Herbal Medicine Used in the Treatment of Human Diseases in the Rif, Northern Morocco

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Abstract
Since the beginning of time, the Moroccan people have used many medicinal plants as a popular medicine to cure many human and livestock health problems. Yet, few studies have been carried in the past to properly document and promote traditional ethnomedicinal knowledge. This study was conducted out from July 1st, 2016 to July 30th, 2018 in the Rif; it was aimed to establish the list of medicinal plants, together with the association of ethnomedicinal knowledge. The ethnomedicinal data obtained were from 1000 traditional healers using semi-structured discussions, free listing, and focus groups. Family importance value, plant part value, fidelity level, the relative frequency of citation, and informant consensus factor were applied in data interpretation. Plant species were accumulated, and deposited at the Plant, Animal Productions and agro-industry laboratory, Ibn Tofail University. A total of 280 medicinal plants belong to 204 genera and 70 families were documented. Asteraceae with 29 species was the most used family in this study area. Rosmarinus officinalis L. (RFC = 0.189) was the species the most commonly prescribed by local traditional healers. Similarly, the leaf was the most useful part of the plant (PPV = 0.364), the most frequent affections were osteoarticular affections (ICF = 0.983), and the majority of herbal remedies were prepared from a decoction (38.6%). The results of the present investigation confirmed the presence of indigenous ethnomedicinal information of plant species in the Rif’s area to treat various disorders. More investigation on phytochemical, pharmacological, and toxicological should be considered to determine new drugs from these reported plants.

Keywords Ethnopharmacology · Human diseases · Medicinal plants · Moroccan Rif · Traditional healers

1 Introduction
Medicinal plants have been prescribed and used extensively for thousands of years to treat various disorders and ailments in traditional herbal medicine systems all over the world [1]. In all ancient civilizations and on all continents, we find traces of this use. Thus, even today, despite advances in pharmacology, the therapeutic use of plants is very present in some countries, especially in developing countries [2]. The World Health Organization (WHO) estimates that unevenly, 80% of the people from developed and developing nations depend on traditional medicines, especially on plant-based medicine in primary healthcare [3].

The use of plant species for healing purposes is a matter of culture and tradition in Morocco. It should be noted that for the primary health needs, a large portion of Moroccan people utilizes traditional methods of medicine to treat their diseases [3–6]. The inability of many developing countries to supply contemporary pharmaceutical medications [7–12], and the high cost of many drugs, has forced local communities to search for alternative products, such as medicinal plants, that have proven effectiveness and safety and are culturally acceptable.

The Rif region is one of the most biologically diverse regions in the Mediterranean, with some of the rarest biogeographical areas in the world and biodiversity of primary importance with many plants of therapeutic interest [13]. For this reason, this region is the source of many medicinal plants marketed throughout Morocco and abroad and the use of plants in herbal medicine is still very present in this region. On the opposite, data on medicinal plants in this
region are rare and insufficient. To complete partial and fragmentary studies those have been carried out throughout the Rif [13, 14], Talassemtane National Park [15], and Tingitane Peninsula [16]. It is, therefore, necessary to undertake them to identify the local uses of plant species.

It is in this context that an ethnopharmacological study was carried out in the Rif, which has a lithological diversity, structural and floristic plants important enough to establish the catalog of medicinal plants used in the traditional treatment of diseases, especially herbal medicine, as an alternative to enhance, preserve and rationally use them.

2 Materials and Methods

2.1 Description of the Study Area

The current study was conducted out in the Tangier-Tetouan-Al Hoceima region (North of Morocco) where the Rif’s area was located. It extends between 34° and 36° of latitude in the North and 4° to 6° of longitude in the East. It is bounded in the North by the Strait of Gibraltar and the Mediterranean Sea, in the South by the Rabat-Sale-Kenitra region and Fez-Meknes region, in the East by the Eastern Region, and in the West by the Atlantic Ocean (Fig. 1). The total geographical area of the Rif is 11,570 km² and the population of the city is about 3,549,512 inhabitants with an average population density of 222.2/km² [17]. The population is mixed between Arabic and Amazigh ethnicity.

The Rif is marked by Mediterranean weather with the highest temperature up to 45 °C during summer (July–August) and below 0 °C during winter (December–January) and the average annual rainfall ranges from 700 to 1300 mm which falls mainly between October and February [18]. It is mountainous with elevations ranging from 145 to 2456 (Jbel Tidirhine) meters above mean sea level and the area dominated by species such as Abies marocana Trab., Pinus halepensis Mill., Cannabis sativa L., Cedrus atlantica (Endl.) Quercus suber L., Quercus ilex L., and Quercus canariensis Willd. Principally families of Rif

Fig. 1 The geographical position of the Rif region
are very much dependent on subsistence farming, livestock, and to a more secondary space, from forest resources for their livelihood.

2.2 Methodology

2.2.1 Ethnopharmacological Survey

Ethnopharmacological investigations were carried out from July 2016 to July 2018 to collect information on medicinal plants utilized to treat multiple human sicknesses in the Rif region. In this work, the sample has been developed through a mode of probabilistic sampling random stratified [19, 20] non-proportional, it is divided into 28 strata, having concerned the cities, villages, douars, and souks weekly in the area of study. It is based on environmental factors (climate, soil, and altitude), vegetation, and the distribution of the population. The techniques employed for data collection were semi-structured interviews [21], open-ended, group discussion, free listing, and noted and recorded with a digital voice recorder. 1000 informants within aged 17–95 were randomly selected for interviews (cautery installer, farmers, elder people, bonesetters, herbalists, and therapists) in Rif (weekly markets, pharmacies, hospitals, houses, and mosques). By conducting a stratified random sampling [22], samples are then formed in each of the 28 strata, including seven urban communes: [S1: Al Hoceim (40), S12: Chefchaouen (40), S15: Tétouan (40), S16: Martil (40), S20: Md’q (40), S21: Fnideq (40), S26: Tanger (41)] and twenty-one rural communes: [S2: Ajdir (35), S6: Izezafien (30), S7: Bni Hadifa (30), S9: Targuit (40), S9: Tizi n Tchin (30), S6: Issaguene (34), S6: Bab Berred (35), S6: Cherrafat (30), S10: Bab Taza (30), S11: Derrada (29), S12: Akchour (35), S13: Fifi (30), S16: Bni Karrich (40), S17: Mallalène (35), S18: Zinat (36), S22: Belyounich (35), S23: Melloussa (39), S24: Ksar Esghir (34), S25: Bni Ouassin (36), S27: Al Bahraouisynine (35), S28: Jouamaa (36)] and they are put together to make up the overall sample of 1000 informants. Knowing that the number of people surveyed varies from one stratum to another depending on the abundance of medicinal plants sought (Fig. 2).

The time spent on each interview was approximately 20 min to one hour. The information collected concerning the profile of the interviewee (age, gender, level of study, monthly income, family situation, and locality) and the ethnopharmacological data for each plant include the common local name, the route of administration, the method of preparation, the dosage, the part used, the condition of the plant used and the diseases treated “Appendix A”. The people in the Rif region speak Amazigh, Arabic dialects and therefore, interviews were conducted in Amazigh or Arabic dialects. All the documented data were later translated into English.

2.2.2 Vegetation data collection

Fertile specimens for the present study were collected in the field (197 plant species), in herbal stores (50 plant species), and at the homes of traditional healers (33 plant species) in the Rif. The informants were always provided with fresh plant material, either collected with them, by them, or available at their market stands (Fig. 3). Field observations were also used to record the habitat of each plant species with the assistance of local guides and interviewed informants.

2.2.3 Plant species identification, and deposition in Herbarium

Based on ethnopharmacological knowledge provided by our informants, plant specimens with their exact taxonomy were ordered alphabetically by ethnomedicinal uses, vernacular name, and family name. The identification and nomenclature of the collected material vegetal were done first in the field and completed at the Plant, Animal Productions, and Agro-industry Laboratory (Fig. 4). These plant species mentioned by the informants were taxonomically identified using floristic and taxonomic references, especially “The medicinal plants of the Morocco” [23], “List of vascular plants of Morocco tomes I and II” [24], and “Practical vegetation of Morocco” [25–27]. All voucher specimens have been preserved during documentation and deposited in the Ibn Tofail University, Morocco Herbarium for future reference.

2.2.4 Statistical Analysis

Ethnopharmacological data collected are recorded on questionnaire sheets to be analyzed, studied, and confirmed or overturned at the end. Then these data were registered and interpreted by Microsoft Excel 2010 and IBM-SPSS Statistics Base 21. A representative and the quantitative scientific method was applied to examine the socio-demographic data of the informants (ANOVA One-way and Independent Samples T-Test). Further, the recorded data were analyzed by various quantitative indices like family importance value (FIV), the relative frequency of citation (RFC), plant part value (PPV), fidelity level (FL), and informant consensus factor (ICF).

2.2.4.1 Family Importance Value (FIV)

The FIV identifies the significance of plant families. It is an indication of therapeutic importance that can be utilized in ethnobotany to assess the value of natural plant species. To determine family importance value, we adopt the following method: $FIV = \frac{FC_{\text{family}}}{N_{q}}$, where $FC_{\text{family}}$ is the number of
informants mentioning the family and \( N_s \) = Total number of species within each family [28].

### 2.2.4.2 Relative Frequency of Citation (RFC) and Frequency (FC)
RFC is calculated by dividing FC by an entire number of interviewees in the research (N). The value of RFC for plant species is based on the citing portion of interviewees for every species. Relative Frequency of Citation was determined by applying the following formula [29]:

\[
\text{RFC} = \frac{\text{FC}}{\text{N}}
\]

with \((0 < \text{RFC} < 1)\).

### 2.2.4.3 Plant Part Value (PPV)
PPV was determined by applying this equation [30]:

\[
\text{PPV} = \frac{\text{RU}_{\text{plant part}}}{\text{RU}}
\]

where RU is the number of applications notified of total portions of the medicinal plant and \( \text{RU}_{\text{plant part}} \) is the number of uses reported per part of the medicinal plant. The part among the most important PPV is the most used by the informants.

