An ethnopharmacological survey of medicinal plants used for wound care in the Fez-Meknes region (Morocco)

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Research

Abstract

Background: Wound healing is a complex medical challenge shaped by diverse biological processes and wound types. In Morocco, medicinal and aromatic plants have been integral to traditional wound care for centuries. However, their use remains poorly documented. To bridge this gap, we conducted an ethnopharmacological study in the Fez-Meknes region, a botanically rich area where phytotherapy plays a crucial role in local healthcare. This study catalogs the plant species used for wound treatment, exploring their preparation methods, applications, and therapeutic significance.

Methods: Over an eight-month period, semi-structured questionnaires were administered to 507 herbalists and traditional healers across seven provinces. Traditional knowledge was assessed using statistical indices such as the Relative Frequency of Citation (RFC), Family Importance Value (FIV), and Rahman's Similarity Index (RSI). The information gathered included plant species used, their parts, states (fresh or dried), preparation methods, application modes, and their roles in treating different wound healing stages, based on the wound color scale (wound healing continuum). Statistical significance and correlation analyses were conducted to examine the relationships within the collected data.

Results: A total of 46 plant species from 26 botanical families were identified. Lamiaceae (FIV= 0.048), Asteraceae (FIV= 0.047) and Asphodelaceae (FIV= 0.032), emerged as the most frequently cited families, with notable species such as *Dittrichia viscosa* (L.) Greuter (RFC= 0.199) and *Teucrium polium* (L.) (RFC= 0.134), known for their analgesic and wound healing properties. Leaves were the most commonly utilized plant part (PPV = 0.544). Fresh plant materials accounted for 74.16% of preparations, predominantly applied in raw or liquid form through wrapping or irrigation. Despite variations in floristic similarities across provinces and regions, the Fez-Meknes region stands out for its rich phytotherapeutic and cultural heritage.

Conclusions: The Fez-Meknes region's ethnopharmacological richness makes it a prime source for innovative plant-based wound therapies. These traditional medicinal plants hold substantial promise for improving and optimizing wound care practices. Further pharmacological and phytochemical investigations are recommended to validate their therapeutic efficacy.

Keywords: Ethnopharmacology, Fez-Meknes region, Medicinal plants, Phytotherapy, Traditional knowledge, Wound healing continuum, Wound treatment.

Background

Wound treatment is a major challenge due to the high incidence of chronic wounds, burns and animal-related injuries, as well as the socio-economic barriers that limit access to healthcare. Wound healing is a complex process influenced by both endogenous (such as pathophysiological conditions) and exogenous factors (such as microbial colonization) (Bowler 2002). Chronic illnesses, notably diabetes, increase the likelihood of persistent wounds, while psychological elements including personality traits such as conscientiousness, also affect the healing process (Lusher *et al.* 2018).

Phytotherapy stands out as a promising and cost-effective approach, seamlessly integrating traditional knowledge with modern scientific advancements. For centuries, medicinal and aromatic plants have been fundamental to healthcare systems across diverse cultures. Despite significant pharmacological progress, their therapeutic applications are experiencing a global resurgence. In developing countries, particularly in Africa, nearly 80% of the population relies on herbal medicine for managing wounds, infectious diseases, and metabolic disorders.

This widespread reliance is largely attributed to Africa's tropical and subtropical climate, which supports the rich biodiversity of medicinal plants. Through evolution, these plants have developed bioactive secondary metabolites as natural defense mechanisms against environmental stressors. Among the most frequently utilized plant families for wound healing in Africa are Lamiaceae (*Hoslundia opposite* Vahl, *Hyptis suaveolens* (Poit), *Leucas hirta* (Heyne ex Roth) Spreng, *Ocimum gratissimum* (L.), *Ocimum sanctum* L., Euphorbiaceae (*Alchornea cordifolia* (Schum. &Thonn.) Muell. Arg, *Jatropha curcas* (L.), *Mallotus oppositifolius* (Geiseler) Müll. Arg.), and Asteraceae (*Ageratum conyzoides* (L.), *Centaurea iberica* Trev. ex Spreng, *Chromolaena odorata* (L.)) (Agyare *et al.* 2016).

Morocco, situated at the crossroads between Africa and Europe, is renowned for its floristic richness, comprising 5,211 species and subspecies of vascular plants, with 800 recognized for their medicinal and aromatic attributes (Taleb 2017). In Moroccan traditional phytotherapy, 743 plant taxa encompassing 101 families and 371 genera are employed**,** with Asteraceae, Lamiaceae, Fabaceae, and Apiaceae among the most prominent (Ait Bouzid *et al.* 2024). The Lamiaceae family alone includes around 50% of Moroccan endemic taxa, followed by Asteraceae (16.66%) and Brassicaceae (4.76%) (Jamaleddine *et al.* 2017).

Approximately 88.47% of the Moroccan population relies on MAPs for therapeutic purposes (Remok *et al.* 2024), primarily to treat gastrointestinal, dermatological, respiratory, and inflammatory conditions (El Mekkaoui *et al.* 2024; El Finou *et al.* 2023; El Oihabi *et al.* 2024; Lefrioui *et al.* 2024). Despite their potential, many of these species remain underexplored in pharmaceutical and biotechnological research. Preparation methods, such as decoctions, infusions, poultices, and tinctures, are commonly used to extract bioactive compounds, often with multiple plant ingredients to enhance efficacy and minimize adverse effects (Sultana *et al.* 2023; Mondal *et al.* 2024; Rankoana 2022). The use of phytotherapy for wound healing in Morocco is deeply rooted in traditional practices, with numerous medicinal plants employed to treat various types of wounds, particularly burns. Commonly used plants include *Agave sisalana* Perrine*, Nerium oleander* (L.), *Lawsonia inermis* (L.), *Dittrichia viscosa* (L.) Greuter and *Marrubium vulgare* (L.), with leaves being the most frequently applied part for treatment (Mrabti *et al.* 2022; Mssillou *et al.* 2022).

However, the ethnopharmacological documentation of plants specifically used for wound healing in Morocco remains remarkably scarce, emphasizing the need for further comprehensive studies to identify and validate their therapeutic applications. The majority of existing research focuses on cataloging the full spectrum of medicinal plants within a given region for general uses, which often leads to an underestimation of the actual number and importance of species with potential applications in phytotherapeutic wound care and dermatological treatments.

The Fez-Meknes region, renowned for its rich ethnobotanical heritage, is reported to host at least 81 medicinal plant species representing 47 families, with Lamiaceae being the most frequently cited (El Finou *et al.* 2023; Ourgha *et al.* 2025). Building on this extensive pharmacopoeia, the present study aims to comprehensively document the plant species traditionally employed in Fez-Meknes for treating both acute and chronic wounds. More specifically, the work seeks to inventory the medicinal plants used, detail their preparation methods, elucidate their modes and forms of application, and the effects on different wound types.

Notably, no systematic database dedicated exclusively to medicinal plants used in wound treatment currently exists for this region, highlighting the novelty and importance of this investigation. The findings will establish a foundation for future research, particularly concerning biotechnological applications that leverage Morocco's diverse medicinal flora to develop innovative wound-healing therapies. Additionally, this study will constitute one of the first systematic compilations validating the traditional use of these plants for wound management in Morocco.

Materials and Methods

Study area description

Located in the north-central part of Morocco, the Fez-Meknes region covers an area of 40.075 km², representing 5.7% of the country's total surface. It comprises nine provinces (Fez, Meknes, Taounate, Taza, Sefrou, El Hajeb, Boulemane, Moulay Yacoub, and Ifrane) with Fez as its regional capital. As of the 2024 census, the region is home to 4.467.911 residents, accounting for 12.5% of Morocco's population, making it a vibrant and dynamic area. Geographically, it is bordered to the north by the Tanger-Tetouan-Al Hoceima region, to the west by Rabat-Sale-Kenitra, to the southwest by Beni Mellal-Khenifra, to the east by the Oriental region, and to the south by Draa-Tafilalet (Figure 1). The religion of the inhabitants is Islam, and Arabic (Moroccan dialect) is the official language of the country (El-Assri *et al.* 2021).

