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Original Research

Diversity of Medicinal Plants Used by the Local Communities of the Coastal Plateau of Safi Province (Morocco)

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Abstract

Traditional herbal medicine is still used for basic healthcare by a significant portion of the population in developing countries. This study aimed to explore the medicinal plant's diversity and to document related traditional knowledge in the Safi region of Morocco. We used semi-structured questionnaires to interview 222 informants living in the study area. To perform data analysis, we used quantitative indices like use value (UV), family use value (FUV), fidelity level (FL), the relative popularity level (RPL), rank of order priority (ROP), and informant consensus factor (ICF). We reported the ethnomedicinal uses of 144 medicinal plants belonging to 64 families. According to the findings, the dominating families were Lamiaceae (17 taxa), Asteraceae (15 taxa), and Apiaceae (12 taxa). The most commonly utilized plant part (48%) was leaves. The decoction was reported as the main preparation method (42%). Highly cited plant species were *Marrubium vulgare* (UV = 0.56), *Salvia rosmarinus* Spenn. (UV = 0.47), *Thymus serpyllum* (UV = 0.32), and *Dysphania ambrosioides* (UV = 0.29). Papaveraceae (FUV = 0.26), and Urticaceae (FUV= 0.23), Geraniaceae (FUV = 0.17), Oleaceae (FUV = 0.17), Lamiaceae (FUV = 0.17) had the highest family use-values. Gastrointestinal disorders (88%), respiratory diseases (85%), and anemia (66%) have the greatest ICF values. This study reveals the indigenous people's reliance on plant-derived traditional medicine to prevent, alleviate, and treat a broad range of health concerns. Our findings will provide a scientific basis for ethnomedicinal legacy conservation and further scientific investigations aimed at new natural bioactive molecules discovery.

Keywords: ethnobotany; traditional knowledge; ethnobotanical surveys; informant consensus factor; fidelity level; ailment

1. Introduction

Since the dawn of civilization, plants and their extracts have been used medicinally in health care. Numerous shreds of evidence indicate that herbal medicines are the oldest and most widely used kind of therapy [1]. Despite the spectacular development of conventional medicine, phytotherapy is still the cornerstone of the traditional therapeutic arsenal in different populations worldwide [2,3]. According to the World Health Organization (WHO), around 80% of the world's population relies on traditional medicine, primarily of plant origin, to address their basic health care needs [4]. The widespread usage of traditional medicinal plants can be attributable to their efficacy, a lack of contemporary medical options, the high cost of biomedical services, a lengthy distance to public health centers, cultural beliefs, or a combination of all these reasons [5–7]. Based on medicinal plant uses in the indigenous systems of medicine, ethnobotanical research has been innovative in drug research and development [6]. Unfortunately, this traditional knowledge is getting lost from generation to generation [8–10]. To overcome the loss of this expertise and conserve and use these biological resources, the documentation of this knowledge is becoming increasingly important [11].

Because of its strategic geographical position, climatic circumstances, and geomorphological traits, Morocco has

been dubbed one of the countries with the most floristic biodiversity in the North Africa region. In Morocco, over 4200 taxa, which represent 981 genera and 155 families, have been recognized, with 22% of them being endemic [12]. Furthermore, approximately 500 species have been reported to be in use as medicinal plants [13]. Together with its high biodiversity, Morocco has a long and rich tradition and expertise in the use of medicinal plants. Phytotherapy is well-rooted in the local culture. This traditional knowledge was acquired from classical Arab medicine, which was subsequently expanded and extended by many ethnic groups that arrived in the region, including Andalusians and European Jews [14,15]. In recent decades, medicinal plants have gained increasing interest among Moroccan scientists. Since the pioneering studies of Bellakhder *et al*., [14,16,17] on Moroccan traditional pharmacopeia, several ethnopharmacological surveys emphasizing various components of health concerns (diabetes, hypertension, cancer, respiratory disorders, renal disease), or just recording the medicinal plants utilized by local inhabitants have been completed all around the country [18–36]. However, many geographical areas of this country were not concerned by these studies. Using quantitative indices (UV, FUV, FL, RPL, ROP, and ICF), the present study sought to provide the first ethnobotanical investigation of the traditional use of medicinal plants among local communities of Safi province (west-center of Morocco).

2. Results and Discussion

2.1 Socio-Demographics of Participants

2.1.1 Use of Medicinal Plants according to Location

In our study, the majority of the respondents (97%) were from rural areas. Traditional medicine has a strong following in rural areas because of its remoteness from official health centers. Our findings support previous research that found that the rural community utilized and knew more about medicinal herbs than the urban group [37]. A similar trend was also observed in previous ethnomedicinal studies in Morocco [24,26,31].

2.1.2 Use of Medicinal Plants according to Gender

Concerning sex, both women and men use traditional medicine. However, this use is more common among women (70% vs. 30% for men). This finding supports the view that women are the principal holders of medicinal plant knowledge. In Morocco, very few studies dealing with gender differences in the ethnobotanical knowledge of medicinal plants exist [38,39]. As is the case for many cultural domains, healing is heavily gendered in Morocco [22,40,41] and depends mainly on gendered social roles and experiences [40,42]. Women are more knowledgeable about the uses of medicinal plants due to the role they play in the process of drying, storing, and preparing recipes for the care of family members at the household level [15]. Therefore, some medicinal plants known only by housewives have been documented in Moroccan rural contexts [43].

2.1.3 Use of Medicinal Plants according to Age

Concerning the age of the participants in the survey, 74% of the interviewers were between 30 and 60 years old. Older people (those over the age of 65) account for 24% of the population. Young people (between 20 and 30 years old) represent only 2% of the interviewers. These proportions are indicative of generational differences in knowledge about medicinal plants. Our results indicate that knowledge of medicinal plants is mainly passed orally (80%) (Table 1). Previous studies conducted in Morocco and other Mediterranean countries have reported similar findings with an average age of people practicing traditional phytotherapy often exceeds 50 years [6,21,24,31]. Nevertheless, the vertical transmission of this knowledge between generations is now diminishing. Young people seem to have a weak belief in traditional medicine. It may result from changing lifestyles through modernization and urbanization or the development of modern medicine [9,10,37].

2.1.4 Use of Medicinal Plants according to Educational Level

Regarding the educational background, 75% of the interviewers were illiterate. The remaining 25% of the informants were divided between primary schooling (11%), informal schooling (8%), and secondary schooling (3%), while 3% of the interviewers had graduate levels. Our results report that illiterate people seem to be more accustomed to using medicinal plants, whereas educated people have very little interest in learning and practicing ethnobotanical knowledge. Other studies in Morocco [24,27,29] and abroad have reported a similar tendency [44–47].

2.2 Medicinal Plants Diversity

Table 2 displays the results of the field documentation, which are organized alphabetically by botanical name, family, and pertinent information. Our research revealed knowledge of 144 helpful plants from 64 families. In terms of identified taxa, the Lamiaceae (17 taxa), Asteraceae (15 taxa), Apiaceae (12 taxa), Fabaceae (8 taxa), Poaceae (6 species), Solanaceae (6 taxa), and Cucurbitaceae (5 taxa) were the most dominating families (Fig. 1). Understanding how people choose plants for therapeutic purposes has long been a focus of ethnobotany. Studies suggesting non-random selection of medicinal plants are becoming more common. Asteraceae, Lamiaceae, and Apiaceae are the most abundant families in Moroccan flora (Asteraceae 500 taxa, Lamiaceae 210 taxa, and Apiaceae 160 taxa) [48]. Shrubby plants are overrepresented in the herbal inventory, which is probably related to their accessibility to the year, compared to annual or biennial taxa that disappear during the summer months. This might justify, at least in part, why some families' species have become so widely used

Table 1. Socio-demographic data of the interviewers in the Safi region (Morocco).

		Percentage
Residence	Rural	97%
	Urban	3%
Age range	[20–30]	2%
	[30–40]	13%
	[40–50]	28%
	[50–60]	33%
	>60	24%
Gender	Women	70%
	Men	30%
Women's age range	[20–30]	3%
	[30–40]	14%
	[40–50]	28%
	[60–50]	32%
	>60	23%
Men's age range	[20–30]	2%
	[30–40]	9%
	[40–50]	26%
	[50–60]	27%
	>60	36%
Educational level	Illiterate	75%
	Koranic school	8%
	Primary	11%
	Secondary	3%
	University	3%
Access to modern medicine	Yes	97%
	No	3%
Use of modern medicine	Yes	76%
	No	24%
Preference of traditional or modern medicine	Traditional	57%
	Modern	15%
	No preference	28%
Source of traditional Medicinal Knowledge	Inherited	80%
	Sociocultural contact	14%
	Personal experience	4%
	Media	2%

in medicine as they're more easily obtainable or abundant locally [49–51]. Our findings are consistent with earlier ethnobotanical investigations that have found similar relevance to these families [26,29,35,39,52,53]. Similarly, investigations conducted in other Mediterranean nations revealed a similar result [46,54–57]. Aside from ecological availability, the physicochemical properties and organoleptic characteristics of Lamiaceae, Asteraceae, and Apiaceae, which drive their activity, may explain their predominance in the local ethnobotanical inventory [58–63].