### 2.2.4.4 Fidelity Level (FL)
Fidelity level is the rate of interviewees who mentioned the uses of certain medicinal plants to treat a particular disease in the study region. The FL ratio is determined using this equation [31]:

\[
\text{FL(\%)} = \frac{N_p}{N} \times 100
\]

where \( N_p \) is the number of interviewees that require the application of a plant species to cure a special affection and \( N \) is the sum of interviewees that use the medicinal species as a drug to treat any given illness.

### 2.2.4.5 Informant Consensus Factor (ICF)
Informant consensus factor (ICF) was determined to investigate an agreement between the interviewees on the related remedies for each group of diseases [32]:

\[
\text{ICF} = \frac{N_u - N_t}{N_u - 1}
\]

where \( N_u \) is the number of use-reports in each disease category and \( N_t \) is many species used. The values for the Informant Consensus Factor range from 0 to 1.
3 Results

3.1 Socio-demographic Data

A total of 1000 respondents were interviewed. Based on socio-demography, these participants were categorized into different classes as given in Table 1. Among the participants, 52.7% were females and the remaining were males 47.3%, with a sex ratio female/male of 1.11. From the total respondents, 76% were married, 10.8% divorced, 9.2% widowed, and 4% unmarried. In terms of age, the age groups of 40–60 were very high compared to other groups (47.6%). Just 30.6% were more than 60 years old, 21.4% were 20–40 years old, and 0.4% of informants were below 20 years old. Regarding educational status, the majority of respondents (69.1%) were illiterate, while 23% and 6.7% respondents attended primary and secondary school, respectively. Only 1.2% of respondents were attended higher education. Considering the income/month, most of the informants were unemployed (41.6%), while 38.6% of these informants had low income/month level, (17%) with average level income/month, and 2.8% with higher-level income/month.

3.2 Most Represented Botanical Family and Their Family Importance Value (FIV)

The floristic analysis of the results obtained identified 280 medicinal species and subspecies belonging to 204 genera and 70 plant families were reported as having rich ethnopharmacological uses in the Rif to treat different human ailments. In terms of the number of species, it appears that the Asteraceae family is the most represented with 29 species or 10.36% of the catalog developed, followed by Lamiauceae (22 species), Fabaceae and Poaceae (21 species each), Apiaceae (17 species), Solanaceae (12 species), Brassicaceae (11 species), Asparagaceae (10 species), Amaranthaceae and Cucurbitaceae (8 species each), Rutaceae (6 species), Myrtaceae and Rosaceae with 5 species each. Besides, Anacardiaceae, Caryophyllaceae, Cupressaceae, Euphorbiaceae, Lauraceae, and Zingiberaceae are each represented by 4 plant species. The Apocynaceae, Malvaceae, Moraceae, Oleaceae, Papaveraceae, Pinaceae, Rubiaceae, and Tamaricaceae are represented by 3 medicinal species each, whereas the other families are those with at most one or two medicinal plant species. Based on the family importance value (FIV), the families most cited by informants are Amaryllidaceae (FIV = 0.104), Lythraceae (FIV = 0.103) Caryophyllaceae (FIV = 0.084), Apocynaceae (FIV = 0.079), Capparaceae (FIV = 0.073), Linaceae (FIV = 0.065), Rubiaceae (FIV = 0.063), Nitrariaceae, Rhamnaceae and Verbenaceae (FIV = 0.053), Rutaceae (FIV = 0.052) and Arecaceae (FIV = 0.049). The vernacular names, scientific names of documented species, their families, used parts, methods of preparations, FL, FC, RFC, and FIV were illustrated in Tables 2, 3, 4, 5, 6, 7, 8, 9.

Fig. 3 Type of sachets used to preserve collected plant species
3.3 Diversity of Medicinal Plants

To assess the relative importance of the reported plant species, the relative frequency of citation (RFC) was calculated from the informants’ citations. In the present study, the highest value reported was 0.189, and the lowest value was 0.001 for each species as given in Tables 2, 3, 4, 5, 6, 7, 8, 9. In the current investigation, the highest RFC value was reported for *Rosmarinus officinalis* L. (RFC = 0.189), *Thymus sericeoides* Coss. (RFC = 0.176), *Dittrichia viscosa* (L.) Greuter. (RFC = 0.165), *Lawsonia inermis* L. (RFC = 0.154), *Arenaria rubra* L. (RFC = 0.153), and *Nerium oleander* L. (RFC = 0.146). Meanwhile, 60 medicinal plant species scored the least RFC value, which is 0.001.

3.4 Habitat of Medicinal Plants

The present study showed that 165 medicinal plant species (59%) used by the Moroccan pharmaceutical medicines today are collected from the agriculture (cultivated) (Fig. 5), 101 species 36% were collected from wasteland (Fig. 6) (All lands affected by water erosion, wind erosion, floods, water-logging, soil salinization, and soil alkalization) and only 14 species (5%) were introduced by marketing in other regions.

3.5 Medicinal Formulations Used During the COVID-19 Lockdown for Improving the Immune System

Medicinal plant species have a fundamental unit for use as alternative medicines systems in Morocco and are the basis for the discovery of natural ingredients for the development of therapeutic agents in pharmacology. The study conducted in the Salé region [33] shows that the local population uses some plants to prevent and treat the COVID-19, which was mentioned by the Moroccan Rif community. In Moroccan Rif, the uses of medicinal species have increased during the COVID-19 pandemic as a preventive behavior. *Citrus limon* (L.) Burm. f. has been used to relieve cough, and as an expectorant in bronchitis. *Allium sativum* L. *Allium cepa*
L. and *Zingiber officinale* Roscoe are indicated for respiratory disease (cold and cough), and other symptoms related to influenza. *Eucalyptus globulus* Labill. is indicated for symptoms of respiratory disease (bronchitis, rhinitis), due to the presence of 1–8-cineol [34]. Indications of respiratory conditions: *Foeniculum vulgare* Mill. *Plantago lanceolata* L., *Pimpinella anisum* L., *Silybum marianum* L., *Laurus nobilis* L., *Malva sylvestris* L., *Thymus vulgaris* L., and *Glycyrrhiza glabra* L. are indicated by informants for cough associated with a cold, sore throat, fever laryngitis, and tonsilitis. *Hedera helix* L. is indicated as antispasmodic, other indications are anti-inflammatory, and in the treatment of flu and fever. Black seeds of *Nigella sativa* L. are globally known as a spice and as such as a food item.

### 3.6 The Fidelity Level (FL) of Medicinal Plants Reported

Fidelity level (FL) designates the choice for medicinal plants to be better for other species in the treatment of a particular ailment. The plant species that are extensively used by the indigenous inhabitants have more important FL values than those that are few popular. In this study, the FL ranged from 45.5% to 100% for medicinal plant use age. The study determined 240 medicinal plant species (85.71%) achieve the greatest fidelity level (FL = 100%) and the remaining 40 plant species achieve reasonable FL.

### 3.7 Disease treated and their ICF values

The results of the ICF calculation show that the value in our study ranges from 0.944 to 0.983 per uses categories (Table 10). Results revealed that the very best ICF (0.983) value was obtained for osteoarticular diseases with 867 use-reports for 16 plant species. It’s followed by dermatological diseases (ICF = 0.981), neurological diseases (ICF = 0.974), genitourinary diseases (ICF = 0.973), metabolic diseases (ICF = 0.972), cardiovascular diseases (ICF = 0.968), digestive system diseases (ICF = 0.945), and respiratory system diseases (ICF = 0.944).

