Ethnomedical inventory of aromatic and medicinal plants in central area of Morocco: Comparative analysis of urban zones and the interactions between plant material, preparation, and administration approaches

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Research

Abstract

Background: In this paper, we conducted an ethnomedicinal survey of the medicinal plants used in the central urban regions of Morocco (Middle Atlas and Saiss Plain). We aimed to evaluate the diversity of medicinal plants and their variability between big cities and small municipalities. Then, we searched the relationships between plants, treated illnesses, used parts, and preparation modes.

Methods: Field visits were conducted in eight urban cities divided into big and small cities during 2017-2018 and 2019-2020. A questionnaire containing sociodemographic features, medicinal plants, used parts, and preparation modes was used to collect data. Descriptive and multidimensional statistics were used to compare the studied parameters and to investigate their relationships.

Results: In total, 155 plants were used by participants, with a higher number in small towns (n=149) compared to big cities (n=100). Most participants (62%) combined modern and traditional treatments. Sociodemographic features, including age, gender, education, and profession, were significantly variable and impacted the used species, treated diseases, used parts, and preparation modes. Further, 21 disease groups were treated based on different parts (n=14) and preparation modes (n=9). Multivariate analysis showed that the medicinal plants, used parts, preparation modes, and treated diseases were correlated. These data are new, fill the gap of medicinal plants in urban areas of Morocco, and offer valuable results for laboratory assays.

Keywords: Ethnobotany, diversity and variability of plants, urban areas, central Morocco, traditional medicine

Background

Since the beginning of history, humans have coexisted with plants and benefited from their dietary and medicinal properties (Giannenas *et al.* 2020, Prasathkumar *et al.* 2021, Hajimonfarednejad *et al.* 2023). Many industries value aromatic and therapeutic herbs (pharmaceuticals, phytosanitary, cosmetics, agri-food, culinary, etc.) because of their biomolecules, which serve as the basis of societal and economic growth (Greff *et al.* 2023, Martins *et al.* 2023, Maache *et al.* 2024).

Ethnobotany is an interdisciplinary field that merges botany and anthropology and can also include pharmacology, nutrition, phytochemistry, and other ways in which traditional communities use plants and their derivatives (Prance 1991, González-Juárez *et al.* 2020, Zhang *et al.* 2023). This approach not only examines the plants themselves but also their relationships with local populations, incorporating ecological and social elements of their use (Hu *et al.* 2020). In the context of this study, ethnobotany provides an important theoretical framework for understanding the traditional practices of medicinal plant selection and use in Morocco and for exploring the relationships between the studied variables, such as the species used, plant parts, preparation methods, and treated diseases.

One Mediterranean country, Morocco, has a long history of using medicinal plants as natural alternatives in medicine, food, and other products (Chaachouay *et al.* 2022, Ait Bouzid *et al.* 2024). Because of their reverence for these botanical treasures, Moroccan civilizations have maintained this legacy over the years (Najem *et al.* 2024). As science advances, scientific pharmacopeia is beginning to use this information in the country (Beniaich *et al.* 2022). Morocco has an abundance of aromatic and medicinal plants due to a range of geographical, soil, and climatic conditions (Ait Bouzid *et al.* 2024, Essaih *et al.* 2024), which calls for additional investigation and progress given the progressively competitive and challenging worldwide market.

Morocco's biogeographical location and the mixture of climates contribute to its incredibly diverse environment, which results in a notable floristic diversity (Boudik *et al.* 2024, Sarroukh *et al.* 2024). The Moroccan pharmacopeia is extensive and varied, with about 5200 plant species, including 900 native species (Barkaoui *et al.* 2017). In addition, only 10% of these plants are cultivated, with the majority being found in the wild (Lamrani-Alaoui and Hassikou 2018, Ibourki *et al.* 2022). Morocco, with all of its scientific, industrial, and social authority, has been able to advance the industry of medicinal plants after realizing its wealth in this field.

Moroccan researchers have conducted a wide range of ethnobotanical surveys (El-Hilaly *et al.* 2003, Ajjoun *et al.* 2022, Noureddine *et al.* 2022). These investigations have addressed wide geographical areas, the diversity of medicinal plants (Kool *et al.* 2012), economy (El-Hilaly *et al.* 2003), therapeutic uses (Jamila and Mostafa 2014), agricultural applications (El Kourchi *et al.* 2024), in vitro and in vivo tests (Bouyahya *et al.* 2017), effects of sociodemographic aspects (Soussi *et al.* 2023). In terms of medicinal uses, investigations have addressed the diversity of used herbs (Chaachouay *et al.* 2023), used parts (El Yaagoubi *et al.* 2023), mod of use, and treated diseases (Aboufaras *et al.* 2023). However, these studies neglected the interactions between the previously cited aspects. For example, the ethnobotanical surveys neglected the comparison of data between urban and peri-urban zones and the interactions between traditional uses and both the application modes and the used parts.

In this study, we aimed to investigate the medicinal plants and their use in central areas of Morocco. first, we addressed the diversity of medicinal plants and the sociodemographic features of the populations. Second, we analyzed the treated diseases, use modes, and utilized parts of each recorded plant. Third, we tested the relationships between all studied parameters. Therefore, the studied features are suggested to fill the gap in the field of Moroccan medicinal plants. This information is sufficient to clarify how local populations select medicinal plants and their parts to manage their illnesses.

Materials and Methods

Study area

This ethnobotanical survey was conducted in the central zone of Morocco. Two areas, including the Plain of Saiss and the Middle Atlas, were selected for this study (Figure 1). The Saiss plain occupies 40.075 km2, or 5.7% of the Moroccan total area. Furthermore, this area administratively combines the two prefectures of Meknes and Fez with the seven provinces of Boulemane, El Hajeb, Ifrane, Moulay Yaâcoub, Sefrou, Taounate, and Taza. This area also contains 194 communes, comprising 161 rural communes and 33 municipalities. The Saiss Plain is rich in medicinal plants (El Yaagoubi *et al.* 2023, Soussi *et al.* 2023), and the majority of them are native, while some species are currently issued from agriculture. The second location is the Middle Atlas, a hilly area that extends eastward from Morocco and starts at Khenifra. This chain relates to four regions: Khenifra-Beni Mellal (West limit), Fez-Meknes (central zone), Deraa Tafilalt (Southeast limit), and Taza-El Hociema (Northeast limit). This area is rich in flora and includes hundreds of medicinal plants (Najem *et al.* 2024).

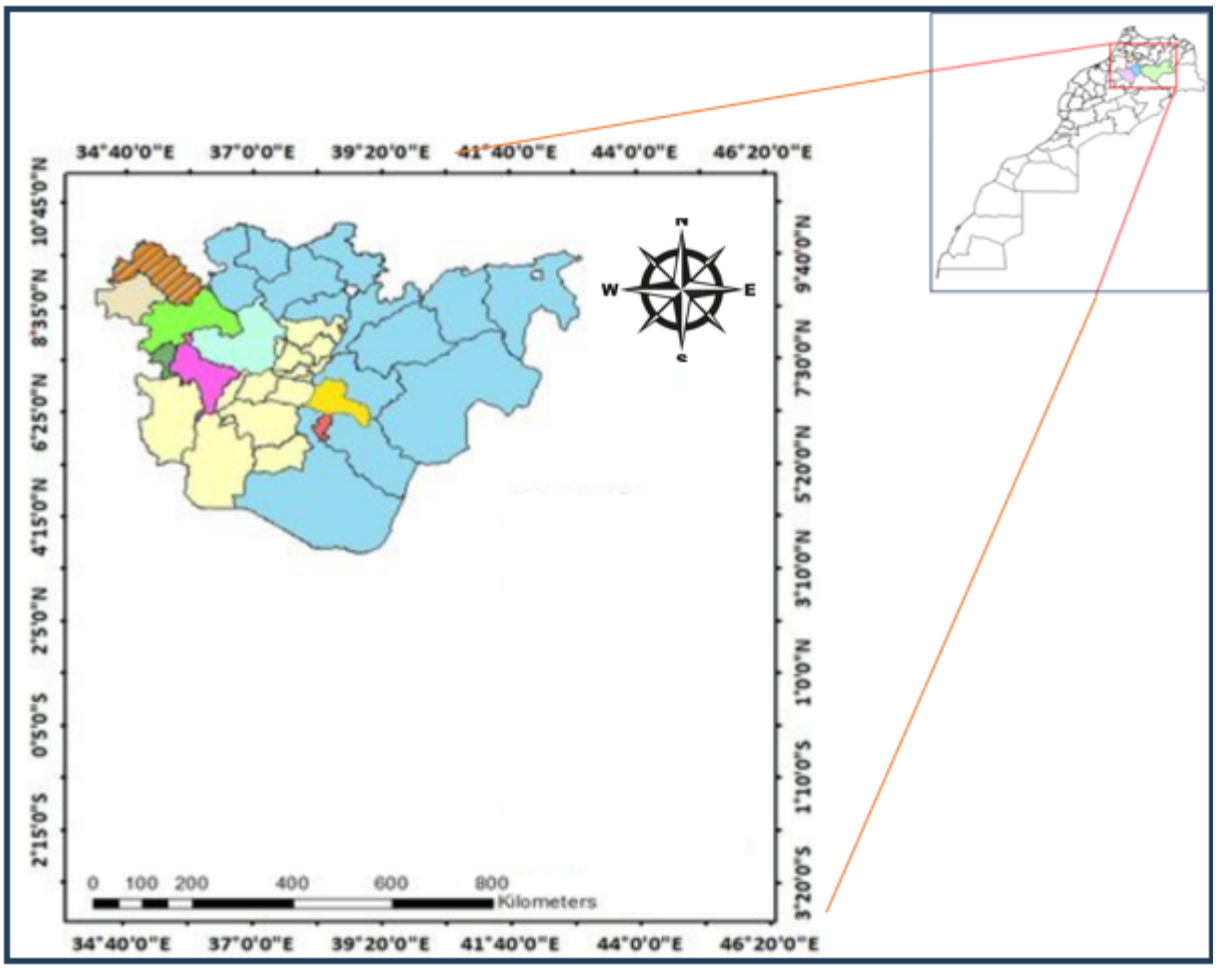

Figure 1. Geographical place of the study regions in central Morocco

Data collection

Interviews with participants

The ethnomedicinal ethnopharmacological survey was conducted during one year from 2018 to 2019. A questionnaire was made and distributed around the study areas to fulfill the objectives of the survey. The questionnaire was divided into three sections. The first section concentrated on the sociodemographic data of the participants, including location, inhabited zone, age, and sex. The second section addressed the diversity of used plants (names, families, orders, and origin) and treated diseases. The third section addresses the usage modes and used parts.

Identification of plants

To determine the collected species, we referred to the works of Professor Fennane from the Botany Research Laboratory (Fennane 1999, Fennane *et al.* 2007, 2014), the book Moroccan Medicinal Plants by Sijelmassi (1993), the traditional Moroccan pharmacopeia, ancient Arabic medicine, and the popular knowledge compiled by Bellakhdar (1997).

In this study, we included common names because both our informants used the Arabic and Roman alphabets to refer to them. We followed Bellakhdar's instructions for romanizing the vernacular names from (Bellakhdar 1997). Further, the scientific names of recorded plants were revised and updated utilizing the Plant List website (www.theplantlist.org) (Rivera *et al.* 2014) and the Global disease categories of WHO (Staub *et al.* 2015).