In terms of plant status, the local population of Safi employs at least 78 native taxa (54%) and 66 introduced taxa (46%) as medicine. The exotic plants reported here were originally introduced as food and food spices (28 taxa, 42%), ornamental (4 taxa, 6%), or cosmetic (3 taxa, 5%). One plant (*Trigonella foenum-graecum*) was likely introduced specifically as medicines. The probable reason for the introduction of 45% of exotic plants remains unknown (Table 3). The inefficiency of native species may lead people to experiment and adopt introduced species in local traditional pharmacopeia [64]. Most of the introduced plants are native to Asia (52%), Europe (18%), America (15%), and Africa (15%).

2.3 Quantitative Analysis of Ethnobotanical Data

2.3.1 Use Values of Taxa

The data compiled during the field studies were analyzed by calculating the use-value (UV) which determines the relative importance of species having more use reports indicated by local informants. During this investigation, 2257 uses were reported. The highest use values were observed by the following species: *Marrubium vulgare* (UV = 0.57), *Salvia rosmarinus* (UV = 0.47), *Thymus serpyllum* (UV = 0.32), *Dysphania ambrosioides* (UV = 0.29), *Eucalyptus globulus* (UV = 0.27), *Papaver rhoeas* (UV = 0.26), *Salvia officinalis* (UV = 0.24), *Urtica dioica* (UV = 0.23), *Echinops glaberrimus* (UV = 0.22), Lavandula angustifolia subsp. *angustifolia* and *Aloysia citrodora* (UV = 0.20) (Fig. 2). Species with the highest UV values may have powerful curative properties that can be useful to manage and alleviate a variety of ailments categories. Previous studies from different regions of Morocco have reported the same sort of finding [27,29,31]. These species are also prominent in traditional medicine practices in the Mediterranean region [6,65].

It is also important to note that for the abovementioned medicinal plants, many other folk uses have been reported in different regions of Morocco. Furthermore, literature-based proof revealed that these species have proven a wide variety of biological and pharmacological activities (Table 4, Ref. [14,17,19–21,23,24,26,28,30,31,34–36,38,39,65–116]), which may confirm the different popular applications of extracts obtained from these plants in traditional medicine.

2.3.2 Family Utilization Value (FUV)

FUV indicates the most biologically significant plant family. In the present research, the use-values of families were calculated and are presented in Table 2. The highest FUV was reported for the families Papaveraceae (FUV = 0.26), Urticaceae (FUV = 0.23), Geraniaceae (FUV = 0.17), Oleaceae (FUV = 0.17), Lamiaceae (FUV = 0.17), Myrtaceae (FUV = 0.16), Amaranthaceae (FUV = 0.15), Aristolochiaceae (FUV = 0.15), Asphodelaceae (FUV = 0.14), Verbenaceae (FUV = 0.12), Capparaceae and Rubiaceae (FUV = 0.11) (Fig. 3). Our study indicates that the most important families (Papaveraceae, Urticaceae, Geraniaceae) are monotypic and are represented by only one species in the study area. High values of FUV might be because the plant species are cited by a large number of people in the study area. While the Lamiaceae family was represented by the highest number of plant species (16 taxa).

Table 2. Inventory of plants in the Safi region with each taxa use-value (UV) and the use-value of the botanical family (FUV).

Family	Taxa	Vernacular names	Status (place of origin)	Folk uses	UR	Parts used	Mode of preparation	UV	FUV
Aizoaceae	*Carpobrotus edulis* (L.) N.E.Br.	Balsamo	Introduced (South Africa)	Skin infection, skin burn and eczema.	05	Leaves, stem	Poultice, powder	0.0225	0.0252
Alliaceae	*Allium porrum* L.	Korita	Native	Digestive troubles, diarrhea, colds	08	Leaves, Roots	Poultice, powder, decoction	0.0360	0.0360
Amaranthaceae	*Chenopodiastrum murale* (L.) S.Fuentes, Uotila Borsch	Talkouta	Native	Fatigue, weakness, pale or yellowish skin eczema	03	Root, leaves, seeds	Poultice, decoction, maceration	0.0135	0.1531
	Dysphania ambrosioides (L.) Mosyakin Clemants	Mkhinza	Introduced (America)	Colds, antitussive, asthma, headache, respiratory infections, carminative, fever, oral infections, anxiety, digestive diseases	65	Leaves, Whole plant, seeds	Poultice, decoction, maceration, infusion	0.2928	
Anacardiaceae	*Pistacia brevifolia* Gand.	Meska lhorra	Native	Kidney stones, renal pains, digestive problems	02		Infusion, decoction	0.0090	0.0090
Apiaceae	*Ammi majus* L.	Tlilan	Native	Cough, influenza, colds, skin disease, skin burn	06	Leaves, seeds	Poultice, decoction, powder	0.0270	
	Ammodaucus leucotrichus Coss.	Camoun Essofi	Native	Diarrhea, digestive troubles, reproductive system, stomach ache, anxiety	12	Leaves, seeds	Decoction, infusion, powder	0.0541	
	Apium graveolens L.	Krafas	Native	Urinary disorders, kidney stones, aphrodisiac	04	Leaves, roots	Decoction, Maceration	0.0180	
	Apium nodiflorum (L.) Lag.	Ziyata	Native	Digestive problems	01	Leaves, roots	Decoction, Powder	0.0045	
	Carum carvi L.	Karwya	Introduced (Eurasia)	Sedative, bronchitis, colds, stomach ache, diabetes	12	Seeds	Infusion, decoction	0.0541	0.0638
	Coriandrum sativum L.	Kosbar	Native	Diabetes, intestinal pains, stomach ache, cancer	10	Leaves, stems, seeds	Decoction, Powder	0.0450	
	Eryngium campestre L.	Nougir	Native	Intestinal pains, digestive troubles	05	Leaves, seeds, fruits	Infusion, Maceration	0.0225	
	Ferula communis L.	Klakh	Native	Antispasmodic, aphrodisiac, magic	24	Flowers, leaves	Decoction, Infusion	0.1081	
	Foeniculum vulgare Mill.	Naffaa	Native	Respiratory disease, oral hygiene	28	Flowers, fruits, leaves	Infusion, decoction, Powder	0.1261	
	Petroselinum crispum subsp. *crispum.*	Maadnos	Native	Digestive pains, renal disorders, aphrodisiac, hypertension	30	Roots, leaves	Decoction, Maceration	0.1351	
	Pimpinella anisum S.G.Gmel.	Habat Hlawa	Introduced (Turkey to Caucasus)	Aphrodisiac, menstrual pains, asthma, diabetes	03	Seeds	Decoction	0.0135	
	Ridolfia segetum (L.) Moris	Tabch	Native	Jaundice, weakness	35	Seeds	Powder	0.1577	

Table 2. Continued.

Family	Taxa	Vernacular names	Status (place of origin)	Folk uses	UR	Parts used	Mode of preparation	UV	FUV
Apocynaceae	*Apteranthes europaea* (Guss.) Murb.	Daghmous	Native	Urine retention, diabetes	15	Stem	juice	0.0675	0.0540
	Nerium oleander L.	Defla	Native	Oral infection, headache, abortive, diabetes, eczema	09	Leaves	Infusion, poultice	0.0405	
Araceae	*Arisarum simorrhinum* Durieu	Yerni	Native	Skin diseases, skin burn	04	Roots	Poultice	0.0180	0.0180
Araliaceae	*Hedera helix* L.	Lwaya	Native	Weakness, wound-healing	02	Leaves	Decoction, poultice	0.0090	0.0090
Arecaceae	*Chamaerops humilis* L.	Doum	Native	Digestive problems, diabetes	01	Leaves	Infusion	0.0045	0.0068
	Phoenix dactylifera L.	Nkhal	Native	Diabetes, hypertension, digestive problems, skin diseases	02	Leaves, seeds, fruits	Decoction	0.0090	
Aristolochiaceae	*Aristolochia baetica* L.	Bereztam	Native	Eczema, skin diseases, skin burn, digestive problems, intestinal infections	34	Roots	Decoction	0.1532	0.1532
Asparagaceae	*Drimia maritima* (L.) Stearn	Elbassila	Introduced (Europe)	Cancer	21	Roots, seeds, fruits	Poultice, Powder	0.0946	0.0946
Asphodelaceae	*Aloe succotrina* Weston	Ssabra	Introduced (South Africa)	Skin infections, skin burn	06	Leaves, Roots	Poultice, decoction, infusion	0.0270	0.0855
	Asphodelus fistulosus subsp. *fistulosus*	Barwag	Native	Digestive problems, infections, cold, eczema	32	leaves	Raw, decoction, poultice	0.1441	
Asteraceae	*Anacyclus pyrethrum* (L.) Lag.	Taqndiche	Native	Analgesic, skin inflammation, digestive and intestinal disorders	02	Leaves, roots	Decoction, Powder	0.00901	0.0135
	Artemisia absinthium L.	Chiba	Native	Abdominal pains, skin problems, swelling, edema, loss of hair	43	Aerial parts, Flowers	Decoction, Infusion	0.1937	
	Artemisia herba-alba Asso	Chih	Native	Diabetes, skin problems, intestinal pains, swelling	25	Aerial parts, flowers	Decoction, Infusion	0.11261	
	Artemisia mesatlantica Maire	Chih EL-Khrayssi	Endemic	Abdominal pains, digestive problems, aerophagia, diarrhea, skin diseases, eczema, infection, wound healing	12	Aerial parts, seeds,	Infusion, Decoction, fumigation (Bkhour)	0.0541	
	Calendula officinalis L.	Jamra	Native	Anemia, weakness, jaundice, bad breath	07	Aerial parts,	Infusion, decoction	0.0500	
	Centaurea maroccana Ball	Nougir	Native	Appetite, digestion, anemia, weakness	03	Leaves, Stems	Decoction, powder, Infusion	0.01351	
	Chamaeleon gummifer (L.) Cass.	choûk el-eulk	Native	Headache, purgative, cosmetic, abortive, skin burn, aerophagia; bloating, , liver disease, antispasmodic	10	Aerial parts, roots	Decoction, maceration, powder	0.0450	
	Cynara cardunculus L.	khorchaf	Native	Stomach ache, vomiting, heartburn, diarrhea, cosmetic	07	Leaves, bulb	Decoction, maceration	0.0315	
	Daucus carota L.	Khyzo	Native	Asthma, appetite stimulant, weakness, anemia, rheumatism	01	Seed	Powder	0.0045	

Table 2. Continued.