| Categories                  | Number of informants | Percent (%) | Average ± E.T | F-Value | p-Value |
|-----------------------------|----------------------|-------------|---------------|---------|---------|
| Gender                      |                      |             |               |         |         |
| Female                      | 527                  | 52.7        | 18.82 ± 2.842 | 5.753   | 0.02    |
| Male                        | 473                  | 47.3        | 16.89 ± 3.166 |         |         |
| Age ranges                  |                      |             |               |         |         |
| < 20 years                  | 22                   | 0.4         | 0.78 ± 0.832  | 306.208 | 0.000   |
| 20–40 years                 | 214                  | 21.4        | 7.64 ± 1.889  |         |         |
| 40–60 years                 | 476                  | 47.6        | 17.00 ± 3.042 |         |         |
| > 60 years                  | 306                  | 30.6        | 10.92 ± 1.783 |         |         |
| Family status               |                      |             |               |         |         |
| Married                     | 760                  | 76          | 2.32 ± 4.784  | 441.234 | 0.000   |
| Divorced                    | 108                  | 10.8        | 3.85 ± 1.580  |         |         |
| Widower                     | 92                   | 9.2         | 3.28 ± 1.629  |         |         |
| Single                      | 40                   | 4           | 27.14 ± 2.927 |         |         |
| Educational level           |                      |             |               |         |         |
| Illiterate                  | 691                  | 69.1        | 24.67 ± 3.464 | 673.173 | 0.000   |
| Primary school              | 230                  | 23          | 8.21 ± 2.166  |         |         |
| Secondary school            | 67                   | 6.7         | 2.39 ± 1.749  |         |         |
| Universitaire               | 12                   | 1.2         | 0.42 ± 0.634  |         |         |
| Income/month                |                      |             |               |         |         |
| Unemployed                  | 416                  | 41.6        | 14.85 ± 1.432 | 359.350 | 0.000   |
| 250–1500 MAD                | 386                  | 38.6        | 13.78 ± 2.024 |         |         |
| 1500–5000 MAD               | 170                  | 17          | 6.07 ± 2.508  |         |         |
| > 5000 MAD                  | 28                   | 2.8         | 1.00 ± 1.018  |         |         |
| Locality                    |                      |             |               |         |         |
| Rural area                  | 497                  | 49.7        | 17.75 ± 3.122 | 246.861 | 0.000   |
| Urban area                  | 251                  | 25.1        | 8.96 ± 1.990  |         |         |
| Village                     | 229                  | 22.9        | 8.17 ± 2.695  |         |         |
| Nomadic                     | 23                   | 2.3         | 0.82 ± 0.904  |         |         |
| Family and scientific name | Vernacular name | Used part | Method of preparation | FL (%) | FC | RFC | FIV |
|-----------------------------|----------------|-----------|----------------------|--------|----|-----|-----|
| **Amaranthaceae**           |                |           |                      |        |    |     |     |
| *Chenopodium album* L.      | Labda, Baremren| Leaf      | Infusion             | 71     | 07 | 0.007 |     |
| *Chenopodium murale* L.     | Talekutta      | Other combination | Infusion | 100   | 01 | 0.001 |     |
| *Salsola kali* L.           | El Herd        | Whole plant| Infusion             | 100    | 01 | 0.001 |     |
| **Anacardiaceae**           |                |           |                      |        |    |     |     |
| *Pistacia atlantica* Desf   | Btem           | Leaf      | Decoction            | 100    | 17 | 0.017 | 0.048|
| **Apiaceae**                |                |           |                      |        |    |     |     |
| *Ammi majus* L.             | Tiillane       | Fruit     | Other                | 100    | 32 | 0.032 |     |
| *Ammi visnaga* (L.) Lam     | Bechnikha      | Fruit     | Infusion             | 91     | 22 | 0.022 |     |
| *Ammodaucus leucotrichus* Coss | Camoun Soufi | Seed     | Cooked               | 100    | 41 | 0.041 |     |
| *Apium graveolens* L.       | Lkrafess       | Leaf      | Decoction            | 100    | 04 | 0.004 |     |
| *Carum carvi* L.            | Karwiya        | Seed      | Infusion             | 100    | 26 | 0.026 |     |
| *Coriandrum sativum* L.     | Alkazbour      | Seed      | Raw                  | 100    | 04 | 0.004 |     |
| *Cumminum cyminum* L.       | Camoun         | Seed      | Infusion             | 100    | 03 | 0.003 |     |
| *Eryngium ilicifolium* Lam. | El Asfour, Chkour | Flower | Raw              | 100    | 15 | 0.015 |     |
| *Foeniculum vulgare* Mill.  | Lbesbas        | Seed      | Decoction            | 100    | 68 | 0.068 |     |
| *Smyrniun ulasratrum* L.    | Lheyyyar       | Leaf      | Infusion             | 100    | 43 | 0.043 |     |
| **Apocynaceae**             |                |           |                      |        |    |     |     |
| *Vinca minor* L.            | El Innakia     | Whole plant| Cooked              | 100    | 01 | 0.001 | 0.079|
| **Arecaceae**               |                |           |                      |        |    |     |     |
| *Chamaerops humilis* L.     | Doum, El Ghaz  | Fruit     | Infusion             | 100    | 51 | 0.051 |     |
| **Asparagaceae**            |                |           |                      |        |    |     |     |
| *Asparagus acutifolius* L.  | Sekkom, Tazzut | Leaf      | Decoction            | 100    | 01 | 0.001 | 0.013|
| *Asparagus densiflora* Kunh. | Sekkom, Tazzut | Whole plant| Other      | 100    | 01 | 0.001 |     |
| *Asparagus officinalis* L.  | Sekkom, Tazzut | Whole plant| Other combination | 100    | 02 | 0.002 |     |
| *Asparagus plumousus* Baker | Sekkom, Tazzut | Stem      | Infusion             | 100    | 01 | 0.001 |     |
| *Asparagus stipularis* Forssk | Sekkom, Tazzut | Rhizome  | Other                | 100    | 01 | 0.001 |     |
| *Drinia maritima* (L.) Stearn | Ansal    | Bulb      | Decoction            | 100    | 04 | 0.004 |     |
| *Muscaria comosum* (L.) Mill. | Bsyla     | Bulb      | Decoction            | 100    | 02 | 0.002 |     |
| **Asteraceae**              |                |           |                      |        |    |     |     |
| *Artemisia absinthium* L.   | Chiba         | Other combination| Decoction | 100    | 75 | 0.075 | 0.038|
| *Cynara humilis* L.         | Khorchef, Timta| Stem    | Raw                  | 94     | 31 | 0.031 |     |
| *Helichrysum italicum* (Roth) G. Don | Dahab Eshams | Whole plant | Infusion | 100    | 01 | 0.001 |     |
| *Matricaria chamomilla* L.  | Babunj        | Whole plant| Decoction           | 100    | 48 | 0.048 |     |
| *Ormenis mixta* (L.) Dumort | Hellâla       | Other combination| Infusion | 100    | 19 | 0.019 |     |
| *Scolymus hispanicus* L.    | Garnina       | Rhizome   | Infusion             | 100    | 50 | 0.050 |     |
| **Brassicaceae**            |                |           |                      |        |    |     |     |
| *Brassica oleracea* f. alba DC | Melfouf, Krub | Leaf      | Other                | 100    | 07 | 0.007 | 0.012|
| *Raphanus sativus* L.       | Fjel          | Whole plant| Decoction           | 100    | 46 | 0.046 |     |
| **Caryophyllaceae**         |                |           |                      |        |    |     |     |
| *Silene vulgaris* (Moench) Gareke | Tigheghet | Leaf      | Decoction            | 100    | 08 | 0.008 | 0.084|
| **Crassulaceae**            |                |           |                      |        |    |     |     |
| *Umbilicus rupestris* (Salisb.) Dandy | Sorrat El Ard | Whole plant | Infusion       | 100    | 01 | 0.001 | 0.001|
| **Cucurbitaceae**           |                |           |                      |        |    |     |     |
| *Bryonia dioica* Jacq       | Aineb Edib    | Root      | Decoction            | 60     | 05 | 0.005 | 0.013|
| *Cucurbita maxima* Duchesne | Elgraa Hamra  | Flower    | Infusion             | 100    | 15 | 0.015 |     |
| **Cupressaceae**            |                |           |                      |        |    |     |     |
| *Capressus sempervirens* L. | Zembale, Sarw | Leaf      | Infusion             | 100    | 01 | 0.001 | 0.043|
| **Cyperaceae**              |                |           |                      |        |    |     |     |
| *Cyperus rotundus* L.       | Tara          | Whole plant| Decoction           | 100    | 01 | 0.001 | 0.001|

This table represents the inventory of plant species used to treat digestive system disorders by indigenous people of Rif, with columns for Family and scientific name, Vernacular name, Used part, Method of preparation, FL %, FC, RFC, FIV.
| Family and scientific name | Vernacular name | Used part | Method of preparation | FL % | FC  | RFC  | FIV |
|-----------------------------|-----------------|-----------|-----------------------|------|-----|------|-----|
| **Fabaceae**                |                 |           |                       |      |     |      |     |
| *Lupinus angustifolius* L.  | Shengala, Bozghiba | Whole plant | Decoction             | 100  | 01  | 0.001| 0.023|
| *Cassia senna* L.           | Sna Mekki       | Leaf      | Decoction             | 100  | 05  | 0.005|      |
| *Ceratonia siliqua* L.      | Salghwa, Kharroub | Fruit     | Decoction             | 100  | 67  | 0.067|      |
| *Glycyrrhiza glabra* L.     | Arq Sûs         | Root      | Infusion              | 83   | 36  | 0.036|      |
| *Trigonella foenum-graecum* L. | Helba  | Seed     | Cooked                | 100  | 54  | 0.054|      |
| *Vicia benghalensis* L.     | Jelbanet Lehnouch | Leaf  | Decoction             | 100  | 01  | 0.001|      |
| *Vicia tenuifolia* Roth     | Bykya           | Whole plant | Infusion             | 100  | 01  | 0.001|      |
| **Fagaceae**                |                 |           |                       |      |     |      |     |
| *Quercus rotundifolia* Lam. | Kerrush, Tasaft | Bark      | Infusion              | 100  | 06  | 0.006| 0.038|
| **Geraniaceae**             |                 |           |                       |      |     |      |     |
| *Pelargonium capitatum* (L.) L’Hér | Laartercha | Leaf      | Decoction             | 100  | 27  | 0.027|      |
| **Iridaceae**               |                 |           |                       |      |     |      |     |
| *Iris × germanica* L.       | Sawsan Almani   | Leaf      | Other                 | 100  | 01  | 0.001| 0.001|
| **Juglandaceae**            |                 |           |                       |      |     |      |     |
| *Juglans regia* L.          | Guergaâ         | Bark      | Other                 | 80   | 05  | 0.005|      |
| **Lamiaceae**               |                 |           |                       |      |     |      |     |
| *Ocimum basilicum* L.       | Lhbak           | Leaf      | Infusion              | 71   | 07  | 0.007| 0.056|
| *Origanum majorana* L.      | Mard’douch      | Whole plant | Infusion             | 65   | 46  | 0.046|      |
| *Origanum vulgare* L.       | Zaat Elma       | Leaf      | Infusion              | 100  | 80  | 0.080|      |
| *Thymus satureioides* Coss. | Z’îtra, Tazuknit | Leaf  | Infusion              | 100  | 176 | 0.176|      |
| **Lauraceae**               |                 |           |                       |      |     |      |     |
| *Cinnamomum zeylanicum* Blume | Qarfa           | Bark      | Infusion              | 100  | 11  | 0.011| 0.035|
| **Lythraceae**              |                 |           |                       |      |     |      |     |
| *Panica granatum* L.        | Remman          | Bark      | Decoction             | 100  | 53  | 0.053| 0.103|
| **Malvaceae**               |                 |           |                       |      |     |      |     |
| *Malva hispanica* L.        | Khobbeyza       | Leaf      | Decoction             | 100  | 04  | 0.004| 0.004|
| *Malva silvestris* L.       | Bakkula         | Leaf      | Cooked                | 100  | 06  | 0.006|      |
| **Myristicaceae**           |                 |           |                       |      |     |      | 0.003|
| *Myristica fragrans* Houtt  | Bsbibissa       | Fruit     | Cooked                | 67   | 03  | 0.003|      |
| **Myrtaceae**               |                 |           |                       |      |     |      | 0.028|
| *Eugenia caryophyllata* Thunb. | Qronfel        | Flower    | Infusion              | 100  | 05  | 0.005|      |
| **Oleaceae**                |                 |           |                       |      |     |      | 0.020|
| *Olea europea* L.           | Zaytoun         | Leaf      | Decoction             | 100  | 51  | 0.051|      |
| *Olea europea* var. sylvestris* (Mill.) Lehr | Zabbouj | Leaf | Decoction             | 100  | 03  | 0.003|      |
| **Piperaceae**              |                 |           |                       |      |     |      | 0.005|
| *Piper nigrum* L.           | Ibzar           | Seed      | Cooked                | 100  | 05  | 0.005|      |
| **Plantaginaceae**          |                 |           |                       |      |     |      | 0.006|
| *Plantago lanceolata* L.    | Lssan lhamel    | Leaf      | Cooked                | 100  | 06  | 0.006|      |
| **Poaceae**                 |                 |           |                       |      |     |      | 0.015|
| *Cymbopogon citratus* (DC.) Stapf | Aoshb Elhamed | Stem    | Decoction             | 100  | 01  | 0.001|      |
| *Hordeum vulgare* L.        | Chaîr, Timzine  | Seed      | Cooked                | 100  | 05  | 0.005|      |
| *Phalaris canariensis* L.   | Hchicht Lkanari | Seed     | Decoction             | 100  | 01  | 0.001|      |
| **Polygonaceae**            |                 |           |                       |      |     |      | 0.005|
| *Emex spinosa* (L.) Campd.  | Houmida         | Whole plant | Cooked                | 100  | 01  | 0.001|      |
| *Rumex acetosa* L.          | Houmida         | Leaf      | Infusion              | 67   | 09  | 0.009|      |
| **Rhamnaceae**              |                 |           |                       |      |     |      | 0.053|
| *Ziziphus lotus* (L.) Lam.  | Nbeg, Tazart    | Seed      | Other                 | 62   | 53  | 0.053| 0.026|
| **Rosaceae**                |                 |           |                       |      |     |      | 0.001|
| *Prunus armeniaca* L.       | Mechmach        | Leaf      | Infusion              | 100  | 01  | 0.001|      |
### 3.8 Plant Parts Used in the Study Area