Data analysis

Recorded data was firstly organized in Excel and divided into sociodemographic, medicinal plants, used parts, and use modes. Further, we calculated the percentages for all studied parameters. A comparison of sociodemographic parameters, diversity of medicinal plants, treated diseases, used parts, and usage modes between urban and peri-urban zones was done with a T-test. Similarly, the sex ratio was compared with the T-test. Further, ages (n=5), education levels (n=5), professions (n=5), therapeutic uses (n=3), used parts (n=14), and usage modes (n=9) were compared with ANOVA followed by a multiple range test.

Multivariate analysis was done to clarify the relationships between the studied parameters. In this study, we selected Correspondence Analysis to clarify the relationship between targeted variables. We searched for the correlation between the recorded plants and treated diseases. Furthermore, we analyzed the relationships between recorded plants, used parts, and usage modes. The obtained results were presented in a plot, and only axes with eigenvalues superior to 1 were selected. Statistical tests were done using SPSS software (version 25).

Results

Sociodemographic features

The results of the sociodemographic features are presented in Figure 2. The comparison of sociodemographic parameters was significantly variable. The gender of the participants was dominated by men (n=127) compared to women (n=73) ($p<0.01$). The age of participants was between 25 and >75 years old and was significantly variable among categories ($p<0.05$). The age of 35 to 44 years was the most observed among participants (n=51) followed by the category of 25 to 34 years (n=22.5), and applicants of 45 to 54 years (n=40). Participants aged between 55 and 64 years and between 65 and 74 years were the less observed with 39 and 25 participants.

The education level of participants was divided into five categories and was statistically different ($p<0.05$). Primary education was the most dominant among participants (n=62), followed by college level (n=49), and both illiterates and high school (n=19 each). The university level was the least observed among interviewed participants (n=6).

The professions of the participants were diverse and significantly different. Herbalists were the most abundant among the interviewed participants (n=35), followed by housewives, farmers, and participants without jobs (n=12 each). Only 5 participants worked in the artisanal and traditional jobs, while 8 participants had other jobs.

Currently, different ethnobotanical studies have addressed the sociodemographic features of participants and revealed variable findings (Teixidor-Toneu *et al.* 2016, Chaachouay *et al.* 2022, El-Ghazouani *et al.* 2024). Our study's recorded data contradicts research done in other Moroccan regions, such as the natural park of Bouhachem in the Rif region (North Morocco), High Plain Moulouya (Central zone), and Nador (Northeast), where the majority of participants were adults over 50 (Benlamdini *et al.* 2014, Bachar *et al.* 2020, Hayat *et al.* 2020). For instance, (Najem *et al.* 2020) conducted an ethnobotanical study in the Middle Atlas (central Morocco). They found that 30.37% and 24.36% of the interviews were people aged 50-60 and above 60, respectively. In another study, (Najem *et al.* 2019) conducted an ethnobotanical survey on poisonous medicinal plants solicited in the traditional phytotherapy of the central Middle Atlas. According to the results, the average age is 34, the lowest is 18, and the highest is 70. The preponderance of individuals is between the ages of 20 and 40 (48.62%), while just 16.36% of those over 60 are included.

Men still outnumber women in phytotherapy and sales of aromatic and medicinal plants, as evidenced by the fact that the majority of interviewees (64%) were men. Additionally, this rate suggests that women are more interested in traditional pharmacopeia, which is contrary to findings reported in Morocco's Middle Atlas (Najem *et al.* 2020), Northwest, and High Atlas (Hilah *et al.* 2016, Bachar *et al.* 2020, Bouayyadi and Zidane 2020), where women made up only 12.60% of the population and men made up 87.40%.

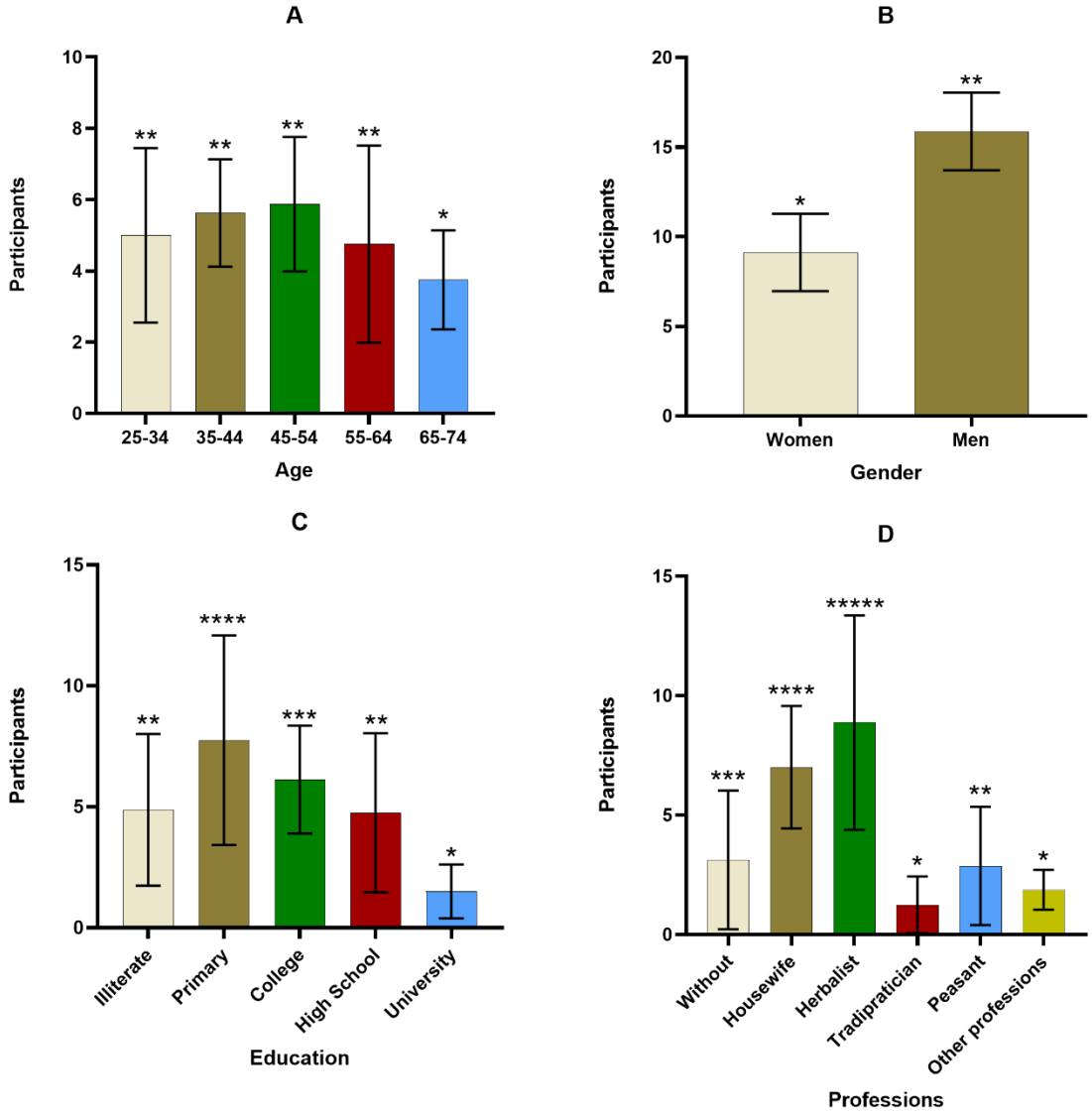

Figure 2. Demographic and social characteristics of the participants in the central areas of Morocco (A: Age; B: Gender; C: Education; D: Profession)

The samples under study had varying levels of education, with elementary and college education accounting for the largest shares (31% and 25%), followed by high school diploma and illiteracy (19%). According to Najem *et al.* (2020), the majority of participants had a medium level of education, which is comparable to 42% of secondary and 28% of primary students in the Middle Atlas.

Traditional medicine practitioners with a secondary education level make up 42% of the population in other Middle Atlas zones (Najem *et al.* 2019). Nonetheless, a sizable portion of respondents (28%) have only completed primary school, while 18% are illiterate. Due to their inability to comprehend conveyed instructions and thrive in the development of herbal medicine, this incidence of illiteracy can pose a serious challenge to the growth of the phytotherapy profession (Bammou *et al.* 2015). Therefore, using medicinal plants in an uncontrolled or untrained manner might lead to drunkenness and major health issues.

According to their profession, respondents were distributed as follows: Herbalists represented 35% of the surveyed population, followed by 28% of housewives and 12% of farmers. These results are in agreement with the findings mentioned by El Yaagoubi *et al.* (2023), where the majority of users of medicinal plants were dominated by herbalists and housewives. These results are very important in the study area because the previous studies conducted in the zone didn't investigate the

professions of populations ((Najem *et al.* 2019, 2020). The use of medicinal plants is directly related to the abundance of herbalists, who are the most important sellers of herbs and their derivatives in Morocco (Elachouri *et al.* 2021, El-Ghazouani *et al.* 2021).

Use of medicinal plants

Modern and traditional treatments

The results of the medicine used by participants in studied regions are presented in Figure 3. The majority of participants (62%) use both modern and traditional medicines (Figure 3 A). Further, modern medicine was used by 8% of participants, while conventional medicine was used by 30%. The medicine used differs depending on the size of the city and location (Figure 3 B). In big cities, no one used traditional medicine, while 8 of the participants used modern medicine, and 42 participants used both treatments. In small cities, 19 participants used traditional medicine, 40 interviewed used modern treatments, and 91 persons used both treatments.

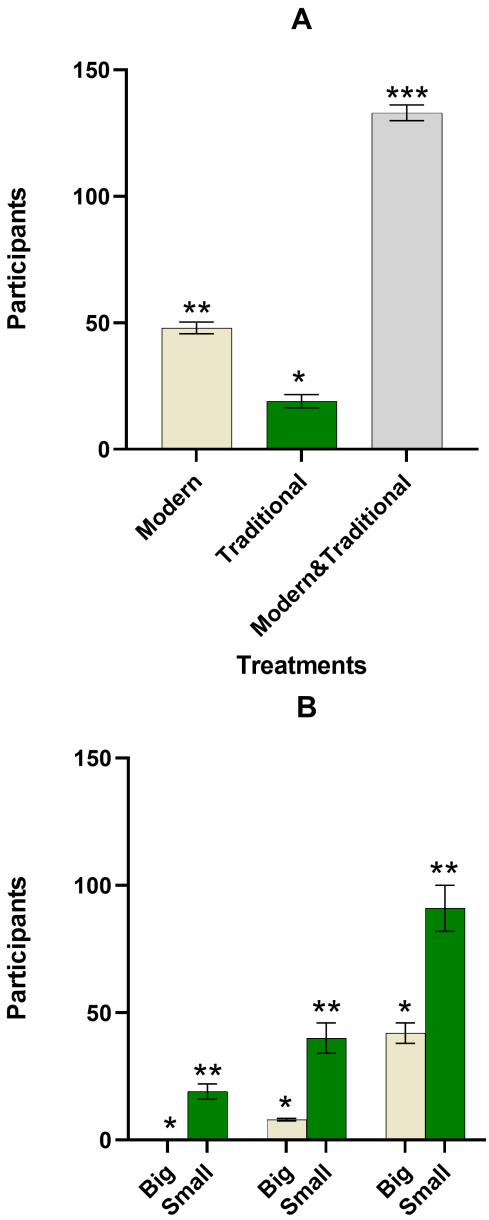

Figure 3. Used medicine by participants (A) and its variation (B) in central areas of Morocco

Currently, different studies have addressed the type of treatments used by local populations in different Moroccan regions, including central, northern, and southern areas. For example, (Kachmar *et al.* 2021) investigated the medicinal uses of plants in the Northeastern regions of Morocco, while (Merrouni *et al.* 2021) evaluated the medicinal plants circulating among the populations of North-Eastern Morocco. El-Ghazouani *et al.* (2021) addressed the medicinal plants used in traditional medicine by women in the Southwest of Morocco. (Lemhadri *et al.* 2023) addressed the diversity of medicinal herbs used by the local communities of the coastal plateau of Morocco. (Beniaich *et al.* 2022) conducted an ethnobotanical survey on medicinal plants used in the central region of Morocco. Despite this huge number of studies, the type of medicine between big and small cities was neglected. In contrast, our study demonstrated that the local populations combine modern and traditional treatments, followed by traditional medicine. These are suggested to be governed by the education level, traditional knowledge, and economic status of the participants. These reasons were mentioned in other studies. For example, the low economic status and easy accessibility of medicinal plants were the main reasons for local populations in the North of Morocco (Redouan *et al.* 2022), the plain of Saiss (Beniaich *et al.* 2022), and the Middle Atlas (Najem *et al.* 2020).