Family	Taxa	Vernacular names	Status (place of origin)	Folk uses	UR	Parts used	Mode of preparation	UV	FUV
	Echinops glaberrimus DC.	Taskra	Introduced (Egypt, Palestine, Saudi Arabia)	Diuretic, diabetes, stomach ache, Eczema, skin burn, skin infection	48	Roots, seeds	Decoction, poultice	0.2162	
	Lepidium sativum L.	Habarchad	Introduced (Europe to Central Asia)	Respiratory infections, constipation, urine retention, cough	06	Seeds	Decoction, powder, infusion	0.0270	
	Leuzea acaulis (L.) Holub	Tafgha	Native	Renal pains, Stomach ache	19	Roots, fruits leaves	Decoction, infusion, poultice	0.0856	
	Matricaria chamomilla L.	Babounj	Native	Hypertension, diabetes, wound healing, labor pains, cosmetic	35	Aerial parts, flowers	Decoction, infusion, poultice	0.1577	
	Scolymus hispanicus L.	Garnina	Native	Asthma, digestive troubles, diabetes	16	Roots, stems, leaves	Decoction, infusion, Powder	0.0721	
	Silybum marianum (L.) Gaertn.	Choka Hmar	Native	Bacterial infection, dysentery, tuberculosis, typhoid, antitoxic, food poisoning	02	Fruits	Decoction, maceration, infusion	0.0090	
Brassicaceae	*Brassica nigra* (L.) W.D.J.Koch	Bu Hammo	Native	Aphrodisiac, asthma, influenza, cold, wound healing, constipation	02	Fruits	Poultice, decoction, Infusion	0.0090	0.0495
	Brassica rapa L.	Left Baldi	Native	Constipation, digestive troubles, intestinal pains	06	Stems	Decoction, infusion, maceration	0.0270	
	Diplotaxis pitardiana Maire	El-kerkaz	Native	Skin disease, eczema, cough	33	Aerial parts	Poultice infusion	0.1486	
	Raphanus raphanistrum subsp. *sativus* (L.) Domin	Fjel	Native	Diabetes, abdominal pains	03	Roots, aerial parts	Raw	0.0135	
Cactaceae	*Opuntia ficus-indica* (L.) Mill.	Hendiya	Introduced (Mexico)	Diarrhea, skin diseases, stomach ache, kidney disorders	21	Aerial parts, fruits, leaves	Decoction, infusion, powder	0.0946	0.0946
Camelliaceae	*Camellia sinensis* (L.) Kuntze	Atay	Introduced (China)	Digestive problems, intestinal pains	03	Leaves	Decoction	0.0135	0.0090
Cannabaceae	*Cannabis sativa* L.	Lkif	Introduced (Central Asia, Pakistan)	Anxiety, sedative, stomach ache, narcotic	02	Leaves, flowers	Powder, inhalation	0.0090	0.0090
Capparaceae	*Capparis spinosa* L.	Kebbar	Native	Appetite stimulant, diabetes, aphrodisiac	25	Seeds	Decoction, infusion	0.1126	0.1126

Table 2. Continued.

Family	Taxa	Vernacular names	Status (place of origin)	Folk uses	UR	Parts used	Mode of preparation	UV	FUV
Caryophyllaceae	*Corrigiola telephiifolia* Pourr.	Sarghina	Native	Lung problems, cosmetic, stomach ache, digestive disorders, diarrhea	10	Root	Decoction	0.0450	0.0615
	Herniaria glabra L.	Harras Hjar	Native	Urinary and kidney diseases	28	Leaves	Decoction	0.1261	
	Saponaria officinalis L.	Tighcht	Introduced (Europe)	Skin diseases, eczema, parasitic skin, wound healing	3	Leaves	Poultice	0.0135	
Cucurbitaceae	*Citrullus colocynthis* (L.) Schrad.	Hdej	Native	Laxative, purgative, cancer, bronchitis, anti-inflammatory.	44	Root, seeds	Decoction, fumigation, maceration	0.1982	0.0477
	Citrullus lanatus (Thunb.) Matsum. Naka	Dalaa	Introduced (Africa)	Constipation, digestive problems	02	Whole plant	Raw	0.0090	
	Cucumis sativus L.	Khyar	Introduced (Asia)	Renal diseases, abdominal pain, diabetes	02	Root	Raw	0.0090	
	Cucurbita pepo L.	Garaa Hamra	Introduced (Mexico)	Laxative, renal disorders	2	Fruit	Decoction, maceration	0.0090	
	Cucurbita moschata Duchesne	Slawi	Introduced (Mexico, Guatemala)	Cosmetic, skincare,	3	Leaves, fruit	Poultice	0.0135	
Cupressaceae	*Cupressus sempervirens* L.	srou	Introduced (Europe, Iran)	Wound healing, cosmetic	01	Leaves	Poultice	0.0045	0.0736
	Platycladus orientalis (L.) *Franco*	Araar	Introduced (Asia)	Abdominal pain, respiratory diseases, bronchitis, cold, influenza	11	Leaves	Infusion, fumigation	0.0495	
	Tetraclinis articulata (Vahl) Mast.	Araar	Native	Digestive pains, anti-infection, diarrhea	02	Leaves	Decoction	0.0090	
Cyperaceae	*Cyperus maculatus* Boeckeler	Tara	Introduced (Africa)	Cosmetic, skin diseases, eczema	02	Leaves	Poultice	0.0090	0.0090
Ephedraceae	*Ephedra nebrodensis* Tineo	Abo	Native	Haircare, diabetes	03	Leaves	Decoction, maceration	0.0135	0.0135
Euphorbiaceae	*Euphorbia tirucalli* L.	Heliliba	Introduced (Ethiopia, South Africa, India)	Uro-genital infections	05	Leaves	Poultice	0.0225	0.0736
	Mercurialis annua L.	Horriga EL Malssa	Native	Wound healing, skin infections, abdominal pain	40	Leaves	Decoction, poultice	0.1802	
	Ricinus communis L.	Kharwaa	Introduced (Africa)	Cosmetic, diabetes, skin problems, abdominal pains	04	Leaves, seeds	Oil, poultice, decoction	0.0180	

Table 2. Continued.

Family	Taxa	Vernacular names	Status (place of origin)	Folk uses	UR	Parts used	Mode of preparation	UV	FUV
Fabaceae	*Ceratonia siliqua* L.	Kharob	Native	Diarrhea, intestinal worms, skin diseases	39	Leaves, seeds	Decoction, raw, infusion.	0.1757	0.0794
	Glycine max (L.) Merr.	Soja	Introduced (Russia, China)	Laxative, digestive disorders, cosmetic, skin diseases	02	Seeds	Decoction, oil	0.0090	
	Glycyrrhiza glabra L.	Aarq Soss	Introduced (Europe, Asia)	Cough, renal problems, constipation, digestive problems, weakness, fatigue	04	Roots, stem	Powder, infusion, oil	0.0180	
	Lupinus angustifolius L.	Rjel Djaja	Native	Diabetes, intestinal pains	05	Leaves, stem	Powder, decoction	0.0225	
	Retama raetam (Forssk.) Webb Berthel.	Retam	Native	Diabetes, renal diseases, cancer	39	Leaves, stem	Decoction, maceration	0.1757	
	Trigonella foenum-graecum L.	Halba	Introduced (Iraq, Pakistan)	Appetite stimulant, digestive problems, anemia, weakness	42	Seeds	Powder, decoction	0.1892	
	Vicia faba L.	Fol	Introduced (Asia)	Renal diseases, bronchitis, weakness, digestive problems	06	Seeds, leaves	Powder, maceration, raw	0.0270	
	Vicia lens (L.) Coss. Germ.	Adass	Native	Jaundice, weakness, fatigue, anemia, digestive problems	04	Seeds	Decoction, powder	0.0180	
Geraniaceae	*Pelargonium graveolens* L'Hér.	Aatarcha	Introduced (South Africa, Zimbabwe)	Anxiety, digestive problems	38	Leaves	Infusion, decoction	0.1712	0.1712
Iridaceae	*Crocus sativus* L.	Zaafrane	Introduced (Greece)	Intestinal parasites, skin diseases, anemia	03	Roots, flowers	Infusion	0.0135	0.0135
Juncaceae	*Juncus acutus* L.	Smar	Native	Renal stones, skin infections, abdominal pains	04	Leaves	Decoction	0.0180	0.0113
	Juncus maritimus Lam	Smar	Introduced (Europe, Central Asia)	Cold, influenza, anxiety	01	Leaves	Decoction, infusion	0.0045	

Table 2. Continued.