In classical pharmacopeia, various parts of medicinal plants identified particularly the seeds, the leaves, the flowers, the fruits, the roots, or maybe the entire plant are exploited by the indigenous people of Rif. supported the plant structure value (PPV) index, the leaf has been reported because the dominant party within the preparation of the herbal remedy within the study area (PPV = 0.364), followed by seed (PPV = 0.226), whole plant (PPV = 0.097), flower (PPV = 0.073), fruit (PPV = 0.060), root (PPV = 0.051), bulb (PPV = 0.044), other combinations (PPV = 0.034), rhizome (PPV = 0.026), bark (PPV = 0.021), and stem (PPV = 0.006), respectively.

### 3.9 Method of Preparation and Administration of Plants

Indigenous people in the study area used many methods of preparation. The results showed that the majority of remedies were prepared from decoction (38.6%) and infusion (34%), followed by cataplasm (11.3%) cooked (7.6%) and raw (2.3%). The percentage of the other methods of preparation grouped (maceration, inhalation, fumigation) doesn’t exceed 6.2%. The main solvent with the plant was water, but milk, butter, tea, and honey, cereal oils were also widely used ingredients. The route of administration in this study varies with the type of disease treated and the actual sites of the ailments. The result revealed that herbal medicine was administered through different routes. Generally, the majority of informants prepared remedies were applied mostly by oral (82.4%) followed by massage (6.3%), swabbing (5.2%), other modes of administration (3.4%), and rinsing (2.7%).

### 4 Discussion

As part of this study, our investigations identified 280 species and subspecies used for medicinal purposes. These medicinal species belong to 204 genera and 70 botanical

| Family and scientific name | Vernacular name | Used part | Method of preparation | FL % | FC | RFC | FIV |
|----------------------------|----------------|-----------|-----------------------|------|----|-----|-----|
| *Prunus persica* (L.) Batsch | Khokh | Leaf | Other | 100 | 02 | 0.002 | 0.052 |
| Rutaceae | | | | | | | |
| *Ruta montana* (L.) L. | Fijel, Iwermi | Root | Decoction | 58 | 12 | 0.012 |
| Salicaceae | | | | | | | |
| *Populus alba* L. | Selsaf | Leaf | Decoction | 100 | 13 | 0.013 |
| *Populus nigra* L. | Selsaf | Leaf | Decoction | 100 | 01 | 0.001 |
| Schisandraceae | | | | | | | |
| *Illicium verum* Hook.f | Badiana | Fruit | Infusion | 100 | 04 | 0.004 |
| Scrophulariaceae | | | | | | | |
| *Verbascum sinuatum* L. | Torah | Flower | Infusion | 100 | 01 | 0.001 |
| Solanaceae | | | | | | | |
| *Solanum lycopersicum* L. | Maticha | Fruit | Cooked | 71 | 14 | 0.014 |
| *Solanum melongena* L. | Denjal | Fruit | Cooked | 60 | 05 | 0.005 |
| *Solanum nigrum* L. | Buqnîna | Leaf | Infusion | 100 | 01 | 0.001 |
| Tamaricaceae | | | | | | | |
| *Tamarix aphylla* (L.) H.Karst | Adba | Flower | Infusion | 100 | 02 | 0.002 |
| *Tamarix gallica* L. | Tamimayt | Leaf | Decoction | 100 | 01 | 0.001 |
| *Tamarix ramosissima* Ledeb. | Athel | Other combination | Infusion | 100 | 01 | 0.001 |
| Theaceae | | | | | | | |
| *Camellia sinensis* (L.) Kuntze | Atây | Leaf | Infusion | 100 | 42 | 0.042 |
| Thymelaeaceae | | | | | | | |
| *Thymelaea virginata* (Desf.) Endl | Matnane | Whole plant | Infusion | 100 | 32 | 0.032 |
| Verbenaceae | | | | | | | |
| *Lantana camara* L. | Nabat Oum Kaltoum | Leaf | Decoction | 100 | 01 | 0.001 |
| Vitaceae | | | | | | | |
| *Vitis vinifera* L. | Aneb, Dalya | Leaf | Infusion | 100 | 17 | 0.017 |
| Zingiberaceae | | | | | | | |
| *Curcuma Longa* L. | Kharqûm | Rhizome | Decoction | 100 | 16 | 0.016 |
Table 3  Inventory of plant species used to treat respiratory diseases by indigenous people of Rif

| Family and scientific name | Vernacular name | Used part | Method of preparation | FL % | FC | RFC | FIV |
|----------------------------|----------------|----------|-----------------------|------|----|-----|-----|
| Aizoaceae                  |                |          |                       |      |    |     |     |
| *Mesembryanthemum acinaciforme* L. | Bousbayeaa | Leaf | Other                | 100  | 01 | 0.001 | 0.001 |
| Anacardiaceae              |                |          |                       |      |    |     |     |
| *Schinus molle* L.         | Foulfol kadib  | Fruit   | Decoction            | 100  | 01 | 0.001 | 0.048 |
| Apiaceae                   |                |          |                       |      |    |     |     |
| *Thapsia garganica* L.     | Deryas         | Whole plant | Cataplasm          | 100  | 02 | 0.002 | 0.032 |
| Araliaceae                 |                |          |                       |      |    |     |     |
| *Hedera helix* L.          | Louwaya        | Leaf    | Cooked               | 100  | 02 | 0.002 | 0.002 |
| Asteraceae                 |                |          |                       |      |    |     |     |
| *Carthamus rhiphaeus* Font Quer & Pau | EL Kertam   | Whole plant | Decoction          | 100  | 05 | 0.005 | 0.038 |
| *Sonchus oleraceus* (L.) L. | Tilfāf        | Whole plant | Cooked             | 100  | 01 | 0.001 | 0.012 |
| Brassicaceae               |                |          |                       |      |    |     |     |
| *Brassica fruticulosa* Cirillo | Harchae     | Seed    | Decoction            | 100  | 01 | 0.001 | 0.043 |
| *Brassica nigra* (L.) K.Koch | Khrdal, Bohamo | Leaf | Infusion             | 100  | 06 | 0.006 | 0.032 |
| *Brassica rapa* L. *Brassicaceae* | Left Lbeldi | Root | Raw                | 100  | 06 | 0.006 | 0.001 |
| *Brassica rapa var. annua* W.D.J.Koch | Left | Leaf | Raw               | 100  | 07 | 0.007 | 0.001 |
| *Lepidium sativum* L.      | Habb Rchad    | Seed    | Cooked               | 100  | 21 | 0.021 | 0.023 |
| *Sinapis alba* L.          | Karkaz        | Seed    | Cooked               | 100  | 01 | 0.001 | 0.025 |
| *Sinapis arvensis* L.      | Khardal       | Leaf    | Cooked               | 100  | 01 | 0.001 |     |
| Cupressaceae               |                |          |                       |      |    |     | 0.056 |
| *Juniperus oxycedrus* L.   | Taqqa         | Leaf    | Infusion             | 100  | 12 | 0.012 | 0.035 |
| Convolvulaceae             |                |          |                       |      |    |     | 0.028 |
| *Cuscuta approximata* Bab  | Lhamoul       | Whole plant | Infusion          | 100  | 01 | 0.001 | 0.056 |
| Cyperaceae                 |                |          |                       |      |    |     | 0.02 |
| *Cyperus alternifolius* L. | Saad          | Whole plant | Infusion         | 100  | 01 | 0.001 | 0.012 |
| Fabaceae                   |                |          |                       |      |    |     | 0.028 |
| *Medicago sativa* L.       | Fessa         | Leaf    | Decoction            | 100  | 05 | 0.005 | 0.02 |
| *Vicia faba* L.            | Elfūl, Ibaouèn | Seed | Cooked             | 100  | 51 | 0.051 | 0.02 |
| Lamiaceae                  |                |          |                       |      |    |     | 0.056 |
| *Lavandula dentata* L.     | Lakhzama      | Other combination | Infusion   | 75.5 | 53 | 0.053 | 0.035 |
| *Lavandula multifida* L.   | Kohhyla, Tiguizte | Leaf | Decoction         | 100  | 23 | 0.023 | 0.028 |
| *Lavandula pedunculata* (Mill.) Cav | Lakhzama   | Leaf    | Decoction          | 100  | 03 | 0.003 | 0.02 |
| *Lavandula stoechas* L.    | Halhal        | Leaf    | Decoction          | 100  | 56 | 0.056 | 0.028 |
| *Mentha cervina* L.        | Menta, Nadgh  | Whole plant | Infusion        | 100  | 11 | 0.011 | 0.028 |
| *Mentha x citrata* Ehrh.   | Nana Elmessa  | Whole plant | Infusion      | 100  | 04 | 0.004 | 0.028 |
| *Mentha x rotundifolia* (L.) Huds | Michichtrou | Leaf | Infusion          | 49.3 | 67 | 0.067 | 0.028 |
| *Mentha suaveolens* Ehrh.  | Marseta, Timersad | Leaf | Decoction      | 89   | 46 | 0.046 | 0.028 |
| Lauraceae                  |                |          |                       |      |    |     | 0.035 |
| *Cinnamomum camphora* (L.) J.Presl. | Kafour     | Leaf    | Infusion            | 100  | 02 | 0.002 | 0.035 |
| Myrtaceae                  |                |          |                       |      |    |     | 0.056 |
| *Eucalyptus camaldulensis* Dehn. | Kaliūtūs | Leaf | Decoction          | 60   | 05 | 0.005 | 0.028 |
| *Eucalyptus globulus* Labill. | Kaliūtūs   | Leaf    | Cataplasm          | 93.8 | 65 | 0.065 | 0.028 |
| Oleaceae                   |                |          |                       |      |    |     | 0.028 |
| *Fraxinus angustifolia* Vahl. | Lsan Ettir  | Other combination | Infusion  | 100  | 06 | 0.006 | 0.028 |
| Platanaceae                |                |          |                       |      |    |     | 0.001 |
| *Platanus orientalis* L.   | Delb Machríqi | Bark | Infusion         | 100  | 01 | 0.001 | 0.028 |
| Poaceae                    |                |          |                       |      |    |     | 0.015 |
| *Avena sativa* L.          | Khortal       | Seed    | Decoction          | 100  | 02 | 0.002 | 0.015 |
families that have been used to treat different ailments in the study area. Among plant families, Asteraceae had the greatest number of species (29) followed by Lamiaceae (22 species), Fabaceae, and Poaceae (22 species each). The dominance of Asteraceae and Lamiaceae might reflect a wide variety of active ingredients in the species taxa belonging to these families and their availability, wider distribution, abundance, and richness in the study area. Besides, people of the area have a piece of high knowledge about plants from these families, i.e., they have been using these plants for many generations and hence the members of these plant families are well known to them. Families groups with high species richness most likely contain a great diversity of morphological and chemical properties [35] (flavonoids, alkaloids, saponins, terpenes, coumarins, organosulfur compounds, glycosides, steroids, tannin, mucus, lignans, anthraquinones, aromatic constituents, phenolic lipids, carotenoids, steroids, and), from which potential multiple uses can be derived. These results are in general agreement with previous ethnobotanical inventories which indicated that the most prominent families were Asteraceae, Lamiaceae, Fabaceae, Poaceae, Apiaceae, and Solanaceae [2, 11, 12, 36–40].

