



Ethnomedicinal Asteraceae of Fez–Meknes: Therapeutic diversity, preparation practices, and Consensus-Based Knowledge

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Ethnobotany Research and Applications 33:56 (2026) - <http://dx.doi.org/10.32859/era.33.56.1-24>

Manuscript received: 11/12/2025 - Revised manuscript received: 28/02/2026 - Published: 01/03/2026

Research

Abstract

Background: The Fez–Meknes region in Morocco possesses considerable biocultural diversity and a long-established use of herbal medicine, wherein Asteraceae species hold significant ethnopharmacological value. Although various studies have been conducted, a consolidated, quantitative report on the applications, preparations, and community consensus surrounding Asteraceae in this area is still required.

Methods: The present research documents the medicinal role of Asteraceae species in the Fez–Meknes region of Morocco. A total of ten culturally prominent taxa were identified through a systematic selection pipeline, after which FPIC-based interviews were conducted with 193 informants. Data were analyzed quantitatively using established ethnobotanical indices.

Results: The study designated *Matricaria chamomilla* as the prominent species (UR=225; CSI=32.00), exhibiting 16 applications across metabolic, external, respiratory, dermatological, and general health categories. *Artemisia herba-alba* (CSI=36.26; UR=136) and *Artemisia absinthium* (CSI=27.20; UR=90) also showed broad therapeutic efficacy, particularly for gastrointestinal and metabolic ailments. Informant consensus was notably high for ICPC categories 'External causes' and 'Endocrine/Metabolic' (ICF=0.96), and strong for 'Respiratory', 'General', and 'Skin' (ICF=0.93–0.95). Rank-order analysis positioned *M. chamomilla* (ROP=84.06) and *Anacyclus pyrethrum* (ROP=83.33) as key species for pharmacological validation and conservation. Reduced present-day utilization of *Dittrichia viscosa* and *Achillea millefolium*, when contrasted with prior reports, may reflect transformations in the transmission of ethnomedical knowledge and treatment preferences.

Conclusions: The results confirm the centrality of Asteraceae, highlight prioritized species, and call for the incorporation of rural and elder knowledge, together with longitudinal, ecological, and clinical approaches, to sustain biocultural resilience and ensure culturally appropriate primary healthcare.

Keywords: Ethnobotanical survey, Asteraceae, Medicinal plants, Traditional medicine, Ethnobotanical indices, Fes-Meknes region, Morocco.

Background

Since ancient times, plants have constituted a source of medical care in developing countries due to limited access to modern medical resources (El Mansouri *et al.* 2011, Güler *et al.* 2019, Karaköse 2022, Mehdioui & Kahouadji 2007, Şen *et al.* 2022). In Morocco, herbal medicine is an important cultural tradition that plays a central role in the daily lives of many people in both rural and urban areas (Bellakhdar 1997, Benchâabane & Abbad 1997). The country's rich cultural and biological diversity is highlighted by its exceptional flora, which includes over 5,000 species of vascular plants, of which around 900 are endemic and over 600 possess medicinal properties (Fennane & Tattou 2008). This practice goes beyond the simple exploitation of natural resources, drawing its roots from a unique cultural heritage shaped by ethnic diversity, millennia of history, deeply rooted beliefs, and socio-cultural particularities (Alami Merrouni & Elachouri 2021, Ajjoun *et al.* 2021).

This study presents an ethnobotanical investigation of the Asteraceae family, particularly their medicinal properties in the Fez-Meknes region. This plant family, known alternatively as Compositae, is one of the largest angiosperm families. Current estimates suggest it spans roughly 1,600–1,700 genera, which accounts for a massive global count of roughly 24,000 to 34,000 species. (Fu *et al.* 2016, Palazzesi *et al.* 2022, Roebler *et al.* 2024). The Asteraceae's remarkable adaptability is expressed through both its near-global ecological distribution and its extensive physical diversity. This evolutionary success is reflected in its status as a major lineage of flowering plants, comprising 8 to 10% of all known angiosperms (Michel *et al.* 2020, Nikolić & Stevović 2015). The family's members are found in nearly every terrestrial habitat, from forests to alpine grasslands, across all continents except Antarctica (Barreda *et al.* 2012, Nikolić & Stevović 2015). This adaptive success is also reflected in the striking morphological diversity within the family, which features life forms as disparate as herbaceous annuals and perennials, shrubs, climbers, trees, and epiphytes (Zhang *et al.* 2024).

This capacity to thrive in a wide array of ecological settings, including arid, temperate, and subtropical climates, is precisely what makes the Asteraceae family so ecologically and economically versatile. Of parallel significance is the family's deep-rooted importance in ethnopharmacology, where, for thousands of years, its species have been cultivated as both crops and traditional remedies (Garcia-Oliveira 2021). Their therapeutic reputation is not unfounded; it is based on a wide array of demonstrable bioactivities (e.g., anti-inflammatory, antimicrobial, antioxidant, hepatoprotective) that arise from a rich and varied phytochemical makeup. This chemical diversity includes essential oils, polyphenols, phenolic acids, lignans, sterols, and polyacetylenes, with the latter being especially prominent in the roots (Garcia-Oliveira 2021).

The Asteraceae family in Morocco exhibits remarkable morphological diversity -encompassing annual and perennial herbs, shrubs, and occasional woody forms- that equips it to endure in the country's temperate, semi-dry, and arid environments (Panda *et al.* 2019). Such morphological flexibility supports the Asteraceae's robustness and broad presence across the region, with more than 500 species spanning the lofty High Atlas ranges down to the expansive Saharan flats. Underpinning their value in traditional medicine is a suite of potent bioactive elements, such as flavonoids, sesquiterpene lactones, and polyphenols, which lend these plants their healing attributes (Elaidi *et al.* 2024).

Ultimately, the Fes-Meknes region of Morocco illustrates a situation in which significant biocultural diversity exists alongside a threat of knowledge loss (Maach *et al.* 2024). The area's unique geography fosters both a rich medicinal flora and a deep cultural reliance on it, particularly concerning the Asteraceae family (Amaghnouje *et al.* 2020, Beniaich *et al.* 2022, El Amri *et al.* 2015, Naceiri Mrabti *et al.* 2021). The current body of literature presents a sparse and incomplete depiction of the ethnobotanical uses of plant species belonging to the Asteraceae family, indicating a pressing need for in-depth exploration; highlighting an urgent requirement for focused research. Detailed ethnobotanical assessments are thus a prerequisite for systematically compiling this intangible heritage. Such work has the parallel benefits of aiding biodiversity conservation, substantiating traditional therapeutic claims, and unlocking the potential for bioprospecting and novel sustainable health strategies (González-Tejero *et al.* 2008, Jaradat *et al.* 2016).

In light of what was stated before, this study aims to achieve several objectives. The initial step was cataloging the most significant medicinal species within the Asteraceae family utilized in the Fez-Meknes region, ensuring that key plants are identified and documented. Subsequently, this study will catalog the various preparation methods and therapeutic uses associated with these plants, documenting the traditional system in detail. A final objective is to measure the level of consensus among informants and communities, which will not only highlight the essence of shared ethnobotanical knowledge but also identify areas of local specialization. The successful completion of these objectives will yield a more integrated understanding of the biocultural landscape and provide critical data for its conservation.

Materials and Methods

Study area

Fez-Meknes, which comprises 6.7% of Moroccan land (47,705 km²), is home to 4.47 million people, which represents 12.1% of the population (HCP 2024). Its exceptional biodiversity, influenced by varied climate conditions and hydro-geographical factors, adds to the region's cultural and historical importance (Kessabi *et al.* 2023). The region's climate spans a wide range, blending Mediterranean and continental elements with pronounced local differences. Though Mediterranean patterns dominate, Boulemane stands out for its warmer winter months. Higher elevations in the Rif and Pre-Rif experience mild summers offset by cold, frost-prone winters, and the continental zones feel the impact of the Chergui wind, which tends to raise ambient temperatures (Hanchane *et al.* 2023). The ethnobotanical field study took place between March and July 2024, targeting four locations: Fez, Imouzzer, Ait Hemmad, and Azerou (Figure 1).