Family	Taxa	Vernacular names	Status (place of origin)	Folk uses	UR	Parts used	Mode of preparation	UV	FUV
Lamiaceae	*Ajuga iva (*L.) Schreb.	Chandgora	Native	Diabetes, hypertension, digestive problems, respiratory disorders	42	Leaves	Decoction	0.1892	0.1692
	Lavandula angustifolia subsp. *angustifolia*	Khzama	Introduced (Europe)	Bronchitis, respiratory problems, influenza, colds, repellent, cosmetic	45	Aerial parts	Decoction, infusion, oil	0.2072	
	Lavandula bipinnata (Roth) Kuntze	Kohila	Introduced (Bangladesh, India)	Digestives and respiratory problems, delivery difficulties	35	Aerial parts	decoction	0.1577	
	Lavandula stoechas L.	Halhal	Native	Digestive problems, diabetes	04	Leaves	Infusion, decoction	0.0180	
	Marrubium deserti (de Noé) Coss.	Jaada	Native	Respiratory problems, cosmetic, skin diseases	03	Aerial parts, roots	Poultice, decoction	0.0135	
	Marrubium vulgare L.	Marriout	Native	Haircare, jaundice, anemia, fatigue, weakness, diabetes, hypertension	126	Aerial parts	Decoction	0.5676	
	Mentha × *piperita* L.	Naanaa Aabdi	Introduced (Artificial hybrid)	Abdominal pain, heartburn, bloating, laxative	03	Aerial parts	Infusion, maceration, raw	0.01351	
	Mentha pulegium L.	Flayyo	Native	Bronchitis, cough, bad breath, chest pain, intestinal pains	35	Aerial parts	Decoction	0.1577	
	Mentha suaveolens Ehrh.	Timija	Native	Digestive disorders, abdominal pains, respiratory difficulties	08	Aerial parts	Decoction, Infusion	0.0360	
	Ocimum basilicum L.	Lahbeq	Introduced (Asia)	Respiratory diseases, bronchitis, sinusitis, hemorrhoids	25	Leaves	Decoction, infusion	0.1126	
	Origanum majorana L.	Mardadoch	Introduced (Turkey, Cyprus)	Caner, digestive disorders, abdominal pains, diabetes, skin diseases	07	Leaves	Decoction, poultice	0.0315	
	Saccocalyx satureioides Coss. Durieu	Zaitra	Native	Respiratory problems, diabetes, hypertension	20	Leaves, aerial parts	Decoction, poultice	0.0901	
	Salvia officinalis L.	Salmia	Introduced (Europe)	Intestinal antiseptic, diabetes, digestives problems	54	Leaves, aerial parts	Decoction, infusion	0.2432	
	Salvia rosmarinus Spenn.	Azir	Native	Intestinal parasites, intestinal pains, diarrhea, anxiety, wound healing	105	Leaves, aerial parts	Decoction, infusion, poultice	0.4730	
	Salvia verbenaca L.	Khwiwita	Native	Skin infections, wound healing	17	Aerial parts	Decoction, poultice	0.0767	
	Thymus serpyllum L.	Zaatar	Introduced (Europe to Siberia)	Bronchitis, allergy, skin diseases, intestinal pains, intestinal worms	72	Leaves, aerial parts	Decoction, poultice	0.3243	

Table 2. Continued.

Family	Taxa	Vernacular names	Status (place of origin)	Folk uses	UR	Parts used	Mode of preparation	UV	FUV
Lauraceae	*Persea americana* Mill.	Avocat	Introduced (Guatemala, Honduras, Mexico, Nicaragua)	Aphrodisiac, anemia, jaundice, weakness, fatigue, respiratory problems	01	Fruits	Raw	0.0045	0.0045
Liliaceae	*Allium cepa* L.	Basla	Introduced (Central Asia)	Infections, cough, asthma, digestive troubles	25	Bulb, rhizome	Raw, powder	0.1126	0.1014
	Allium sativum L.	Toma	Introduced (Iran, Kazakhstan, Uzbekistan)	Antiseptic, intestinal parasites, cold, influenza	20	Bulb, rhizome	Raw, powder	0.0901	
Linaceae	*linum usitatissimum* L.	Zariaat Elkattan	Introduced (Turkey, Iran)	Urinary problems, cough, skin infections, eczema	04	Seeds	Powder, infusion, decoction	0.0180	0.0180
Lythraceae	*lawsonia inermis* L.	Lhana	Introduced (Africa, Arabian Peninsula, Pakistan, India)	Haircare, skin diseases, eczema, vomiting	10	leaves	Decoction, poultice	0.0450	0.0450
Malvaceae	*Althaea officinalis* L.	Bakola/Khobiza	Native	Digestive problems, abdominal pains, diarrhea	14	Leaves	Decoction, infusion	0.0631	0.06306
Moraceae	*Ficus carica* L.	Kerma	Introduced (E. Medit. Asia, Afghanistan)	Laxative, digestive problems, diabetes, constipation	13	Fruits, leaves	Raw, decoction, infusion	0.0586	0.0586
Myristicaceae	*Myristica fragrans* Houtt.	Goza	Introduced (Banda Islands)	Skin diseases, digestive problems, abdominal pains, constipation, tooth care, painful gum	02	Nutmeg bark, leaves,	Decoction, infusion, raw	0.0090	0.0090
Myrtaceae	*Eucalyptus globulus* Labill.	Kalitus	Introduced (Australia)	Diabetes, respiratory diseases, asthma, bad breath, digestive problems, influenza	61	Leaves	Decoction, inhalation	0.2748	0.1599
	Syzygium aromaticum (L.) Merr. L.M.Perry	Qrenfal	Introduced (Maluku)	Tooth care, painful gum, intestinal pains, digestive problems	10	Fruits	Decoction, infusion, raw	0.0450	
Nitrariaceae	*Peganum harmala* L.	Harmal	Native	Jaundice, anemia, weakness, digestive problems, cold, nervous problems, magic	13	Seeds, whole plant, root	Decoction, infusion, fumigation	0.0586	0.0585
Oleaceae	*Olea europaea* L.	Zeitoun	Native	Cosmetic, mouth hygiene, digestive problems, skin diseases, cold, influenza	38	Fruits, leaves	Oil, decoction, infusion,	0.1712	0.1711

Table 2. Continued.

Family	Taxa	Vernacular names	Status (place of origin)	Folk uses	UR	Parts used	Mode of preparation	UV	FUV
Papaveraceae	*Papaver rhoeas* L.	Belaaman	Native	Sedative, bronchitis, insomnia, respiratory disorders, intestinal pains	58	Leaves, seeds	Decoction, infusion	0.2613	0.2613
Pedaliaceae	*Sesamum indicum* L.	Jaljlane	Introduced (Bangladesh, India)	Stress, bad breath, bronchitis, sinusitis, chest pain, sedative	02	seeds	Decoction, infusion, powder	0.0090	0.0090
Pinaceae	*Pinus halepensis* Mill.	Tayda	Native	Digestive problems, cold, respiratory diseases	07	Leaves, roots	Poultice, decoction, powder	0.0315	0.0315
Plantaginaceae	*Plantago major* L.	Msasa	Native	Cancer, skin diseases	08	Leaves, whole plant	Poultice, powder	0.0360	0.0360
Poaceae	*Cynodon dactylon* (L.) Pers.	Njem	Native	Renal disease, diuretic	05	Stem, roots	Decoction, powder	0.0225	0.0210
	Hordeum vulgare L.	Chaair	Introduced (Palestine)	Digestive problems, jaundice, anemia, weakness	06	Aerial parts, Seeds	Powder, maceration	0.0270	
	Panicum miliaceum L.	Illan	Introduced (India)	Skin diseases, digestive problems	03	Seeds	Powder, infusion	0.0135	
	Phragmites australis (Cav.) Trin. ex Steud.	Qsab	Native	Skin diseases, cosmetic	03	Root, stem	Decoction, poultice	0.0135	
	Triticum sp	Qamh	Introduced (Central Asia, India, Ethiopia)	Anemia, jaundice, digestive problems	01	Seeds	Powder	0.0045	
	Zea mays L.	Dra	Introduced (Mexico, Guatemala)	Anemia, weakness, digestive problems	10	Seeds	Raw, powder	0.0450	
Polygonaceae	*Rumex acetosa* L.	Homayda	Native	Influenza, bronchitis, chest pain, bad breath, abdominal pains	05	Leaves, whole plant, roots	Powder, maceration, decoction	0.0225	0.0225
Portulacaceae	*Portulaca oleracea* L.	Rejla	Native	Anemia, weakness, jaundice, diabetes	08	Leaves, whole plants,	Decoction, infusion	0.0360	0.0360
Punicaceae	*Punica granatum* L.	Romman	Introduced (Turkey to Pakistan)	Digestive problems, stomach ache, stomach ulcer, skin-care	10	Fruit barks	Decoction, maceration	0.0450	0.0450
Ranunculaceae	*Ranunculus arvensis* L.	Ouden Halouf	Native	Chest pain, painful breath, insomnia	03	Leaves	Decoction	0.0135	0.0135
Rhamnaceae	*Ziziphus oenopolia* (L.) Mill.	Nbeg	Introduced (China, Tropical Asia)	Diabetes, respiratory disorders, hair care	11	Flowers, leaves, roots	Decoction, infusion, raw	0.0495	0.0495

Table 2. Continued.