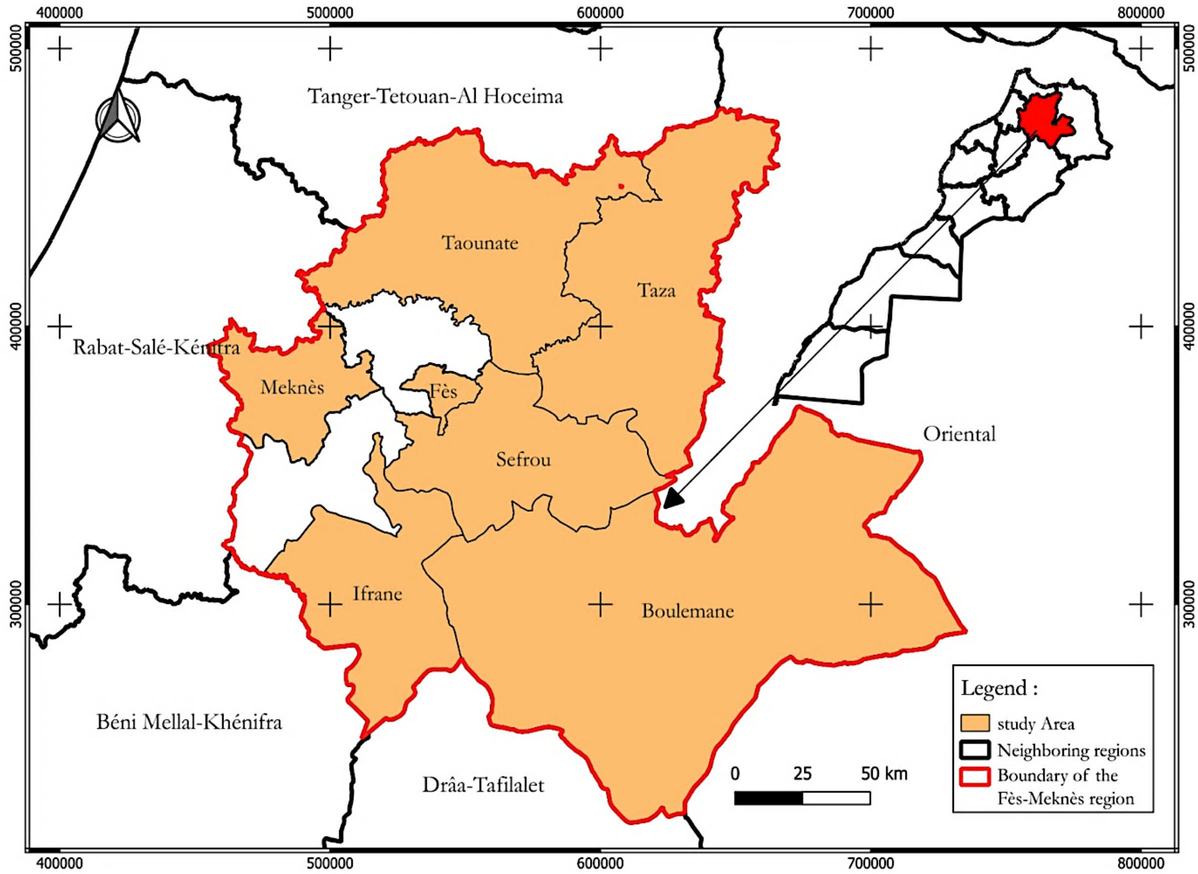

Figure 1. Location map of the study area (QGIS Software).

Fez-Meknes is celebrated for its breathtaking natural contrasts and agricultural abundance. The region's landscape, framed by the majestic Middle Atlas Mountains, features fertile plains like the Saïs Plain, lush valleys, and a network of rivers that sustain its thriving agriculture. With 1.235.521 ha of cultivated land (15% of Morocco's total) and 1.246.255 ha of forest (14% of the national forest cover), it stands out as one of the country's most productive regions. The region experiences three distinct climates: a continental climate, characterized by hot, dry summers and cold, humid winters; a cold and humid climate in the mountainous areas, with very cold, snowy winters and temperate summers; and a semi-arid climate in the high hills of Boulemane, where winters are particularly cold and snowy (Tlemcani *et al.* 2023). This diverse climate system further enhances the region’s agricultural and ecological richness.

The region produces a diverse range of agricultural products, including cereals, olives, and grapes, with flagship products such as olive oil and saffron achieving international recognition (El Finou *et al.* 2023). Additionally, the forests and mountains are abundant in medicinal and aromatic plants, prized for their traditional therapeutic uses and their significance in modern industries. This exceptional combination of natural resources and agricultural vitality positions Fez-Meknes as a cornerstone of Morocco's economic and ecological landscape (Bouichou *et al.* 2024).

Data collection and considerations

Ethnopharmacological data were collected over an eight-month field study conducted from November 2023 to June 2024, aimed at documenting medicinal and aromatic plants utilized in wound treatment. The research encompassed seven distinct locations within the Fez-Meknes region (Fez, Meknes, Taounate, Sefrou, Taza, Ifrane, and Boulemane) covering both rural areas (villages, douars, souks) and urban centers (cities). These locations represent a diverse mix of traditional and modern settings, enabling a comprehensive exploration of healthcare practices that integrate modern medical systems with culturally rooted traditional healing methods.

Herbalists and traditional healers were purposively selected across the seven provinces based on their expertise and active involvement in traditional wound care practices. Semi-structured questionnaires and free-listing exercises were conducted through face-to-face interviews and focus groups, following the standardized methodology established by Martin (2004).

Prior to participation, all informants were clearly informed of the study’s purpose and provided their free and informed consent. Interviews were carried out in Amazigh or Arabic, depending on the informants’ linguistic preferences. The study was conducted in full compliance with ethical research standards and in accordance with the Nagoya Protocol on access to genetic resources and the fair and equitable sharing of benefits arising from their utilization.

The questionnaire used consists of two parts: the first part addresses the sociodemographic characteristics of the informants, while the second part gathers detailed information on each medicinal plant mentioned. This section evaluates the informants' knowledge regarding the uses of the plant, the types of wounds treated, the state of the plant, preparation methods and forms, modes of application, and its effects on the wound. The type of wound was classified based on the healing stage at which a plant is used. For this purpose, we adopted the international wound color scale, also known as the Wound Healing Continuum (WHC), which associates each stage with a specific color: black, yellow, red, and pink, representing the necrotic, sloughy, granulating, and epithelializing phases of healing, respectively (Gray *et al.* 2008; Haney *et al.* 2021; Lusher *et al.* 2018; Niri *et al.* 2021).

Data statistical analysis

All data collected from this ethnopharmacological survey were transcribed and subjected to descriptive analysis using Microsoft Office Excel 2021 and in-depth analysis using SPSS version 26 software (Statistical Package for the Social Sciences) and JMP software.

To explore the relationships between variables and identify factors influencing the dataset, we conducted a series of bivariate and multivariate statistical analyses. Pearson’s chi-squared (χ^2) tests were performed to assess significant associations between variable pairs. Specifically, medicinal plants were analyzed in relation to their utilization state, geographic origin (provinces), and the profiles of the informants who provided the data.

Multiple correspondence analysis (MCA) was conducted to explore multidimensional relationships and visualize patterns among categorical variables. In particular, it was employed to examine the associations between plant parts, preparation methods, routes of administration, and forms of application.

A contingency analysis was performed to evaluate the degree of association between medicinal plants and different wound types. This approach allowed us to identify specific plants frequently used for certain types of wounds, highlighting their traditional roles and effectiveness in wound care practices. By examining these associations, we gained deeper insights into the practical uses of these plants and their cultural significance in traditional healing methods, providing a foundation for further pharmacological research and potential therapeutic advancements.

The ***Relative frequency of citation (RFC)*** is used to show the importance of each species in the region studied. It was obtained by dividing the number of respondents who cited the species (FC) by the number of respondents (N) according to the formula (1) (Tardío & Pardo-De-Santayana 2008).

$$\mathrm{RFC} = \frac{\mathrm{FC}}{\mathrm{N}} \ (1)$$

The ***Family Importance Value (FIV)*** represents the relative importance of families. It was used to evaluate the biological taxonomic value of plants and is determined by dividing the number of respondents revealing the family (FC family) by the number of species within each family (NS) according to the formula (2) (Sreekeesoon & Mahomoodally 2014).

$$\mathrm{FIV} = \frac{\mathrm{FC\ family}}{\mathrm{NS}} \ (2)$$

Plant part value (PPV) indicates the frequency of use of each plant part. It was calculated by dividing the number of reported uses for all plant parts (RU plant part) by the sum of reported uses per plant part (RU) according to the formula (3) (Gomez-Beloz 2002).

$$\mathrm{PPV} = \frac{\mathrm{RU\ plant\ part}}{\mathrm{RU}} \ (3)$$

Rahman's Similarity Index (RSI), introduced by Inayat Ur Rahman and Farhana Ijaz, is a quantitative measure used to compare the findings of a given study with previously published research at local, regional, national, and global scales. RSI is calculated based on the percentage of plant species analyzed and commonly cited with similar medicinal uses across studies (Rahman *et al.* 2019). The applied formula (4) is:

$$\mathrm{RSI} = \frac{\mathrm{d}}{\mathrm{a + b + c - d}} \times 100 \ (4)$$

Where a represents the number of species unique to area A, b represents the number of species unique to area B, c denotes the number of species common to both areas A and B, and d refers to the number of common species used for similar ailments in both areas. The conditions for the calculation are a & b ≠ 0 and c & d ≥ 0.

Results and Discussion

Socio-demographic data

A total of 507 participants across seven provinces were surveyed, as shown in Table 1. The results reveal a varied distribution of ethnopharmacological knowledge in the Fez-Meknes region, with Fez leading at 25.84%, followed by Taounate (19.33%) and Meknes and Taza (14.40% each). The smaller provinces, Sefrou, Ifrane, and Boulmane, account for 10.26%, 9.66%, and 6.11%, respectively.

Table 1. Distribution of ethnopharmacological surveys according to the studied sites.

Province	Number of surveys	Percentage (%)
Fez	131	25.84
Meknes	73	14.40
Taounate	98	19.33
Taza	73	14.40
Sefrou	52	10.26
Ifrane	49	9.66
Boulmane	31	6.11

Sociodemographic information, including gender, age, education level, profession, and duration of practice, highlights key patterns in the transmission of traditional medicinal knowledge (Table 2). Most informants were herbalists (57.59%), with a significant proportion (42.41%) being traditional healers. The gender distribution showed that 77.71% of informants were male and 22.29% were female. In terms of age, 51.08% were over 60 years old, and 43.39% were between 40 and 59 years. Educationally, 61.54% were illiterate, and 29.19% had only primary education. Lastly, 65.29% of the informants had more than 20 years of experience.

