetum typhoides* | 62.50 | | *Mentha spicata*. | 57.89 |
| | *Linum usitatissimum* | 60.00 | | *Rosmarinus officinalis* | 50.00 |
| | *Artemisia inculta* | 59.26 | | *Salvia officinalis* | 50.00 |
| | *Kleinia anteuphorbium* | 57.14 | | *Pelargonium hederfolum* | 50.00 |
| | *Mentha suaveolens* | 55.56 | Bone fractures | *Kleinia anteuphorbium* | 85.71 |
| | *Petroselinum crispum.* | 52.94 | | *Capparis spinosa* | 57.14 |
| | *Peganum harmala* | 50.00 | Sunstroke | *Mentha spicata* | 57.89 |
| Diabetes | *Opuntia ficus-indica .* | 85.71 | Nervous disorders | *Peganum harmala* | 66.67 |
| Nervous disorders | *Peganum harmala* | 66.67 | Sexual impotence | *Pelargonium hederfolum* | 66.67 |
| Injuries | *Globularia alypum* | 59.09 | Cosmetic care | *Argania spinosa* | 60.00 |
| | *Myrtus communis* | 50.00 | Sciatica | *Citrullus colocynthis* | 50.00 |
| Kidney diseases | *Olea europaea* | 84.62 | Fever | *Chenopodium ambrosioides* | 100 |

The ICF ranged from 0.13 to 0.86, as shown in Table 4. The highest value (0.86) was recorded for respiratory conditions, indicating a high degree of agreement among informants regarding the use of plants for this purpose. Fever had the second highest ICF value (0.84), followed by intestinal and urinary conditions (0.81), and diarrhea (0.80). On the other hand, cough had the lowest ICF value (0.13), suggesting a lower level of agreement among informants regarding the plants used for treating this ailment.

Table 4. Informant consensus factor for diseases.

| Diseases | ICF | Diseases | ICF |
|---|---|---|---|
| Respiratory diseases | 0.86 | Sciatica | 0.67 |
| Fever | 0.84 | Kidney disorders | 0.65 |
| Intestinal disorders | 0.81 | Cosmetic care | 0.65 |
| Urinary disorders | 0.81 | Fungal infections | 0.58 |
| Diarrhea | 0.80 | Nerve disorders | 0.57 |
| Various pains | 0.77 | Vertigo | 0.57 |
| Bloating | 0.76 | Indigestion | 0.56 |
| Fatigue | 0.76 | Sexual impotence | 0.55 |
| Gum disease | 0.75 | Bone fractures | 0.54 |
| Injuries | 0.75 | Sunstroke | 0.54 |
| Prostate | 0.75 | Headache | 0.50 |
| Pharyngitis | 0.74 | Insect bites | 0.50 |
| Digestive disorders | 0.74 | Diabetes | 0.48 |
| Skin conditions | 0.73 | Large intestine | 0.48 |
| Hypertension | 0.73 | Genital conditions | 0.47 |
| Burns | 0.72 | Heart failure | 0.44 |
| Flu | 0.71 | Joint disorders | 0.42 |
| Back pain | 0.68 | Asthma | 0.38 |
| Ear conditions | 0.67 | Liver disorders | 0.33 |
| Period pain | 0.67 | Cough | 0.13 |

Figure 3 illustrates the used parts of the plants, with leaves being the most used (48%), followed by stems (20%) and seeds (15%). The use of other plant parts, such as roots, fruits, bulbs, stigmata, and flowers, was less frequent (4% each for roots, fruits, and bulbs; 2% for stigmata; 1% for flowers). In terms of preparation methods (Fig. 4), most remedies were prepared as decoctions (36%), followed by infusions (27%) and powders (22%). Other methods, such as fumigation (6%), poultice, and friction (4% each), as well as cooked preparations (1%), were less commonly used. Regarding administration routes, most remedies were taken orally (82%), followed by external applications (15%) and inhalation (3%).