Family	Taxa	Vernacular names	Status (place of origin)	Folk uses	UR	Parts used	Mode of preparation	UV	FUV
Rosaceae	*Prunus amygdalus* Batsch	Louz	Introduced (Transcaucasus)	Skin problems, headaches	01	Fruits	Raw, oil, decoction	0.0045	0.0203
	Rosa x centifolia L.	Lward	Introduced ((Artificial hybrid)	Laxative, intestinal pains, skin care, hair care	08	Flowers	Decoction, maceration, oil	0.0360	
Rubiaceae	*Rubia tinctorum* L.	Fowa	Introduced (Europe, Himalaya, Vietnam)	Digestive problems, constipation	25	Roots	Decoction	0.1126	0.1126
Rutaceae	*Citrus* × *aurantium* L.	Limon	Introduced (Artificial hybrid)	Anemia, weakness, fatigue	05	Fruits	Juice	0.0225	0.0450
	Citrus × *limon* (L.) Osbeck	Lhamad Baldi	Introduced (Artificial hybrid)	Diarrhea, digestive problems, oral hygiene, cold, bronchitis	05	Fruits	Juice	0.0225	
	Ruta montana (L.) L.	Fijel, ourmi	Native	Skin diseases, vitiligo, sterility, vermifuge	20	Leaves	Decoction	0.0901	
Salicaceae	*Populus nigra* L.	Safssaf	Native	Digestive problems, respiratory disorders, skin diseases	01	Leaves	Decoction, powder,	0.0045	0.0045
Sapotaceae	*Sideroxylon spinosum* L.	Argane	Native	Hear care, skin infection, diabetes, aphrodisiac, eczema	02	Fruits, seeds,	Poultice, decoction, infusion	0.0090	0.0090
Schisandraceae	*Illicium verum* Hook.f.	Najma sinia	Introduced (China, Vietnam)	Digestive and respiratory problems, constipation, laxative, asthma	09	Leaves, fruits	Infusion	0.0405	0.0405
Solanaceae	*Capsicum frutescens* L.	Flfla Hamra	Introduced (Bolivia, Brazil)	Digestive problems, intestinal parasites, abdominal pains, tonifying, appetite stimulant, anemia, diabetes	01	Fruits	Raw, decoction, chewing	0.0045	0.0188
	Hyoscyamus albus L.	Sikran	Native	Tooth care, painful gum	11	Seeds	Decoction, infusion	0.0495	
	Mandragora autumnalis Bertol.	Bayd Ghol	Native	Narcotic, sedative, cancer, respiratory problems	07	Aerial parts, seeds	Maceration, decoction	0.0315	
	Nicotiana glauca Graham	Taba	Introduced (Bolivia, Brazil)	Sedative, digestive problems, intestinal parasites,	04	Leaves	powder	0.0180	
	Solanum lycopersicum var. *esculentum (Mill.) Voss*	Maticha	Introduced (Peru)	Skincare, cosmetic	01	Fruits	Maceration	0.0045	
	Solanum nigrum L.	Ain dib	Native	Sedative, antiseptic, antispasmodic, intestinal pains	01	Leaves	decoction	0.0045	
Thymelaeaceae	*Thymelaea hirsuta* (L.) Endl.	Almatnane	Native	Bad breath, tooth care, diabetes, constipation	02	Leaves, seeds	Decoction, infusion	0.0090	0.0090

Table 2. Continued.

Family	Taxa	Vernacular names	Status (place of origin)	Folk uses	UR	Parts used	Mode of preparation	UV	FUV
Urticaceae	*Urtica dioica* L.	Horriga Harcha	Native	Renal problems, urinary system disorders, diabetes, skin-care	51	Leaves, aerial parts	Maceration, infusion, poultice	0.2297	0.2297
Vitaceae	*Vitis vinifera* L.	Laanab	Introduced (Europe, Asia)	Jaundice, anemia, weakness, headache	01	Leaves, fruits	Decoction, maceration	0.0045	0.0045
Verbenaceae	*Aloysia citrodora* Paláu	Lwiza	Introduced (Bolivia, Argentina)	Sedative, digestive problems, intestinal pains, anxiety	46	leaves	Decoction, infusion	0.2027	0.1171
	Vitex agnus-castus L.	Sadrat Maryam	Native	Digestive problems, skincare	06	Leaves	Poultice, decoction	0.0270	
Zingiberaceae	*Curcuma longa* L.	Lark sfar	Introduced (E. Medit. to Iran)	Anemia, jaundice, weakness, fatigue	02	Stem, roots	Powder	0.0090	0.0105
	Elettaria cardamomum (L.) Maton	Bsibissa	Introduced (India)	Digestive problems, sterility	02	Seeds	Decoction, powder	0.0090	
	Zingiber officinale Roscoe	Sekkin jbir	Introduced (India, China)	Respiratory diseases, influenza, cough, diabetes	03	Seeds	Powder, decoction	0.0135	

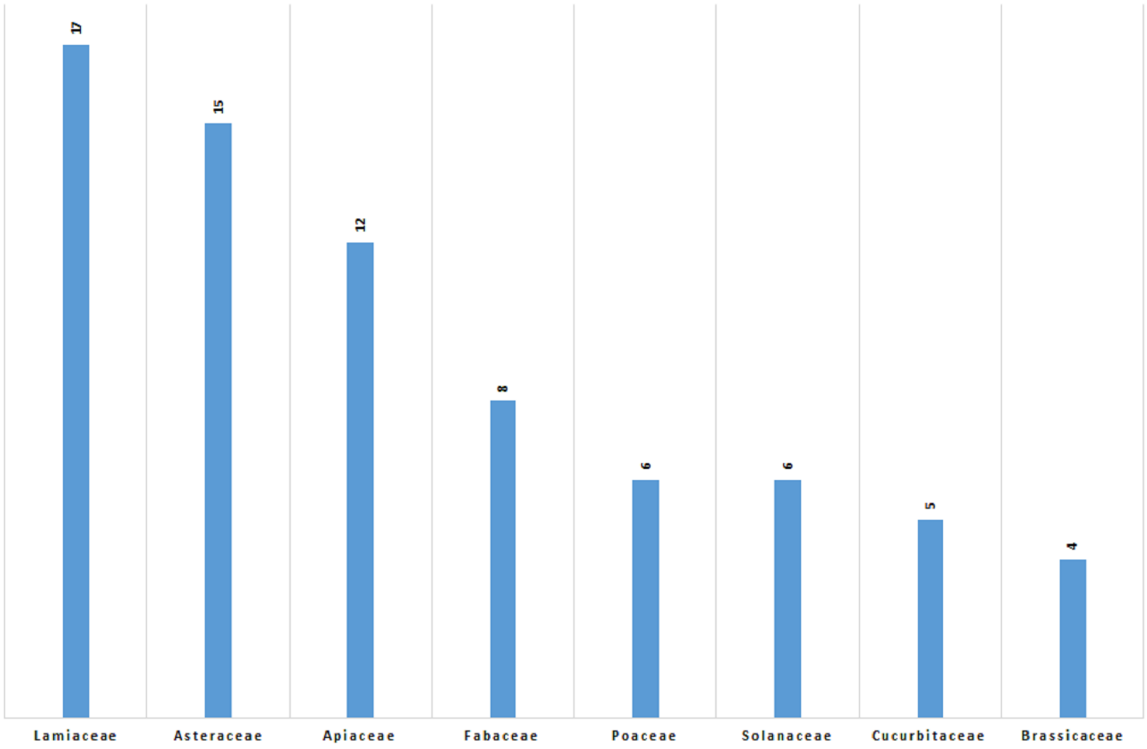

Fig. 1. Species frequency of major plant families used in the Safi Province (Morocco).

2.4 Traditional Medicine Knowledge

2.4.1 Parts of Plants, Method of Preparation, and Administration

In the current investigation, we report the use of different plants' parts for medical purposes by the local population (Figs. 4,5). Leaves are the part most used (48%), followed by stems (16%), flowers and inflorescence (12%), underground parts (the roots) (11%), and the whole plant (7%). The leaves are easily accessible, which can explain their high use in the medicinal recipe's preparation. The potential leaves' curative effectiveness may be due to the higher concentration of bioactive compounds. This finding agrees with most medicinal plant studies in Morocco [23,24,28,29,31] and neighboring countries [2,47,117–119].