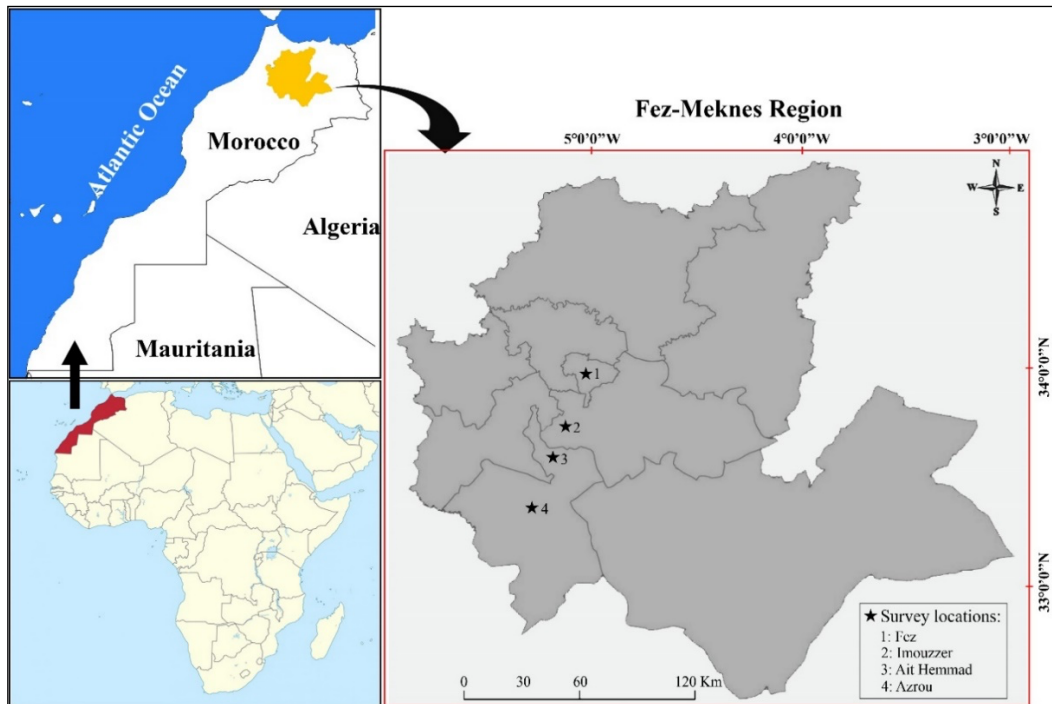


Figure 1. Locations of research sites in Fez-Meknes, Morocco.

Plant selection

To gather relevant literature, a comprehensive search was conducted. Boolean operators were utilized in combination across several databases: Scopus, ScienceDirect, PubMed, and Google Scholar. Keywords such as "Ethnobotany," "Ethnomedicine," and "Traditional medicine" were commonly combined with "Morocco" to pinpoint pertinent sources. A recurring search strategy involved the string "Ethnobotanical study AND Morocco AND Medicinal plants" for accessing suitable articles from scientific databases.

In its first part, this search employed four main steps to identify and select the published articles included in the analysis (Figure 2). A total of 476 records were initially identified through database searches. After eliminating duplicate records, 391 records remained. Records were screened based on their titles and abstracts; 306 were excluded because they were not relevant to Moroccan ethnobotany or because of the lack of full text access. Another 37 studies were excluded because they were not field studies or did not encompass key information, such as specified medicinal uses or mentioning species from the Asteraceae family. The final set included 48 articles that met the inclusion criteria.

In the next part of this search, data concerning Asteraceae plant species from each study were meticulously extracted, which allowed the development of a list of sixty-four species. Subsequently, forty-three plants were excluded due to the lack of three or more attributes, such as the part used, preparation mode, administration route, medicinal uses, and the frequency of use. The remaining species were the subject of a pilot study involving thirty local herbalists to check if they are available and well known in the region; this led to the removal of eleven additional species (Figure 2). The final list consists of the following ten species: *Achillea millefolium* L., *Anacyclus pyrethrum* (L.) Lag., *Artemisia absinthium* L., *Artemisia herba-alba*

Asso, *Calendula officinalis* L., *Dittrichia viscosa* (L.) Greuter, *Matricaria chamomilla* L., *Scolymus hispanicus* L., *Silybum marianum* (L.) Gaertn., *Taraxacum campylodes* G.E.Haglund.

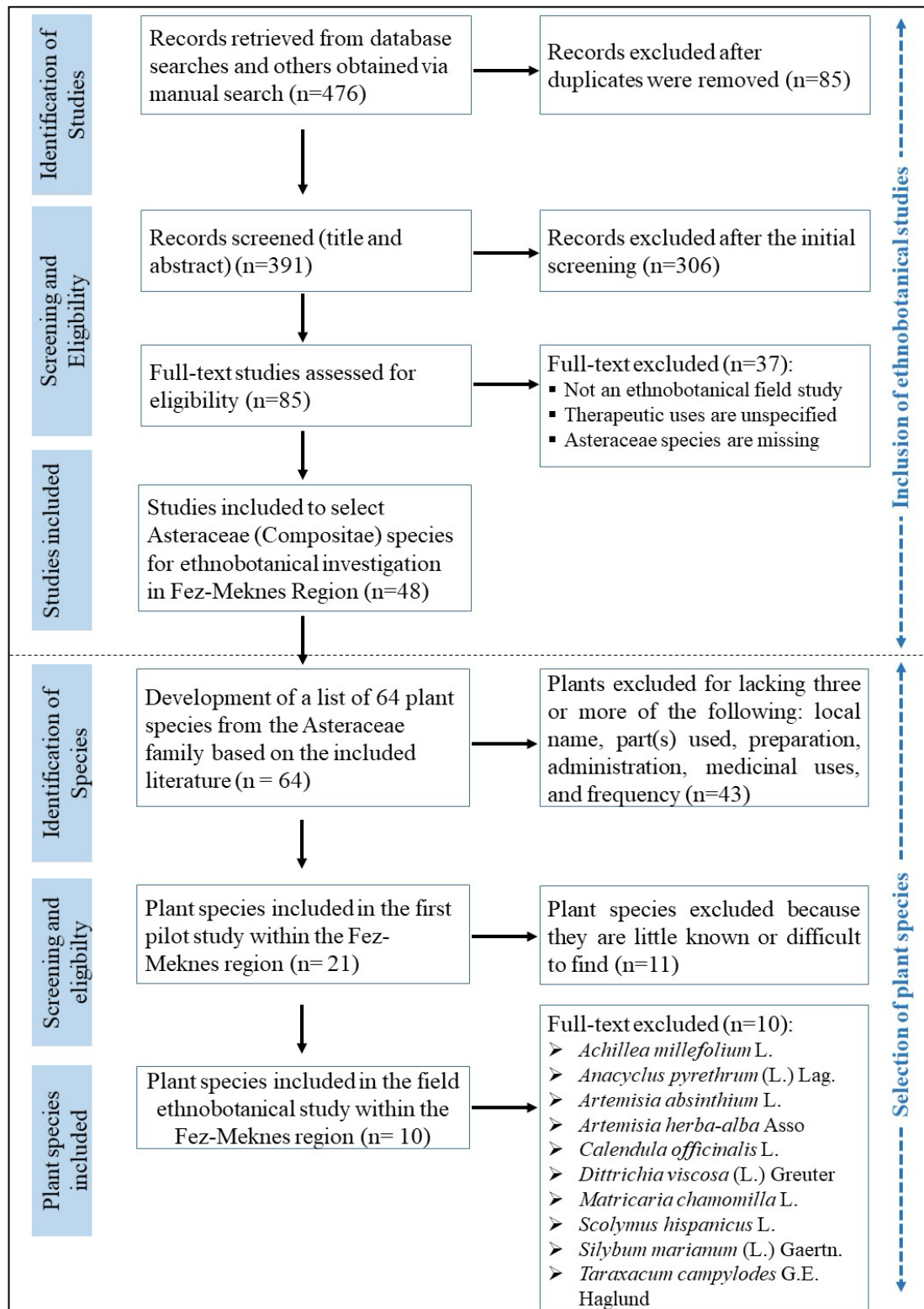


Figure 2. Flow diagram illustrating Asteraceae plant species selection for field research.

Plant collection and identification

All mentioned plants were collected. Some were acquired directly from a local herbalist's shop, and others were harvested in the wild. Taxonomic identification of plant species follows the Moroccan identification keys; (Fennane *et al.* 1999, Fennane

et al. 2007, Fennane *et al.* 2014) 'Vascular Flora of Morocco, Inventory and Chorology' (Fennane *et al.*, 2005), 'Flora of North Africa' (Maire 1952-1987), 'Moroccan Plants Catalogue,' and 'Flora of Sahara' (Jahandiez & Maire 1934, El-Gharbaoui *et al.* 2017). All scientific names of plant species were examined through The Plant List database (<http://www.theplantlist.org>) and the World Flora Online database (<https://wfoplantlist.org/>). Voucher specimens of each plant were coded and deposited in the herbarium of the Faculty of Sciences, Dhar El-Mahraz, Fez. Additionally, a detailed botanical album was constructed, offering visual documentation of each plant species through clear and informative images for use later in the survey.

Ailment categories

The reported therapeutic uses of Asteraceae species were classified according to the International Classification of Primary Care (ICPC). This is a hierarchically structured system, first established for primary care settings, which classifies health conditions according to both the body system involved and the typical clinical features observed (Cho *et al.* 2022). A key advantage of the ICPC for ethnobotanical research is its capacity to bridge the gap between biomedical and folk taxonomies of disease. Our analysis drew upon seventeen of its chapters, which spanned the digestive, respiratory, cardiovascular, musculoskeletal, neurological, and urological systems, in addition to general symptoms, dermatological issues, endocrine/metabolic conditions, psychological ailments, matters of reproductive health, and social problems (Staub *et al.* 2015). A simplified, fourteen-category version of the ICPC was developed by collapsing specific domains, ensuring the classification mirrored the terminology and health issues reported by informants (Table 1). Each use-report -defined as a participant citing a plant for a specific ailment within a single category- was recorded once per category, even if multiple ailments within the same category were mentioned.

Table 1. Organized list of ailments and disorders using ICPC model.