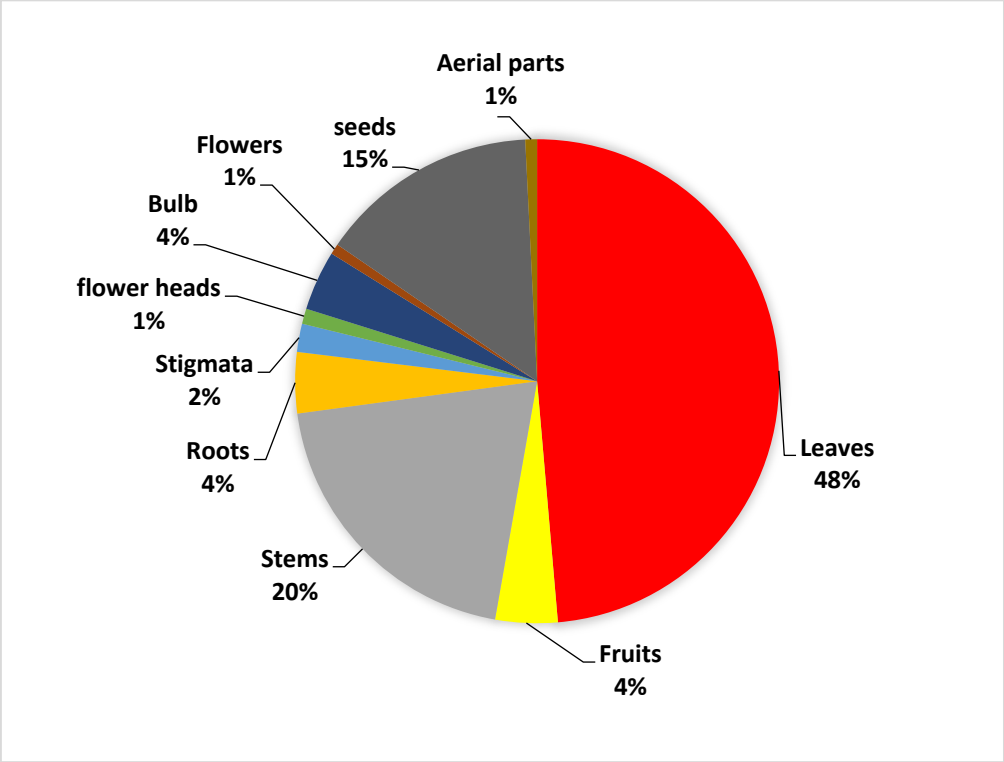


Figure 3. Used parts of medicinal plants

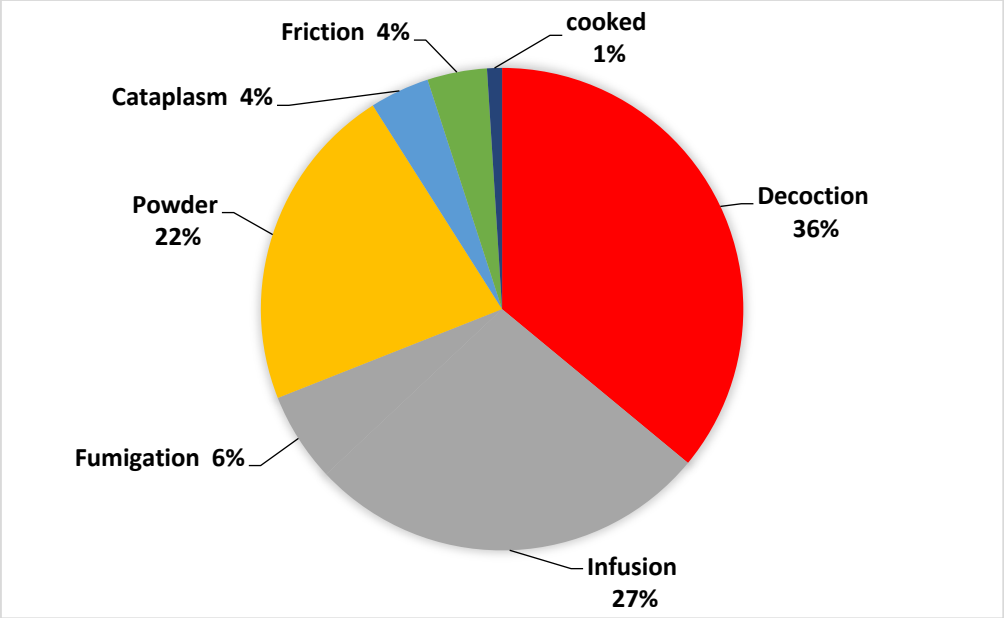


Figure 4. Method of preparation of remedies

## Discussion

**Socio-cultural aspects of informants**

Characterized by mountainous terrain, the study zone of this work has limited economic activities such as subsistence farming and limited pastoral activity. The lack of adequate infrastructure, including transportation and hotels, has hindered the development of tourism despite the presence of natural attractions. These economic challenges harm the standard of living, education, and employment opportunities in the area. The socio-economic profile of the informants reflects these challenges, with a high unemployment rate (48%), low incomes (82% earning less than $200 per month), a significant level of illiteracy (48% were illiterate), and a lack of medical insurance (84% had no medical insurance). These factors contribute to the reliance on herbal medicine as a healthcare option. The availability and accessibility of medicinal plants (Msanda *et al.* 2021), coupled with their affordability, are crucial factors that drive their widespread use in the community. In fact, 30% of respondents reported utilizing medicinal plants due to their easy access, and 26% for their low cost. Indeed, the relationship between the socio-economic context and the use of traditional medicine is complex and multifaceted. According to the WHO (2010), financial barriers significantly hamper access to health care in developing countries. Many people cannot afford to pay expenses related to consultations, medicines and treatments. As a result, they may delay seeking care or opt for cheaper alternative options, such as traditional medicine (Oxfam, 2019). Inadequate