The preparation of recipes from medicinal plants is represented by many methods, such as infusion, decoction, inhalation, and powder. Fig. 6 summarizes the methods of preparation found in this study. The decoction was the most widely used method in the study area for herbal preparation, with a percentage contribution of 42%, followed by infusion, powder, and poultice, which were used in 20%, 18%, and 17% of the preparations, respectively. The remaining 3% was used as inhalation, or "bkhour" (Fig. 6). The higher frequency of decoction use might be related to the simple preparation method. Similarly, the same sort of conclusions has been observed in previous studies [29,31,47,117–119].

2.4.2 Fidelity Level, Relative Popularity Level, and Ranking Order Priority

Fidelity level determines the relative plant's healing potential. High FL values indicate that a plant is mainly used to treat a single therapeutic category and low FL values show that plants are used for a wide range of diseases. FL is artificially high for plants with few use reports, thus species with less than five use reports were excluded from the discussion. Only 10 plants show high fidelity values to certain diseases category. We report *M. vulgare*, *S. rosmarinus* Spenn., *T. serpyllum*, *D. ambrosioides*, *E. globulus*, *P. rhoeas*, *S. officinalis*, *U. dioica*, *E. glaberrimus*, and *A. citriodora* as the most important species (Table 4). Concerning gastrointestinal disorders, *S. rosmarinus*, *T. serpyllum*, *A. citriodora*, and *S. officinalis* have the highest FL values (89%, 77%, 53%, and 50%, respectively). *E. globulus* is popular in the traditional treatment of respiratory disease (FL = 61%) and *M. vulgare* for cancer treatment (FL = 44%) (Table 5). Plants with recurrent uses are more likely to be pharmacologically active [120]. Validation of this ethnomedicinal knowledge through in-depth phytochemical and pharmacological studies could be innovative in novel drug research and development approaches.

The distribution of species knowledge concerning the richness of the resources referenced in the examined use category was determined using Rank Order Priority (ROP). As our study showed, the highest ROP values were observed for *S. rosmarinus* (ROP = 74%), *M. vulgare* (ROP =

Table 3. Probable reason for the introduction of exotic medicinal plants in Safi region (Morocco).

Probable reason for introduction (% of total exotic plants)	Taxa
Food (31%)	*Opuntia ficus-indica, Camellia sinensis, Citrullus lanatus, Cucumis sativus, Cucurbita pepo, Cucurbita moschata*, *Glycine max*, *Persea americana, Allium cepa*, *Allium sativum*, *Ficus carica, Hordeum vulgare*, *Triticum* sp, *Zea mays* , *Punica granatum*, *Prunus amygdalus, Capsicum frutescens*, *Solanum lycopersicum* var. *esculentum*, *Urtica dioica*, *Vitis vinifera*, *Aloysia citrodora* .
Food spices (11%)	*Carum carvi*, *Pimpinella anisum*, *Crocus sativus*, *linum usitatissimum*, *Sesamum indicum*, *Elettaria cardamomum*, *Zingiber officinale*.
Ornamental (6%)	*Aloe succotrina*, *Ocimum basilicum*, *Rosa x centifolia*, *Carpobrotus edulis*.
Cosmetic (5%)	*Glycyrrhiza glabra, Lawsonia inermis, Syzygium aromaticum*.
Medicinal (2%)	*Trigonella foenum-graecum*.

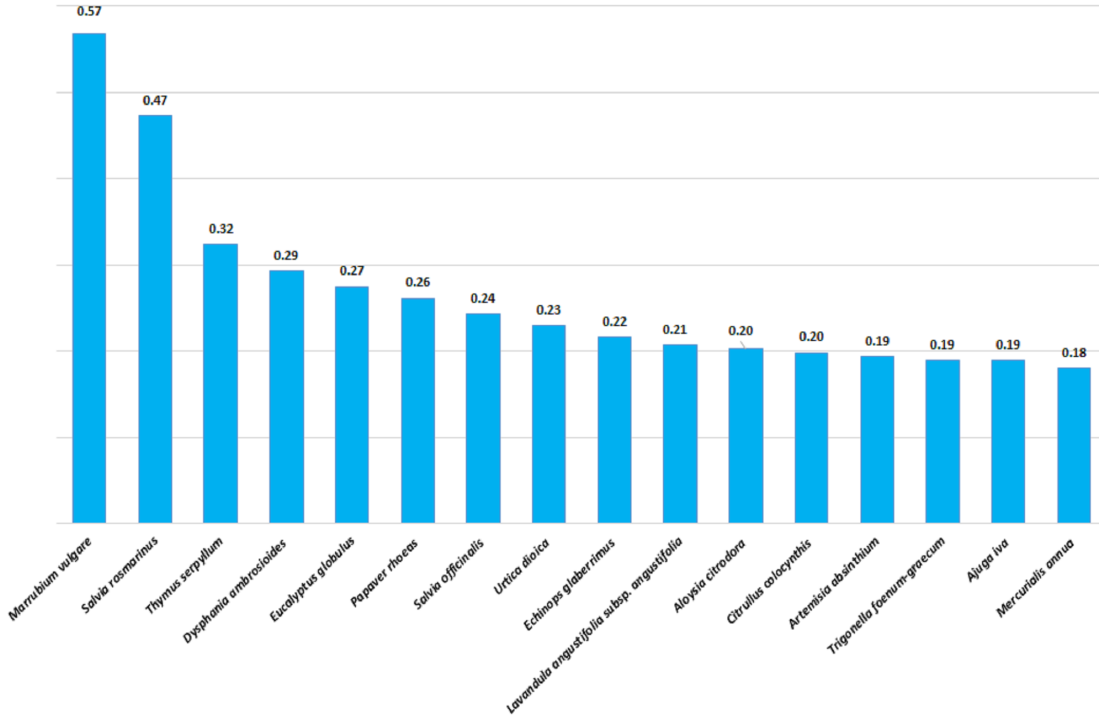

Fig. 2. Use values of the most used medicinal plants in the Safi Province (Morocco).

47%), and *T. serpyllum* (ROP = 44%), indicating that these species are the most well known in the Safi region. While, *U. dioica* (ROP = 8%), and *E. glaberrimus* (ROP = 8%) had a lower priority and were considered unpopular among medicinal plants used by the local population.

2.4.3 Informant Consensus Factor

The ICF measures the agreement between informants and plants used for each disease. Based on the plants' use reports, we classified the reported ailments into five disease categories (Table 6). Gastrointestinal disorders, respiratory diseases, and anemia have the highest ICF values (85%, 82%, and 66%, respectively), suggesting that these ailments were prevalent in the study area.

The prevalence of gastrointestinal disorders may be due to more common and easily identifiable clinical signs. Among other factors, poor hygienic conditions such as consumption of contaminated food or low drinking water quality may exacerbate digestive troubles in the study area. In the case of respiratory diseases, air quality is a significant risk factor in the development and exacerbation of the disease. Long-term exposure to high levels of pollution, particularly in childhood, raises the risk of developing respiratory disorders [121]. Because the region is home to a large and highly polluting chemical and para-chemical industry, the high ICF recorded for this disease category may explain, at least in part, the high ICF. Anemia received the third-highest ICF value (66%). The majority of cases of anemia are caused by malnutrition or a lack of proper nutrition, which results in iron and other micronutrient deficiencies. In the 2014 Moroccan census, the Safi area had a poverty rate of 10–15% [122]. This fact can explain, at least in part, the prevalence of anemia in this region. Several studies conducted in other areas in Morocco [22,29,53,123], Algeria

Table 4. Traditional use and evidence-based pharmacological properties of the most used species in the study area.

	Other folk uses in Morocco	Evidence-based pharmacological properties
Marrubium vulgare	Diabetes, hypertension, hair care, fever, jaundice, diarrhea, intestinal pains, cough, colds, respiratory problems, ear pains, menstrual pains [14,20,21,26,31,36,39,116]	Antioxidant acitivities [65], hepatoprotective effect [66], antidiabetic effect [67–69], antihypertensive activities [70,71], hypolipidemic effect [70], gastroprotective effect [72], antibacterial effect [73]. No reports on toxicity.
Salvia rosmarinus	Allergy, diabetes, hypertension, intestinal parasites, rheumatism, kidney diseases, sedative, wounds healing [19,20,23,28,35,116]	Antidiabetic effect [74], anti-inflammatory, antinociceptive activities [75], antioxidant effect [76]. No reports on toxicity.
Thymus serpyllum	Stimulant, aid to menstruation, digestive stimulant, against headache, cardiac stimulant [14,19]	Antioxidant activities [77], antimicrobial effect [78], antitumor and cytotoxic activities [79]. No reports on toxicity.
Dysphania ambrosioides	Hypertension, cold, antitussive, emmenagogue, diabetes, menstrual pains, asthma, analgesic, headache, respiratory infections, fever, oral infections, anxiety [17,20,21,35,114].	Antibacterial effect [80], anticancer effect [81], antidiabetic activity [82], antidiarrheal effect [83], anti-inflammatory and antinociceptive activities [84], antioxidant activity [85], anti-ulcer effect [86], immunomodulatory effect [87]. Decoctions and infusions of this plant may have a genotoxic effect [88].
Eucalyptus globulus	Diabetes [20], renal colic [34], influenza [28,35], stomach pain [31], typhoid [19].	Antidiabetic activities [89,90], anti-inflammatory effect [91], cytotoxic activities [92], hypotensive action [93]. No reports on toxicity
Papaver rhoeas	Diabetes, cosmetic, sedative, sterility, menstrual pains, cough, bronchitis, insomnia, analgesic, allergy Kidney stones, kidney inflammation [17,19,21,34,38,114].	Cytotoxic and antiproliferative activities [94], antiulcerogenic effect [95], antimicrobial effect [96]. May be toxic [97].
Salvia officinalis	Diabetes, hemostatic, respiratory problems, hypertension, intestinal antiseptic, kidney stones, diuretic, renal colic [17,19,21,30,34,35,38,114].	Gastroprotective action [98], antioxidant effect [99], anti-diabetic effects [100], antinociceptive and anti-inflammatory activities [101], hepatoprotective action [102], hypolipidemic effect [103]. No reports on toxicity
Urtica dioica	Diabetes, hypertension, renal diseases, digestive problems, rheumatism, diarrhea, allergy [21,24,34,35,114].	Diuretic [104], hypotensive [105], antidiabetic [106], anti-inflammatory [107], immunomodulatory [108], analgesic [109], hepatorenal protective [110]. No reports on toxicity
Echinops glaberrimus	diuretic, hypoglycemiant, stomachic, liver disorders, post-partum care [17,19], kidney stones [34].	Anti-inflammatory [111], renal inflammation [112], antibacterial [113]. No reports on toxicity
Aloysia citrodora	Digestive problems, hypertension, diabetes, headache, colds [31,114], diuretic [34,35].	Cytotoxic and antibacterial [114], sedative and cardiovascular effects [115]. No reports on toxicity