Diversity of medicinal plants

The diversity and variability of medicinal plants used by the participants are presented in Table 1. In total, 153 medicinal plants were identified in the studied cities. These species belong to 54 families. However, the recorded species were different among cities. In big cities, 100 medicinal plants were recorded, compared to 149 species in small towns. The most used species were *Urtica pilulifera* (n=85), followed by *Mentha pilegium* (n=83), *Herniaria glabra* (n=83), *Thymus zygis* (n=82), *Rosmarinus officinalis* (n=80), and *Salvia officinalis* (n=80) were the most used plants. Two species, including *Schinus molle* and *Cymbopogon citratus* were mentioned by two participants from the city of Fez.

Concerning families, Lamiaceae with 23 species, Asteraceae with 18 species, and Apiaceae with 14 species were the most dominant families in both big and small cities. In contrast, Acanthaceae, Berberidaceae, Cactaceae, Capparaceae, Caprifoliaceae, Cannabaeceae, Cucurbitaceae, Cupressaceae, Ericaceae, Iridaceae, Geraniaceae, Linaceae, Malvaceae, Moraceae, Myristicaceae, Nitariaceae, Oleaceae, Papaveraceae, Pinaceae, Portulacaceae, Rubiaceae, Salicaceae, Schisandraceae, Solanaceae, Taxaceae, Urticaceae, and Verbenaceae were the less dominant families with one species each.

Table 1. Diversity and variability of medicinal plants in the cities of central areas of Morocco

Species	**Abreviation**	**Common name/ vernacular name**	**Family**	**Number of species**
Ajuga iva (L.) Schreb.	Aju.i	Chendgora/ šendgūra, tûf ṭolba/ iva	Lamiaceae	24
Calamintha officinalis Moench	Cal.o	Menta/ mantā, l-mantā/ common calamint	Lamiaceae	
Hyssopus officinalis L.	Hys.o	Hyssopus/ hyssop/ Izoop/ zaatar farissi	Lamiaceae	
Lavendula angustifolia MilL.	Lav.o	Lavender/ English lavender	Lamiaceae	
Lavendula dentata L.	Lav.d	Fringed lavender/ kẖūzama	Lamiaceae	
Lavendula stoechas L.	Lav.s	Stoechade lavender/ ḥelḥāl/ Khzama Farachiya	Lamiaceae	
Marrubium vulgare L.	Mar.v	Marrubium/ merriūt, merrîwa, ifezzi/ Farasiyun	Lamiaceae	
Mentha pulegium L.	Men.pu	Pennyroyal/ fliyyo, fliyou	Lamiaceae	
Mentha suaveolens Ehrh.	Men.s	Apple mint/ mšīštru, l-marsitā, timerşad/ Nana' Msassa	Lamiaceae	
Mentha spicata L.	Men.sp	Common mint/ Spearmint/ Menthe verte/ Na'na' khdar	Lamiaceae	
Mentha x piperita L.	Men.p	Peppermint/ Menthe poivrée/ Na'na' filfili	Lamiaceae	
Ocimum basilicum L.	Oci.b	Basil/ ḥbaq, laḥbaq	Lamiaceae	
Origanum compactum Benth.	Ori.c	Zaâtre Baldi/ zaɛtar	Lamiaceae	
Origanum vulgare L.	Ori.v	Oregano/ Wild marjoram	Lamiaceae	

Origanum majorana L.	Ori.m	Marjoram/ merdeddūš/ Mardaqush	Lamiaceae	
Rosmarinus officinalis L.	Ros.o	Rosemary/ azīr/ Iklīl al-jaba	Lamiaceae	
Salvia officinalis L.	Sal.o	Salmia/ sālmiya, es-sâlmiya, tamejjūt	Lamiaceae	
Salvia verbenaca L.	Sal.v	Wild clary/ ḫiyyāṭa	Lamiaceae	
Sideritis incana L.	Sid.i	Mountain tea	Lamiaceae	
Teucrium fruticans L.	Teu.f	Tree Germander/ Germandrée arbrisseau/ Strauchgamander/ Mato-branco	Lamiaceae	
Teucrium polium L.	Teu.p	Felty germander/ Ja'ada	Lamiaceae	
Thymus zygis L.	Thy.z	Thym rouge/ zɛitra/ Spanish oregano	Lamiaceae	
Ziziphora hispanica L.	Ziz.h	Gnawas beans/ Petit-Basilic	Lamiaceae	
Cinnamomum verum J. Presl	Cin.v	Wild marjoram/ qārfā,, l-qārfā, l-ġlīdā	Lamiaceae	
Achillea millefolium L.	Ach.m	Common yarrow	Asteraceae	19
Anacyclus pyrethrum (L.) Lag.	Ana.p	Mount Atlas daisy/ tāġendest, ɛāqer qerḥā	Asteraceae	
Anthemis nobilis L.	Ant.n	Roman chamomile	Asteraceae	
Artemisia absinthium L.	Art.a	Wormwood/ šība	Asteraceae	
Artemisia herba-alba Asso	Art.s	White wormwood/ šīḥ, îzrî	Asteraceae	
Artemisia mesatlantica Maire	Art.a	Blue mugwort/ shih	Asteraceae	
Atractylis cancellate L.	Atr.c	Cage Thistle	Asteraceae	
Atractylis gummifera L.	Atr.g	Chamaeleon gummifer/ addād, ahfyūn	Asteraceae	
Chrysanthemum coronarium L.	Chr.c	Edible chrysanthemum/ crown flower	Asteraceae	
Dittrichia viscosa (L.) Greuter	Dit.v	False yellowhead/ magramān , amerril	Asteraceae	
Echhinops spinosissimus Turra	Ech.s	Thorny globe thistle/ hedgehog	Asteraceae	
Lactuca serriola L.	Lac.s	Prickly lettuce/ Scarole sauvage/ Khass barri	Asteraceae	
Launaea arborescens (Batt.) Murb.	Lau.a	Wicked dandy/ cardaviejo	Asteraceae	
Mantisalca salmantica (L.) Briq. & CavilL.	Man.s	Dagger flower/ Bariaderas/ thazmourth	Asteraceae	
Matricaria chamomilla L.	Mat.c	Chamomile/ bābnūj, bābūnej	Asteraceae	
Ormenis scariosa Litard. & Maire	Orm.s	Irezghi	Asteraceae	
Santolina rosmarinifolia L.	San.r	Green Lavender/ Holy Flax	Asteraceae	
Senecio vulgaris L.	Sen.v	Common Groundsel/ groundsel	Asteraceae	
Berberis vulgaris L.	Ber.v	Common barberry/ Barbaris	Asteraceae	
Ammi majus Walter	Amm.m	bishop's weed/ Khalla Shaytani	Apiaceae	14
Ammi visnaga (L.) Lam.	Amm.v	toothpick weed/ bū šniḫa, tabešnîḫt/ Khilla	Apiaceae	
Ammodaucus leucotrichus Coss.	Amm.l	Wooly cumin/kemmūn şūfi	Apiaceae	
Anethum graveolens Ucria	Ane.g	Dill/ Shibt	Apiaceae	
Angelica archangelica L.	Ang.a	Garden angelica/ Archangel	Apiaceae	
Apium graveolens L.	Api.g	Chinese Celery/ krāfes/ Wild celery	Apiaceae	

Carum carvi L.	Car.c	Caraway/ karwiyâ	Apiaceae	
Coriandrum sativum L.	Cor.s	Coriander-parsley/ qezbūr	Apiaceae	
Cuminum cyminum L.	Cum.c	Cumin/ Kamoun	Apiaceae	
Eryngium tricuspidatum Pančić	Ery.t	Moroccan eryngo	Apiaceae	
Ferula communis L.	Fer.c	Giant fennel/ Kallakh	Apiaceae	
Foeniculum vulgare MilL.	Foe.v	Common fennel/ n-nāfaɛ, âmsâ, tamsawt	Apiaceae	
Petroselinum sativum Hoffm. ex Gaudin	Pet.s	Parsley/ mɛadnūs, imẓi	Apiaceae	
Pimpinella anisum L.	Pim.a	Aniseed/ ḥabbat ḥlāwa	Apiaceae	
Adenocarpus bacquei Batt. & Pit.	Ade.b	Adenocarpus-Aghoultmte	Fabaceae	8
Astragalus gummifer LabilL.	Ast.g	Gum tragacanth-ktîrâ	Fabaceae	
Astragalus lusitanicus Lam.	Ast.l		Fabaceae	
Cassia senna L.	Cas.s	Wild Senna/ sena	Fabaceae	
Ceratonia siliqua L.	Cer.s	Carob/ l-ḫerrūb, sliġwa/ kharoub	Fabaceae	
Medicago sativa L.	Med.s	Alfalfa-lucerne/ lfassa	Fabaceae	
Retama sphaerocarpa (L) Boiss.	Ret.s	Rtem	Fabaceae	
Trigonella foenum graecum L.	Tri.g	Fenugreek/ l-ḥelba, afiḍās, tifiḍas	Fabaceae	
Brassica rapa L.	Bra.r	Turnip rape/ left	Brassicaceae	6
Brassica napus L.	Bra.n	Rapeseed	Brassicaceae	
Brassica nigra W.D.J.Koch	Bra.n	Black mustard/ Khardal Kahal	Brassicaceae	
Diplotaxis erucoides sp	Dip.s	Wall-rocket/ wild mustards	Brassicaceae	
Lepidium sativum L.	Lep.s	Cress/ ḥabb r-ršād, l-ḥarf	Brassicaceae	
Nasturtium officinale R. Br.	Nas.o	Watercress/ Jarjir Maa	Brassicaceae	
Euphorbia falcata L.	Eup.f	Zeggoum/ Euphorbe en faux	Euphorbiaceae	4
Euphorbia helioscopia L.	Eup.h	Spurge/ Madwoman's milk/ Sonnen-Wolfsmilch	Euphorbiaceae	
Euphorbia resinifera O. Berg	Eup.r	Moroccan Mound/ daghmous	Euphorbiaceae	
Mercurialis annua L.	Mer.a	Dog's Mercury	Euphorbiaceae	
Arundo donax Forssk.	Aru.d	Giant reed/ Qassab	Poaceae	5
Cymbopogon citrartus DC.	Cym.c	Lemongrass/ Limoncillo/ Citronnelle Nimbu ghas/ Lwiza romya	Poaceae	
Cynodon dactylon (L.) Pers.	Cyn.d	Bermuda Grass/ Tnej	Poaceae	
Panicum miliaceum Blanco	Pan.m	Proso millet/ Dakhn	Poaceae	
Sorghum vulgare Pers.	Sor.v	Sorghum/ Dra	Poaceae	
Clematis flammula L.	Cle.f	Fragrant virgin's bower	Ranunculaceae	4
Delphinium staphisagria L.	Del.s	habb r-ras/ Sonnen-Wolfsmilch	Ranunculaceae	
Nigella sativa L.	Nig.s	Black caraway/ šanūj, l-ḥabba sawda	Ranunculaceae	
Ranunculus bullatus L.	Ran.b	Autumn buttercup	Ranunculaceae	
Corrigiola telephiifolia Pourr.	Cor.t	Corrigiola	Caryophyllaceae	3
Herniaria glabra L.	Her.g	Smooth rupturewort	Caryophyllaceae	
Saponaria Vaccaria L.	Sap.a	Cowherb	Caryophyllaceae	
Agrimonia eupatoria Kitam.	Agr.e	Agrimony	Rosaceae	3
Crataegus monogyna Jacq.	Cra.m	Common hawthorn/ admām/ Za'rour	Rosaceae	