health infrastructure, particularly in rural areas, further hampers access to health services (MSF, 2018). Shortages of health facilities, health professionals and essential supplies exacerbate the problem (UNDP, 2015), forcing individuals to travel long distances and incur high transport costs to access care (World Bank, 2017). The fragmentation of healthcare financing systems and the reliance on out-of-pocket payments also pose challenges to access to healthcare (World Bank, 2017). Limited government investment in health care compounds the problem (IMF, 2016), leading to underfunded health systems and high health costs for individuals (WHO, 2010). Cultural beliefs and social norms significantly influence health-seeking behavior (UNDP, 2015). Traditional healing practices may be preferred due to cultural beliefs (MSF, 2018).

Most users of herbal medicine were women. This result agrees with many works carried out in Morocco (Benkhnigue et *al.* 2010, El-Ghazouani *et al.* 2021, Mehdioui & Kahouadji 2007). In fact, women play a central role as holders of medicinal plants knowledge throughout Morocco (El-Hilaly *et al.* 2003, El Rhaffari & Zaid 2002, Fakchich & Elachouri 2014, Merzouki *et al.* 2000), but also in other regions of the world (Begossi *et al.* 2002, Howard 2003, Kainer 1992, Qureshi *et al.* 2009, Razafindraibe *et al.* 2013, Voeks 2007). This has been attributed to gendered work and spatial segregation affecting the harvesting and handling of plant resources (Howard 2003, Montanari 2014, Razafindraibe *et al.* 2013, Voeks 2007), but also to women's responsibility in caring for family members, especially in case of emergency or inaccessibility to health facilities (Howard 2003, Teixidor-Toneu *et al.* 2017, Voeks, 2007, Wayland 2001).