Code	Category	Manifestations
A	General and Unspecified	Non-specific symptoms such as fever, fatigue, malaise, general weakness, or unexplained discomfort.
B	Blood, Blood Forming Organs and Immune Mechanism	Anemia, leukemia, immune deficiencies (e.g., HIV/AIDS), bleeding disorders, lymphadenopathy.
D	Endocrine, Nutritional and Metabolic	Diabetes mellitus, thyroid disorders, obesity, malnutrition, vitamin deficiencies.
F	Mental and Behavioral Disorders	Mental health conditions like depression, anxiety, and schizophrenia, as well as behavioral problems like substance abuse and eating disorders.
K	Eye Disorders	diseases and conditions affecting the eye, such as conjunctivitis, cataracts, refractive errors and glaucoma.
L	Ear Disorders	Diseases affecting the ear, such as otitis media, tinnitus, ear infections. and hearing loss.
N	Respiratory System Disorders	Diseases affecting the respiratory system, including pneumonia, bronchitis, asthma, and chronic obstructive pulmonary disease.
P	Cardiovascular Problems	Diseases affecting the heart and blood vessels, including coronary heart disease, heart failure, arrhythmias, and hypertension.
R	Digestive Problems	Diseases affecting the digestive system, such as gastritis, peptic ulcers, and irritable bowel syndrome.
S	Skin and Subcutaneous Tissue	Diseases affecting the skin, hair, and nails, including eczema, psoriasis, and acne.
T	Musculoskeletal Problems	Diseases affecting the muscles, bones, and joints, including arthritis, back pain, and osteoporosis.
U	Genitourinary Problems	Diseases affecting the urinary and reproductive systems, such as urinary tract infections, kidney disease, and prostate problems.
X	External Causes of Morbidity	Injuries and other health problems caused by external factors, such as accidents, falls, and poisoning.
Y	Social Problems	Environmental factors that can impact health, such as poverty, unemployment, and domestic violence.

Interviews for ethnobotanical data collection

A total of 193 informants provided ethnobotanical data through in-person interviews conducted between March and July 2024, covering four localities: Fez (n=139), Azrou (n=28), Imouzzer (n=15), and Aït Hemmad (n=11). Due to the uneven distribution of traditional knowledge, this research favored depth over breadth by adopting a mixed purposive sampling method. This approach deliberately sought out key participants with specialized ethnobotanical knowledge—local herbalists, herb sellers, traditional healers, elderly women, and other knowledgeable individuals—whose specialized ethnobotanical expertise is often missed by random probability methods (Palinkas *et al.* 2015, Tongco 2007). To ensure geographic representation, we stratified the collection sites into urban (Fez), mid-sized (Imouzzer and Azrou), and rural (Aït Hemmad) clusters. Where community networks were tight or informants were elusive, a secondary chain-referral (snowball) mechanism was activated, leveraging initial expert contacts to broaden the participant pool (Agize *et al.* 2022, Espinosa *et al.* 2013, Tongco, 2007).

The current research was conducted in full compliance with international ethical standards for human participation. By conducting interviews in the participants' native Moroccan dialects, we were able to provide a comprehensive account of the methodology and the voluntary nature of the work, allowing for a truly informed consent process (Rosenthal 2006). We eschewed financial incentives to maintain the integrity of the data, ensuring that informants understood their right to cease participation at any time (Akerreta *et al.* 2007, Tahraoui *et al.* 2023). Anchored in the ISE Code of Ethics, the study's ethical framework mandated that consent documentation—whether in written or oral form—be adapted to align with local practices. Following the anonymization of datasets to ensure individual privacy, the findings were employed exclusively for academic purposes.

During this investigation, a structured questionnaire was administered in two stages. The first stage documented the participants' demographic characteristics (gender, age, informant category, education). In the second stage, a botanical album with photographs of Asteraceae species was used as a visual aid during interviews. For each species shown, the interview protocol prompted participants for its identification, its name in the local dialect, and a full account of its medicinal applications. The investigation also meticulously documented the plant's ecological distribution, which parts were utilized, the procedures for its preparation, and the ways of its administration. The systematic nature of this data collection was intentionally designed to build a comprehensive ethnobotanical record, while the entire engagement was predicated on the foundational ethical commitments to informed consent and the respect for the informants' individual autonomy.

Data analysis

Data were initially organized using Microsoft Excel 2016. Subsequently, a set of quantitative indices was determined to analyze ethnobotanical data, including Use Report per species (UR), Fidelity Level (FL), Frequency of Citation (FC), Relative Frequency of Citation (RFC), Use Value (UV), Informant Consensus Factor (ICF) and Cultural Significance Index (CSI). The analysis and data graphing were mainly performed using R 4.5.1 software for Windows. Various R packages were used to efficiently accomplish these tasks. Most of the quantitative ethnobotanical indices (UR, FL, FC, RFC, UV) were computed using the 'ethobotanyR' package (Whitney 2022). ICF and CSI were determined using the 'dplyr' and 'tidyr' packages. The 'FactoMineR,' 'factoextra,' and 'ggpubr' packages were used for PCA analysis. The 'circlize' package was used for creating chord diagrams (Gu *et al.* 2014, Maach *et al.* 2024).

Use Report per species (UR)

The cultural significance of plant taxa is frequently assessed through an analysis of the cumulative number of use-reports (UR) attributed to each species, herein represented by the symbol "s." The mathematical formula of this calculation is as follows:

$$UR_s = \sum_{u=1}^{u=NC} \sum_{i=1}^{i=N} UR_{ui}$$

URs represents the summation of all documented applications for a particular species (s), as reported by all informants (i.e., from i_1 to i_N), disaggregated by relevant use-categories. The operationalization of this involves first tallying the number of informants who independently mention each specific use-category (NC) for a given species, and then aggregating all recorded uses within each of these distinct use-categories (from u_1 to u_{NC}) (Tardío & Pardo-de-Santayana 2008).

Frequency of Citation (RFC)

The RFC index, as outlined by Tardío and Pardo-De-Santayana (2008), was assessed by dividing the count of informants mentioning species use (FC) by the overall participating informant count (N) in the survey ($RFC=FC/N$). The citation frequency (FC) was determined using the following ratio:

$$FC = \frac{\text{Number of times a particular species was mentioned}}{\text{Total number of times that all species were mentioned}}$$

The value of RFC spans from "0," indicating no mention of plant usefulness, to "1," signifying unanimous recognition of plant utility among informants.

Use value for one species (UV)

The Use Value index (UV) was used to quantify a species' local significance based on the frequency of usage reports provided by informants within the research region. This index is commonly employed to identify the most significant species to the local community (Leonti 2022, Vitalini *et al.* 2013). It is calculated as follows:

$$UV_s = \sum U_i / N$$

That is, UVs is defined as the ratio between the total number of use citations for a given species and the number of informants N. This ratio serves as the basis for determining the relative importance of species, thereby reflecting their cultural and therapeutic relevance (Andrade-Cetto & Heinrich 2011).

Cultural significance index (CSI)

The cultural significance index (CSI) served as the metric for assessing the relationship between reported uses of a particular species and the inter-informant agreement concerning that knowledge. This index was determined in accordance with the following formula:

$$CSI = \sum (i \times e \times c) \times CF$$

Herein, (i) is to the management category of the species, with a score of 2 assigned to cultivated or managed species and 1 to wild, unmanaged species. The variable (e) indicates use preference, where 2 is attributed to preferred species and 1 to non-preferred species. The parameter (c) denotes the frequency of use, with 2 for species frequently reported by informants and 1 for those seldom cited. The correction factor (CF) is calculated as the ratio between the citation frequency of the species and that of the most frequently reported species (Majeed *et al.* 2020).

Correlation study

Correlation between different parameters such as RFC, CSI, and UVs were determined and visualized using Pearson's correlation using 'ggpubr' and 'ggplot2' in R software for Windows (v 4.5.1) (Iqbal *et al.* 2021).

Fidelity Level (FL%)

The Fidelity Level (FL) denotes a quantitative parameter developed to highlight the primary utilization of a plant species and to analyze the relative weight of informant reports distributed across different categories of use (Ogwu *et al.* 2025). Its calculation is performed using the formula presented below:

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

Where N_p is the number of use reports for a specific use category and N is the total number of informants citing the species for any use category. FL values range from 0 to 100%, with elevated values suggesting a higher prevalence and significance of use (Friedman *et al.* 1986).

Rank Order Priority (ROP)

Plant species having different values of fidelity level (FL) and relative popularity level (RPL) were attributed the correction factor (ROP) to properly rank the reported species. The ROP was calculated by multiplying FL and RPL (Umair *et al.* 2017, Majeed *et al.* 2020):

$$ROP = FL \times RPL$$

When species exhibit the same Fidelity Level (FL), their therapeutic potential cannot be separated. To resolve this, the Relative Popularity Level (RPL) is applied, defined as the ratio of ailments treated by a species to the total informants reporting those ailments. Species cited by more than half of informants are classified as popular, while the rest are non-popular. For popular species, RPL is assigned a value of 1, whereas 0 indicates no reported curative role (Majeed *et al.* 2020).