Rosa canina Siev. ex Ledeb.	Ros.c	Dog rose/ ward beldi, tiḫfert	Rosaceae	
Alpinia officinarum Hance	Alp.o	Blue ginger/ Khoulanjan	Zingiberaceae	3
Elettaria cardamomum (L.) Maton	Ele.c	green cardamom seed/ Qaqulla/ Hill	Zingiberaceae	
Zingiber officinalis Roscoe	Zin.o	Ginger/ skinjbir	Zingiberaceae	
Eucalyptus globulus LabilL.	Euc.g	Eucalyptus/ kalitûs, kalibtûs	Myrtaceae	3
Eugenia caryophyllata Thunb.	Eug.c	Clove/ Qronfel	Myrtaceae	
Myrtus communis L.	Myr.c	Common Myrtle/ Rīḥān	Myrtaceae	
Linum usitatissimum L.	Lin.u	Flax/ kettān, zerrîɛt l-kettân	Linaceae	2
Lawsonia inermis L.	Law.i	Lin / ḥenna, l-ḥenna	Lythraceae	
Borago officinalis L.	Bor.o	Borage/ Lisan Ath-Thawr	Boraginaceae	2
Heliotropium europaeum Aitch.	Hel.e	European heliotrope	Boraginaceae	
Caralluma europaea Zohary	Car.e	Caralluma/ daġhmūs	Apocynaceae	2
Nerium oleander L.	Ner.o	Oleander/ defla, alili	Apocynaceae	
Allium cepa L.	All.c	Common onion/ bṣel, beṣla	Liliaceae	
Allium sativum L.	All.s	Garlic/ tūma, tiskert	Liliaceae	2
Pistacia atlantica Desf.	Pis.a	Atlas pistachio/ Btoum	Anacardiaceae	3
Pistacia lentiscus L.	Pis.l	Mastic tree/ fādis / ḍru	Anacardiaceae	
Schinus molle L.	Sch.m	Peruvian peppertree/ Pimiento/ Faux poivrier	Anacardiaceae	
Dysphania ambrosioides (L.) Mosyakin & Clemant	Che.a	Mexican tea/ mkḫīnza	Amaranthaceae	2
Haloxylon scoparium Pomel	Hal.s	woody plant	Amaranthaceae	
Cistus ladanifer L.	Cis.l	Gum rockrose	Cistaceae	2
Cistus salviifolius L.	Cis.s	Salvia cistus	Cistaceae	
Quercus rotundifolia Lam.	Que.r	Holm oak-ballota/ Ballout	Fagaceae	2
Quercus suber L.	Que.s	Cork oak/ Fallin	Fagaceae	
Buxus balearica Lam.	Bux.b	Balearic boxwood	Buxaceae	2
Buxus sempervirens L.	Bux.s	Boxwood/ Shamraj	Buxaceae	
Rhamnus alaternus L.	Rha.a	Evergreen buckthorn	Rhamnaceae	2
Ziziphus lotus (L.) Lam.	Ziz.l	Moroccan wild jujube/ sedra, tazuggwart, nnbeg	Rhamnaceae	
Citrus aurantium L.	Cit.a	Bitter Orange/ Naranj	Rutaceae	2
Ruta montana L.	Rut.m	Fidjel-aourmi/ fjīla, awermi	Rutaceae	
Daphne gnidium L.	Dap.g	Flax-Leaved Daphne	Thymelaeaceae	2
Thymelaea hirsuta (L.) EndeL.	Thy.h	Methnane	Thymelaeaceae	
*Digitalis mauretanica (*Humbert & Maire) Ivanina	Dig.m		Scrophulariaceae	2
Verbascum sinuatum Hablitz	Ver.s	Wavyleaf Mullein	Scrophulariaceae	
Illicium verum Hook. f.	Ill.v	star anise/ l-badiāne, badīāna	Schisandraceae	1
Acanthus mollis L.	Aca.m	Clorofila	Acanthaceae	1
Spinacia oleracea L.	Spi.o	Spinach/ Sabaneekh	Chenopodiaceae	1
Aristolochia paucinervis Pomel	Ari.p	Birthwort	Aristolochiaceae	1
Opuntia ficus-indica (L.) MilL.	Opu.i	Barbary fig/ hendiya, zaɛbul/ sebbar	Cactaceae	1
Capparis spinosa L.	Cap.s	Caper bush/ Kabbar	Capparaceae	1
Sambucus nigra L.	Sam.n	European elder	Adoxaceae	1
Cannabis sativa L.	Can.s	Cannabis-hemp/ Kif	Cannabaceae	1

Citrullus colocynthis (L.) Schrad.	Cit.c	Bitter cucumber/ leḥdej, ḥdej, âferzîz	Cucurbitaceae	1
Juniperus phoenicea PalL.	Jun.p	Phoenician juniper or Arâr	Cupressaceae	1
Arbutus unedo L.	Arb.u	Moroccan Strawberry/ Qatlab	Ericaceae	1
Laurus nobilis L.	Lau.n	Laurel/ ɛşat sīdna mūsa, rand	Lauraceae	1
Crocus sativus L.	Cro.s	Moroccan Saffron/ Za'fran	Iridaceae	1
Pelargronium asperum Ehrh. Ex Spreng.	Pel.a	Rose geranium/ Itriyah	Geraniaceae	1
Asphodelus tenuifolius sp	Asp.t	Asphodel/ Brouq	Asphodelaceae	1
Urginea maritima (L.) Baker	Urg.m	Sea onion/ Bassel Skeran	Hyacinthaceae	1
Punica granatum L.	Pun.g	rommān, tarommānt	Lythraceae	1
Malva sylvestris L.	Mal.s	Common mallow-Khobiza/ beqqŭla	Malvaceae	1
Ficus carica L.	Fic.c	Common fig/ karmous	Moraceae	1
Myristica fragrans Houtt.	Myr.a	Nutmeg tree/ Jouzat At-Teeb	Myristicaceae	1
Peganum harmala L.	Peg.h	African rue-harmal	Nitrariaceae	1
Olea europeae L.	Ole.e	Olive/ zitūn, z-zūtin	Oleaceae	1
Papaver rhoeas L.	Pap.r	Common poppy/ Shaqayeq Nu'man	Papaveraceae	1
Pinus halepensis MilL.	Pin.h	Pine/ Snouber	Pinaceae	1
Portulaca oleracea L.	Por.o	Common Purslane/ Rejla	Portulacaceae	1
Paeonia corallina Retz.	Pae.c	Coral Peony	Paeoniaceae	1
Rubia tinctorum L.	Rub.t	Tarrubia/ Fouwwa	Rubiaceae	1
Salix alba L.	Sal.a	White willow/ Safsaf	Salicaceae	1
Datura stramonium L. test	Dat.s	Chedecq ejmel/ Dhatoura	Solanaceae	1
Taxus baccata Thunb.	Tax.b	Common yew	Taxaceae	1
Urtica pilulifera L.	Urt.p	Roman nettle/ Hriga	Urticaceae	1
Aloysia citrodora Paláu	Alo.c	Lemon verbena-Hérit/ lwīza	Verbenaceae	1

Different results were recorded in different areas of Morocco. For example, 86 medicinal plants, grouped into 60 families, were cited in the region of Fez-Meknes (Beniaich *et al.* 2022). The most cited plants were *Lavandula dentata*, *Matricaria chamomilla*, and Rosmarinus officinalis, and the Lamiaceae was the most quoted family. In the Central Middle Atlas, 76 medicinal plants, including 67 genera and 40 families, were recorded as antidiabetic (Hachi *et al.* 2016). In another study, 96 plants belonging to 48 families and 92 herbs belonging to 43 families were cited by herbalists and housewives from Agadir in Southwest Morocco (El-Ghazouani *et al.* 2021). The dominant plant families were the following: Apiaceae, Lamiaceae, Asteraceae, and Fabaceae. In the Ain Leuh, 123 medicinal plants from 53 families have been identified for use in traditional medicine (Akdime *et al.* 2015). These studies demonstrated the diversity of medicinal plants used by populations in Morocco. However, they showed the spatial variation of medicinal plants among regions without any information on comparing small and big cities. Therefore, this study is suggested to fill the gap in medicinal plants in Morocco, mainly in big and small towns.

Used parts and preparation modes

The results of the used parts are presented in Figure 4. In total, 14 parts of recorded plants were used in traditional treatments. The leaves were the most used parts (n=98), followed by roots (n=34), flowers (n=30), fruits (n=30), and leafy stems (n=22). In the second round, participants used seeds (n=13), resin (n=8), bulbs (n=2), and rhizomes (n=2) moderately (Figure 4A). In contrast, nuts, grains, stigmates, and ecorces were used less (n=1) in the study zone. Different preparations are used to prepare the medicinal plants and their derivatives (Figure 4B). Decoction was the preferred preparation mode (n=108) by the local populations, followed by brewing (n=91), cataplasm (n=51), powder (n=49), essential oils (n=49), and raw plants (n=31). An important portion of the population used the cooked parts of medicinal plants for treatment. In contrast, fumigation and maceration were the least used preparation modes with 4 and one participant, respectively.