The variation in ethnopharmacological knowledge across the different provinces may reflect differences in geographical accessibility, cultural practices, and the transmission of traditional knowledge (El Oihabi *et al.* 2024). Urban areas, such as Fez, are likely to have a greater number of documented medicinal plant uses due to easier access to knowledge, the significant presence of herbalists and traditional healers, particularly in the old medina, whereas more remote regions may depend on local, generational practices (Ourgha *et al.* 2025; Tlemcani *et al.* 2023). Economic and social factors also provide a strong rationale for the greater prevalence of herbalists and traditional healers in urban areas, where demand and infrastructure support their development. These findings highlight the importance of considering regional factors when studying the diversity of medicinal plants.

The predominance of herbalists, along with a substantial representation of traditional healers reflects the importance of practical, hands-on experience in medicinal plant use (Wanjohi *et al.* 2020). The gender distribution suggests that herbalism and traditional healing are predominantly male-dominated fields, though the role of women in local healing practices may be underrepresented (Torres-Avilez *et al.* 2016). While this gender distribution contradicts the findings of El Mekkaoui *et al.* (2024), it aligns with the results reported by Louafi *et al.* (2024) and Lefrioui *et al.* (2024).

Table 2. Socio-demographic characteristics of informants (n=507).

Variables	Categories	Number of informants	Percentage (%)
Interviewee	Herbalist	292	57.59
	Traditional healer	215	42.41
Gender	Male	394	77.71
	Female	113	22.29
Age (years)	18-24	0	0.00
	25-39	28	5.52
	40-59	220	43.39
	>60	259	51.08
Level of education	Illiterate	312	61.54
	Primary	148	29.19
	Secondary	37	7.30
	University	10	1.97
Duration of practice (years)	0-5	6	1.18
	5-10	22	4.34
	10-20	148	29.19
	>20	331	65.29

The demographic trend indicating that traditional knowledge is primarily held by older generations aligns with global concerns about the loss of indigenous knowledge as older practitioners age (El Hachlafi *et al.* 2020; Famo & Machate 2023; Kacunguzi 2022). These findings are consistent with those of S. Jeddi *et al.* (2024) and Chaachouay *et al.* (2019).

The high rate of illiteracy and low formal education levels among informants highlights the role of informal, experiential learning in passing down knowledge (Chaachouay *et al.* 2019). On the other hand, people with a higher level of education possess less traditional knowledge about medicinal plants. Similar results were obtained by El Mekkaoui *et al.* (2024), Chaachouay *et al.* (2022) and Idrissi (2022). Furthermore, the long duration of experience among informants underscores the deep-rooted and long-term nature of their traditional practices (Awoke *et al.* 2024).

Floristic analysis

The floristic analysis identified 46 medicinal species belonging to 26 plant families. The families, along with their scientific and vernacular names, frequency of citations, and relative frequency of citation, are detailed in Table 3. Regarding the number of species per family, the most representative families are Asteraceae (10 species), followed by Lamiaceae (8 species). Apiaceae, Anacardiaceae, Euphorbiaceae, and Solanaceae each contribute 2 species, while the remaining families are represented by a single species.

Family importance value (FIV)

Based on the FIV index, as shown in Figure 2, the Lamiaceae family (FIV = 0.048) emerges as the most significant, highlighting its prominent use in traditional wound healing practices. The Asphodelaceae family (FIV = 0.047) also holds a prominent position in traditional wound care, followed by the Asteraceae family (FIV = 0.031), which shows notable use. Families such as Plantaginaceae (FIV = 0.026) and Pinaceae (FIV = 0.024) demonstrate moderate levels of importance.

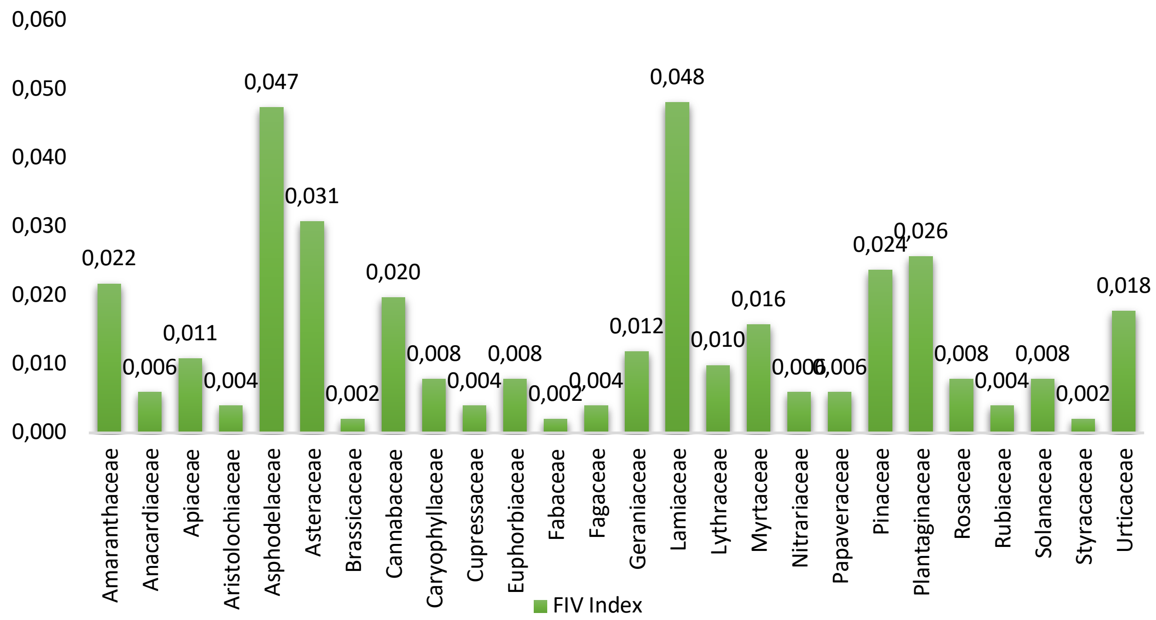

Figure 2. Family importance value (FIV) of medicinal plants.

The significance of the Lamiaceae family may be attributed to the presence of bioactive compounds, such as tannins and flavonoids, in species like *Salvia officinalis* (L.) and *Teucrium polium* (L.), which possess potent astringent and antimicrobial properties (Tsitsigianni *et al.* 2023; Yassine *et al.* 2024; Kowalczyk *et al.* 2023). Similarly, the high FIV value of the Asphodelaceae family reflects the known anti-inflammatory and skin-regenerative effects of species such as *Aloe barbadensis* Mill. (Catalano *et al.* 2024). Furthermore,the notable use of the Asteraceae family is supported by the antimicrobial activities of species like *Dittrichia viscosa* (L.) Greuter and *Calendula officinalis* (L.) (Belal *et al.* 2022; Jerada *et al.* 2024). The moderate relevance of Plantaginaceae and Pinaceae can be linked to the astringent and anti-inflammatory properties of *Plantago major* (L.) and *Pinus halepensis* Mill., traditionally used to absorb wound exudate and promote healing (Haichour *et al.* 2021; Anaya-Mancipe *et al.* 2023).

Frequency of citation and relative importance of medicinal plants

The analysis of the Frequency of Citation (FC) and Relative Frequency of Citation (RFC) underscores the ethnopharmacological significance of various plant species and families utilized for wound treatment in the Fez-Meknes region. The RFC, calculated based on informants' citations of specific medicinal plants (Table 3), serves as a quantitative measure to assess the relative importance of these species. High FC and RFC values highlight the prominence of certain species and families in traditional medicinal practices.

Among the identified families, Asteraceae stands out prominently, with *Dittrichia viscosa* (L.) Greuter achieving the highest citation values (FC = 101, RFC = 0.199). Similarly, the family Lamiaceae demonstrates significant representation, with species such as *Teucrium polium* (L.) (FC = 68, RFC = 0.134) and *Salvia officinalis* (L.) (FC = 45, RFC = 0.089) ranking highly. In contrast, *Melissa officinalis* (L.) (Lamiaceae, FC = 32, RFC = 0.063) demonstrates moderate yet noteworthy usage. Other families, including Plantaginaceae, represented by *Plantago major* (L.) (FC = 13, RFC = 0.026), and Pinaceae, with *Pinus halepensis* Mill. (FC = 12, RFC = 0.024), also contribute to traditional wound treatments.

The high FC and RFC values reflect the therapeutic efficacy and cultural relevance of these species in local ethnopharmacological practices (Nazneen & Nausheed 2022). The multifaceted applications of *Dittrichia viscosa* (L.) Greuter, including its wound-healing, antiseptic, soothing, and exudate absorption properties, emphasize its integral role in traditional medicine, reflecting its richness in key bioactive compounds such as sesquiterpenes, monoterpenes, flavonoids, and phenolic acids (Jerada *et al.* 2024). These findings are consistent with previous studies highlighting the pharmacological importance of this species, particularly in wound treatment (Rhimi *et al.* 2019; Bentarhlia *et al.* 2024; Jerada *et al.* 2024).