**Medicinal plants**

To assess plant species' importance, versatility, consistency, and consensus within traditional knowledge systems, RFC, UV, FL, and ICF metrics were used. Understanding these parameters facilitates biodiversity conservation, sustainable resource management, and cultural preservation efforts in ethnobotany. RFC helps to understand the prevalence of plant species mentioned within a community. It highlights the frequently cited species, indicating their importance in local customs, traditions, and practices. High RFC values often signify plants with significant cultural, medicinal, or economic value, guiding efforts for documentation and preservation. UV quantifies the versatility of a plant species by considering the number of distinct uses attributed to it. It reflects the ecological adaptability and cultural significance of plants within a community. UV assists in identifying key species that play diverse roles in traditional practices, such as medicinal, culinary, or ritual uses. Understanding UV informs strategies for sustainable resource management, conservation, and utilization. FL measures the consistency of mentioning a plant for a specific use across informants. It reflects the degree of agreement among individuals regarding the importance of a plant for a particular purpose. A high FL indicates the cultural importance and effectiveness of the plant species for a specific use. Such plants are often targeted for further research to validate traditional knowledge and develop conservation or utilization strategies. ICF assesses the degree of agreement among informants regarding the significance of a plant for specific uses or categories. It provides insights into cultural consensus and shared knowledge within a community. ICF helps to evaluate the reliability and validity of reported plant uses, highlighting areas of consensus or variability in traditional knowledge. It guides the selection of priority species for further investigation and informs the development of culturally appropriate interventions.

The population in the study area relied on medicinal plants primarily from four families: Lamiaceae, Apiaceae, Anacardiaceae, and Fabaceae. These families are commonly found in Morocco and Mediterranean countries, indicating their significance in traditional medicine practices (Abouri *et al.* 2012, Benítez *et al.* 2010). Interestingly, many of the plants used by the population were also spices or food plants, with a total of 36 species falling into this category. This aligns with previous

observations of using food plants for medicinal purposes. Food plants are easily accessible in homes or local markets, making them convenient options for medicinal use (Alqethami *et al.* 2017). Otherwise, the rich and diverse flora of the occidental High Atlas environment facilitated easy access to a wide range of medicinal plants (Msanda *et al.* 2021). This was particularly the case of *A. spinosa* (UV 3.67) which produces argan oil rich in unsaturated fatty acids and antioxidants and used for food and cosmetics (Belcadi-Haloui *et al.* 2018), *O. ficus-indica* (UV 3.57) commonly used for human and animal food (FAO 2018), and *T. articulata* (UV 3.27) widely present in the study area and valued for its quality wood (Msanda *et al.* 2021).

Most of the plant species mentioned by the interviewees were used to treat digestive and respiratory diseases. Many of these herbs have anti-inflammatory and antimicrobial properties, which can help reduce inflammation and combat infections contributing to symptoms. Plant-based digestive preparations operate through multiple mechanisms, including inhibiting *Helicobacter pylori* (bacteria responsible for gastric ulcers), stimulating both mechanical and chemical digestion, promoting smooth and regular bowel movements, enhancing bowel frequency, eliminating toxins, and soothing stomach aches (Chen et al. 2023; Kmail 2024). Regarding respiratory conditions, many herbs possess mucolytic and expectorant properties, which help thin mucus in the airways and facilitate its expulsion (Bone & Mills 2013). Certain compounds like organosulfurs present in garlic possess beneficial effects on health by modulating inflammation and oxidative stress, which are common pathogenic mechanisms in pulmonary diseases (Sánchez-Gloria et al. 2020). Some herbs have antitussive effects, meaning they can help suppress coughing by acting on the cough reflex in the brain or soothing irritated throat tissues (Eccles 2003). Other plant species from the Lamiaceae family have bronchodilator effects, which help relax and widen the airways, making breathing easier (Najem et al. 2021). Herbs from genera like *Ocimum* and *Zingiber* are used for respiratory conditions due to their anti-inflammatory and antimicrobial properties, which help reduce airway inflammation and combat infections that may exacerbate symptoms (Ouled Taarabt et al., 2021).