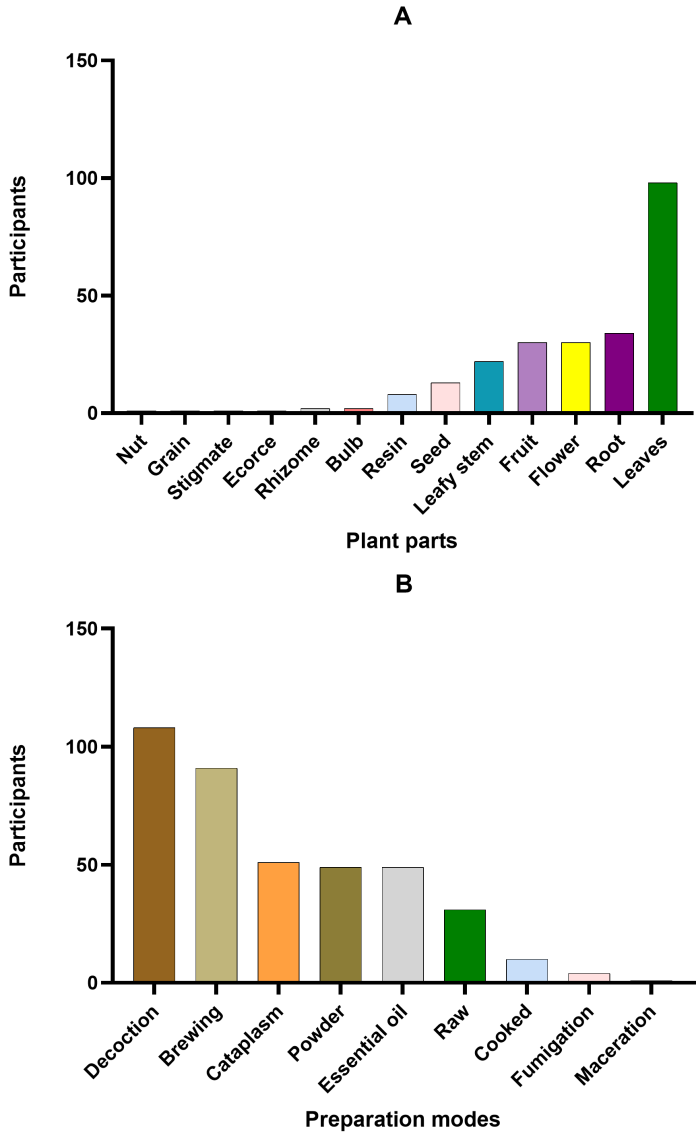

Figure 4. Used parts of medicinal plants (A) and preparation modes (B) in the central zone of Morocco

The used parts and preparation of medicinal plants and their derivatives are among the most important data in ethnomedicinal surveys (Yigezu *et al.* 2014, Iyamah and Idu 2015, Ullah *et al.* 2020). They permit us to understand which portions of medicinal plants are used by local populations and how they prepare each plant. Further, these data are suggested to clarify how human diseases are treated by traditional treatments (Bouafia *et al.* 2021, Siddique *et al.* 2021). In Morocco, several ethnobotanical surveys have addressed the used parts and preparation modes of medicinal plants and recorded variable results. In terms of used parts, an ethnobotanical study of the therapeutic plants utilized by the inhabitants of northeastern Morocco was carried out by (Merrouni *et al.* 2021). With a proportion of 21.4%, the leaves are the most often utilized portions in medical preparation, followed by fruits (12.2%) and the entire plant (12.1%), according to the statistics obtained. Further, El Yaagoubi *et al.* (2023) assessed the portions of medicinal plants that were used in central Morocco. They noted that participants used varying percentages of medicinal plant parts, such as the stem, flower, leaf, resin, fruit, root, seed, stigma, rhizome, bark, bulb, nut, aerial portion, and complete plants. With a percentage of 33%, leaves were the most used section, followed by stems (17%) and flowers (16%). In their study of the medicinal plant parts used in the Al-Haouz Rehamna region of Morocco, (Benkhnigue *et al.* 2023) found that the most commonly utilized parts were leaves and seeds. The comparison of our results and those reported in the bibliography is significantly variable. The selection of medicinal plants or their parts in our study can be explained by the simplicity of leaf, stem, and flower collection (Shikov *et al.* 2022, Hamrouni *et al.* 2023), as well as by the fact that leaves serve as both a photosynthetic and secondary metabolite

storage site (Matowa *et al.* 2020). Therefore, local populations select the areal parts, mainly leaves, to obtain maximum bioactive molecules.

In terms of preparation modes, various ethnobotanical surveys demonstrated that the preparation modes of medicinal plants vary widely depending on used plants, parts, treated diseases, and geographical areas (Soussi *et al.* 2023, Che *et al.* 2024, Maache *et al.* 2024). Maache *et al.* (2024) revealed infusion and decoction as the most dominant preparation mode of medicinal plants in the Fez-Meknes region. In the same area (Fez-Meknes), Soussi *et al.* (2023) demonstrated that local populations mainly use tisane of *Pimpinella anisum* L., and the dominant preparation form was infusion. To manage analgesic and anti-inflammatory disorders in north-central Morocco, populations use principally decoctions and infusions as preparation methods with percentages of 38.3 % and 19.2 %, respectively (Lefrioui *et al.* 2024). The methods of preparing medicinal plants in the Al-Haouz Rehamna region of Morocco were examined by Benkhnigue *et al.* (2023). The findings gathered indicated that the most popular method (34.88%) is decoction. The variation of preparation modes is simple because of the nature of plant materials, treated diseases, and the knowledge of participants are variable. For example, skin diseases need liquid or viscose preparations (Gupta and Gupta 2024), while drinkable forms are mostly suitable for digestive and cardiovascular diseases (Benkhnigue *et al.* 2023, Juthi *et al.* 2024, Singh *et al.* 2024).

Administration methods

Different administration methods of medicinal plants were mentioned by participants from central zones of Morocco (Figure 5). In total, six administration approaches were mentioned by the interviewed participants with variable percentages. The oral administration of medicinal plants was the most recorded approach with a percentage of 58%, followed by the dipping method with 22%, and massage with 12%. Participants administrate medicinal plants rarely by rinsing (5%), inhalation (2%), and eye drops (1%). Similarly, oral administration was the most used to manage fifteen illness categories in central areas of Morocco (Maache *et al.* 2024). Oral administration was used by 95 % of participants from the Drâa-Tafilalet region of Southeastern Morocco to manage urogenital disorders (Elhasnaoui *et al.* 2024). (El-Assri *et al.* 2021) studied the administration techniques and carried out an ethnobotanical survey of the medicinal plants used in Taounate (North Morocco). According to the statistics, the majority of plants (57.61%) were consumed orally, followed by rinsing in 16.17% and inhaling in 11.56%. The percentage of alternative modes of use, such as massage, is 7.38%. based on the results of this study and those of the literature, the administration methods differ depending on the interviewed populations, treated diseases, and used parts of plants.

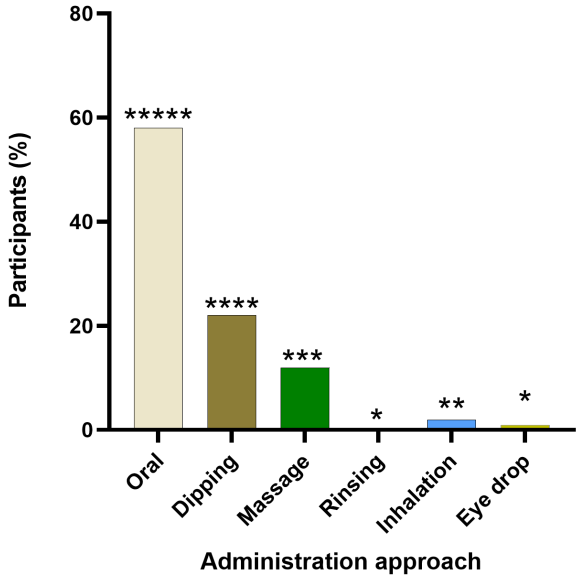

Figure 5. Comparison of the administration methods of medicinal plants among the interviewed participants in central areas of Morocco.

Treated diseases

The treated groups of diseases with medicinal plants are presented in Table 2. In total, participants mentioned 21 categories of diseases. Regarding the use of medication to treat certain conditions, the Informant Consensus Factor (ICF) showed the consistency of information provided by several informants. The categories with the highest ICF values were Cancer (0.97),

followed by Fever with an ICF of 0.96, Cardiovascular with 0.95, and both Anemia and Aphrodisiac with 0.94 each. According to (Lin *et al.* 2002). These high ICF values demonstrated that natural medicines are seen as being very effective and indicate the reasonable reliability of informants regarding the usage of herbal species.

Digestive disorders were treated with the highest number of medicinal plants (n=84), followed by Dermatological illnesses (n=35), and respiratory diseases (n=31). In contrast, Anemia, Immunity, and Aphrodisiac disorders were the diseases that were treated with the lowest number of plants (n=3), followed by Ophthalmologic disorders (n=2).
In detail, 108 diseases were treated with medicinal plants in our study zone (Figure 6). However, the treatments with medicinal plants differ significantly among cited plants. Stomachic disease was the most treated disease, with a total of 32 plants (9.82%), followed by pain treated with 23 plants (7.06%), cold, and digestive disorders treated with 22 plants (6.75%) each. The other diseases were treated with a lower number of medicinal plants.

Table 2. Treated disorders, number of used species, and Informant Consensus Factor (ICF) values

Diseases	Total number of plant species	Records	ICF
Cancer	3	74	0.97
Fever	5	96	0.96
Cardiovascular	5	80	0.95
Anemia	3	35	0.94
Aphrodisiac	3	31	0.93
Appetizer	4	40	0.92
Ophthalmologic	2	12	0.91
Neurological	7	71	0.91
Headache	9	88	0.91
Otorhinolaryngology	12	98	0.89
Immunity system	3	15	0.86
Oral	12	58	0.81
Insomnia	6	27	0.81
Rheumatology	19	92	0.80
Antiinflammatory	9	40	0.79
Urogenital	16	67	0.77
Diabete illnesses	24	99	0.77
Blood pressure	9	30	0.72
Respiratory and pulmonary	31	110	0.72
Dermatological	35	103	0.67
Digestive illnesses	84	178	0.53

In Morocco and North Africa, medicinal plants are widely used to manage various diseases (Bouyahya *et al.* 2017, Hamrouni *et al.* 2023, El-Ghazouani *et al.* 2024). However, the number and type of treated diseases with medicinal plants differ depending on the interviewed populations, geographical zones, and diversity of medicinal plants. Lemhadri *et al.* (2023) investigated the diseases treated with medicinal plants among communities of the Coastal Plateau in Safi Province (Morocco). In total, 144 medicinal species belonging to 64 families were used to manage 15 diseases, including gastrointestinal (88%), respiratory (85%), and anemia (66%). (Tlemcani *et al.* 2023) conducted an ethnobotanical survey of human diseases treated with medicinal plants in the Fez-Meknes area (central Morocco). A total of 57 medicinal species were used to manage 10 diseases including digestive affections (16%), dermatological disorders (15%), and respiratory disorders (13%). In our study, we detailed the treated disease groups and we counted the number of medicinal plants used to manage each disorder. In total, 108 diseases were treated with medicinal plants. Stomachic disease was the most treated disease with a total of 32 plants (9.82%), followed by pain treated with 23 plants (7.06%), cold, and digestive disorders treated with 22 plants (6.75%) each. The other diseases were treated with a lower number of medicinal plants. These results showed that each disease is treated with different plants. Similar results were reported in other ethnobotanical surveys. For example, 216 medicinal plants have been used by Moroccan populations to treat digestive diseases (Idm'hand *et al.* 2023). Further, a total of 104 plant species were used for inflammatory and pain treatment in north-central Morocco (Lefrioui *et al.* 2024). Moreover, 47 plant species were used for the treatment of type 2 diabetes in the Casablanca-Settat territory, Morocco (Arraji *et al.* 2024).