Table 3. Plant species used in the treatment of wounds in the region of Fez-Meknes.

Family	*Scientific name*	Vernacular name	FC	RFC	Part used	Mode of preparation	Form of application	Mode of application	Effect on the wound
Amaranthaceae	*Chenopodium ambrosioides* L.	Mkhinza	11	0.022	Leaves	Decoction	Liquid extract	Irrigation	SO, AN, WH
Anacardiaceae	*Pistacia atlantica* Desf.	L-btem	3	0.006	Seeds, Flowers	Grinding, Decoction	Powder, Liquid extract	Wrap, Irrigation	AS, WH
	Rhus pentaphylla (Jacq.) Desf.	Tizgha	3	0.006	Leaves	Decoction	Liquid extract	Irrigation	WH, AN
Apiaceae	*Ferula communis* L.	Lboubal	3	0.006	Aerial parts	Infusion, Decoction	Liquid extract	Irrigation	WH, AS, SO
	Visnaga daucoides Gaertn.	Bechnikha	8	0.016	Aerial parts	Decoction, Distillation	Liquid extract, Essential oil	Irrigation	WH, AS, HE
Aristolochiaceae	*Aristolochia longa* L.	Berztem	2	0.004	Roots	Grinding	Powder	Wrap	WH
Asphodelaceae	*Aloe barbadensis* Mill.	Aloe-vera	24	0.047	Leaves	Raw	Raw	Wrap	WH, HE, AS
Asteraceae	*Anacyclus pyrethrum* (L.) Lag.	Tighnest	2	0.004	Aerial parts	Decoction	Liquid extract	Irrigation	WH, AS
	Anvillea radiata Coss. & Durieu	Awrem	3	0.006	Aerial parts, Stem	Grinding	Powder	Wrap	WH, AN
	Artemisia absinthium L.	Chiba	1	0.002	Aerial parts	Infusion	Liquid extract	Irrigation	WH, AN, SO
	Artemisia herba-alba Asso	Chih	6	0.012	Stem, Leaves, Flowers	Raw, Infusion, Decoction	Raw, Liquid extract	Wrap, Irrigation	WH, AN, SO
	Calendula officinalis L.	Al-Bekkourya	22	0.043	Leaves, Flowers	Grinding, Raw, Maceration, Decoction	Powder, Raw, Liquid extract	Wrap, Irrigation	WH, AN, EA
	Chamaemelum nobile (L.) All.	Babounj	8	0.016	Aerial parts	Infusion, Distillation	Liquid extract, Essential oil	Spray, Irrigation	WH, AN, AS, EA
	Dittrichia viscosa (L.) Greuter	Magramane / Tirehla	101	0.199	Leaves, Aerial parts	Grinding, Raw, Infusion, Decoction, maceration, Distillation	Powder, Raw, Liquid extract, Essential oil	Spray, Wrap, Irrigation	WH, AS, AN, SO, EA
	Lactuca virosa Thunb.	Ahchlaf-nssem	3	0.006	Leaves	Raw	Raw	Wrap	WH

	Silybum marianum (L.) Gaertn.	Taymant	4	0.008	Aerial parts	Grinding, Raw	Powder, Raw	Wrap	WH, AN
	Sonchus asper (L.) Hill	Tifaf	6	0.012	Leaves	Raw, Decoction	Raw, Liquid extract	Wrap, Irrigation	WH
Brassicaceae	*Capsella bursa-pastoris* Medik.	kis-erraii	1	0.002	Leaves	Decoction	Liquid extract	Irrigation	HE
Cannabaceae	*Cannabis sativa* L.	Al-kif	10	0.020	Leaves	Grinding, Raw, Infusion	Powder, Raw, Liquid extract	Wrap, Irrigation	AN, AS, WH
Caryophyllaceae	*Saponaria officinalis* L.	Tighacht	4	0.008	Leaves, Whole plant	Decoction	Liquid extract	Irrigation	WH
Cupressaceae	*Tetraclinis articulata* (Vahl) Mast.	Arâar	2	0.004	Fruits	Infusion	Liquid extract	Irrigation	WH
Euphorbiaceae	*Euphorbia falcata* L.	Hayat-nofos	4	0.008	Whole plant	Infusion, Decoction	Liquid extract	Irrigation	WH
	Ricinus communis L.	Kherouâ	4	0.008	Leaves	Infusion	Liquid extract	Irrigation	SO, AN, WH
Fabaceae	*Vachellia farnesiana* (L.) Wight & Arn.	Talh	1	0.002	Leaves	Decoction	Liquid extract	Irrigation	WH
Fagaceae	*Quercus suber* L.	Debagh, Fernan	2	0.004	Fruits	Grinding, Decoction	Powder, Liquid extract	Wrap, Irrigation	WH, AN
Geraniaceae	*Pelargonium odoratissimum* [Soland.]	Atarcha	6	0.012	Leaves, Flowers	Grinding, Infusion, Distillation	Powder, Liquid extract, Essential oil	Wrap, Irrigation	AS, HE, WH
Lamiaceae	*Ajuga iva* (L.) Schreb.	Chendgoura	7	0.014	Leaves	Infusion, Distillation	Liquid extract, Essential oil	Irrigation	EA, AS
	Lavandula officinalis f. alba (Ging.) Rehder	Khzama	3	0.006	Leaves, Flowers	Raw, Infusion	Raw, Liquid extract	Wrap, Irrigation	WH, AN
	Marrubium vulgare L.	Marriwa	19	0.037	Leaves	Raw, Infusion	Raw, Liquid extract	Wrap, Irrigation	WH, HE
	Melissa officinalis L.	Hbak-tranjani	32	0.063	Leaves, Aerial parts	Decoction, Infusion, Distillation	Liquid extract, Essential oil	Spray, Irrigation	WH, AN, EA, AS
	Mentha × rotundifolia (L.) Huds.	Marseta	7	0.014	Leaves	Infusion	Liquid extract	Irrigation	WH, AS, AN

	Origanum compactum Benth.	Zaâtar	14	0.028	Leaves, flowers, Aerial parts	Infusion, Decoction, Maceration	Liquid extract	Irrigation	WH, AN, HE
	Salvia officinalis L.	Salmia /Mrimya	45	0.089	Leaves, Flowers	Decoction, Infusion	Liquid extract	Irrigation	WH, AS, SO, AN
	Teucrium polium L.	Al-khyata	68	0.134	Leaves, Aerial parts	Grinding, Raw, Decoction, Infusion, Distillation	Powder, Raw, Liquid extract, Essential oil	Spray, Wrap, Irrigation	WH, HE, AN, EA, AS
Lythraceae	*Lawsonia inermis* L.	Henna	5	0.010	Leaves	Raw	Raw	Wrap	WH
Myrtaceae	*Myrtus communis* L.	Rihan	8	0.016	Leaves, Flowers	Grinding, Infusion	Powder, Liquid extract	Wrap, Irrigation	AS, WH
Nitrariaceae	*Peganum harmala* L.	L-Harmal	3	0.006	Seeds	Grinding	Powder	Wrap	WH, AS
Papaveraceae	*Papaver rhoeas* L.	Bellaâmane	3	0.006	Fruits	Infusion	Liquid extract	Irrigation	WH
Pinaceae	*Pinus halepensis* Mill.	Tayda	12	0.024	Fruits, Roots	Grinding, Decoction	Powder, Liquid extract	Wrap, Irrigation	WH, AN
Plantaginaceae	*Plantago major* L.	Messasa	13	0.026	Leaves	Raw	Raw	Wrap	EA, WH
Rosaceae	*Crataegus monogyna* Jacq.	Zaârour / Admam	4	0.008	Leaves, Fruits	Infusion	Liquid extract	Irrigation	AS, WH
Rubiaceae	*Galium aparine* L.	Lassayqa	2	0.004	Leaves	Raw	Raw	Wrap	WH, EA
Solanaceae	*Capsicum annuum* L.	Tahmira	5	0.010	Fruits	Raw	Raw	Wrap	AS, EA, WH
	Capsicum frutescens L.	Sudanya	3	0.006	Fruits	Decoction	Liquid extract	Wrap	WH
Styracaceae	*Styrax officinalis* L.	Jawi	1	0.002	Whole plant	Grinding	Powder	Wrap	WH, SO
Urticaceae	*Urtica dioica* L.	Harriga	9	0.018	Leaves	Raw, Decoction	Raw, Liquid extract	Wrap, Irrigation	WH, AS

Legend:

Effect on the wound: AN = Analgesic, AS = Antiseptic, EA = Exudate Absorption, HE = Hemostatic, SO = Soothing, WH = Wound Healing.

Likewise, the significant presence of *Teucrium polium* (L.) and *Salvia officinalis* (L.) reflects their well-known antimicrobial, astringent, and analgesic properties, which support their widespread use in wound care (Al-Naemi *et al.* 2024; Aljuboori *et al.* 2024). The moderate citation of *Melissa officinalis* (L.) can be attributed to its documented anti-inflammatory and skin-regenerative effects (Zam *et al.* 2022). Similarly, the relevance of *Plantago major* (L.) and *Pinus halepensis* Mill. lies in their traditional application for absorbing wound exudate and promoting tissue repair.