Our quantitative analysis showed that the highest RFC was calculated for Rosmarinus officinalis L. (RFC = 0.189), Thymus satureoides Coss. (RFC = 0.176), and Dittrichia viscosa (L.) Greuter. (RFC = 0.165). Several studies about Rosmarinus officinalis L., with biological, pharmacological, and phytochemical approaches have been conducted and indicate anti-proliferative, anti-inflammatory, anti-bacterial, and anti-oxidant healing properties [41–43]. As this plant species is widely distributed in almost all Moroccan regions, including the study area, and is easily spread, it is frequently used and a widely available raw material. According to these results, it is recommended that medicinal species having high RFC values should be further screened in pharmacological, toxicological, phytochemical, and biological activities for any novel molecules or chemicals for treating various ailments. Moreover, these species should also be prioritized for conservation as their preferred uses may place their populations under threat due to over-harvesting. Furthermore, the ethnopharmacological plants with greater values of RFC confirm the fact that these plant species were well accepted to the largest of the autochthonous people [44]. Among the 280 medicinal plants, 86 species were used for the treatment of digestive system diseases, whereas 41 species were used to treat respiratory system diseases, 30 species neurological diseases, 29 species cardiovascular diseases, 29 species metabolic diseases, 27 species genitourinary diseases, 22 species dermatological diseases, and 16 species were used to treat osteoarticular diseases.

The fidelity level (FL) of each species is also evaluated from the available information. It indicates the informant’s choice for each ailment and the potential of the species related to the diseases as well. FL values in this study varied from 45.5% to 100%. The study determined 240 species of plants with an FL of 100%, even without considering plants that were mentioned only once for better accuracy, whereas below FL values are obtained for plant species that are employed for several purposes. This result means that the indigenous people tended to rely on one specific medicinal plant for treating one certain disease than for several illnesses. Consequently, plant species not previously studied and have maximum FL should be recommended for further study related to clinical practice [45].

The diseases treated in the Rif region were classified into 8 ailment categories. The highest ICF values were recorded

### Table 3 (continued)

| Family and scientific name | Vernacular name | Used part | Method of preparation | FL % | FC | RFC | FIV |
|----------------------------|----------------|-----------|----------------------|------|----|-----|-----|
| Cynodon dactylon (L.) Pers. | N’jem | Rhizome | Infusion | 100 | 02 | 0.002 | 0.016 |
| Pontederiaceae | Eichhornia crassipes (Mart.) Solms. | Sounbel | Whole plant | Cooked | 100 | 16 | 0.016 |
| Ranunculaceae | Nigella sativa L. | Sanûj | Seed | Infusion | 100 | 78 | 0.078 |
| Lamiaceae | Citrus sinensis (L.) Osbeck | Limoun | Fruit | Other | 100 | 02 | 0.002 |
| Solanaceae | Mandragora autumnalis Mill. | Bid Al Ghol, Taryâla | Leaf | Other | 100 | 36 | 0.036 |
| Rutaceae | Styrax officinalis L. | Jawi | Bark | Other | 100 | 05 | 0.005 |
| Zingiberaceae | Alpinia officinarum Hance | khodenjal | Rhizome | Decoction | 100 | 02 | 0.002 |
| Elettaria cardamomum (L.) Maton | Qaaqella | Seed | Decoction | 100 | 01 | 0.001 |
| Zingiber officinale Roscoe | Skinbir | Rhizome | Infusion | 89.6 | 106 | 0.106 |
Table 4  Inventory of plant species used to treat cardiovascular diseases by indigenous people of Rif

| Family and scientific name | Vernacular name | Used part | Method of preparation | FL % | FC | RFC | FIV |
|-----------------------------|-----------------|-----------|-----------------------|------|----|-----|-----|
| Amaranthaceae               | *Spinacia oleracea* L | Sabanikh, Selq | Leaf | Raw | 100 | 56 | 0.056 |
| Amaryllidaceae              | *Allium porrum* L | Borro | Bulb | Infusion | 100 | 72 | 0.072 |
|                            | *Allium sativum* L | Touma, Tishert | Bulb | Cooked | 100 | 118 | 0.118 |
| Apiaceae                    | *Daucus carota* L | Khizou | Leaf | Decoction | 100 | 102 | 0.102 |
| Arecaceae                   | *Phoenix dactylifera* L | Tmar, Tazdayet | Fruit | Other | 78 | 46 | 0.046 |
| Asteraceae                  | *Carduus getulus* Pomel | Lssan Maghribi | Leaf | Other | 100 | 01 | 0.001 |
|                            | *Cynara scolymus* L | Lqoq | Whole plant | Decoction | 100 | 09 | 0.009 |
| Cactaceae                   | *Opuntia ficus indica* (L.) Mill | Sbar, Zaâboul | Fruit | Infusion | 100 | 01 | 0.001 |
| Cannabaceae                 | *Cannabis sativa* L | Lkif | Seed | Cataplasm | 100 | 11 | 0.011 |
| Dryopteridaceae             | *Dryopteris filix-mas* (L.) Schott | Sarkhs Dakar | Leaf | Decoction | 100 | 01 | 0.001 |
| Fabaceae                    | *Lens culinaris* Medik | Aaddes | Seed | Cooked | 100 | 48 | 0.048 |
|                            | *Medicago polymorpha* L | Fessa | Whole plant | Decoction | 100 | 14 | 0.014 |
|                            | *Vicia sativa* L | Guersana | Whole plant | Infusion | 100 | 01 | 0.001 |
| Geraniaceae                 | *Erodium cicutarium* (L.) L’Hér | Rakma Chokrania | Leaf | Cooked | 100 | 03 | 0.003 |
| Iridaceae                   | *Gladiolus italicus* Mill | Dalbout Itali | Leaf | Other | 100 | 01 | 0.001 |
| Lauraceae                   | *Laurus nobilis* L | Wrak Sidnamossa, Rend | Leaf | Decoction | 89 | 91 | 0.091 |
|                            | *Persea gratissima* C.F.Gaertn | Avocat | Fruit | Cataplasm | 100 | 35 | 0.035 |
| Malvaceae                   | *Hibiscus sabdariffa* L | Karkadé | Leaf | Decoction | 100 | 01 | 0.001 |
| Poaceae                     | *Avena barbata* Pott ex Link | Chofan Barri | Whole plant | Raw | 100 | 01 | 0.001 |
|                            | *Glyceria fluitans* (L.) R.Br | Aaima | Whole plant | Other | 100 | 01 | 0.001 |
|                            | *Hordeum murinum* L | Chaair El Firan | Leaf | Infusion | 100 | 01 | 0.001 |
|                            | *Pennisetum setaceum* (Forssk.) Chiov | Dyl Ethaalab | Seed | Decoction | 100 | 01 | 0.001 |
|                            | *Phragmites communis* Trin | Kseb | Root | Infusion | 100 | 74 | 0.074 |
|                            | *Zea mays* L | Dra | Fruit | Decoction | 100 | 08 | 0.008 |
| Ranunculaceae               | *Ranunculus bulbatus* L | Wden Elhallouf | Root | Decoction | 100 | 02 | 0.002 |
| Rosaceae                    | *Rubus ulmifolius* Schott | Oualik, Tabgha | Leaf | Raw | 100 | 49 | 0.049 |
| Rubiaceae                   | *Galium aparine* L | Lsak | Leaf | Infusion | 100 | 01 | 0.001 |
|                            | *Rubia peregrina* L | Fûwa, Tarubya | Root | Infusion | 100 | 123 | 0.123 |
| Solanaceae                  | *Solanum sodomaeum* Dunal | Tfah Lfar | Fruit | Cataplasm | 100 | 07 | 0.007 |
for osteoarticular diseases (ICF = 0.983), followed by dermatological diseases (ICF = 0.981), and neurological diseases (ICF = 0.974). The least (0.944) ICF was associated with Respiratory system diseases. Ethnopharmacological studies have shown that in some parts of the world, osteoarticular diseases are a first-use category [7, 46, 47]. Osteoarticular