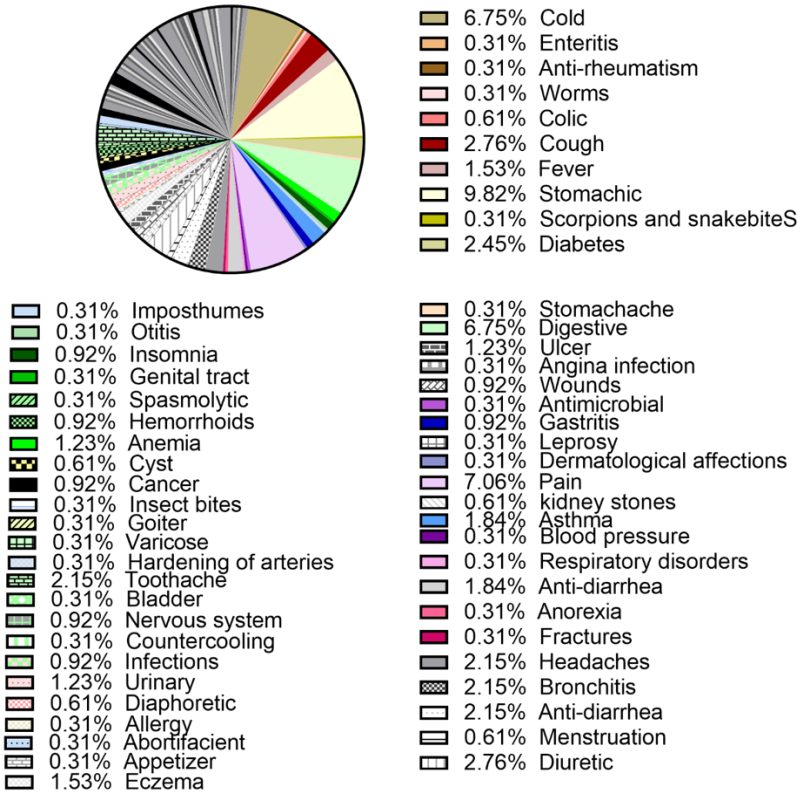

Figure 6. Treated diseases by medicinal plants in central areas of Morocco.

Interactions between parameters

The multivariate analysis (Detrended Correspondence) plot of relationships between medicinal plants and their used parts is presented in Figure 7. The results showed six correspondence groups between plants and the parts they used. The first group includes 146 medicinal plants, and participants used mostly their leaves, roots, seeds, fruits, resin, drains, seeds, flowers, leafy stems, and bulbs. Rhizome was most selected for *Allium cepa* (All.c) and *Spinacia oleracea* (Spi.o), while bulbs were the most used part for *Digitalis mauretanica* (Dig.m) and *Salix alba* (Sal.a). Further, in *Teucrium fruticans* (Teu.f) and *Origanum vulgare* (Ori.v), *the bark* (ecorce) was the most selected part by interviewed participants, while stigmates and nuts were the only used parts for *Astragalus gummifer* (Ast.g) and *Ziziphora hispanica* (Ziz.h), respectively.

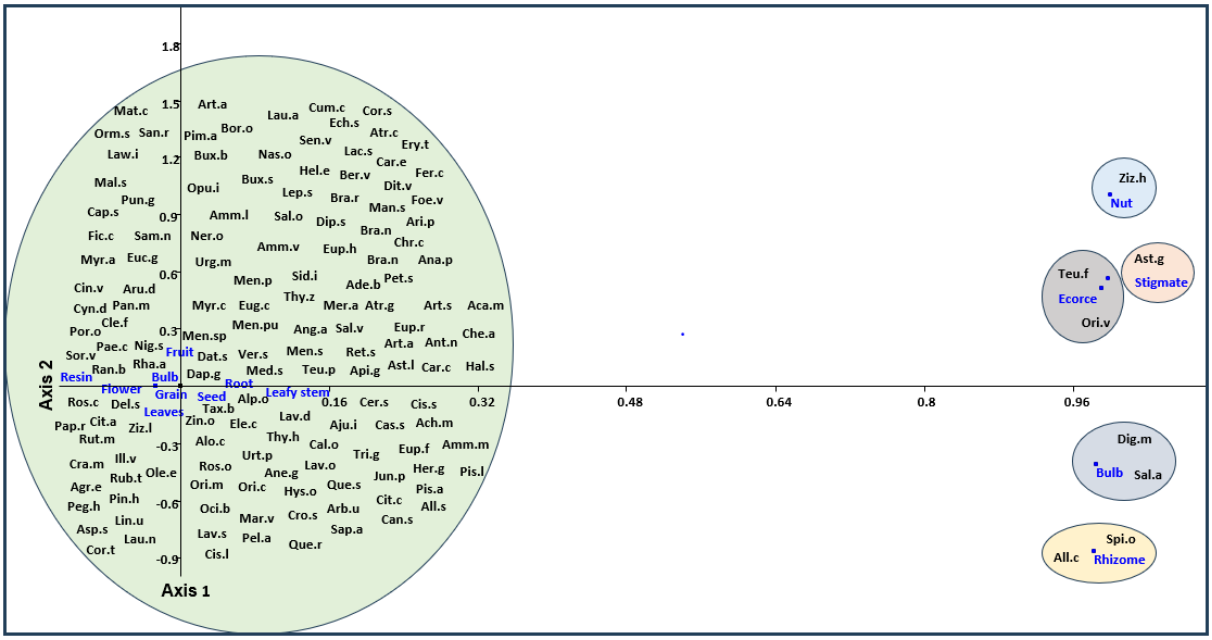

Figure 7. Detrended Correspondence plot of relationships between medicinal plants and their used parts.

The multivariate analysis (Detrended Correspondence) plot of relationships between medicinal plants and their used parts is presented in Figure 8. The obtained results showed six groups of correspondence between plants and the preparation approaches. The first group includes 142 medicinal plants, and participants prepare them mostly by fumigation, brewing, essential oils, cataplasm, and decoction. Nine plants we mostly cooked. *Citrullus colocynthis* (Cit.c) was mostly used in raw form, while *Lepidium sativum* (Lep.s) was prepared by maceration.

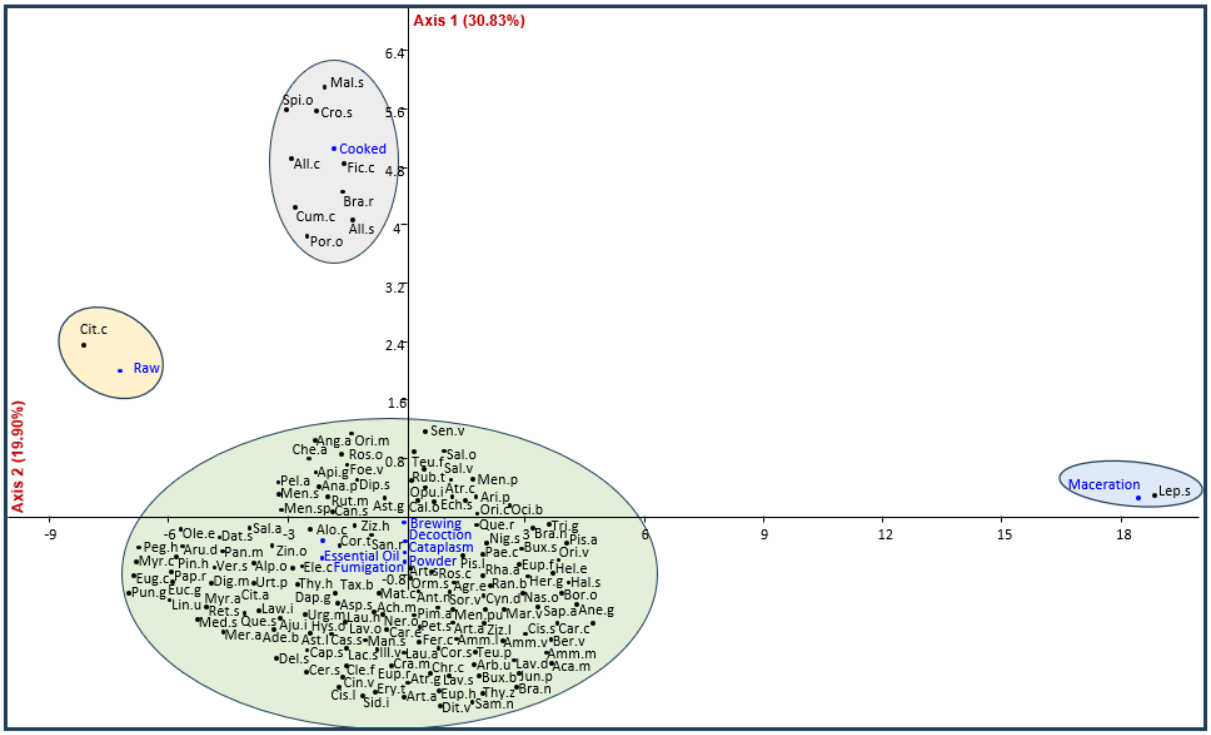

Figure 8. Detrended Correspondence plot of relationships between medicinal plants and their preparation modes.

A wide range of ethnobotanical studies conducted in different areas of Morocco have addressed the use of medicinal plants in traditional treatments. These investigations have addressed the used parts of plants and preparation methods. However, these studies neglected the correlation between plants, used parts, and preparation modes. (El-Assri *et al.* 2021) conducted an ethnobotanical survey of medicinal plants used in Taounate (North Morocco) and addressed the used parts and preparation modes. Obtained results showed that the leaves were the most used part, followed by the aerial parts. Additionally, Taounate's locals use a variety of methods to prepare medicinal herbs, particularly infusion, maceration, decoction, and fumigation. With a proportion of 25.18%, the decoction technique of preparation is used to extract the active components of plants. With a percentage of 22.50%, infusion comes in second, followed by cataplasm (11.94%). (Belhaj *et al.* 2020) recorded similar results in other regions of Morocco, mainly the Central High Atlas. (Bencheikh *et al.* 2021) inventoried the used plants, used parts, and preparation modes to deal with kidney diseases in the North-Eastern region of Morocco. With a frequency of 23%, the leaves were the most commonly used medicinal plant part, followed by the entire plant at 15%, aerial parts at 12%, fruits at 10%, seeds at 7%, and rhizomes at 6%. The remaining parts, including stems, flowers, roots, bulbs, bark, and twigs, were represented at a rate below 6%. Further, decoction was the most common preparation method used by the people of North-Eastern Morocco to treat kidney disorders (51%), followed by infusion with a percentage of 23%, maceration, powder, and juice with a percentage of 6% each. However, the cited studies didn't address the correlations between used parts, preparation methods, and species. In contrast, these studies demonstrated that leaves, roots, and seeds were the most used parts for 146 medicinal plants. Further, decoction, fumigation, brewing, essential oils, and cataplasm were the most dominant preparation methods for 142 medicinal plants. Therefore, this study demonstrated that the used parts, preparation methods, and administration approaches depend on the used plant. However, this study has some limitations. Its scope is restricted to urban areas in central Morocco, which means the results cannot be generalized to other regions, particularly rural areas. For more comprehensive conclusions, it would be beneficial to extend the study to other geographical regions and include a wider diversity of participants. Additionally, the socio-economic and cultural factors that may influence the use of medicinal plants were not addressed in this study.

For future research, it would be valuable to expand the study to other regions of Morocco to better understand geographic variations. An analysis of the chemical components of the most commonly used plants could also provide insights into their

effectiveness. Moreover, exploring the integration of traditional and modern medicine would be beneficial for optimizing medical practices.