Among the 101 plants documented, eight species showed high RFC values: *T. broussonetii, T. satureioides, T. articulata, C. ambrosioides, P. crispum, A. citriodora, A. sativum*, and *A. inculta*. These plants have been extensively used in other regions of Morocco as well (Belhaj *et al.* 2020, El Hilaly *et al.* 2003, Fakchich & Elachouri 2014, Naceiri *et al.* 2019). Other plant species are commonly used in various regions of Morocco but are not included in our study site. For instance, *Maerua crassifolia*, *Rhus tripartita*, and *Adansonia digitata* are utilized in the Tarfaya region (South of Morocco), while *Ammi visnaga* is employed in the Rif Mountain (North of Morocco) for treating digestive diseases (Idm'hand et al., 2020). Additionally, plants such as *Olea europaea* (Fakchich and Elachouri, 2014), *Citrus limon* (Elhilaly et al., 2003), *Cistus albidus, Cistus crispus, Crataegus monogyna*, and *Ceratonia siliqua* (Bouyahya et al., 2017) are cited for their use in treating respiratory diseases in Northern, Northwestern, and Oriental Morocco respectively.

Forty-eight species showed a high level of agreement among informants regarding which plants to use for specific diseases, with a FL above 50. This knowledge was primarily based on the experience of others, indicating the accumulation and improvement of knowledge with age. The mechanisms of this knowledge transmission are numerous and varied. Paniagua-Zambrana et al. (2017) described an inter-generational knowledge transfer that corresponds to the transmission of information from elders to younger generations through storytelling and practical demonstrations. Voeks (2004) reported the transmission of information through community rituals and ceremonies. During these events, community members learn about the medicinal properties of plants through direct participation and observation. According to Berkes et al. (2000), collaborative foraging and harvesting play a crucial role in the transmission of information. As community members work together to identify, harvest, and process plants, consensus builds regarding their medicinal uses, contributing to the transmission of traditional knowledge. The exchange of information within social and family networks likely contributed to the high consensus observed in plant usage elsewhere in Morocco (Merzouki et al 2003, El-Ghazouani et al, 2021) and other countries (Alqethami *et al.* 2020).

The remedies prepared by the population in the study area were predominantly in the form of decoctions and infusions using leaves and were primarily administered orally. Infusion remains the most frequently reported method of preparation in Morocco. For example, Mikou et al (2016), Ouhaddou et al (2014) and Rhattas et al (2016) report remedy preparation frequencies by infusion of 44% in the city of Fez, 30.34% in the Western Rif, and 31% in the province of Agadir Ida Ou Tanane. These authors explain this result by the fact that infusion better preserves the active principles that could be transformed or destroyed during preparation. However, decoction was the most common method in other regions of Morocco. Decoction preparation frequencies of 47%, 40.55% and 33% are reported for the Commune of Imi n'Tlit, the High Moulouya and the Daraa Tafilalt region (Benlamdini et al. 2014; Eddouks et al. 2017; Mehdioui and Kahouadji 2007).

The remedies were primarily aimed at treating digestive tract ailments with a high agreement between informants (High ICF). Gastrointestinal disorders are significant health concerns globally, including in Morocco, and traditional medicine is often employed to address these conditions (Heinrich *et al.* 1998, Es-Safi *et al.* 2020). Respiratory diseases were also prevalent and had a high ICF. Similar findings were reported in other regions of Morocco (Bouyahya *et al.* 2017). The prevalence of these conditions may be attributed to the cold and dry climate of the High Atlas region during winter (Garrido *et al.* 2019). Urinary tract diseases also had a high ICF (0.80). Previous studies documented the high ICFs for these ailments in various regions of Morocco, with the use of over 270 plant species throughout the country (Fakchich & Elachouri 2014). *C. ambrosioides*, with a FL value of 100% for fever, appears to be highly effective, which aligns with previous reports (El-Ghazouani *et al.* 2021).