Informant Consensus Factor (ICF)

The Informant Consensus Factor (ICF), also known as F_{ic} , represents a culturally significant metric designed to evaluate the degree of agreement among informants concerning the use of plant species in the treatment of specific ailments. Initially formulated by Trotter and Logan (1986) and later streamlined by Heinrich *et al.* (2009), the ICF functions by classifying ailments into defined categories and calculating the degree of consensus in plant selection. A value close to 1 reflects a high level of uniformity, typically associated with the use of well-established species, whereas a value near 0 denotes a lack of agreement, implying random or inconsistent plant usage. The ICF thereby provides a quantitative framework linking the number of reported uses to the diversity of taxa employed within each ailment category, as represented by the following formula:

$$ICF = \frac{N_{ur} - N_t}{N_{ur} + N_t}$$

N_{ur} indicates the total number of usage reports for each disease category, while N_t denotes the number of species used within that specific category (Andrade-Cetto & Heinrich 2011).

Results

Demographic features

Table 2 presents the demographic features of the 193 informants, a group diverse yet skewed toward urban residence and higher education. This is largely attributable to Fez city, which alone represents 72% of respondents. Rather than constituting a methodological weakness, this predominance reflects Fez's demographic scale and its recognized role as a center of ethnobotanical knowledge and commercial hub, making the sample a faithful representation of regional practices. Women represented 55% of the sample, a modest majority that may have enhanced the reporting of household remedies. Age groups were well distributed: 44% were 30–50 years, 29% in their twenties and thirties, and 27% over 50, ensuring both continuity and generational change were represented. Urban dwellers dominated (77%), while suburban (17%) and rural (6%) participants were fewer, raising the possibility of urban-specific adaptations that deserve closer analysis. Marital status was skewed toward married respondents (72%), which may have amplified family-centered accounts. Most participants were relatively well educated, with 76% having completed secondary or higher studies. By contrast, 7% had only primary schooling and 17% had none. This pattern likely contributed to the clarity of responses but may have limited the representation of tacit, experience-based knowledge often carried by elders with little formal education. The demographic profile, while robust, suggests that future work should seek greater balance.

Table 2. General demographic data of interviewed informants.

Gender	Male	45%
	Female	55%
Age (years)	From 20-30	29%
	From 30-50	44%
	> 50	27%
Locality	Urban	77%
	Suburban	17%
	Rural	06%
Marital status	Married	72%
	Single	28%
Education	No formal education	17%
	Primary education	07%
	Secondary or tertiary education	76%

Quantitative analysis of ethnomedicinal knowledge on Asteraceae species

As detailed in Table 3, the ethnobotanical compilation of ten Asteraceae species in Morocco's Fez-Meknes area reveals the deep-rooted local remedies at play, with quantitative indices like use reports (UR), relative frequency of citations (RFC), use value (UV), and cultural significance index (CSI) underscoring the family's prominent position in traditional care practices within this evolving Mediterranean environment.

According to the ethnomedicinal data, *M. chamomilla* stands out as the most dominant species, a status quantified by its higher Use Report (UR) and Relative Frequency of Citation (RFC) values. Its versatility is evidenced by 16 recorded therapeutic uses, highlighting its importance in treating diabetes and inflammation. Additionally, the species is frequently sought for its sedative properties and its role in healing wounds and managing psychological distress. Infusions are the customary mode of administration, prepared for oral, otic, and topical use. This practice yields a Use Value (UV) of 1.18 and a Cultural Significance Index (CSI) of 32.00. These figures confirm the species' position as a cornerstone of the Berber-Arabic pharmacopoeia, a status reinforced by its ready availability in wild habitats.

Following in importance are *A. herba-alba* and *A. absinthium*. The therapeutic applications of both plant species extend to approximately 21 ailments. Their therapeutic action is predominantly centered on gastrointestinal problems, parasitic diseases, and health conditions linked to external etiologies. The greater proportion of remedies are prepared from the leaves or other above-ground parts, typically rendered as decoctions, infusions, or finely ground powders. These plant materials are frequently derived from cultivated or semi-managed populations, a circumstance that enhances their management scores within the CSI framework and highlights the genus's established role in treating digestive, urinary, and infectious disorders typical of arid regions.

In contrast, species such as *D. viscosa* and *A. millefolium* are linked to more narrowly defined therapeutic applications. These primarily target dermatological disorders or health concerns related to diabetes and societal issues. Their commensurately reduced Use Values (UVs), approximating 0.12, and Relative Frequencies of Citation (RFCs), ranging from 0.10 to 0.11, may be interpreted as indicators of either localized scarcity or an established preference for alternative therapeutic options within the local ethnobotanical repertoire.

The consistent identification of eight wild species underscores a significant dependence on spontaneous flora, with roots (e.g., in *A. pyrethrum*) or aboveground components being preferentially employed for standard preparations such as macerations and infusions. While this pattern generally supports sustainable, low-intervention foraging, it concurrently raises important considerations regarding the ecological sustainability of less prominent species, for instance, *T. campyloides* (CSI=1.36, whose primary uses pertain to ocular and digestive relief). The extensive array of multilingual vernacular names eloquently demonstrates cultural assimilation and the enduring nature of oral traditions, a perspective further supported by the observed congruence between elevated Cultural Significance Index (CSI) values and Use Values (UVs) exceeding 0.5 for the most significant species.

Relationships among RFC, UV, and CSI were examined to test the internal alignment of these ethnobotanical measures and to elucidate how citation prevalence, use multiplicity, and cultural valuation correspond across taxa (Fig. 3A–C). A robust positive correlation was found between RFC and UV ($r = 0.96, p < 0.001$), showing that taxa more frequently cited are those with more varied uses. RFC was also positively associated with CSI ($r = 0.83, p < 0.01$), implying that commonly referenced species typically possess elevated cultural significance. The link between CSI and UV was likewise strong and significant ($r = 0.86, p < 0.01$), underscoring that culturally prominent taxa tend to combine diverse uses with practical ethnomedicinal importance. In essence, this strong correlation between indices indicates that culturally significant species (high CSI) are frequently cited (high RFC) and versatile (high UV), with the CSI being most aligned with citation-based metrics (Majeed *et al.* 2020).

Table 3. Asteraceae medicinal plants in the Fez-Meknes region: species, local names, distribution, parts used, form, and quantitative indices.

Species [Voucher number]	Local name	Ecological distribution	Part used	Form and (use)	Medicinal use	Indices			
						UR	RFC	UV	CSI
<i>Anacyclus pyrethrum</i> (L.) Lag. [AS25-01]	tāgendest, ēāqer qerhā, lggest	Wild	Aerial parts, Roots	Maceration (Oral, Otic, Topical)	A [if], B [al], F [sd], L [ea], N [cc, ri], P [ar], R [od, ta, st], S [dm], T [rm, sc], U [ut], X [po], Y [vl]	113	0.19	0.59	16.07
<i>Matricaria chamomilla</i> L. [AS25-02]	bābnūj, bābūnej	Wild	Aerial parts, Flowers	Infusion (Oral, Otic, Topical)	A [if], D [db], F [ax, ir, sd], K [ei], L [ti], P [ht], R [ig, uc], S [wh], T [rm, rp], U [md] , X [po, wd]	225	0.36	1.18	32.00
<i>Taraxacum campylodes</i> G.E.Haglund [AS25-03]	adgurrū hindabā	Wild	Whole plant, Aerial parts	Infusion (Ocular, Oral)	K [cj, ei], R [dg], S [si], U [ut], A[if]	51	0.13	0.27	1.36
<i>Silybum marianum</i> (L.) Gaertn [AS25-04]	šouk jmel, bū zerwāl, tawra	Wild	Seeds	Decoction, Maceration (Oral, Topical)	A [if], B [al], D [db], R [ap, gs, lp], S [si], U [md]	44	0.08	0.23	1.56
<i>Scolymus hispanicus</i> L. [AS25-05]	ēāšlūj, gernīna, tağdut	Wild	Aerial parts, Stem, Roots	Decoction (Oral, Ocular)	D [db], K [ie], S [si], T [rp], A [if, fv], X [po]	30	0.05	0.16	0.80
<i>Dittrichia viscosa</i> (L.) Greuter [AS25-06]	magramān , amerril	Wild	Leaves	Maceration, Powder (Oral, Topical)	S [dm, si, wh]	22	0.11	0.12	0.39
<i>Calendula officinalis</i> L. [AS25-07]	azwiwel, bū kruruš, jemra,	Wild	Flowers	Infusion (Oral), Cataplasm (Topical)	A [if], B [al], D [db], S [si, wh], T [ms, rp]	59	0.08	0.31	3.15
<i>Artemisia absinthium</i> L. [AS25-08]	šība, šibat al-‘ajūj	Cultivated	Aerial parts, Leaves	Infusion (Oral), Cataplasm (Topical)	A [fv, if, sw], B [al], D [db], F [dp], K [cj], L [ti], N [cc], R [ig, ip], S [si], T [rp], U [md, ut], X [po, ss]	90	0.15	0.47	27.20
<i>Achillea millefolium</i> L. [AS25-09]	eḥhala, rišiya	Wild	Leaves, Flowers	Decoction, Infusion (Oral, Topical)	D [db], K [cj], S [wh], Y [vl]	22	0.10	0.12	0.59
<i>Artemisia herba-alba</i> Asso [AS25-10]	šīḥ, īzrī, ifsī	Wild, Cultivated	Aerial parts, Leaves	Decoction, Infusion, Powder (Oral, Topical)	A [fv, if], B [al], D [db], K [cj, ei], L [ti], N [cc], R [ad, dg, he], S [co], T [rp], U [md, ut], X [po]	136	0.23	0.71	36.26

Ethnobotany indices:

CSI: Cultural significance index, RFC: Relative frequency of citations, UR: Use report, UV: Use value.