| Family and scientific name | Vernacular name | Used part | Method of preparation | FL % | FC | RFC | FIV |
|----------------------------|----------------|-----------|-----------------------|------|----|-----|-----|
| Asparagaceae                |                |           |                       |      |    |     |     |
| Agave sisalana Perrine      | Aloe Vera      | Leaf      | Cataplasm             | 100  | 01 | 0.001 | 0.013 |
| Asteraceae                  |                |           |                       |      |    |     |     |
| Anacyclus radiatus Loisel   | Far Dahabya    | Whole plant |Infusion               | 100  | 01 | 0.001 | 0.038 |
| Artemisia herba-alba Asso   | Chih, Izri     | Leaf      | Decoction             | 97.9 | 95 | 0.095 |     |
| Artemisia mesatlantica Maire| Chih, Izri     | Leaf      | Decoction             | 100  | 01 | 0.001 |     |
| Chrysanthemum coronarium L  | Lgahwân, Lgentus| Flower    | Infusion              | 100  | 63 | 0.063 |     |
| Xanthium spinosum L         | Lzik Chouki    | Leaf      | Decoction             | 100  | 01 | 0.001 |     |
| Cucurbitaceae               |                |           |                       |      |    |     |     |
| Citrullus vulgaris Schrad   | Dlah           | Leaf      | Decoction             | 100  | 09 | 0.009 | 0.013 |
| Cucumis melo L              | Btikh          | Leaf      | Infusion              | 100  | 13 | 0.013 |     |
| Ecballium elaterium (L.) A.Rich | Faggous El Hemar | Fruit | Other | 100  | 02 | 0.002 |     |
| Lagenaria siceraria (Molina) Standl | El garâa-slâwiya | Fruit | Cataplasm | 100  | 05 | 0.005 | 0.043 |
| Cupressaceae                |                |           |                       |      |    |     |     |
| Tetraclinis articulata (Vahl) Mast | El A'râr | Leaf | Infusion | 100  | 81 | 0.081 | 0.023 |
| Fabaceae                   |                |           |                       |      |    |     |     |
| Retama monosperma (L.) Boiss| Rtem          | Stem      | Decoction             | 100  | 32 | 0.032 | 0.056 |
| Retama raetam (Forssk.) Webb| Rtem          | Root      | Decoction             | 75.61| 41 | 0.041 |     |
| Lamiaceae                  |                |           |                       |      |    |     |     |
| Marrubium echinatum Ball    | Mrywt, Ifzi    | Other combination |Cataplasm           | 100  | 134| 0.134 | 0.104 |
| Mentha x piperita L         | Na'na El-Aabdi | Leaf      | Infusion              | 100  | 06 | 0.006 | 0.013 |
| Mentha pulgium L            | Fliyou         | Whole plant |Infusion              | 100  | 67 | 0.067 | 0.001 |
| Mentha spicata L            | Na'a Na'a      | Whole plant |Infusion              | 100  | 23 | 0.023 | 0.001 |
| Vitex agnus-castus L        | Kharwae        | Seed      | Infusion              | 100  | 15 | 0.015 | 0.048 |
| Amaryllidaceae              |                |           |                       |      |    |     |     |
| Allium cepa L               | Bassla, Azalim | Bulb      | Cataplasm             | 51.22| 123| 0.123 | 0.013 |
| Asparagaceae                |                |           |                       |      |    |     |     |
| Asphodelus microcarpus Salzm. & Viv | Lberwag, Inghri | Bulb | Decoction | 100  | 36 | 0.036 | 0.001 |
| Nyctaginaceae               |                |           |                       |      |    |     |     |
| Mirabilis jalapa L          | Chob Ellayl    | Root      | Decoction             | 100  | 01 | 0.001 | 0.014 |
| Pinaceae                   |                |           |                       |      |    |     |     |
| Cedrus atlantica (Endl.)    | Arz            | Leaf      | Other                 | 100  | 96 | 0.096 | 0.063 |
| Poaceae                    |                |           |                       |      |    |     |     |
| Dactyloctenium aegyptium (L.) Wild | Njem Rjel Djaja | Seed | Decoction | 100  | 08 | 0.008 | 0.025 |
| Rubiaceae                  |                |           |                       |      |    |     |     |
| Coffea arbica L             | Qahwa          | Seed      | Decoction             | 100  | 65 | 0.065 | 0.001 |
| Solanaceae                 |                |           |                       |      |    |     |     |
| Datura stramonium L         | Chedak Jmal    | Seed      | Other                 | 100  | 02 | 0.002 | 0.053 |
| Lycium europaeum L          | Haded Europa   | Leaf      | Cataplasm             | 100  | 01 | 0.001 |     |
| Nicotiana glauca Graham     | Tembak Berri   | Flower    | Decoction             | 100  | 23 | 0.023 |     |
| Solanum tuberosum L         | Batâta         | Leaf      | Cataplasm             | 100  | 78 | 0.078 |     |
| Typhaceae                  |                |           |                       |      |    |     |     |
| Typha angustifolia L        | Bot, Kseb     | Stem      | Other                 | 100  | 01 | 0.001 | 0.053 |
| Verbenaceae                |                |           |                       |      |    |     |     |
| Aloysia citrodora Palau     | Lwiza          | Leaf      | Infusion              | 95.24| 105| 0.105 |     |

for osteoarticular diseases (ICF = 0.983), followed by dermatological diseases (ICF = 0.981), and neurological diseases (ICF = 0.974). The least (0.944) ICF was associated with Respiratory system diseases. Ethnopharmacological studies have shown that in some parts of the world, osteoarticular diseases are a first-use category [7, 46, 47]. Osteoarticular
diseases were prevalent in the study area which can be attributed to the limited availability of hygienic food mineral salts (calcium, magnesium, phosphorus) and vitamins (Vitamin D). Higher rates meant that only a few medicinal plants are used by the interviewees to treat a particular disease. The plants frequently used to treat these disorders might contain active ingredients and thus were well known by locals. It expresses the best consensus between medicinal plants and treated osteoarticular diseases because informants interviewed used specific plant species commonly for

| Family and scientific name | Vernacular name | Used part | Method of preparation | FL % | FC | RFC | FIV |
|---------------------------|----------------|-----------|-----------------------|------|----|-----|-----|
| Amaranthaceae             |                |           |                       |      |    |     |     |
| *Beta vulgaris* L.        | Lbarba         | Seed      | Infusion              | 100  | 06 | 0.006 | 0.024 |
| Apioaceae                 |                |           |                       |      |    |     |     |
| *Ferula communis* L.      | Lkalkha        | Leaf      | Decoction             | 100  | 04 | 0.004 | 0.032 |
| *Ridolfia segetum* (L.) Moris | Sili           | Leaf      | Cooked                | 70.6 | 17 | 0.017 |     |
| Asteraceae                |                |           |                       |      |    |     |     |
| *Calendula arvensis* M.Bieb | Jemra, Azwiwel | Flower    | Infusion              | 100  | 96 | 0.096 | 0.038 |
| *Helianthus annuus* L.    | Abbad Shems    | Seed      | Infusion              | 100  | 21 | 0.021 |     |
| *Lactuca sativa* L.       | Elkhas         | Leaf      | Infusion              | 100  | 22 | 0.022 |     |
| *Sonchus asper* (L.) Hill | Tifaf          | Whole plant| Decoction             | 100  | 01 | 0.001 |     |
| *Sonchus tenerrimus* L.   | Tifaf          | Leaf      | Decoction             | 48   | 25 | 0.025 |     |
| *Tanacetum vulgare* L.    | Lbalssem       | Leaf      | Infusion              | 52.4 | 42 | 0.042 |     |
| Brassicaceae              |                |           |                       |      |    |     |     |
| *Anastatica hierochuntica* L. | Kaff Mariam     | Root      | Decoction             | 80   | 25 | 0.025 | 0.012 |
| *Brassica oleracea* L.    | Karnabite      | Leaf      | Other                 | 77.8 | 09 | 0.009 |     |
| Cucurbitaceae             |                |           |                       |      |    |     |     |
| *Citrullus colocynthis* (L.) Schrad | Lhdej, Taferzizte | Seed  | Infusion              | 100  | 09 | 0.009 | 0.013 |
| *Cucurbita pepo* L.       | Garaa Khedra   | Fruit     | Cooked                | 100  | 43 | 0.043 |     |
| Cupressaceae              |                |           |                       |      |    |     |     |
| *Juniperus phoenicea* L.  | Arar Finiqi    | Leaf      | Decoction             | 100  | 79 | 0.079 | 0.043 |
| Euphorbiaceae             |                |           |                       |      |    |     |     |
| *Euphorbia peplus* L.     | Laaya, Haliba  | Whole plant| Other                 | 100  | 01 | 0.001 | 0.030 |
| Fabaceae                  |                |           |                       |      |    |     |     |
| *Acacia albida* Delile    | Chok Telh      | Root      | Decoction             | 100  | 02 | 0.002 | 0.023 |
| *Lupinus pilosus* L.      | Rjel Djaja     | Seed      | Infusion              | 100  | 07 | 0.007 |     |
| *Phaseolus aureus* Roxb   | Soja           | Seed      | Decoction             | 100  | 02 | 0.002 |     |
| *Phaseolus vulgaris* L.   | Loubya         | Seed      | Cooked                | 100  | 36 | 0.036 |     |
| Lamiaeaceae               |                |           |                       |      |    |     |     |
| *Marrubium vulgare* L.    | Merriwta Hara, Ifzi | Leaf  | Infusion              | 100  | 01 | 0.001 | 0.056 |
| *Rosmarinus officinalis* L. | Azir, Yazir    | Leaf      | Infusion              | 100  | 189| 0.189 |     |
| *Salvia officinalis* L.   | Salmiya        | Leaf      | Infusion              | 100  | 119| 0.119 | 0.065 |
| Linaceae                  |                |           |                       |      |    |     |     |
| *Linum usitatissimum* L.  | Zeri’t El Kettan | Seed    | Cooked                | 100  | 65 | 0.065 | 0.030 |
| Moraceae                  |                |           |                       |      |    |     |     |
| *Ficus carica* L.         | Karmous, Chiha  | Leaf      | Infusion              | 70   | 10 | 0.010 | 0.014 |
| *Ficus carica* var. dottato | Karmous, Chiha | Fruit    | Other                 | 100  | 11 | 0.011 |     |
| *Morus alba* L.           | Ettout         | Leaf      | Infusion              | 58.8 | 68 | 0.068 |     |
| Papaveraceae              |                |           |                       |      |    |     |     |
| *Fumaria officinalis* L.  | Hchicht Essibyan | Root  | Decoction             | 100  | 01 | 0.001 | 0.005 |
| Portulacaceae             |                |           |                       |      |    |     |     |
| *Portulaca oleracea* L.   | Rejla, Tasmanine | Leaf  | Cooked                | 100  | 05 | 0.005 | 0.026 |
| Rosaceae                  |                |           |                       |      |    |     |     |
| *Malus domestica* Borkh   | Tûffah         | Fruit    | Other                 | 100  | 76 | 0.076 |     |
osteoarticular diseases. Hence, species with high ICF values show that the plants traditionally used to treat these illnesses are worth exploring for bioactive compounds [48], while low values are associated with many plant species with an almost equal or high use reports suggesting a lower level of