The choice of specific plants for the treatment of gastrointestinal and respiratory conditions is influenced by a combination of traditional beliefs, empirical evidence, and cultural practices. In Moroccan culture, the use of medicinal plants is deeply rooted in historical and spiritual traditions. Many plants are selected based on ancestral knowledge passed down through generations. This knowledge is often intertwined with local beliefs about the healing properties of certain plants. For example, plants like *F. vulgare* and *Mentha* spp. are traditionally believed to have digestive benefits and are used to relieve symptoms such as bloating. These beliefs are supported by the long-standing use of these plants in traditional Moroccan medicine (Bellakhdar, 1997). Empirical evidence also plays a significant role in the selection of medicinal plants. Over centuries, practical experience and observation have demonstrated the efficacy of certain plants in treating specific conditions. Studies have supported some of these traditional uses. For instance, Badgujar et al. (2014) reported that fennel has antispasmodic and carminative properties, which help alleviate digestive issues. Similarly, mint was proven to have antimicrobial and anti-inflammatory properties, making it effective in treating both gastrointestinal and respiratory conditions (McKay & Blumberg, 2006). The preparation and administration of these plants are often linked to specific rituals and customs. For example, the use of herbal teas (infusions) is a common practice for treating digestive ailments. Mint tea is not only a daily beverage, but also a remedy for stomach discomfort. The preparation of such teas is often a communal activity, reinforcing social bonds and facilitating the transmission of traditional knowledge (Bellakhdar, 1997). Many of the plants used are locally grown or wild-harvested, making them readily accessible and affordable. This practical aspect ensures that these remedies remain an integral part of local healthcare practices, especially in rural areas where access to modern medical facilities may be limited (Merzouki et al., 2003). In some cases, traditional practices are integrated with modern medical approaches. Health practitioners in Morocco may recommend traditional remedies in conjunction with conventional treatments, recognizing the value of these plants in providing symptomatic relief and improving overall well-being. This integrative approach helps bridge the gap between traditional and modern medicine, ensuring a more holistic approach to healthcare (Fadli et al., 2013).

The flora and the traditional knowledge of herbal medicine also vary across the regions of Morocco. The knowledge reflects a blend of Berber, Arab, African, and Andalusian influences and is deeply integrated into the daily lives and cultural practices of communities. Certain plant species are widely used in Morocco for their medicinal properties. Argan (*A. spinosa*) is native to the south-western regions and appreciated throughout the country for its oil (Charrouf & Guillaume, 2008). Rosemary (*R. officinalis*), found throughout the country, is utilized for digestive and anti-inflammatory purposes, aiding in respiratory issues and improving circulation (Bellakhdar, 1997). Mint (Mentha spp.) is extensively cultivated and used in traditional Moroccan tea for its digestive benefits, such as relieving stomachaches and headaches (Bellakhdar, 1997).

Regional differences highlight the adaptation of herbal medicine to local climates, cultures, and health needs. In northern Morocco, characterized by a Mediterranean climate, plants like sage (*S. officinalis*) and oregano (*Origanum compactum*) are extensively used for their anti-inflammatory and antibacterial properties, commonly treating respiratory and digestive ailments (Bellakhdar, 1997). Inhabitants of the Atlas Mountains rely on endemic plants such as thyme (*T. satureioides*) and wormwood (*A. herba-alba*) for treating digestive issues and respiratory conditions, reflecting the local climate and high-altitude living conditions (Bellakhdar, 1997). The harsh and arid climate of the Sahara Desert requires the use of plants like the date palm (*Phoenix dactylifera*), which serves as a crucial food source and medicinal plant, while herbs like *Peganum harmala* are used for their psychoactive effects (Bellakhdar, 1997). In coastal areas such as Essaouira and Agadir, the use of seaweed and other marine plants is common due to their rich mineral content, and they are used in skin treatments and dietary supplements (Bellakhdar, 1997).