Use categories:

A: General and Unspecified, B: Blood, Blood Forming Organs and Immune Mechanism, D: Endocrine, Nutritional and Metabolic, F: Mental and Behavioral Disorders, K: Eye Disorders, L: Ear Disorders, N: Respiratory System Disorders, P: Cardiovascular Problems, R: Digestive Problems, S: Skin and Subcutaneous Tissue, T: Musculoskeletal Problems, U: Genitourinary Problems, X: External Causes of Morbidity, Y: Social Problems.

Manifestations:

Abdominal pain (ap), Allergies (al), Antidiarrheal (ad), Anxiety (ax), Arrhythmias (ar), Choleric (ch), Common cold (cc), Conjunctivitis (cj), Cosmetic (co), Depression (dp), Dermatitis (dm), Diabetes (db), Digestive (dg), Ear infections (ea), Eye infections (ei), Fever (fv), Gas (gs), Helminthiasis (he), Hemostatic (hm), Hypertension (ht), Indigestions (ig), Inflammation (if), Intestinal parasites (ip), Irritation (ir), Liver problems (lp), Menstrual disorders (md), Muscle spasms (ms), Oral diseases (od), Poisoning (po), Respiratory issues (ri), Rheumatic pain (rp), Rheumatism (rm), Sciatica (sc), Scorpion sting (ss), Sedative (sd), Skin infections (si), Stomatitis (st), Swelling (sw), Tinnitus (ti), Toothaches (ta), Ulcers (uc), Urinary tract problems (ut), Violence (vl), Wound (wd), Wound healing properties (wh).

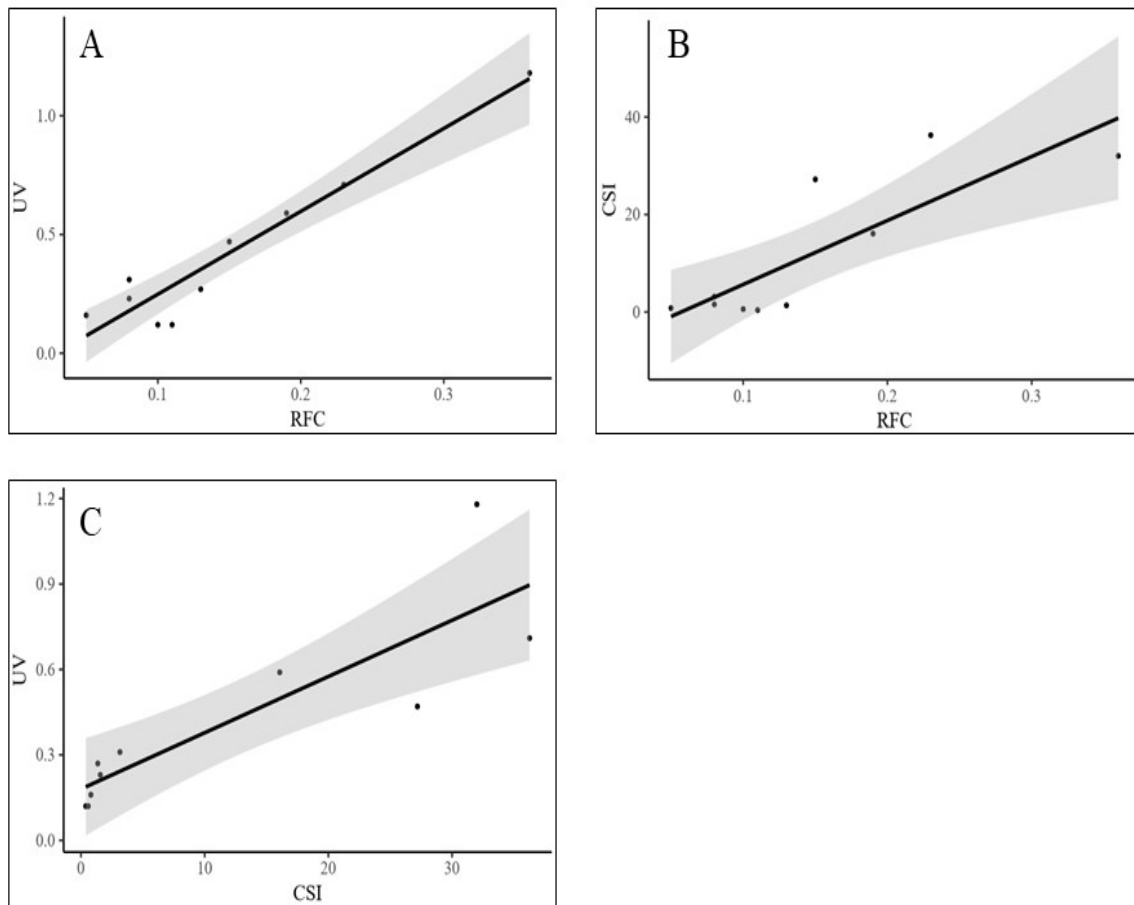


Figure 3: Correlations between quantitative indices. A) RFC vs UV, B) RFC vs CSI, and C) CSI vs UV. CSI: Cultural significance index, RFC: Relative Frequency of Citation, UV: Use value.

Relative popularity of species

The joint assessment of fidelity, popularity, and priority indices among the ten Asteraceae taxa of the Fez–Meknes region reveals a well-defined stratification in community perception and therapeutic deployment (Table 4).

Table 4. Asteraceae medicinal plants in the Fez-Meknes region with FL, RPL and ROP.

Species name	I _u	NA	MUC	I _p	FL (%)	RPL	ROP
<i>Anacyclus pyrethrum</i> (L.) Lag.	36	11	D	30	83.33	1	83.33
<i>Matricaria chamomilla</i> L.	69	11	X	58	84.06	1	84.06
<i>Taraxacum campylodes</i> G.E.Haglund	26	5	D	26	100	0.75	75.36
<i>Silybum marianum</i> (L.) Gaertn	16	5	D	15	93.75	0.55	51.63
<i>Scolymus hispanicus</i> L.	10	6	D	10	100	0.46	46.38
<i>Dittrichia viscosa</i> (L.) Greuter	22	1	S	10	100	0.29	28.99
<i>Calendula officinalis</i> L.	16	5	S	15	93.75	0.64	59.78
<i>Artemisia absinthium</i> L.	28	11	D	18	64.29	0.81	52.18
<i>Achillea millefolium</i> L.	19	4	S	10	100	0.46	46.38
<i>Artemisia herba-alba</i> Asso	44	11	D	30	68.18	1	68.18

I_u: Sum of participants who claimed the use of a plant species for any category of ailments, NA: Number of ailments treated, MUC: Major use category, I_p: Number of participants who reported the use of a plant species for specific category of ailments, FL: Fidelity level, RPL: Relative popularity level, ROP: Rank order priority.

Use categories: D: Endocrine, Nutritional and Metabolic, S: Skin and Subcutaneous Tissue, X: External Causes of Morbidity.

M. chamomilla emerges as the most prominent taxon, with the highest informant use count ($I_u = 69$), broad ailment coverage ($NA = 11$), high fidelity ($FL = 84.06\%$), and the maximum relative popularity level ($RPL = 1$), yielding the highest rank order priority ($ROP = 84.06$). *A. herba-alba* shows a comparable breadth of citation ($I_u = 44$; $NA = 11$) but lower fidelity ($FL = 68.18\%$)—yet its relative popularity is also maximal ($RPL = 1$), underscoring that popularity can be decoupled from strict consensus on a single indication. *A. pyrethrum* and *C. officinalis* combine high fidelity ($FL = 83.33\%$ and 93.75% , respectively) with elevated relative popularity ($RPL = 1$ and 0.64), translating into substantial priority ($ROP = 83.33$ and 59.78). By contrast, several species attain perfect or near-perfect diagnostic consensus but more modest popularity: *T. campylodes* ($FL = 100\%$, $RPL = 0.75$), *S. hispanicus* ($FL = 100\%$, $RPL = 0.46$), *A. millefolium* ($FL = 100\%$, $RPL = 0.46$), and *D. viscosa* ($FL = 100\%$, $RPL = 0.29$). The reduced relative popularity of these plants exerts a downward influence on ROP scores, despite consistent reporting of their use, thereby indicating their association with specialized therapeutic practices of limited diffusion. *S. marianum* follows a similar trajectory ($FL = 93.75\%$, $RPL = 0.55$), resulting in a moderate priority level ($ROP = 51.63$). Overall, the data show that relative popularity of species is a decisive modifier of rank order priority: taxa simultaneously characterized by strong informant consensus and high popularity—exemplified by *M. chamomilla* and *A. pyrethrum*—emerge as focal candidates for pharmacological follow-up and conservation planning, whereas highly faithful but less popular species occupy niche therapeutic roles.