Plant part value (PPV)

In the Fez-Meknes region, various parts of medicinal plants are used to prepare traditional remedies for wound treatment. According to the Plant Part Value (PPV) index, leaves exhibit the highest PPV (0.544), making them the most frequently utilized plant part (Figure 3). Following this, aerial parts, which include stems, flowers, and leaves, rank second (PPV = 0.236), underscoring their combined relevance in wound treatment. Flowers, although less frequently used, show a PPV of 0.086. Subsequently, fruits and stems follow with PPVs of 0.051 and 0.034, respectively. Meanwhile, bulbs (PPV = 0.019), whole plants (PPV = 0.015), seeds (PPV = 0.008), and roots (PPV = 0.007) demonstrate relatively low usage in traditional wound care.

The dominant use of leaves can be attributed to their year-round availability, ease of collection, and richness in bioactive compounds such as polyphenols, flavonoids, and volatile substances (Barba *et al.* 2014). These compounds are widely recognized for their wound-healing, anti-inflammatory, and antimicrobial properties (Trinh *et al.* 2022; Criollo-Mendoza *et al.* 2023). This finding aligns with a previous ethnobotanical study in the Fez-Meknes region by El Oihabi *et al.* (2024), which reported that 85.40% of remedies traditionally relied on leaves.

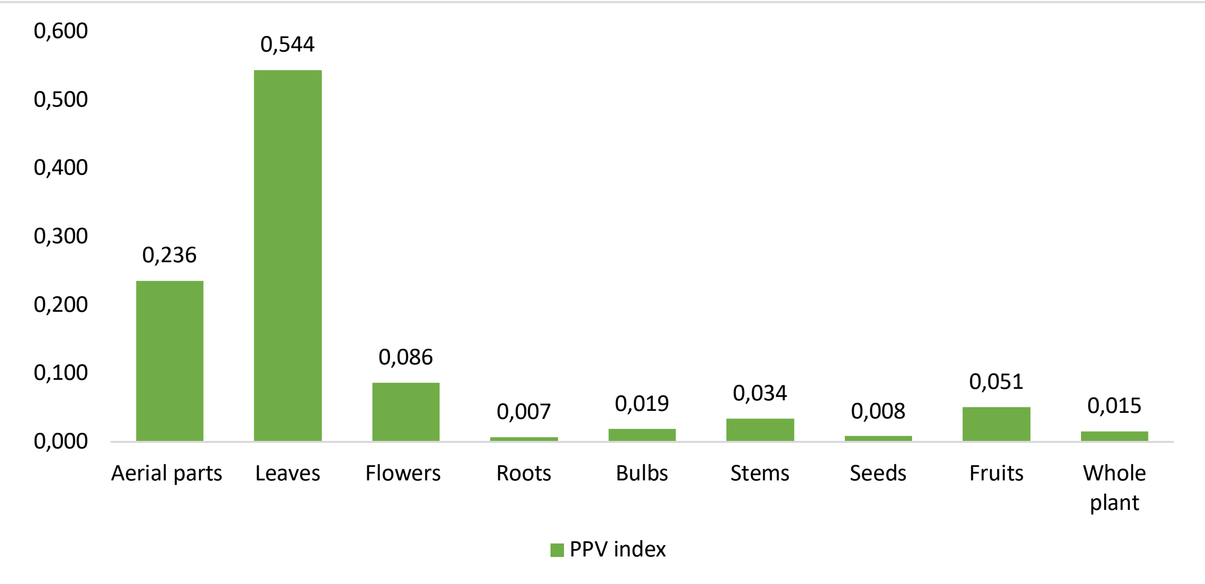

Figure 3. Plant part value (PPV) of medicinal plants.

The significant PPV of aerial parts further underscores their therapeutic relevance, suggesting their utility in the management of wounds and skin-related conditions (García-Bores *et al.* 2020). Although used less frequently, flowers are notable for their antioxidant and regenerative properties, particularly in promoting skin repair (Chen *et al.* 2018). Moreover, the therapeutic relevance of fruits and stems is associated with their astringent and hydrating effects, reflecting the richness of bioactive compounds that support tissue regeneration and promote optimal wound healing (He *et al.* 2015). By contrast, bulbs are used infrequently, possibly due to their high concentrations of alkaloids and saponins. Similarly, the low PPV of whole plants likely reflects a preference for specific parts with higher concentrations of active compounds, allowing for more targeted therapeutic applications (Kumar *et al.* 2024). Lastly, the minimal use of seeds and roots suggests their roles in wound healing are limited to specific contexts (Lalthansangi *et al.* 2024).

Plant state, preparation method, and form application

The analysis of plant usage states reveals that the majority of medicinal plants are utilized in their fresh form (74.16%), while a smaller proportion (25.84%) are employed in a dried state (Figure 4A). As illustrated in Figure 4B, the methods of preparation show significant diversity, with raw usage being the most prevalent (38.07%). Infusion (23.67%), decoction

(12.03%), and grinding (16.96%) are also widely adopted. In contrast, techniques such as distillation (7.50%) and maceration (1.78%) are less frequently employed.

In terms of the form in which medicinal plants are applied, raw preparations constitute the largest proportion (39.25%) (Figure 4C). Liquid extracts follow closely (37.48%), while powders account for 15.78% of applications. Essential oils represent 6.71%, and hydrosols show minimal usage (0.79%).

As shown in Figure 4D, wrapping (55.03%) is the predominant method of application. Irrigation is the second most common technique (31.76%), followed by spraying (13.21%).

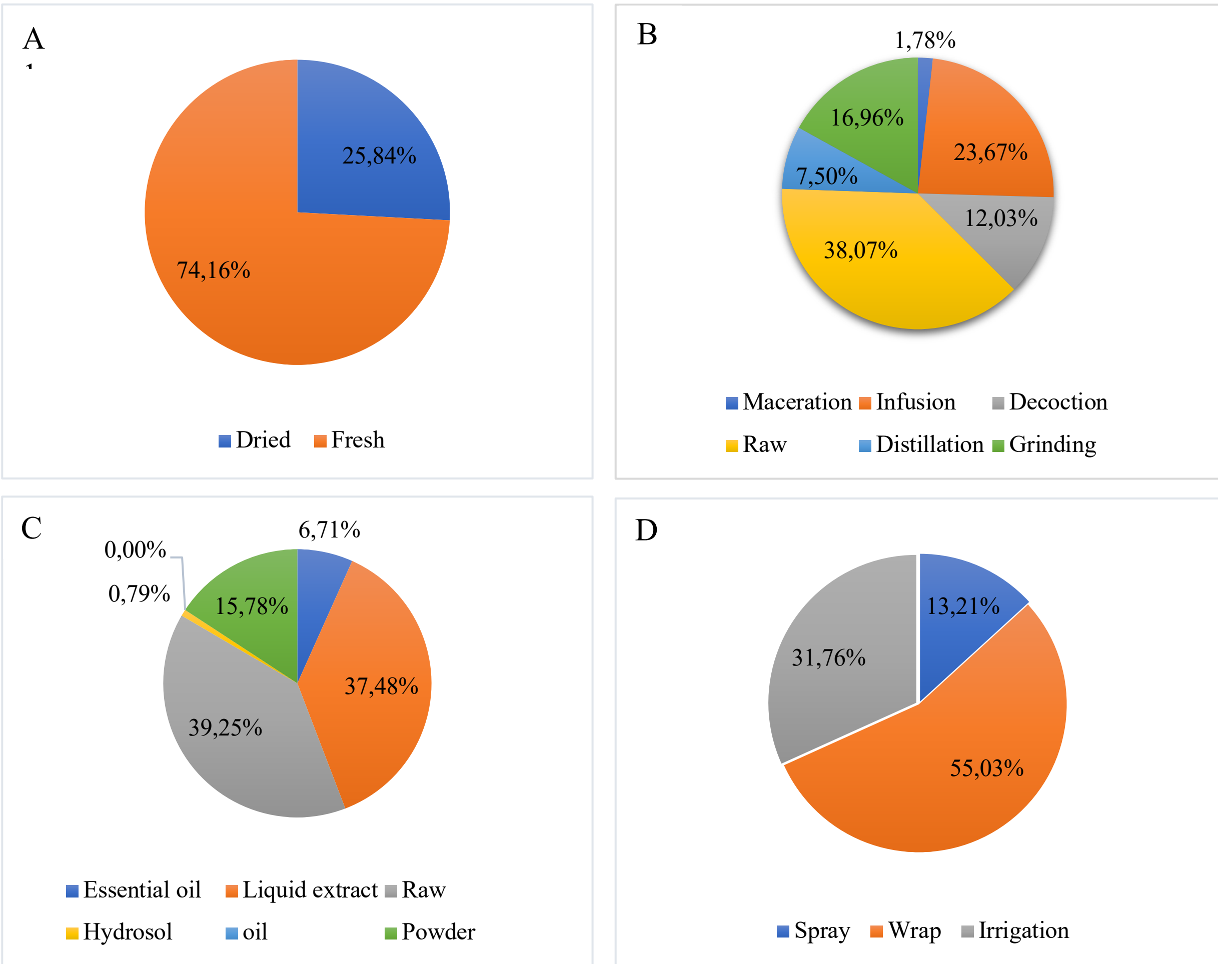

Figure 4. Ethnobotanical analysis: plant state (A), method of preparation (B), form of application (C), and method of application (D).