Conclusion

In Morocco, several studies have addressed medicinal plants, including their traditional uses, the extraction of biomolecules, and culinary assays. In terms of traditional uses, ethnobotanical surveys neglected the effects of urban zones and interactions between plants, treated diseases, used parts, preparation modes, and administration forms. Therefore, this study investigated the medicinal plants and their use in urban areas of central Morocco. The main axes of the study were the diversity of plants and sociodemographic features of users, as well as relationships among treated disorders, used parts, preparation modes, and administration forms. The obtained results showed that the interviewed participants were mostly men and aged between <25 and >75 years old with a significant variation. The education level of participants was divided into five categories and was statistically dominated by primary education. Equally, the professions of participants were diverse and significantly different, with the dominance of herbalists. These parameters are suggested to impact the knowledge and selection of medicinal plants among participants. Therefore, the majority of participants combine traditional and modern medicine with a concentration of traditional treatments in small cities. In total, 153 medicinal plants were used, with 98 species in big cities compared to 149 species in small towns. In total, 21 categories of diseases were treated by medicinal plants, and digestive disorders were treated with the highest number of species, including 84 medicinal plants, followed by Dermatological illnesses with 35 plants and respiratory diseases with 31 species. To manage the treated diseases, participants used 14 parts of the mentioned pants, while preparation modes were 9 methods. Further, six administration approaches were mentioned by the interviewed participants, with the dominance of the oral approach. The multivariate analysis demonstrated that the use of medicinal plants, treated disorders, used parts, preparation, and administration approaches are statistically related. These data are new and are suggested to fill the gap of traditional medicine in municipalities and big urban centers. Equally, this study is the first to clarify the interactions between medicinal plants, treated disorders, used parts, preparation, and administration approaches.

This study highlights the economic potential of medicinal plants, particularly in urban areas, suggesting that their sustainable exploitation could enhance the income of rural populations while incorporating traditional knowledge into public health policies.

Declarations

Ethics approval and consent to participate: Before conducting interviews, prior informed consent was obtained from all participants. No further ethics approval was required.

Consent for publication: Not applicable

Availability of data and materials: The data used to support the findings of this study are included within the article

Competing interests: Not applicable

Funding: Not applicable

Author contributions: Conceptualization, N.J., M.S., F.E and A.T.; methodology, N.J., S.M, H.A and M.T.; Software, validation, formal analysis N.J, A.T.,S.Z., and S.M; Writing—original draft preparation, N.J., A.T., M.S., H.A, F.E.; Writing—review and editing, S.B. and S.E.; Visualization, F.E, M.T. and S.H; supervision, S.H., M.T and F.E.

Literature cited

Aboufaras M, Selmaoui K, Ouzennou N. 2023. Efficacies and side effects of medicinal plants used by patients with cancer in Morocco: A retrospective treatment-outcome study. Journal of Ethnopharmacology 301: 115783.

Ait Bouzid H, Ibourki M, Hamdouch A, Oubannin S, Asbbane A, Hallouch O, Bijla L, Koubachi J, Majourhat K, Gharby S. 2024. Moroccan aromatic and medicinal plants: A review of economy, ethnobotany, chemical composition, and biological activities of commonly used plants. Food and Humanity 2: 100259.

Ajjoun M, Kharchoufa L, Alami Merrouni I, Elachouri M. 2022. Moroccan medicinal plants traditionally used for the treatment of skin diseases: From ethnobotany to clinical trials. Journal of Ethnopharmacology 297: 115532.

Akdime H, Boukhira S, Mansouri LEL, El AH, Bousta D. 2015. Ethnobotanical study and traditional knowledge of medicinal plants in Ain Leuh Region (Middle-Atlas of Morocco). American Journal of Advanced Drug Delivery 3: 248-263.

Arraji M, Al Wachami N, Boumendil K, Chebabe M, Mochhoury L, Laamiri FZ, Barkaoui M, Chahboune M. 2024. Ethnobotanical survey on herbal remedies for the management of type 2 diabetes in the Casablanca-Settat region, Morocco. BMC Complementary Medicine and Therapies 24: 160.

Bachar M, Elyacoubi H, Zidane L, Rochdi A. 2020. Ethnomedicinal and traditional phytotherapeutic plants used in Bouhachem Natural Regional Park (Rif of Morocco): Case of Bni-Leit and Al-Oued districts. Journal of Pharmacy & Pharmacognosy Research 9: 284-312.

Bammou M, Daoudi A, Sellam K, El Rhaffari L, Ibijbijen J, Nassiri L. 2015. Ethnobotanical survey of Asteraceae family used in Meknes-Tafilalet region (Morocco). International Journal of Innovation and Applied Studies 13: 789-815.

Barkaoui M, Katiri A, Boubaker H, Msanda F. 2017. Ethnobotanical survey of medicinal plants used in the traditional treatment of diabetes in Chtouka Ait Baha and Tiznit (Western Anti-Atlas), Morocco. Journal of Ethnopharmacology 198: 338-350.

Belhaj S, Dahmani J, Belahbib N, Zidane L. 2020. Ethnopharmacological and Ethnobotanical study of Medicinal plants in the High Atlas Central, Morocco. Ethnobotany Research and Applications 20: .

Bellakhdar J. 1997. The traditional Moroccan pharmacopoeia: ancient Arabic medicine and popular knowledge. Editions Le Fennec, Casablanca/Ibis Press, Paris, 764 p

Bencheikh N, Elbouzidi A, Kharchoufa L, Ouassou H, Alami Merrouni I, Mechchate H, Es-safi I, Hano C, Addi M, Bouhrim M, Eto B, Elachouri M. 2021. Inventory of Medicinal Plants Used Traditionally to Manage Kidney Diseases in North-Eastern Morocco: Ethnobotanical Fieldwork and Pharmacological Evidence. Plants 10: 1966.

Beniaich G, Salim R, Ech-chihbi E, El-Hajjaji F, Rais Z, Abdellaoui A, Taleb M. 2022. Ethnobotanical survey about medicinal plants used in traditional treatment of insomnia, asthenia, and oral and gum infections in the region Fez-Meknes, Morocco. Environmental Science and Pollution Research 29: 133-145.

Benkhnigue O, Khamar H, Bussmann RW, Chaachouay N, Zidane L. 2023. Ethnobotanical and ethnopharmacological study of medicinal plants used in treating some liver diseases in the Al-Haouz Rehamna region (Morocco). Ethnobotany Research and Applications 25: 1-32.

Benlamdini N, Elhafian M, Rochdi A, Zidane L. 2014. Étude floristique et ethnobotanique de la flore médicinale du Haut Atlas oriental (Haute Moulouya). Journal of applied biosciences 78: 6771-6787.

Bouafia M, Amamou F, Gherib M, Benaissa M, Azzi R, Nemmiche S. 2021. Ethnobotanical and ethnomedicinal analysis of wild medicinal plants traditionally used in Naâma, southwest Algeria. Vegetos 34: 654-662.

Bouayyadi L, Zidane L. 2020. Botanical and medicinal profile of aromatic and medicinal plants: Case of the Gharb region, Morocco. Journal of Pharmacy & Pharmacognosy Research 8: 269-279.

Boudik S, Khamar H, Magri N, Belahbib N, Zidane L, Benkhnigue O, Dahmani J. 2024. Study of the Floristic Diversity of the Moulay Driss Zerhoun Region in the Prerif Range, Morocco. Egyptian Journal of Botany .

Bouyahya A, Abrini J, Et-Touys A, Bakri Y, Dakka N. 2017. Indigenous knowledge of the use of medicinal plants in the North-West of Morocco and their biological activities. European Journal of Integrative Medicine 13: 9-25.

Chaachouay N, Azeroual A, Ansari MKA, Zidane L. 2023. Use of Plants as Medicines and Aromatics by Indigenous Communities of Morocco: Pharmacognosy, Ecology and Conservation. Plants as Medicine and Aromatics CRC Press.

Chaachouay N, Douira A, Zidane L. 2022. Herbal Medicine Used in the Treatment of Human Diseases in the Rif, Northern Morocco. Arabian Journal for Science and Engineering 47: 131-153.

Che C-T, George V, Ijinu TP, Pushpangadan P, Andrae-Marobela K. 2024. Chapter 2 - Traditional medicine. In: SB McCreath and YN Clement, editor. Pharmacognosy (Second Edition) Academic Press. p. 11-28.

El Kourchi C, Belhoussaıne O, Elhrech H, Harhar H, Ullah R, Bari A, Maggi F, Caprioli G, Bouyahya A, Tabyaouı M. 2024. Antidiabetic, antioxidant, and phytochemical profile of Pennisetum glaucum cultivated in central-southern Morocco and imported from India. Journal of Agriculture and Food Research 16: 101197.

El Yaagoubi W, ElGhadraoui L, Soussi M, Ezrari S, Belmalha S. 2023. Large-scale ethnomedicinal inventory and therapeutic applications of medicinal and aromatic plants used extensively in folk medicine by the local population in the middle atlas and the plain of Saiss, Morocco. Ethnobotany Research and Applications 25: 1-29.

Elachouri M, Kharchoufa L, Fakchich J, Lorigooini Z, Subhasis P, Subhash M. 2021. Ancestral phytotherapeutic practices in Morocco: regards on history, current state, regulatory and safety of commonly used herbal medicine. Arabian Journal of Chemical and Environmental Research 8: 133-149.

El-Assri E, Barnossi AE, Chebaibi M, Hmamou A, Asmi HE, Bouia A, Eloutassi N. 2021. Ethnobotanical survey of medicinal and aromatic plants in Taounate, Pre-Rif of Morocco. Ethnobotany Research and Applications 22: 1-23.

El-Ghazouani F, Boukhanfer R, Yacoubi B, Zekhnini A. 2024. Ethnobotanical study of medicinal plants used in the rural area of the Western High Atlas (Morocco). Ethnobotany Research and Applications 29: 1-26.

El-Ghazouani F, El-Ouahmani N, Teixidor-Toneu I, Yacoubi B, Zekhnini A. 2021. A survey of medicinal plants used in traditional medicine by women and herbalists from the city of Agadir, southwest of Morocco. European Journal of Integrative Medicine 42: 101284.

Elhasnaoui A, Janah I, El bouny H, Amssayef A, Haidani A, Lahrach N. 2024. Medicinal plants used in the treatment of urogenital disorders in the Drâa-Tafilalet region of Southeastern Morocco: An ethnobotanical survey. Scientific African 26: e02464.

El-Hilaly J, Hmammouchi M, Lyoussi B. 2003. Ethnobotanical studies and economic evaluation of medicinal plants in Taounate province (Northern Morocco). Journal of Ethnopharmacology 86: 149-158.

Essaih S, Sahel K, Aboukhalaf A, Chamlal H, Elbiyad J, Atouife S, El-jamal S, El-Amraoui B, Belahsen R. 2024. Biodiversity of wild edible-medicinal and cosmetic plants with traditional uses in in the Moroccan province of Taounat in the Rif mountain Planta silvestre comestible- medicinal y cosmética Eestudio etnobotánico Provincia de Taounat Marruecos. 49: 07-35.

Fennane M (1957-) A. 1999. Flore pratique du Maroc : manuel de détermination des plantes vasculaires. Institut scientifique.

Fennane M, Ibn Tattou M, Ouyahya A, El Oualidi J. 2007. Practical flora of Morocco. Manual of determination of vascular plants 2. Casablanca.

Fennane M, Tattou MI, El Oualidi J. 2014. Flore pratique du Maroc: manuel de détermination des plantes vasculaires. Dicotyledones (pp), Monocotyledones/éditeurs Mohamed Fennane, Mohammed Ibn Tattou, Jalal El Oualidi. Institut Scientifique, Service d'édition.

Giannenas I, Sidiropoulou E, Bonos E, Christaki E, Florou-Paneri P. 2020. Chapter 1 - The history of herbs, medicinal and aromatic plants, and their extracts: Past, current situation and future perspectives. In: P Florou-Paneri, E Christaki, and I Giannenas, editor. Feed Additives Academic Press. p. 1-18.