Therapeutic uses of Asteraceae species in the Fez-Meknes region

Drawing together the quantitative indicators in Table 5 and the visual syntheses in Figures 4–6, the ethnopharmacological profile of Asteraceae use in the Fez–Meknes region is both strongly convergent and hierarchically organized around a small set of high-demand ICPC categories and culturally central taxa. Table 5 shows very high informant agreement ($ICF > 0.95$) for Mental/Behavioral Disorders (F), Cardiovascular Problems (P), External Causes (X), and Endocrine/Nutritional/Metabolic Disorders (D), alongside large numbers of use reports and relatively compact species pools, with similarly elevated consensus ($ICF > 0.9$) for Respiratory conditions (N), General/unspecified (A) and Skin/subcutaneous tissue (S) complaints. By contrast, consensus weakens for Digestive (R) and Social (Y) problems, where small report bases and more diffuse species selection suggest idiosyncratic practices.

Table 5. Informant Consensus Factor (ICF) analysis of Asteraceae plant species reported by informants for treating various categories of ailments

Use category	N_{ur}	N_t	ICF
F	3	1	1
P	3	1	1
X	108	5	0.96
D	191	9	0.96
N	63	4	0.95
A	96	8	0.93
S	122	10	0.93
B	55	6	0.91
U	27	4	0.89
K	43	6	0.88
T	48	7	0.87
L	22	4	0.86
R	8	3	0.71
Y	3	2	0.50

ICF: Informant Consensus Factor; N_t : number of species utilized within a category; N_{ur} : count of use reports

Use categories: A: General and Unspecified, B: Blood, Blood Forming Organs and Immune Mechanism, D: Endocrine, Nutritional and Metabolic, F: Mental and Behavioral Disorders, K: Eye Disorders, L: Ear Disorders, N: Respiratory System Disorders, P: Cardiovascular Problems, R: Digestive Problems, S: Skin and Subcutaneous Tissue, T: Musculoskeletal Problems, U: Genitourinary Problems, X: External Causes of Morbidity, Y: Social Problems.

These patterns align closely onto the ICPC-structured heat map (Figure 4), in which the densest cells concentrate in D, S, X, and A categories, led by *M. chamomilla* (mc) with substantial spillover across these domains, and supported by *A. herba-alba* (ah), *A. absinthium* (aa), and *A. pyrethrum* (ap), these taxa with high versatility seem to be a panacea used to treat a vast

range of various ailments in local traditional medicine. Moreover, narrowly focused contributions from *A. millefolium* (am) and *D. viscosa* (dv) reinforce the salience of Skin indications.

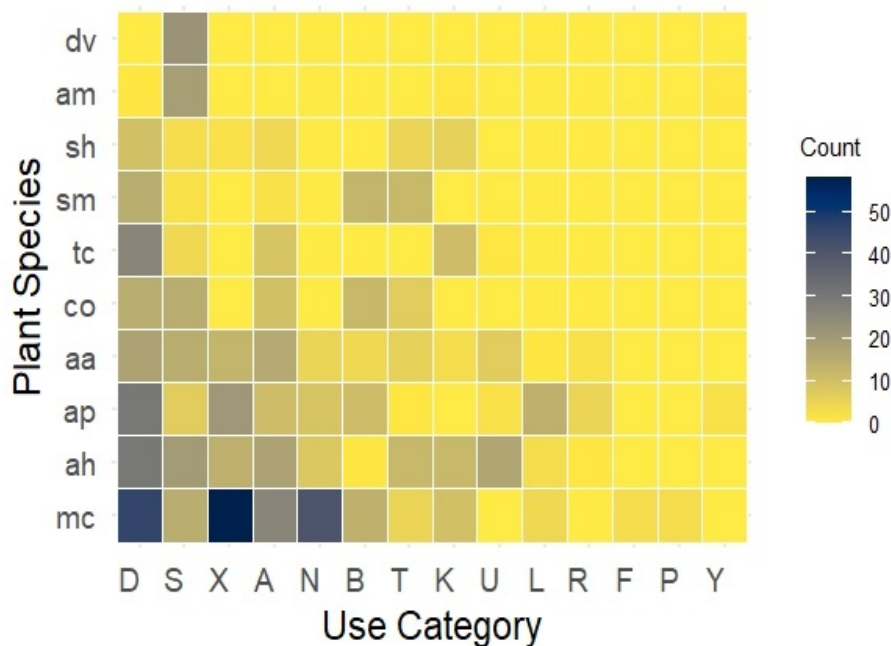


Figure 4. Heat map of use frequency for ten Asteraceae species across fourteen use categories in the Fez-Meknes Region, Morocco.

A: General and Unspecified, B: Blood, Blood Forming Organs and Immune Mechanism, D: Endocrine, Nutritional and Metabolic, F: Mental and Behavioral Disorders, K: Eye Disorders, L: Ear Disorders, N: Respiratory System Disorders, P: Cardiovascular Problems, R: Digestive Problems, S: Skin and Subcutaneous Tissue, T: Musculoskeletal Problems, U: Genitourinary Problems, X: External Causes of Morbidity, Y: Social Problems.

aa: *A. absinthium*, ah: *A. herba-alba*, am: *A. millefolium*, ap: *A. pyrethrum*, co: *C. officinalis*, dv: *D. viscosa*, mc: *M. chamomilla*, sh: *S. hispanicus*, sm: *S. marianum*, tc: *T. campyloides*.

The chord diagram (Figure 5) confirms this topology: thick, multiplex links funnel from a few taxa—especially *M. chamomilla*—into D, X, N and A, with secondary flows to S and K, whereas categories such as Cardiovascular (P) and Mental/behavioral (F) are characterized by sparse, species-specific connections indicative of niche use.

Finally, the Principal Component Analysis biplot (Figure 6), with its two primary dimensions accounting for a cumulative 64.1% of the total variance (Dim1: 42.5%, Dim2: 21.6%), effectively illustrates the associations between various plant species and their medicinal use categories. Dimension 1 primarily differentiates *M. chamomilla* (mc) from other species, showing its strong positive correlation with use categories such as D (Endocrine, Nutritional and Metabolic), X (External Causes of Morbidity), N (Respiratory System Disorders), and P (Cardiovascular Problems), all of which are significant contributors to this dimension. Conversely, species including *A. millefolium*, *D. viscosa*, *S. marianum*, *S. hispanicus*, and *T. campyloides* are found on the negative side of Dimension 1, suggesting weaker associations with the uses under study. On the other hand, Dimension 2 demonstrates a strong positive correlation of *A. pyrethrum* with Y (Social Problems), together with L (Ear Disorders) and R (Digestive Problems), indicating its particular relevance. Other species like *A. herba-alba* (ah) and the categories T (Musculoskeletal Problems) and K (Eye Disorders) are situated in the lower-right quadrant, implying a moderate association. Species such as *A. absinthium* (aa), *C. officinalis* (co), and S (Skin and Subcutaneous Tissue) are located closer to the origin, indicating more generalized or less pronounced associations, with *A. absinthium* showing a moderate link to B (Blood, Blood Forming Organs and Immune Mechanism), and S (Skin and Subcutaneous Tissue).

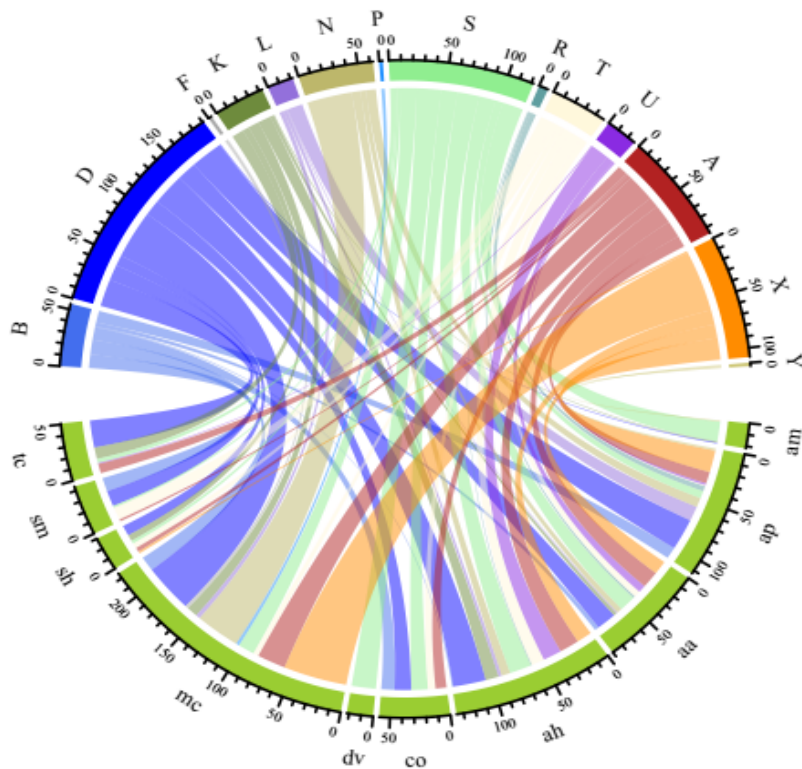


Figure 5. Chord diagram of 792 use reports across 10 Asteraceae species and 14 categories in the Fez-Meknes Region, Morocco, showing use categories in the upper half and Asteraceae medicinal plants in the lower half.