Fresh herbs are believed to retain a higher concentration of biologically active compounds, which can diminish during the drying process, suggesting their utility in in applications where maximum potency is desired, such as in traditional medicine (Deepthi *et al.* 2024). The preference for raw usage may be due to the fact that unprocessed plant extracts retain most of their bioactive components, supporting their direct application in traditional wound care (Khan *et al.* 2023; Koçak & Pazir 2018).

Infusion, decoction and grinding are commonly preferred for their practicality and demonstrated effectiveness in extracting bioactive compounds from medicinal plants. Specifically, infusion by steeping plant material in hot water offers a rapid and accessible method; however, it may be less effective for extracting constituents from denser or lignified tissues (Azmir *et al.* 2013). Similarly, decoction, which entails boiling, enhances the release of active compounds from hard or fibrous parts, yet it carries the risk of degrading thermolabile molecules (Muhammad Khairol Alaika *et al.* 2024). In contrast, grinding enhances extraction efficiency and dosing consistency by increasing surface area, although it can degrade sensitive compounds and generate dust, whereas raw utilization preserves phytochemical integrity with minimal processing but results in variable dosing and lower extraction yields (Fotsing *et al.* 2022; Tembane 2022). On the other hand, the relatively limited use of distillation and maceration may be attributed to practical constraints and perceptions of lower efficacy. For instance, distillation primarily employed for isolating essential oils yields highly pure extracts, but it requires specialized equipment and may cause the loss of volatile compounds during processing (Belokurov *et al.* 2019; Verep *et al.* 2023). Likewise, maceration performed at ambient temperature is gentle on heat-sensitive constituents; nevertheless, it is time-intensive and generally less efficient in terms of extraction yield (Jha & Sit 2022).

The high use of raw preparations suggests their efficacy in enabling topical and transdermal delivery of bioactive compounds. Moreover, liquid extracts are valued for their ease of application, which makes them particularly effective in treating superficial wounds. The use of powders reflects their solubility and adaptability, particularly in managing exudative wounds (Zhao *et al.* 2024). Furthermore, their frequent combination with honey or oils further enhances therapeutic outcomes through synergistic effects (Zaheri-Abdevand & Badr 2023). However, essential oils are less commonly used, possibly due to potential adverse effects such as skin irritation at higher doses (Sarkic & Stappen 2018), while the limited use of hydrosols may be linked to their comparatively lower bioactive compound concentrations (Almeida *et al.* 2024).

The predominance of wrapping as a method of application highlights the importance of simple, effective external treatments like poultices or compresses (Chotikamas *et al.* 2018). Irrigation is likely used for surface or internal wound rinsing, while spraying may be less common due to its specific use with liquid formulations such as oils and hydrosols (Bharadwaj & Singh 2020).

Statistical analyses

Chi-square test

The statistical results presented in Table 4 highlight the relationships between categorical variables related to medicinal plant species used for wound treatment, as assessed using the Chi-square test. The variables analyzed include informant, province, and state of use, each showing a highly significant association, with p-values < 0.001.

For the informant variable, the Chi-square value was 116.327, with a Phi/Cramer's V coefficient of 0.479, indicating an expressive effect size. The province variable yielded a remarkably high Chi-square value of 1091.208 and a Phi/Cramer's V coefficient of 0.599, reflecting a strong effect size. Similarly, for the state of use variable, the Chi-square value was 181.812, with a Phi/Cramer's V coefficient of 0.599, also indicating a strong effect size.

Table 4. Chi-square analysis of the associations between medicinal plant species and informant type, province, and plant utilization state.

	Medicinal plant species		
	Chi-square	**P-value**	**Phi/ v Cramer**
Informant	116.327	<0.001	0.479
province	1091.208	<0.001	0.599
Utilization state	181.812	<0.001	0.599

These statistical results reflect meaningful associations between the variables studied and the observed patterns in medicinal plant use. The significant association with the informant variable suggests that knowledge, practices, or preferences of individuals notably influence the selection and use of medicinal plant species.

The strong effect size associated with the province variable emphasizes the critical role of geographic location in shaping ethnopharmacological practices, likely reflecting regional biodiversity, cultural traditions, or ecological availability.

Lastly, the significant relationship observed with the state of use variable suggests that the decision to use plants in fresh or dried form is not random but influenced by specific characteristics of the plant species and local therapeutic practices.

Multiple correspondence analysis of medicinal plants, utilization state, informant profiles, and provincial distribution

The application of multidimensional correspondence analysis (MCA) (Figure 5) revealed distinct relationships among various medicinal plant species, their utilization states (fresh or dried), the geographical regions from which they were reported, and the types of informants (traditional healer or herbalist). This approach allowed for a comprehensive visualization of how these variables interact, highlighting specific associations and usage patterns.

The "Fresh" and "Dried" utilization states are positioned separately in the MCA biplot, indicating differing preferences for plant species according to their processing state. Several plant species exhibit unique placements within the two-dimensional solution. *Capsicum frutescens* (L.) and *Peganum harmala* (L.) cluster in the positive region of Dimension 2, suggesting an association with the variables or informants located in that quadrant. Conversely, *Capsella bursa-pastoris* Medik. and *Anacyclus pyrethrum* (L.) Lag. align with the negative region of Dimension 2, indicating divergent usage patterns.

Certain plants show strong spatial associations with specific regions. For example, *Calendula officinalis* (L.) is closely associated with Fez and Meknes, while *Plantago major* (L.) aligns with Sefrou, and *Papaver rhoeas* (L.), *Ricinus communis* (L.), and *Vachellia farnesiana* (L.) cluster with Taza.

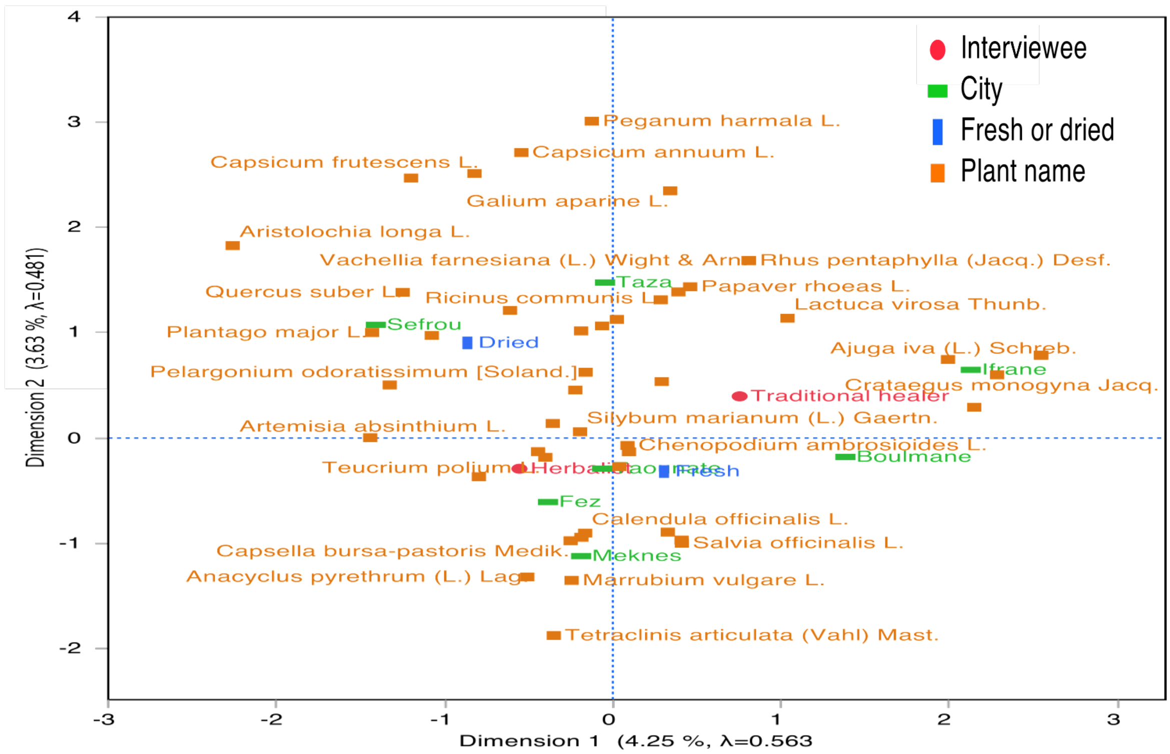

Figure 5. Multiple Correspondence Analysis (MCA) illustrating associations among medicinal plant species, informant categories, geographic distribution, and plant preparation forms in traditional wound care across the Fez-Meknes region.

The proximity of "Traditional Healer" and "Herbalist" categories to specific clusters of plant species suggests differentiated usage patterns between the two informant groups. In some cases, their preferences overlap, while in others, they diverge clearly.

The separation of "Fresh" and "Dried" usage states in the MCA plot underscores the distinct preferences for certain plant species based on their processing form. This finding highlights the importance of preparation methods in traditional pharmacopoeia, as some plants are predominantly used fresh while others are preferred dried.