Cultural practices also differ regionally. In northern Morocco, the strong Andalusian cultural influence leads to the use of certain herbs in both medicinal and culinary practices, blending traditional herbal medicine with culinary traditions to enhance health (Bellakhdar, 1997). The Atlas Mountains are dominated by Berber traditions, featuring unique rituals and

ceremonies involving medicinal plants, such as the use of juniper smoke in purification rites, which reflect the integration of spiritual and medicinal plant use (Mehdioui & Kahouadji, 2007). Nomadic tribes in the Sahara Desert have developed distinct practices for preserving and using medicinal plants, often drying and powdering herbs for long-term storage to ensure a stable supply despite the harsh desert conditions (Bellakhdar, 1997).

Many of the plant species identified in this study are also utilized in other regions of Morocco (El Hilaly *et al.* 2003, Fakchich & Elachouri 2014, Naceiri *et al.* 2019, Belhaj *et al.* 2020). However, the rural population of Imouzzer reported some new uses for certain plants, partially confirming previous reports from the nearby city of Agadir (El-Ghazouani *et al.* 2021). For example, *O. natrix* was cited for treating hepatic disorders, *A. leucotrichus* for digestive and respiratory ailments, and *T. articulata* for diarrhea. Nonetheless, further research is necessary to identify the specific compounds responsible for the therapeutic properties of these plants.

This study focused on a specific geographic area, which may limit the generalizability of findings to other regions with different ecological, cultural, and environmental contexts. The applicability of ethnobotanical findings to other regions depends on the similarity of environmental conditions, plant species composition, and cultural practices. Many plant species available in the region of the Western High Atlas may not be present in other rural regions, and cultural practices surrounding plant use may vary significantly between communities. In addition, traditional knowledge about plants and their uses is dynamic and may change over time due to various factors such as cultural assimilation and environmental degradation. Conducting comparative ethnobotanical studies across multiple regions can help identify commonalities and differences in plant use and traditional knowledge across diverse cultural and ecological contexts. Longitudinal ethnobotanical studies are needed to track changes in traditional knowledge over time and understand the factors driving these changes. Long-term monitoring can help identify emerging trends, assess the impact of environmental changes, and inform conservation and management strategies for culturally significant plant species. Collaboration with local communities can facilitate cross-cultural research initiatives that explore plant use patterns and traditional knowledge across different cultural groups and geographic regions. Integrating traditional knowledge with scientific methodologies can enhance the validity and applicability of ethnobotanical research findings. Collaborative research initiatives that involve local communities in data collection, analysis, and interpretation can ensure the relevance and applicability of research outcomes to local contexts.

## Conclusion

The occidental High Atlas region, characterized by its rich flora, provides the local population with abundant medicinal plant resources (101 species from 54 families and 90 genera). These plants serve as an alternative healthcare option in the absence of sufficient medical infrastructure in this mountainous area. The remedies prepared through decoction and infusion are predominantly employed to address gastrointestinal, respiratory, and urinary ailments. It is noteworthy that medicinal plant usage is primarily observed among the elderly population, with a particular emphasis on women. These findings align with the societal roles of women in rural Moroccan communities, where they assume responsibilities for household chores, education, and the health of their family members.

## Declarations

**List of abbreviations:***:* UV = use value, RFC = relative frequency of citation, FL = fidelity level, ICF = Informant consensus factor

**Ethics approval and consent to participate:** Ethical approval was obtained from the Bioethics Advisory Committee of the Faculty of Sciences of Agadir (approval number AE-2019-0001).

**Consent for publication:** Oral permission was taken from all participants

**Availability of data and materials:** Data are available upon reasonable request

**Competing interests:** There are no conflicts of interest in this article.

**Funding:** *The authors have not received any funding for this research*

**Author contributions:** *:* FE: Investigation, Analysis, Writing Original Draft. RB: Investigation, Analysis. BY: Supervision, Analysis. AZ: Conceptualization, Writing - Review & Editing.

## Acknowledgements

We thank the informants for their invaluable participation. We would also like to express our gratitude to Prof. F. Msanda for helping to identify the plants collected.

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