A: General and Unspecified, B: Blood, Blood Forming Organs and Immune Mechanism, D: Endocrine, Nutritional and Metabolic, F: Mental and Behavioral Disorders, K: Eye Disorders, L: Ear Disorders, N: Respiratory System Disorders, P: Cardiovascular Problems, R: Digestive Problems, S: Skin and Subcutaneous Tissue, T: Musculoskeletal Problems, U: Genitourinary Problems, X: External Causes of Morbidity, Y: Social Problems.

aa: *A. absinthium*, ah: *A. herba-alba*, am: *A. millefolium*, ap: *A. pyrethrum*, co: *C. officinalis*, dv: *D. viscosa*, mc: *M. chamomilla*, sh: *S. hispanicus*, sm: *S. marianum*, tc: *T. campyloides*.

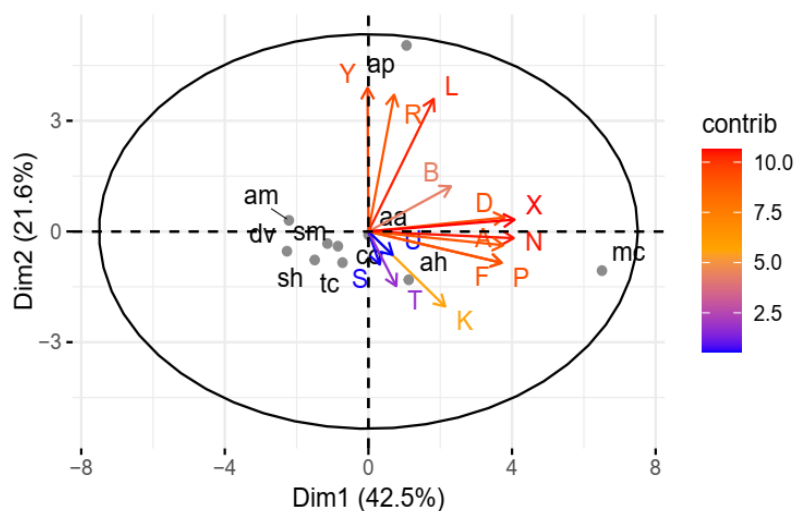


Figure 6. Principal Component Analysis illustrating associations between plant species and use categories.

A: General and Unspecified, B: Blood, Blood Forming Organs and Immune Mechanism, D: Endocrine, Nutritional and Metabolic, F: Mental and Behavioral Disorders, K: Eye Disorders, L: Ear Disorders, N: Respiratory System Disorders, P: Cardiovascular Problems, R: Digestive Problems, S: Skin and Subcutaneous Tissue, T: Musculoskeletal Problems, U: Genitourinary Problems, X: External Causes of Morbidity, Y: Social Problems.

aa: *A. absinthium*, ah: *A. herba-alba*, am: *A. millefolium*, ap: *A. pyrethrum*, co: *C. officinalis*, dv: *D. viscosa*, mc: *M. chamomilla*, sh: *S. hispanicus*, sm: *S. marianum*, tc: *T. campyloides*.

Discussion

Members of the Asteraceae family form the backbone of traditional herbal practice across Morocco and the Mediterranean, as well as in diverse herbal traditions across the globe; with approximately 1,600 to 1,700 genera and 24,000 to 34,000 species, this family is widely recognized as a leading botanical group in ethnomedicine, owing to its phytochemical diversity, which includes sesquiterpene lactones, flavonoids, phenolic acids, essential oils, and polysaccharides, underpinning its therapeutic versatility (Benítez *et al.* 2021, Nadaf *et al.* 2025, Nikolić & Stevović 2015, Rolnik & Olas 2021, Saral & Karaköse 2024, Tegegne *et al.* 2025).

On a global scale, members of the Asteraceae family occupy a central role in immunomodulatory, anti-inflammatory, antimicrobial, antidiabetic, gastrointestinal, respiratory, and skin disorder therapies, as confirmed by ethnobotanical syntheses from Eastern Europe, the Mediterranean countries, Iran, Pakistan, Ethiopia, Zimbabwe, Mexico, and North America (García-Herrera *et al.* 2014, Hussain 2024, Kachura & Harris 2022, Lucía *et al.* 2021, Maroyi 2023, Nadaf *et al.* 2025, Sharma *et al.* 2022, Woldeamanuel *et al.* 2022). These outcomes affirm the enduring ethnomedical importance of Asteraceae and point to their considerable promise as a source of innovative pharmacological compounds capable of mitigating urgent health challenges such as antimicrobial resistance and metabolic pathologies (Khouchlaa *et al.* 2023, Tegegne *et al.* 2025, Zouhri *et al.* 2023).

Throughout the Mediterranean basin, traditional applications of Asteraceae species, particularly those belonging to genera such as *Artemisia* and *Matricaria*, extend to the therapeutic management of approximately 45 to 64 pathological states (Benítez *et al.* 2021, Rolnik & Olas 2021, Zouhri *et al.* 2023). The overlap in Asteraceae-based treatments for many conditions between Morocco and Andalusia suggests a long-standing, shared Mediterranean-North African medical tradition. Many of these uses have now been validated by pharmacological research, especially for their anti-inflammatory, antioxidant, and metabolic effects (Benítez *et al.* 2021, Panda *et al.* 2019).

A nationwide Moroccan review identified 905 medicinal species, with the Asteraceae family being the most common (111 species), mostly used for digestive, skin, diabetes, and urinary problems (Jamila & Mostaf 2020). Also, regional surveys in Morocco show that Asteraceae is one of the most important families in terms of number of species and family importance values. It is often used to treat gastrointestinal, osteoarticular, respiratory, metabolic, and chronic diseases (Belhaj *et al.* 2020, Chaachouay *et al.* 2021, Hachlafi *et al.* 2020, Idm'hand *et al.* 2020, Jamila & Mostafa 2014). The present study, by contrast, reports that the investigated Asteraceae species are used primarily for Endocrine/ Nutritional and Metabolic diseases, skin problems, and External causes of morbidity, rather than placing digestive disorders at the core. This pattern is only partially anticipated in previous work: endocrine/metabolic uses of Asteraceae are documented but not usually as the leading category (Benítez *et al.* 2021, Jamila & Mostafa 2014).

This research quantitatively evaluates ten Asteraceae species, identifying *M. chamomilla* as the most significant taxon in the local medicinal context. This species had the highest values for UR, RFC, UV, and CSI, indicating that informants are knowledgeable about it and that it has various medical applications. There are 16 different uses for *M. chamomilla*, including treating inflammatory conditions, metabolic disorders like diabetes, mental health issues, and wound care. Evidence from prior investigations provides further substantiation for its widespread utilization. Flowers, representing the most frequently utilized plant part, were prepared as infusions, decoctions, or powders for the treatment of oral and gum inflammation, insomnia (Beniaich *et al.* 2022), eczema, psoriasis, depression, and intestinal colic (Kachmar *et al.* 2021). The use of decoctions and infusions was strongly linked to diabetes treatment (Naceiri Mrabti *et al.* 2021), but their applications extended to hypertension, digestive ailments, colds, acne, diarrhea, and nervous system problems (Ghabbour *et al.* 2023). Preparations derived from the whole plant and leaves were most often associated with nervous system disorders (Maache *et al.* 2024). Other uses included anti-inflammatory, digestive, and hair care purposes (Tlemcani *et al.* 2023). Together, these findings underscore the dual cultural and pharmacological importance of *M. chamomilla*, spanning a wide spectrum of therapeutic domains.

Following *M. chamomilla*, *A. herba-alba*, *A. absinthium* and *A. pyrethrum* occupy a position of considerable ethnomedical importance, being collectively employed for approximately twelve categories of ailments, especially gastrointestinal disorders, dermatological, musculoskeletal problems, respiratory disorders, and external conditions. The consistent use of aerial parts, most often obtained from cultivated or semi-managed populations, illustrates both cultural embeddedness and intentional resource governance, factors that plausibly account for the elevated CSI values reported (Majeed *et al.* 2020). Within the Fes-Meknes region, ethnopharmacological investigations consistently highlight the significance of *A. herba-alba* in the therapeutic management of diabetes (Jeddi *et al.* 2024, Jouad *et al.* 2001, Naceiri Mrabti *et al.* 2021). Furthermore, a

substantial number of reports indicate its application for gastrointestinal ailments, including colic, gastralgia, infections, and certain neoplastic conditions (Jeddi *et al.* 2024, Moussaoui *et al.* 2014). Reported applications also include renal lithiasis (Chebaibi *et al.* 2020), mental health disorders such as depression and anxiety (Aumage *et al.* 2020), microbial infections, and oral diseases (Amrati *et al.* 2021). Though less common, their use as antiseptic, antihypertensive, and anti-rheumatic agents is also documented (Khabbach *et al.* 2012, Tlemceni *et al.* 2023). *A. absinthium* likewise demonstrates therapeutic versatility, with diabetes representing the most frequently referenced ailment (Bousta *et al.* 2014, Jouad *et al.* 2001, Tlemceni *et al.* 2023). Digestive problems are also frequently cited (Jeddi *et al.* 2024, Maache *et al.* 2024), in addition to uses for intestinal parasites, dyspepsia, and renal colic (Kachmar *et al.* 2021). Its comprehensive ethnomedicinal profile extends to include psychological, oral, dermatological, and respiratory conditions (Aumage *et al.* 2020, Benamar *et al.* 2023, Jeddi *et al.* 2024, Maache *et al.* 2024), as well as applications for headaches, fever, sexually transmitted infections, and as an anthelmintic (Akdime *et al.* 2015, Ghabbour *et al.* 2023). The extensive ethnomedicinal uses of *A. pyrethrum* are well-documented through ethnobotanical research. For renal conditions, aerial parts were applied as reported by a study of 289 individuals (Chebaibi *et al.* 2020). The roots, however, were specifically employed for digestive system disorders and skeletal-muscular complaints, as evidenced by another inquiry in the study area (Maache *et al.* 2024). Although less frequently cited, root-based treatments were also associated with stomatology and tooth pain (Akdime *et al.* 2015).