Table 5. Fidelity Levels, Relative Popularity Levels, and Ranking Order Priority of the most used plants in Safi region (Morocco).

Taxa	Frequent disease category	Fidelity level (FL) %	Relative popular level (RPL) %	Ranking order priority (ROP) %
Marrubium vulgare	Respiratory diseases	47%	100%	47%
	Cancer	44%	100%	44%
Salvia rosmarinus	Gastrointestinal disorders	89%	83%	74%
Thymus serpyllum	Gastrointestinal disorders	77%	57%	44%
	Respiratory diseases	30%	57%	17%
Dysphania ambrosioides	Respiratory diseases	49%	52%	25%
Eucalyptus globulus	Respiratory diseases	61%	48%	29%
Papaver rhoeas	Respiratory diseases	40%	46%	18%
	Dermatological diseases	28%	46%	13%
Salvia officinalis	Gastrointestinal disorders	50%	43%	21%
Urtica dioica	Respiratory diseases	20%	40%	8%
	Gastrointestinal disorders	18%	40%	7%
	Dermatological diseases	14%	40%	6%
Echinops glaberrimus	Gastrointestinal disorders	21%	38%	8%
Aloysia citrodora	Gastrointestinal disorders	53%	36%	19%

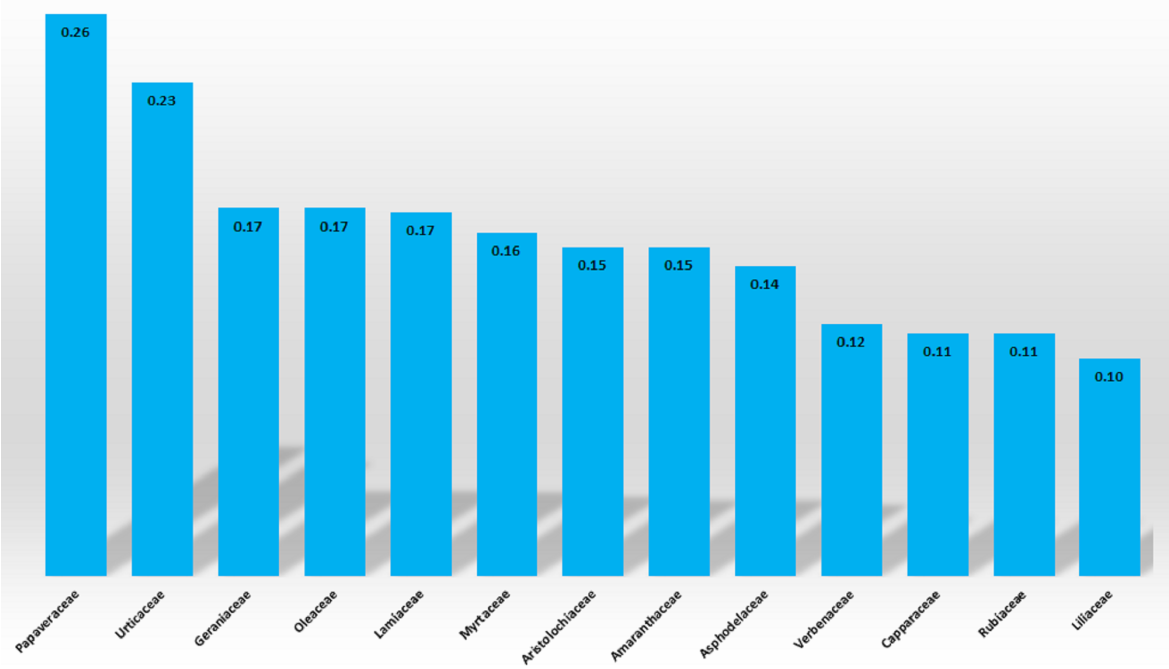

Fig. 3. Family use values of medicinal plants used in the Safi Province (Morocco).

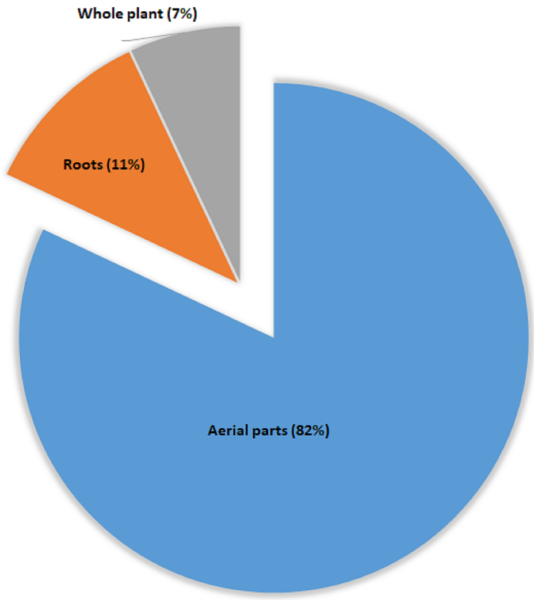

Fig. 4. Used parts of medicinal plants.

[47,54,124], Pakistan [125], and the Mediterranean region [6] show a similar high prevalence of ICF value for digestive and respiratory diseases.

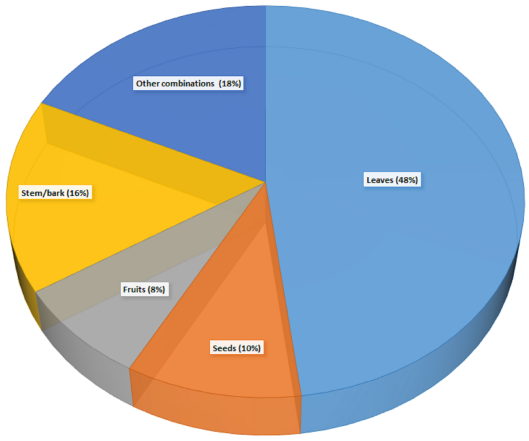

Fig. 5. Used aerial parts of medicinal plants.

Table 6. Ailment's categories and their ICF values.

Ailments category	Nur	Nut	ICF%
Respiratory diseases	391	61	85%
Dermatological diseases	169	52	70%
Gastrointestinal disorders	670	83	88%
Cancer	124	25	80%
Anemia	75	26	66%

ICF, Informant Consensus Factor; Nur, number of use reports for a particular ailment category; Nut, number of taxa used for an ailment category by all informants.

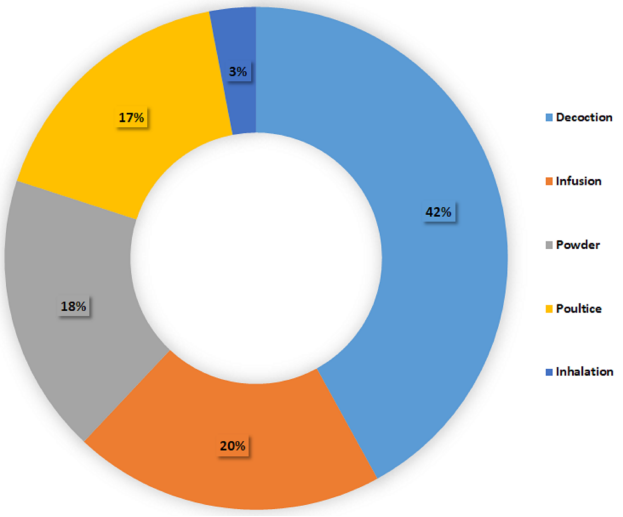

Fig. 6. Mode of the utilization of medicinal plants.