| Family and scientific name | Vernacular name | Used part | Method of preparation | FL % | FC | RFC | FIV   |
|----------------------------|----------------|----------|-----------------------|------|----|-----|------|
| Amaranthaceae              |                |          |                       |      |    |     | 0.024|
| *Atriplex halimus* L.      | Legtef         | Leaf     | Infusion              | 100  | 03 | 0.003|
| Anacardiaceae              |                |          |                       |      |    |     | 0.048|
| *Pistacia lentiscus* L.    | Drou           | Leaf     | Infusion              | 83.5 | 97 | 0.097|
| Apiaceae                  |                |          |                       |      |    |     | 0.032|
| *Conium maculatum* L.     | Choukran       | Leaf     | Cataplasm             | 100  | 13 | 0.013|
| *Petroselinum sativum* Hoffm | Maâdrous     | Leaf     | Decoction             | 100  | 109| 0.109|
| *Pimpinella anisum* L.    | Habbat Hiawa   | Seed     | Other                 | 100  | 35 | 0.035|
| Apocynaceae               |                |          |                       | 0.079|
| *Caralluma europaea* (Guss.) N.E.Br | Daghmous | Leaf     | Infusion              | 100  | 89 | 0.089|
| Aristolochiaceae          |                |          |                       | 0.043|
| *Aristolochia baetica* L. | Berztem        | Leaf     | Cataplasm             | 100  | 43 | 0.043|
| Asteraceae                |                |          |                       | 0.038|
| *Silybum marianum* (L.) Gaertn | Tawra        | Seed     | Decoction             | 100  | 76 | 0.076|
| Boraginaceae              |                |          |                       | 0.014|
| *Borago officinalis* L.   | El Hamhem      | Flower   | Infusion              | 100  | 02 | 0.002|
| Caryophyllaceae           |                |          |                       | 0.084|
| *Arenaria rubra* L.       | Herras Lehjar  | Whole plant | Decoction           | 53   | 153| 0.153|
| *Corrigiola telephifolia* Pourr | Sarghina  | Whole plant | Decoction             | 100  | 71 | 0.071|
| Euphorbiaceae             |                |          |                       | 0.030|
| *Mercurialis annua* L.    | Hrriyga Lmelsa | Whole plant | Decoction             | 100  | 05 | 0.005|
| Fabaceae                  |                |          |                       | 0.023|
| *Cicer arietinum* L.      | Hommes         | Seed     | Decoction             | 83.3 | 18 | 0.018|
| Lamiaceae                 |                |          |                       | 0.056|
| *Lavandula officinalis* Chaix | Lkhzama     | Flower   | Infusion              | 45.5 | 112| 0.112|
| *Marrubium heterocladum* Emb. and Maire | Mriwta | Leaf     | Decoction             | 100  | 01 | 0.001|
| Myrtaceae                 |                |          |                       | 0.028|
| *Myrtus communis* L.      | Rayhan         | Leaf     | Decoction             | 76.8 | 56 | 0.056|
| *Pimenta dioica* (L.) Merr | Nwiwira   | Fruit    | Infusion              | 100  | 08 | 0.008|
| Pedaliaceae               |                |          |                       | 0.007|
| *Sesamum indicum* L.      | Jenjlane       | Seed     | Infusion              | 100  | 07 | 0.007|
| Poaceae                   |                |          |                       | 0.015|
| *Eleusine indica* (L.) Gaertn | Njem         | Whole plant | Decoction           | 100  | 01 | 0.001|
| *Festuca arundinacea* Schreb | Aguzmir   | Seed     | Infusion              | 100  | 05 | 0.005|
| Rosaceae                  |                |          |                       | 0.026|
| *Eriobotrya japonica* (Thunb.) Lindl | Lemzah | Leaf     | Infusion              | 100  | 02 | 0.002|
| Rutaceae                  |                |          |                       | 0.052|
| *Citrus ×aurantium* L.    | Larnej         | Flower   | Cooked                | 100  | 25 | 0.025|
| *Citrus limetta* Risso    | Lhamed Beldi  | Fruit    | Cooked                | 100  | 06 | 0.006|
| *Citrus limon* (L.) Osbeck | Lhamed   | Fruit    | Other                 | 100  | 06 | 0.006|
| *Citrus reticulata* Blanco | Lmandarine | Fruit    | Cooked                | 100  | 01 | 0.001|
| Urticaceae                |                |          |                       | 0.028|
| *Urtica urens* L.         | Lhurriga       | Leaf     | Decoction             | 100  | 14 | 0.014|
| Zygophyllaceae            |                |          |                       | 0.002|
| *Tribulus terrestris* L.  | Ders Elajouz   | Whole plant | Cooked               | 100  | 02 | 0.002|
agreement among the informants on the use of these plant species to treat a particular disease category [39].

The Rifain people used many various plant parts for preparing remedies. In our investigation, leaves were the most commonly utilized plant part with PPV = 0.364 application in traditional medicinal remedies, followed by seed (PPV = 0.2263), and whole plant (PPV = 0.097). Many studies conducted elsewhere in other countries also showed the dominance of leaves in the preparation of remedies [1, 2, 4, 37, 49–51]. The reason why leaves and aerial parts were mostly used could be that they are most easily accessible and their richness in secondary metabolites produced by photosynthesis. From the conservation point of view, the use of leaves is sustainable, since, if the withdrawal of aerial parts is not excessive, will not prevent the development and/or reproduction of the plant [52]. In this context, the use of leaves in herbal preparations implies a more sustainable practice but the harvesting of roots (which oftentimes requires uprooting) may result to plant death [53]. On the other hand, collecting leaves has a less detrimental impact on plants compared to the harvesting of roots and stem barks especially where there are no sustainable harvesting strategies in place [54]. Besides, a collection of leaves would be

### Table 8 Inventario of plant species used to treat dermatological diseases by indigenous people of Rif

| Family and scientific name | Vernacular name | Used part | Method of preparation | FL % | FC | RFC | FIV |
|----------------------------|----------------|-----------|-----------------------|------|----|-----|-----|
| Amaranthaceae              |                |           |                       |      |    |     |     |
| Chenopodium ambrosioides L.| Mklinza        | Leaf      | Decoction             | 60.2 | 93 | 0.093 | 0.024 |
| Anacardiaceae              |                |           |                       |      |    |     |     |
| Rhus pentaphylla (Jacq.) Desf | Tizgha     | Leaf      | Decoction             | 60.5 | 76 | 0.076 | 0.048 |
| Araceae                    |                |           |                       |      |    |     |     |
| Arisarum vulgare O.Targ.Tozz | Irni        | Whole plant| Decoction             | 100  | 14 | 0.014 | 0.014 |
| Asparagaceae               |                |           |                       |      |    |     |     |
| Agave Americana L.         | Sabra          | Whole plant| Cataplasm            | 100  | 82 | 0.082 | 0.013 |
| Asteraceae                 |                |           |                       |      |    |     |     |
| Atractylis gummifera Salzm. ex L. | Addad   | Whole plant| Other                 | 60   | 05 | 0.005 | 0.038 |
| Dittrichia viscosa (L.) Greuter | Magraman, Terrahla | Leaf | Other             | 100  | 165| 0.165 |
| Lactuca virosa Habl        | Achehlaf Nssem | Leaf       | Other                 | 100  | 16 | 0.016 |
| Sonchus fragilis Ball      | Tifaf         | Leaf      | Cataplasm            | 100  | 07 | 0.007 |
| Caryophyllaceae            |                |           |                       |      |    |     |     |
| Silene ibisii Emb. and Maire | Tigheghecht   | Whole plant| Decoction             | 100  | 105| 0.105 | 0.084 |
| Euphorbiaceae              |                |           |                       |      |    |     |     |
| Euphorbia falcata L.       | Hayat Nofos    | Whole plant| Infusion             | 84.1 | 63 | 0.063 |
| Ricinus communis L.        | Kheroua, Uwriwra Krank | Leaf | Infusion            | 90.2 | 51 | 0.051 |
| Fabaceae                   |                |           |                       |      |    |     |     |
| Acacia raddiana Savi       | Talh          | Leaf      | Decoction             | 100  | 19 | 0.019 |
| Fagaceae                   |                |           |                       |      |    |     |     |
| Quercus suber L.           | Dbagh, Fernan | Bark      | Decoction             | 71.4 | 70 | 0.070 |
| Lythraceae                 |                |           |                       |      |    |     |     |
| Lawsonia inermis L.        | Henna         | Leaf      | Cataplasm            | 100  | 154| 0.154 |
| Papaveraceae               |                |           |                       |      |    |     |     |
| Glaucoma flavum Crantz    | Merzak Halabi  | Flower    | Decoction             | 100  | 06 | 0.006 |
| Papaver rhoeas L.          | Bela’man      | Flower    | Infusion             | 100  | 34 | 0.034 |
| Pinaceae                   |                |           |                       |      |    |     |     |
| Pinus pinaster Aiton       | Tayda         | Bark      | Decoction             | 100  | 04 | 0.004 |
| Pinus sylvestris L.        | Sanouber      | Bark      | Decoction             | 100  | 45 | 0.045 |
| Poaceae                    |                |           |                       |      |    |     |     |
| Triticum aestivum L.       | Lgamh, Farina  | Leaf      | Infusion             | 100  | 14 | 0.014 |
| Triticum turgidum L.       | Zraa, Irden   | Whole plant| Decoction             | 60   | 05 | 0.005 |
| Solanaceae                 |                |           |                       |      |    |     |     |
| Capsicum annuum L.         | Tahmira       | Fruit     | Cataplasm            | 100  | 87 | 0.087 |
| Capsicum frutescens L.     | Sudaniya, Filfel Har   | Fruit       | Decoction             | 100  | 05 | 0.005 |
Table 9  Inventory of plant species used to treat osteoarticular diseases by indigenous people of Rif