González-Juárez DE, Escobedo-Moratilla A, Flores J, Hidalgo-Figueroa S, Martínez-Tagüeña N, Morales-Jiménez J, Muñiz-Ramírez A, Pastor-Palacios G, Pérez-Miranda S, Ramírez-Hernández A, Trujillo J, Bautista E. 2020. A Review of the Ephedra genus: Distribution, Ecology, Ethnobotany, Phytochemistry and Pharmacological Properties. Molecules 25: 3283.

Greff B, Sáhó A, Lakatos E, Varga L. 2023. Biocontrol Activity of Aromatic and Medicinal Plants and Their Bioactive Components against Soil-Borne Pathogens. Plants 12: 706.

Gupta V, Gupta S. 2024. Natural Plant Extracts for UV Protective Textiles. Advances in Renewable Natural Materials for Textile Sustainability CRC Press.

Hachi M, Rochdi A, Zidane L. 2016. Contribution to the ethnobotanical study of antidiabetic medicinal plants of the Central Middle Atlas region of Morocco. Lazaroa 37: 135-144. doi: 10.5209/LAZAROA.51854

Hajimonfarednejad M, Ostovar M, Hasheminasab FS, Shariati MA, Thiruvengadam M, Raee MJ, Hashempur MH. 2023. Medicinal Plants for Viral Respiratory Diseases: A Systematic Review on Persian Medicine. Evidence-Based Complementary and Alternative Medicine 2023: 1928310.

Hamrouni H, Idoudi S, Romdhane M, Elfalleh W. 2023. Ethnobotanical study of medicinal plants used in southern Tunisia. Euro-Mediterranean Journal for Environmental Integration 8: 807-821.

Hayat J, Mustapha A, Abdelmajid M, Mourad B, Ali S, Said E, Saadia B. 2020. Ethnobotanical survey of medicinal plants growing in the region of "Oulad Daoud Zkhanine" (Nador Province), in Northeastern Morocco. Ethnobotany Research and Applications 19: 1-12.

Hilah FE, Akka FB, Bengueddour R, Rochdi A, Zidane L. 2016. Étude ethnobotanique des plantes médicinales utilisées dans le traitement des affections dermatologiques dans le plateau central marocain. Journal of Applied Biosciences 98: 9252-9260.

Hu R, Lin C, Xu W, Liu Y, Long C. 2020. Ethnobotanical study on medicinal plants used by Mulam people in Guangxi, China. Journal of Ethnobiology and Ethnomedicine 16: 1-50.

Hussain S, Sher H. 2023. Indigenous ecological knowledge and wild harvesting of morel mushrooms: the resource productivity and marketing in Swat, Pakistan. Environment, Development and Sustainability 25: 1773-1791.

Ibourki M, Ait Bouzid H, Bijla L, Sakar EH, Asdadi A, Laknifli A, El Hammadi A, Gharby S. 2022. Mineral Profiling of Twenty Wild and Cultivated Aromatic and Medicinal Plants Growing in Morocco. Biological Trace Element Research 200: 4880-4889.

Idm'hand E, Msanda F, Cherifi K. 2023. Medicinal plants used for gastrointestinal disorders in Morocco. Ethnobotany Research and Applications 26: 1-29.

Iyamah PC, Idu M. 2015. Ethnomedicinal survey of plants used in the treatment of malaria in Southern Nigeria. Journal of Ethnopharmacology 173: 287-302.

Jamila F, Mostafa E. 2014. Ethnobotanical survey of medicinal plants used by people in Oriental Morocco to manage various ailments. Journal of Ethnopharmacology 154: 76-87.

Juthi TS, Uddin MZ, Hassan MA, Rashid MA. 2024. Ethnomedicinal Plants for Cardiovascular Diseases Management in Manikganj District. Bangladesh Journal of Plant Taxonomy 31: 101-121.

Kachmar MR, Naceiri Mrabti H, Bellahmar M, Ouahbi A, Haloui Z, El Badaoui K, Bouyahya A, Chakir S. 2021. Traditional Knowledge of Medicinal Plants Used in the Northeastern Part of Morocco. Evidence-Based Complementary and Alternative Medicine 2021: e6002949.

Kool A, Boer HJ de, Krüger Å, Rydberg A, Abbad A, Björk L, Martin G. 2012. Molecular Identification of Commercialized Medicinal Plants in Southern Morocco. Plos One 7: e39459.

Lamrani-Alaoui M, Hassikou R. 2018. Rapid risk assessment to harvesting of wild medicinal and aromatic plant species in Morocco for conservation and sustainable management purposes. Biodiversity and Conservation 27: 2729-2745.

Lefrioui Y, Chebaibi M, Bichara MD, Mssillou I, Bekkari H, Giesy JP, Bousta D. 2024. Ethnobotanical survey of medicinal plants used in north-central Morocco as natural analgesic and anti-inflammatory agents. Scientific African 25: e02275.

Lemhadri A, Achtak H, Lamraouhi A, Louidani N, Benali T, Dahbi A, Bouyahya A, Khouchlaa A, Shariati MA, Hano C, Lorenzo JM, Chen J-T, Lyoussi B. 2023. Diversity of Medicinal Plants Used by the Local Communities of the Coastal Plateau of Safi Province (Morocco). Frontiers in Bioscience-Scholar 15: 1.

Lin J, Puckree T, Mvelase TP. 2002. Anti-diarrhoeal evaluation of some medicinal plants used by Zulu traditional healers. Journal of Ethnopharmacology 79: 53-56.

Maache S, Tahraoui A, Nouioura G, Lakhdar Y, El-Yagoubi K, Elarabi I, Lyoussi B. 2024. Ethnobotanical knowledge of Medicinal plants in Fez-Meknes region: Origin of used species, plant-disease associations, used parts, and preparation forms. Ethnobotany Research and Applications 29: 1-20.

Martins M, Ribeiro MH, Almeida CMM. 2023. Physicochemical, Nutritional, and Medicinal Properties of Opuntia ficus-indica (L.) Mill. and Its Main Agro-Industrial Use: A Review. Plants 12: 1512.

Matowa PR, Gundidza M, Gwanzura L, Nhachi CFB. 2020. A survey of ethnomedicinal plants used to treat cancer by traditional medicine practitioners in Zimbabwe. BMC Complementary Medicine and Therapies 20: 278.

Merrouni IA, Kharchoufa L, Bencheikh N, Elachouri M. 2021. Ethnobotanical profile of medicinal plants used by people of North-eastern Morocco: Cross-cultural and Historical approach (Part I). Ethnobotany Research and Applications 21: 1-45.

Najem M, Harouak H, Ibijbijen J, Nassiri L. 2020. Oral disorders and ethnobotanical treatments: A field study in the central Middle Atlas (Morocco). Heliyon 6: e04707.

Najem M, Ibijbijen J, Nassiri L. 2019. Quantitative ethnobotanical study of toxic plants used in the traditional pharmacopoeia of the central Middle Atlas -Morocco-. Ethnobotany Research and Applications 18: 1-17.

Najem M, Nassiri L, Mderssa ME, Ibijbijen J. 2024. Originality and meaning of the vernacular names of medicinal plants common in the central Middle Atlas - Morocco. Ethnobotany Research and Applications 29: 1-39.

Noureddine B, Mostafa E, Mandal SC. 2022. Ethnobotanical, pharmacological, phytochemical, and clinical investigations on Moroccan medicinal plants traditionally used for the management of renal dysfunctions. Journal of Ethnopharmacology 292: 115178.

Pei S, Alan H, Wang Y. 2020. Vital roles for ethnobotany in conservation and sustainable development. Plant Diversity 42: 399-400.

Prance GT. 1991. What is ethnobotany today? Journal of Ethnopharmacology 32: 209-216.

Prasathkumar M, Anisha S, Dhrisya C, Becky R, Sadhasivam S. 2021. Therapeutic and pharmacological efficacy of selective Indian medicinal plants - A review. Phytomedicine Plus 1: 100029.

Redouan FZ, Yebouk C, Crisafulli A, Picone RM, Merzouki A. 2022. Ethnopharmacological preparations used for digestive system disorders in Talassemtane National Park (North of Morocco). Ethnobotany Research and Applications 24: 1-25.

Rivera D, Allkin R, Obón C, Alcaraz F, Verpoorte R, Heinrich M. 2014. What is in a name? The need for accurate scientific nomenclature for plants. Journal of Ethnopharmacology 152: 393-402.

Sarroukh M, Lahlou K, Farah M, Kebir M. 2024. Effect of global warming and new equivalent temperature zoning maps for asphalt pavement design in Morocco. Energy and Buildings 303: 113820.

Shikov AN, Mikhailovskaya IYu, Narkevich IA, Flisyuk EV, Pozharitskaya ON. 2022. Chapter 35 - Methods of extraction of medicinal plants. In: PK Mukherjee, editor. Evidence-Based Validation of Herbal Medicine (Second Edition) Elsevier. p. 771-796.

Siddique Z, Shad N, Shah GM, Naeem A, Yali L, Hasnain M, Mahmood A, Sajid M, Idrees M, Khan I. 2021. Exploration of ethnomedicinal plants and their practices in human and livestock healthcare in Haripur District, Khyber Pakhtunkhwa, Pakistan. Journal of Ethnobiology and Ethnomedicine 17: 55.

Sijelmassi A. 1993. Medicinal plants of Morocco. Le Fennec, Casablanca, Morocco .

Singh N, Sharma U, Mishra B, Kandalkar AM, Jain SK. 2024. Herbs and Herbal Formulations for the Management and Prevention of Gastrointestinal Diseases. In: SC Izah, MC Ogwu, and M Akram, editor. Herbal Medicine Phytochemistry: Applications and Trends Cham: Springer International Publishing. p. 657-691.

Soussi M, Yaagoubi WE, Benjelloun M, Ghadraoui LE. 2023. Deep ethnobotanical survey of Anise (Pimpinella anisum L.) in Morocco: variation of therapeutic uses, sources of information, and efficacy. Ethnobotany Research and Applications 26: 1-15.

Staub PO, Geck MS, Weckerle CS, Casu L, Leonti M. 2015. Classifying diseases and remedies in ethnomedicine and ethnopharmacology. Journal of Ethnopharmacology 174: 514-519.

Teixidor-Toneu I, Martin GJ, Ouhammou A, Puri RK, Hawkins JA. 2016. An ethnomedicinal survey of a Tashelhit-speaking community in the High Atlas, Morocco. Journal of Ethnopharmacology 188: 96-110.

Tlemcani S, Lahkimi A, Eloutassi N, Bendaoud A, Hmamou A, Bekkari H. 2023. Ethnobotanical study of medicinal plants in the Fez-Meknes region of Morocco. Journal of Pharmacy and Pharmacognosy Research 11: 137-159.

Ullah A, Munir S, Badshah SL, Khan N, Ghani L, Poulson BG, Emwas A-H, Jaremko M. 2020. Important Flavonoids and Their Role as a Therapeutic Agents and Molecules 25: 5243.

Yigezu Y, Haile DB, Ayen WY. 2014. Ethnoveterinary medicines in four districts of Jimma zone, Ethiopia: cross sectional survey for plant species and mode of use. BMC Veterinary Research 10: 76.

Zhang Q, Cheng Z, Fan Y, Zhang D, Wang M, Zhang J, Sommano S, Wu X, Long C. 2023. Ethnobotanical study on edible flowers in Xishuangbanna, China. Journal of Ethnobiology and Ethnomedicine 19: 43.