The specific spatial positioning of plant species in relation to geographic regions suggests regionally distinct ethnobotanical practices. For instance, the association of *Calendula officinalis* (L.) with Fez and Meknes may reflect localized medicinal traditions or ecological availability. Similarly, the placement of *Plantago major* (L.) near Sefrou, and *Papaver rhoeas* (L.), *Ricinus communis* (L.), and *Vachellia farnesiana* (L.) near Taza, points to strong regional preferences and knowledge transmission patterns.

The MCA also reveals meaningful differences in how traditional healers and herbalists utilize medicinal plants. Their proximity to different species clusters suggests that professional specialization influences plant selection, though areas of overlap also indicate shared ethnomedical knowledge.

Overall, the MCA plot effectively demonstrates that the closer the variables (plant species, regions, or informant types) are in the two-dimensional space, the stronger their underlying associations. These findings collectively reflect the convergence of local knowledge, geographic context, and informant specialization in shaping medicinal plant usage patterns.

Multiple correspondence analysis of medicinal plant parts, preparation methods, and application modes

The results of the Multiple Correspondence Analysis (MCA) reveal associations between various plant parts, preparation methods, and their respective applications, as represented in Figure 6. The plot is organized into four quadrants, each illustrating distinct groupings and specific correlations among the analyzed variables.

In the upper left quadrant, roots, bulbs, and seeds are primarily associated with grinding as a preparation method and powder as a form of application. These plant parts, located farthest from the origin along Dimension 2, exhibit a strong correlation with solid-state processes. In the upper right quadrant, flowers and fruits are closely linked to maceration as a preparation method and liquid extracts as the main form of application. In the lower right quadrant, aerial parts and leaves are associated with distillation and irrigation as methods of application. Finally, the lower left quadrant contains items such as raw preparations and wraps, which are positioned near the origin, indicating minimal processing and limited correlation with other variables.

The spatial grouping of roots, bulbs, and seeds suggests their predominant role in solid-state preparations, likely due to their structural characteristics and traditional suitability for grinding and powdering. Their distance from the origin emphasizes their strong and distinct association with these processes.

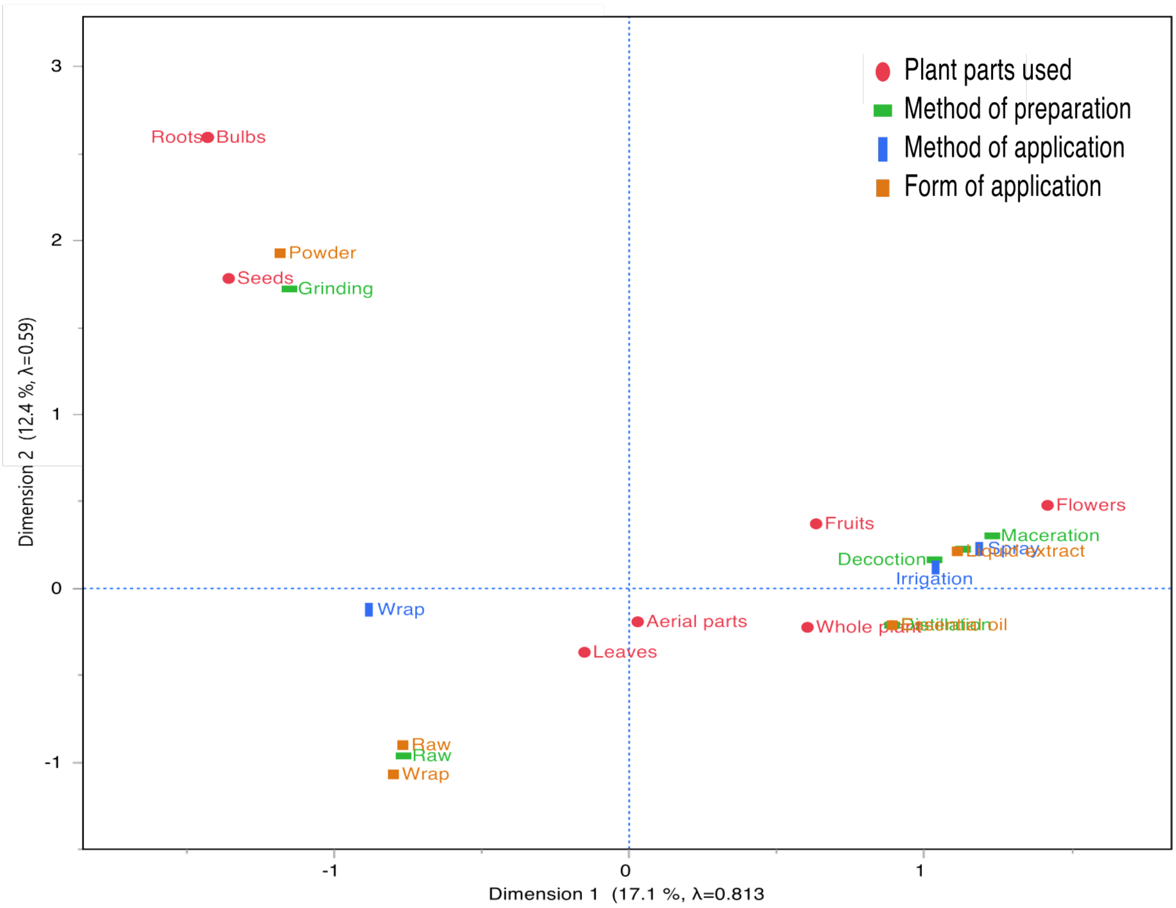

Figure 6. Multiple Correspondence Analysis (MCA) illustrating the relationships between plant parts, preparation methods, and modes of application in traditional wound treatment practices.

Conversely, the positioning of flowers and fruits in the upper right quadrant highlights their biochemical suitability for liquid-based preparations. Their strong correlation with maceration and liquid extracts may be attributed to the ease with which

The association of aerial parts and leaves with distillation and irrigation underscores their compatibility with advanced liquid handling methods and chemical manipulation. This placement reflects their flexibility in preparation and application, particularly in treatments involving volatile or soluble compounds. Raw preparations and wraps, positioned near the origin, suggest minimal processing requirements. Their limited correlation with other variables likely reflects their direct-use nature and alignment with traditional, low-intervention healing practices.

Overall, the MCA reveals clear distinctions in how different plant parts relate to specific preparation and application methods. Roots, bulbs, and seeds are linked to solid forms, while flowers, fruits, aerial parts, and leaves are more associated with liquid-based techniques. In contrast, raw preparations and wraps represent simplified, traditionally rooted practices requiring minimal transformation.

Contingency analysis of medicinal plant species associated with wound types

A contingency analysis examining the association between medicinal plants and specific wound types, namely necrotic, epithelializing, sloughy, and granulation stages, provides valuable insights into their therapeutic roles and diversity in wound care (Figure 7). *Salvia officinalis* (L.) is strongly associated with "Granulation/Sloughy" wounds, highlighting its role in tissue regeneration and slough management. In contrast, plants such as *Dittrichia viscosa* (L.) Greuter, *Teucrium polium* (L.), and *Melissa officinalis* (L.) are predominantly linked to epithelializing wounds, suggesting their potential to promote epithelial cell growth and accelerate wound closure.

Several plants are used across all healing stages ("All types"), including *Calendula officinalis* (L.), *Artemisia herba-alba* Asso, and *Melissa officinalis* (L.), indicating their multi-phase healing potential. Conversely, species like *Aloe barbadensis* Mill. and *Ajuga iva* (L.) Schreb. show specialization, being significantly associated with the "Necrotic/Sloughy" wound category. This reflects their targeted efficacy in managing advanced wound stages involving infection and necrotic tissue.
The strong associations between specific medicinal plants and distinct wound types underscore their potential as promising candidates for further phytochemical and pharmacological investigations. Such research could help validate their therapeutic efficacy and support their integration into evidence-based wound care protocols.

Generalist plants, which exhibit activity across multiple wound healing stages, offer substantial promise for the development of broad-spectrum or multi-phase topical formulations. Their versatility suggests potential utility in comprehensive wound management strategies, especially in traditional or integrative medical systems.

Therapeutic effects of medicinal plants in traditional wound care

As illustrated in Figure 8, the distribution of plant species based on their functional roles in wound care and therapeutic applications provides valuable insights. A notable 45% of the documented plant species exhibit wound-healing capabilities, underscoring their predominant role in regenerative medicine. Analgesic properties rank second, accounting for 21% of the species, followed by antiseptic properties, which are observed in 13% of the species.

Other functional roles include hemostatic activity (7%), exudate absorption (8%), and soothing effects (6%). Although these latter functions are less prevalent, they contribute meaningfully to specific aspects of wound management.

The high proportion of plants with wound-healing properties reflects their widespread use in both traditional and modern therapeutic practices aimed at tissue repair. The significant presence of analgesic and antiseptic species highlights the dual focus on pain relief and infection control, two essential pillars of wound treatment.

In contrast, the relatively lower representation of hemostatic, exudate-absorbing, and soothing functions may suggest their more specialized application in wound care, or possibly a gap in ethnopharmacological research and documentation. These findings indicate that plant-based therapeutics primarily target core aspects of wound healing, while niche roles remain underexplored and warrant further investigation.