| Family and scientific name | Vernacular name | Used part | Method of preparation | FL % | FC | RFC | FIV |
|----------------------------|-----------------|-----------|-----------------------|------|----|-----|-----|
| Apocynaceae                |                 |           |                       |      |    |     |     |
| Nerium oleander L.         | Defla, Alili    | Leaf      | Decoction             | 95.2 | 146| 0.146|     |
| Asteraceae                 |                 |           |                       |      |    |     |     |
| Anacyclus pyrethrum (L.) Lag | Tiguentest, Ginass | Root    | Infusion              | 100  | 81 | 0.081|     |
| Calendula eckerleini Ohle  | Jemra           | Flower    | Cataplasm             | 100  | 67 | 0.067|     |
| Carduus martinezii Pau     | Chok Mchaar     | Leaf      | Decoction             | 100  | 91 | 0.091|     |
| Boraginaceae               |                 |           |                       |      |    |     |     |
| Anchoya italica Retz       | Lsan Etthawr    | Flower    | Infusion              | 100  | 26 | 0.026|     |
| Capparaceae                |                 |           |                       |      |    |     |     |
| Capparos spinosa L.        | Kebar, Taglulut | Seed      | Infusion              | 100  | 73 | 0.073|     |
| Convolvulaceae             |                 |           |                       |      |    |     |     |
| Convolvulus althaeoides L. | Lablab El hokol | Flower   | Decoction             | 100  | 63 | 0.063|     |
| Fabaceae                   |                 |           |                       |      |    |     |     |
| Pisum sativum L.           | Jelbana         | Seed      | Cataplasm             | 100  | 25 | 0.025|     |
| Nitrariaceae               |                 |           |                       |      |    |     |     |
| Peganum harmala L.         | El Harmel       | Seed      | Cataplasm             | 100  | 53 | 0.053|     |
| Poaceae                    |                 |           |                       |      |    |     |     |
| Agrostis reuteri Boiss     | Ziwan Khachabi  | Flower    | Decoction             | 85.7 | 14 | 0.014|     |
| Bromus squarrosus L.       | Amlsikh, Chwira | Leaf      | Decoction             | 75   | 16 | 0.016|     |
| Oryza sativa L.            | Rûz             | Seed      | Cooked                | 94   | 101| 0.101|     |
| Poa annua L.               | Kabaa Howli     | Leaf      | Decoction             | 100  | 8 | 0.008|     |
| Setaria verticillata (L.) P. Beauv | Dayl Eddib | Flower | Cooked                | 100  | 17| 0.017|     |
| Solanaceae                 |                 |           |                       |      |    |     |     |
| Withania frutescens (L.) Pauquy | Ali Amlal, Tayrta | Leaf | Decoction             | 88.9 | 45 | 0.045|     |
| Urticaceae                 |                 |           |                       |      |    |     |     |
| Urtica dioica L.           | Hriga           | Leaf      | Cataplasm             | 100  | 41 | 0.041|     |

Fig. 5  Cultivation of *vicia faba* L. in Izefzafen region

Fig. 6  *Salsola kali* L. in a wasteland of Tizi n Tchin
much easier and sustainable than that of roots or flowers [55].

Concerning the methods of preparation, decoction (38.6%), and infusion (34%), are the most common preparation methods that are used by indigenous people of Rif. The major solvent with the plant was water, but milk, butter, tea, and honey, oils were also extensively used as ingredients. Local people of Rif add honey, sugar, salt, orange peel, banana, or lemon to increase the palatability of a preparation. Moreover, honey is considered sacred to Muslims and occupies an important place in Islamic popular medicine [56, 57]. Indeed, honey is considered an instant energy source and is often used in all parts of the world to improve the acceptability of medicinal plants having a bitter taste unbearable. The decoction is a mostly used method for the preparation of indigenous herbal practices due to its easy preparation by mixing with water or tea [58]. However, the decoction provides assemble the greatest for the active constituents and attenuates or eliminates the toxic effect of some compounds. Decoction and infusion are very valued and often favored by popular healers in Morocco [4, 7, 15, 59, 60]. The predominance of decoction of the different plant species in the Rif is in total agreement with most of the carried out ethnobotanical studies [4, 50, 51, 61–64]. Generally, the main route of application for herbal therapies was oral (82.4%). Furthermore, the oral mode of administration is a preferred route all over the world [10, 14, 36, 38, 39, 65]. The predominance of oral treatment may be explained by a large incidence of internal illnesses in the Rif region. The administration of oral treatment may be defined by a high degree of internal illnesses in the region [66].

### 5 Conclusions

Our investigation revealed that the use of plant species is playing an essential purpose in satisfying the basic healthcare requirements of the indigenous people residing in the Rif, northern Morocco. In this study, an ethnopharmacological catalog constituted of 280 plant species, belonging to 204 genera in 70 families, has been developed, these results of the study showed that there is a great variety of medicinal plants. The number of medicinal plants recorded for the prevention and therapy of human ailments is a good indicator of the potential that exists locally so long as the scientific procedure is added to the indigenous knowledge in terms of traditional herbal medicine. In light of this, medicinal plants with the most important RFC and FL values were identified could be taken up for further phytochemical, pharmacological, and clinical studies that allow the development of new herbal preparations or formulation of novel drugs addressed to improve the quality of life for treating various human diseases.
Appendix A

**Questionnaire sheets: Medicinal plants and herbal medicine**

| Date: | Region: | Commune: | Survey number: |
|------|---------|----------|---------------|

**Informant:**

Profession: .................................................................

Sex: Male □ Female □

Age: \( \leq 20 \) □ \{20 - 40\} □ \{40 - 60\} □ \{ \geq 60 \} □

Family situation: Single □ Divorced □ Widower □ Married □

Level of study: Illiterate □ Primary □ Secondary □ University □

Locality: Nomadic □ Town □ Village □ City □

Income / month (MAD): Unemployed □ \{250 - 1500\} □ \{1500 - 5000\} □ \{ \geq 5000\} □

**Therapeutic practices:**

When you feel sick, you address:

To traditional medicine, why?

- Effective □
- Cheapest □
- Acquisition □
- Ineffective medication □

To modern medicine, why?

- Effective □
- More precise □
- Toxicity of plants □

If it is two that it is the first:

- Traditional medicine □
- Modern medicine □

**Vegetal material:**

Vernacular name: .................................................................

Scientific Name: .................................................................

Plant Type: Spontaneous □ Cultivated □ Introduced □

Use of the plant: Therapeutic □ Cosmetic □ Other □

Harvesting technique: Manual □ Mechanical □

Harvest Time: Summer □ Fall □ Winter □ Spring □ Any year □

Drug preparation: Plant alone □ Possible association (of plants) □

If association of plants, quote the recipe: .................................................................

Use of the plant: Fresh □ Desiccated □ After treatment □

If desiccated, drying method: Sun exposure □ In the Shade □
Declarations

Conflict of interest We declare that there is never a conflict of interest with any commercial business about the document.

Consent for publication Consent for publication was obtained from participants.

Ethical Approval and Consent to participate The study was authorized by the ethical committee of Ibn Tofail University. Before starting data collection, we obtained oral informed permission in each case on a site level and then individually before each interview. We also informed indigenous people that it was a student academic project and investigation was only for our research purposes, not for any financial or other benefits. Informants provided verbal informed consent to engage in this study; they were free to withdraw their information at any point in time. Those informants have accepted freely the idea and they have consented to have their names and personal data to be published.

Acknowledgments We wish to send our honest thankfulness to all the guides and inhabitants of the Rif region for their help. To all sellers of medicinal plants (Attar). We also extend our acknowledgments to all those who participated in the achievement of this product.

Author contributions NC carried out field research in the Rif, compiled the literature sources, data analysis, Realization manuscript and evaluation, interpretation, and wrote the manuscript, helped in data, and made a substantial contribution to data analysis. AD performed data analysis and drafted the manuscript. LZ designed the research and identification of plant species. All contributors see and confirm the final paper.

Funding This investigation did not receive any particular grant from funding businesses in the public, commercial, or not-for-profit areas.

Availability of supporting data All data collected and analyzed in this paper are included in the article and attached in the form of ‘Appendices’ as additional files. Plant specimens are collected and deposited in Ibn Tofail University, Kenitra, Morocco.
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