3. Materials and Methods

3.1 Study Area

The present study was conducted in five different coastal localities: Ayyer, El Beddouza, Had Hrara, Khat Azakan, and Safi City in the Safi Province (Morocco) (Fig. 7). The study area is administratively part of the Marrakech-Safi Region. It is located in the Western Central Plain of Morocco and lies about 32°18'N, 9°13'W. It is surrounded by the Atlantic coast on the west, Sidi Bennour province on the north, Youssoufia province on the east, and Essaouira province on the south (Fig. 7). The climate of the study area falls into the semi-arid type: cold and humid in winter and hot and dry in summer. During the year, there is little rainfall. Precipitation fluctuates around 300 to 400 mm/year. The average annual temperature is 18.4 °C, and the warmest month is July, with an average maximum temperature of 28 °C. The coldest month is January, with an average maximum temperature of 18 °C (Weather-atlas.com).

In the 2014 Moroccan census, the Safi area had a population of about 691.983 people [122]. Amazigh and Arab descent constitute the majority of the local population.

3.2 Data Collection

Between March 2019 and March 2020, ethnobotanical surveys were conducted to compile knowledge of plants used in the area. A total of 222 informants of various ages were chosen at random for interviews. The International Society of Ethnobiology (ISE) code of ethics (https://www.ethnobiology.net/ethics.php) was strictly followed, and the purpose of the study was explained to the participants before conducting the interviews, and verbal informed consent was obtained from them.

Semi-structured interviews were used to collect ethnobotanical data [126], and the stratified sample (5 stratums) sampling technique was used [29]. The questionnaires have two sections. The first one included personal

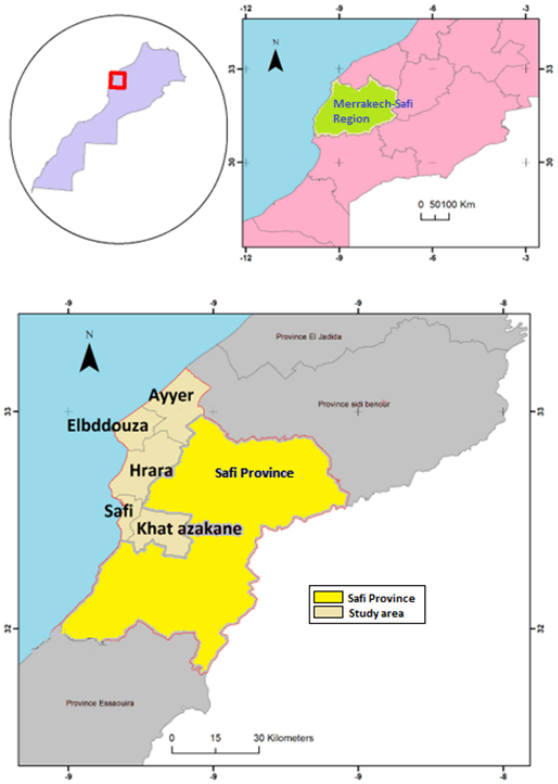

Fig. 7. Localization of the study area.

information from participants, such as age, gender, educational level, location, access to modern medicine, use of conventional medicine, preference for traditional or modern medicine, and how they learned about traditional medicine. The second one included open questions to gather information about medicinal plants, such as vernacular names (dialectal, Arabic, Tamazight, or literary).

The collected information also includes emic disease classification categories (as recorded in interviews) and an etic disease classification category into pathological groups, followed by the WHO's international disease classification (International Classification of Primary Care (ICPC)) [127].

The above questionnaires complied with the guidelines for conducting and reporting ethnopharmacological field studies and an ethnopharmacological survey [126, 128].

3.3 Botanical Identification

During fieldwork, identification was mainly based on the local names of plants. For taxonomic confirmation, we used standard botanical references for Moroccan flora:

Food, aromatic, condiment, medicinal, and toxic plants in Morocco [129].

Statistics and comments on the current inventory of vascular flora in Morocco [130].

Elements for a red book of the vascular flora of Morocco [131].

We also used the online database https://powo.science.kew.org, the African plant database (http://www.ville-ge.ch/musin/bd/cjb/africa/recherche.php), and the International Plant Name Index (IPNI) (http://www.ipni.org/) for checking the scientific names and synonyms of plants. Voucher specimens of each identified plant have been deposited in the herbarium of our laboratory (Environment and Health Research Team, Polydisciplinary Faculty of Safi).

3.4 Quantitative Analysis

In the last few decades, the scientific precision of ethnobotanical research has increased substantially. One significant part of ethnobotany is the quantitative evaluation of indigenous knowledge of plants to produce meaningful yet intangible data. In ethnobotany, quantitative indices provide the data, enabling hypothesis testing, statistical verification, and comparative analysis [132]. Ethnobotanical information was examined in this study using Use Value (UV), Family Use Value (FUV), Fidelity Level (FL), Relative Popularity Level (RPL), Ranking Order Priority (ROP), and Informant Consensus Factor (ICF).

3.4.1 Use Value (UV)

The UV, first described by Prance *et al*. [133], represents the relative importance of a species reported locally by taking into account the number of usage reports given by people in the research region. This quantitative index has been frequently used in ethnobotany to determine the species that are most important to specific people. The formula described below was used to calculate it:

$$UV = \sum Ui/N$$

$\sum$Ui is the sum of the total number of use reports concerning a given species and N is the total number of informants interviewed [134]. The most-reported plants have the highest UV values.

3.4.2 Family Use-Value (FUV)

To describe the most important plant families in the study area, Family Use Value (FUV) was calculated from the use-values of the species using the following formula [134].

$$FUV = \sum UV/N$$

Where UV is the use-values of the species belonging to the family, and N is the total number of species within each family.

3.4.3 Fidelity Level (FL%)

Fidelity levels identify the main use of each plant and calculate the use report's relative importance for each category of use. The FL was calculated using the following formula based on Friedman *et al*. [135].

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

Where Np: is the number of use reports for a use category and N is the total number of informants citing the species for the treatment of any use.

3.4.4 Relative Popularity Level (RPL).

RPL is the ratio between the number of ailments treated by a particular plant species and the total number of informants for any disease [129,130].

3.4.5 Rank Order Priority (ROP).

ROP is a correction factor derived from FL by multiplying RPL and FL values as explained earlier [131,132].

$$ROP = FL \times RPL$$

FL is the Fidelity Level and RPL is the Relative Popularity Level.

3.4.6 Informant Consensus Factor (ICF)

Informant Consensus Factor highlights plants of particular cultural relevance and assesses the agreement among informants on the plant species used against a disease category as originally proposed by Trotter and Logan [136] and simplified by Heinrich *et al*. [137]. To use this tool, illnesses were classified [127]. ICF is based on the correlation between an informant's knowledge and is calculated using the following formula:

$$ICF = (\text{ Nur-Nut })/(\text{ Nur-1 })$$

Nur is the total number of the use reports in each use category and Nut is the total number of species used in that category.

ICF values lie between "0.00 and 1.00". A value near 1 indicates that there is a homogeneity of information among informants, while low ICF values indicate that informants do not agree on which plant to use.

3.5 Bibliographic Review

An in-depth literature search concerning the most cited plants' biological activities reported in this study was made using the following confident electronic databases: PubMed, Science Direct, Google Scholar, Scopus, and Web

of Science. We have used the following keywords: ”ethnobotanical uses”, ”hypertension”, ”diabetes”, ”renal disease”, “biological activity” in association with the plant’s scientific name.

4. Conclusions

Traditional knowledge about medicinal plants has received increasing academic attention. Our study mainly contributed to highlighting, on the one hand, the place of traditional herbal medicine in the study area and, on the other hand, the diversity of plants used in the preparation of medicinal remedies. Thus, it constitutes the first scientific study aimed at listing and documenting traditional therapeutic knowledge in this semi-arid region of Morocco. The results obtained justify the importance of the use of medicinal plants along the coastline of the Safi region. In addition, this study allowed us to assess the know-how and the importance of traditional practices used by the population of the study area. This natural (specific floristic richness) and human (accumulation of experiences) potential are likely to bring added value by developing the activities of women’s cooperatives and herbalists. Thus, offering a source of income, in particular, in semi-urban areas and rural areas. This traditional heritage is essentially passed down orally from generation to generation. The collection and analysis of ethnobotanical data would make it possible for the conservation of the biocultural heritage of this region by creating a database of medicinal plants used and their therapeutic uses. However, the use of medicinal plants for treatment is not always without risk. The indigenous knowledge regarding the toxicity of plants is modest. The misuse of some plants could be fatal. To raise awareness among the local population, an inventory of poisonous plants and their study is essential.

Availability of Data and Materials

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Author Contributions

The design of the study was carried out by ALe, HA, AD, and BL. NL and ALa were the main data collectors and analyzers. The manuscript was prepared and edited by Ale, AB, AK. MAS, TB, CH, JML and JTC revised the manuscript. Lastly, the final manuscript was read and confirmed by all authors.

Ethics Approval and Consent to Participate

Not applicable.

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Conflict of Interest

The authors declare no conflict of interest. JTC is serving as one of the Guest editors of this journal. We declare that JTC had no involvement in the peer review of this article and has no access to information regarding its peer review. Full responsibility for the editorial process for this article was delegated to GD.

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