This investigation, especially in relation to the lower frequency reports, demonstrates the multiplicity of medicinal functions inherent in *T. campyloides*, *S. marianum*, *S. hispanicus*, and *C. officinalis*. When compared with earlier ethnobotanical investigations from the Fez-Meknes region, the findings underscore both the persistence of traditional therapeutic roles and the evolving trajectories of application associated with these species. In the context of the current survey, *T. campyloides* is cited for its efficacy across a wide range of ailments, spanning ocular, oral, digestive, cutaneous, and genitourinary systems, contrasting with earlier findings that cited more specialized uses, such as infusions for asthenia (Beniaich *et al.* 2022) and preparations (decoctions or powders) for diabetes (Naceiri Mrabti *et al.* 2021). Similarly, earlier research emphasized the use of *S. marianum* capitula and seeds in the treatment of jaundice, more recent investigations attribute to the plant a wider range of applications, encompassing general health as well as blood, metabolic, digestive, skin, and urinary conditions (Akdime *et al.* 2015). *S. hispanicus* also demonstrates a shift in emphasis: the present study records its use for metabolic, ocular, skin, musculoskeletal, and external conditions, while earlier data linked it to cardiac disorders (Ghabbour *et al.* 2023), hepatoprotective purposes, jaundice, and even dietary consumption (Akdime *et al.* 2015, El Amri *et al.* 2014). Finally, *C. officinalis* is currently employed for general, blood, metabolic, skin, and musculoskeletal ailments, whereas previous studies highlighted its topical role in cicatrization, burns, and acne management (Akdime *et al.* 2015, El Amri *et al.* 2014). These collective comparisons illuminate a discernible expansion of therapeutic reach in present-day medical approaches. This phenomenon is attributed to the concurrent evolution of contextual knowledge and the increasingly widespread integration of these species into heterogeneous health frameworks.

The present findings indicated that the therapeutic efficacy of *D. viscosa* and *A. millefolium* was somewhat constrained, particularly in the treatment of cutaneous diseases, diabetic complications, and certain social determinants of health. Their relatively modest UVs and RFCs may reflect either ecological limitations or the substitution of these taxa with alternative remedies in the ethnobotanical repertoire (Bognounou *et al.* 2011). This outcome diverges from earlier ethnomedicinal studies, which emphasized *D. viscosa* as a versatile and widely utilized species, reported by larger sample groups and administered through a variety of preparations, including infusions, decoctions, powders, poultices, and raw applications. Earlier studies emphasized its strong association with diabetes (Naceiri Mrabti *et al.* 2021), but also highlighted significant roles in digestive and circulatory disorders (Ghabbour *et al.* 2023, Jeddi *et al.* 2024), dermatological and wound treatments (Tlemceni *et al.* 2023, Maache *et al.* 2024), as well as psychological conditions such as depression and anxiety (Aumage *et al.* 2020), osteoarticular pain (Kachmar *et al.* 2021), and traumatic injuries (Maache *et al.* 2024). Even less common applications, including tuberculosis, pneumonia, and pediatric tonics (El Amri *et al.* 2014, Khabbach *et al.* 2012), reinforced its broad therapeutic scope. Similarly, while the present findings on *A. millefolium* point to a narrower range of uses, earlier research in the Fez-Meknes region documented its importance in treating digestive, gynecological, skin, and respiratory ailments (El Yaagoubi *et al.* 2023, Najem *et al.* 2020), as well as its role in addressing insomnia, asthenia, and oral or gum infections (Beniaich *et al.* 2022). Such collective evidence reveals a reduction in the reported therapeutic applications within the confines of this study, in contrast to the extensive and multifaceted uses chronicled in previous ethnobotanical investigations. This pattern is indicative of potential alterations in the mechanisms of local knowledge perpetuation, variations in the prevalence of specific plant species, or evolving preferences regarding medicinal interventions (Pirker *et al.* 2012).

Finally, both the most cited *M. chamomilla* and *A. herba-alba* in the current study are central to Moroccan traditional medicine; their popularity presents both opportunities and challenges that threaten their wild populations. The intensive

harvesting of *A. herba-alba* for the high-value aromatic trade has pushed the species into a "threatened" category, according to local sources (Aljaiyash *et al.* 2018). To counter this, there is a growing emphasis on domestication and cultivation—tools that are now seen as vital for balancing economic demand with biological preservation (Aljaiyash *et al.* 2018, Hinane *et al.* 2020). On the other hand, *M. chamomilla* is globally one of the cultivated species; agronomic trials and phytochemical studies highlight its suitability for rain-fed and irrigated cultivation, suggesting strong potential to shift demand from wild stands to managed fields, thereby relieving harvesting pressure in areas where it occurs spontaneously (Shabankareh *et al.* 2025, Demir *et al.* 2025). Such findings imply that Morocco's community-based conservation should focus on mapping *A. herba-alba* in vulnerable areas, developing local cultivation to reduce wild collection (Aljaiyash *et al.* 2018, Goda *et al.* 2025, Hinane *et al.* 2020), and promoting *M. chamomilla* cultivation while protecting wild populations (Shabankareh *et al.* 2025, Soubra *et al.* 2028).

Conclusion

This study strengthens and broadens the evidence for the centrality of Asteraceae in the ethnomedicine of Fez–Meknes, where *M. chamomilla* and *A. herba-alba* constitute the core of a pharmacopeia validated across metabolic, respiratory, dermatological, external, and general health domains. The convergence of RFC, UV, and CSI values, along with high ICF scores in high-demand ICPC categories, demonstrates a coherent and culturally embedded practice. Nonetheless, the contraction of therapeutic uses compared with earlier reports points to evolving dynamics in knowledge transmission, species distribution, and therapeutic selection. While the urban-weighted, cross-sectional design and citation-based metrics temper causal inference, the study furnishes prioritized candidates for pharmacological follow-up and community-led conservation. Future work should broaden rural and elder representation, integrate longitudinal and seasonal sampling, triangulate diagnoses with clinical proxies, and pair quantitative indices with ecological assessments to safeguard biocultural resilience and translate validated uses into context-appropriate primary care.

Declarations

List of abbreviations: Use category abbreviations: A- General and Unspecified, B- Blood, Blood Forming Organs and Immune Mechanism, D- Endocrine, Nutritional and Metabolic, F- Mental and Behavioral Disorders, K- Eye Disorders, L- Ear Disorders, N- Respiratory System Disorders, P- Cardiovascular Problems, R- Digestive Problems, S- Skin and Subcutaneous Tissue, T- Musculoskeletal Problems, U- Genitourinary Problems, X- External Causes of Morbidity, Y- Social Problems.

Ethnobotany index abbreviations: CSI- Cultural significance index, FL- Fidelity level, ICF: - Informant Consensus Factor, RFC- Relative frequency of citations, ROP- Rank order priority, RPL- Relative popularity level, UR- Use report, UV- Use value.

Plant name abbreviations: aa- *Artemisia absinthium*, ah- *Artemisia herba-alba*, am- *Achillea millefolium*, ap- *Anacyclus pyrethrum*, co- *Calendula officinalis*, dv- *Dittrichia viscosa*, mc- *Matricaria chamomilla*, sh- *Scolymus hispanicus*, sm- *Silybum marianum*, tc- *Taraxacum campylodes*.

Ethics approval and consent to participate: To conduct the present research, verbal and written consent was sought and obtained from all participants. All participants provided their informed consent prior to the study.

Consent for publication: Not applicable

Availability of data and materials: The datasets and materials used in this study are available from the corresponding authors upon reasonable request.

Competing interests: The authors confirm no conflict of interest.

Funding: Not applicable

Author contributions: A.Z. collected the data and wrote the original draft. D.O. contributed to the theoretical background, monitored data collection, and assisted in discussions. A.D. analyzed the data and contributed to manuscript writing and editing. I.E. contributed to the methodology, supervised and validated the data, and reviewed the manuscript.

Acknowledgements

We appreciate the contributions and knowledge shared by all who participated in this study.

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