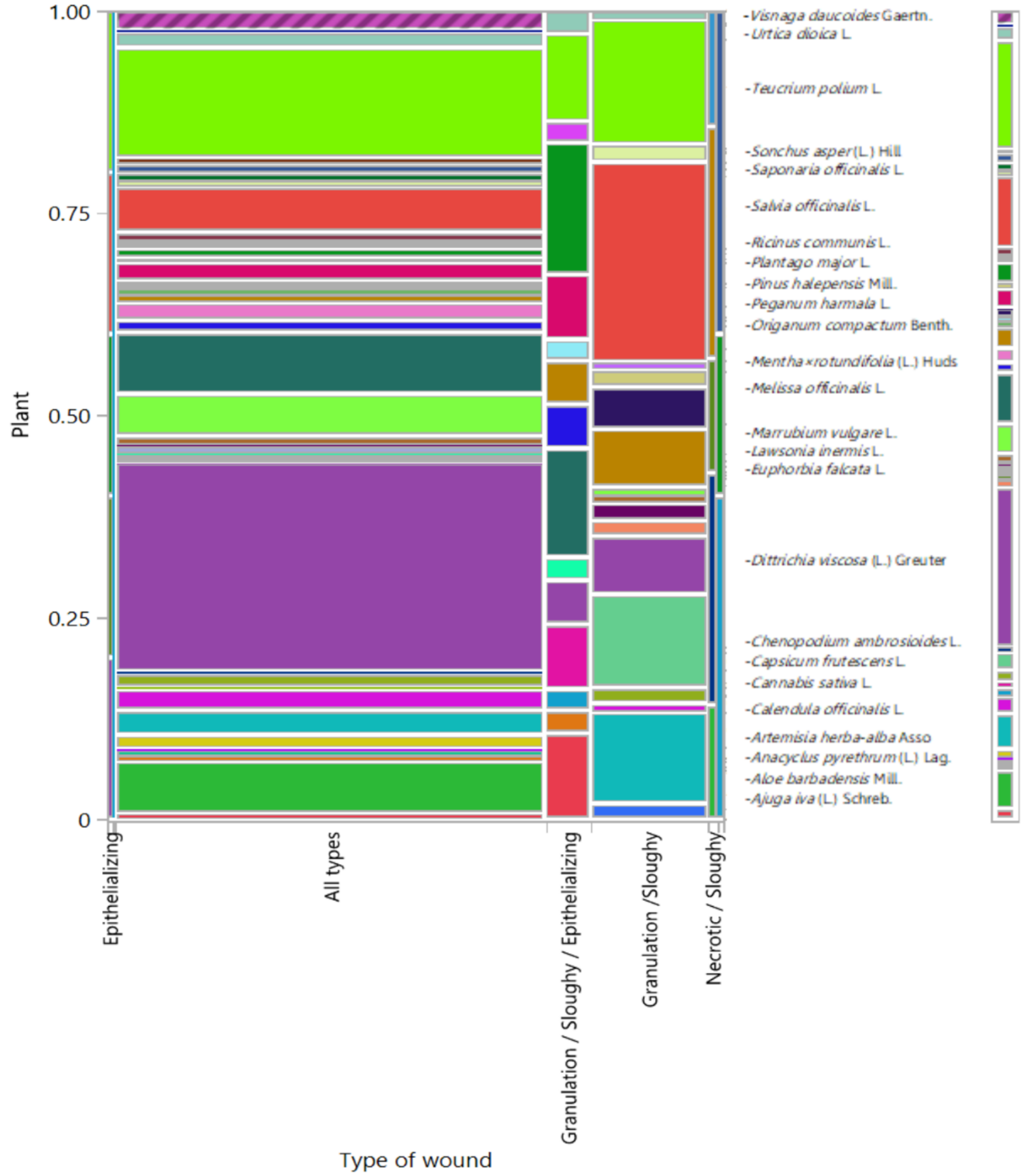

Figure 7. Mosaic plot illustrating the association between medicinal plant species and wound healing stages as classified by the Wound Healing Continuum (WHC).

Rahman's similarity index (RSI)

Rahman's Similarity Index (RSI) provides a quantitative measure of floristic similarity, allowing for a comprehensive comparison of the provinces within the Fez-Meknes region and their relationship with other Moroccan regions, specifically in the context of wound-related medicinal plant usage (Table 5). The RSI values within the Fez-Meknes region exhibit substantial variation, reflecting differing degrees of shared medicinal plant use between its provinces. The highest similarity is observed between Ketama (14.04) and Taza (12.5), suggesting a notable botanical and ethnomedicinal link, possibly due to comparable ecological conditions and cultural practices. Taounate (8.59) also demonstrates a moderate level of similarity, reinforcing the botanical continuity in the northern part of the region. Conversely, Ifrane (1.21) and Meknes (1.49) exhibit the lowest RSI values, indicating more distinct medicinal plant utilization patterns that may be influenced by ecological differences or urbanization effects.

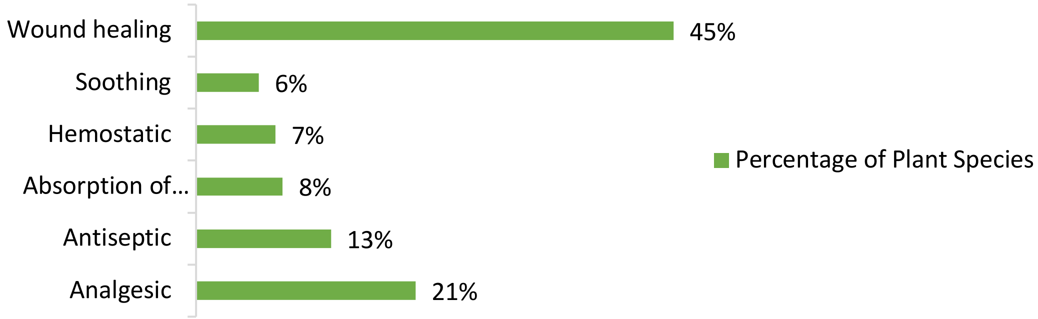

Figure 8. Distribution of medicinal plant species based on their reported therapeutic properties related to wound treatment.

When extending the comparison beyond the Fez-Meknes region, Rabat-Salé-Kénitra (15) and Beni Mellal-Khénifra (14.29) show the highest RSI values, implying significant floristic and ethnobotanical similarities with Fez-Meknes. This may be attributed to shared climatic conditions, geographical proximity, or cultural exchange. Moderate similarity is noted with Casablanca-Settat (7.25), Marrakech-Safi (6.37), and Drâa-Tafilalet (6.10), suggesting the presence of commonly used medicinal species but also highlighting regional variation in plant selection and traditional medical practices. In contrast, the lowest RSI values are recorded for Laâyoune-Saguia al Hamra (1.86) and Guelmim-Oued Noun (2.27), likely reflecting the impact of distinct Saharan and semi-arid environments, where the medicinal flora differs considerably from that of the Fez-Meknes region.

The analysis demonstrates a notable botanical and medicinal plant connections not only within the Fez-Meknes region but also with adjacent regions such as Rabat-Salé-Kénitra and Beni Mellal-Khénifra. These results provide a unique ethnopharmacological perspective on wound-healing plants, highlighting the depth of traditional knowledge embedded in local practices.

The variation in similarity indices across provinces reflects the region's diverse cultural and ecological heritage. Notably, this is the first ethnopharmacological study in the region to focus specifically on medicinal plants used for wound treatment. The data reveal a notably higher diversity of plant species compared to previous studies, underscoring the Fez-Meknes region's important contribution to traditional healing practices.

Table 5. Comparative analysis of floristic similarity and medicinal plant usage for wound healing across the Fez-Meknes and other Moroccan regions using the Rahman Similarity Index (RSI).

	Province /Region	**RSI (%)**	**References**
Fez-Meknes region	Boulmane	3.43	(Remok *et al.* 2024)
	Fez	7.23	(Tlemcani *et al.* 2023)
	Ifrane	1.21	(Radi *et al.* 2022)
	Ketama	14.04	(El-Mernissi *et al.* 2024)
	Meknes	1.49	(Fadil *et al.* 2015)
	Taounate	8.59	(M. Jeddi *et al.* 2021)
	Taza	12.50	(Mrabti *et al.* 2022)
Other regions of Morocco	Beni Mellal – Khénifra	14.29	(Belhaj *et al.* 2020)
	Casablanca – Settat	7.25	(El Abbouyi *et al.* 2014)
		4.72	(Essaih *et al.* 2023)
	Drâa – Tafilalet	6.10	(Eddouks *et al.* 2017)
	Guelmim - Oued Noun	2.27	(Ghourri *et al.* 2012)
	Laâyoune - Saguia al Hamra	1.86	(Idm'Hand *et al.* 2020)
	L'Oriental	4.49	(Fakchich *et al.* 2022)
	Marrakech – Safi	6.37	(Lemhadri *et al.* 2023)
	Rabat - Salé - Kénitra	15	(Salhi *et al.* 2019)
	Tangier - Tetouan - Al Hoceima	5.94	(Smaili *et al.* 2023)

Beyond its scientific significance, this research promotes the conservation and sustainable use of medicinal plant resources. It positions the Fez-Meknes region as a valuable repository of traditional medical knowledge and establishes this study as a key reference for ethnopharmacological research at both regional and national levels.

Conclusion

This ethnopharmacological study highlights the extensive biodiversity and deep-rooted traditional knowledge of medicinal plants used for wound treatment in Morocco's Fez-Meknes region. A total of 46 plant species from 26 botanical families were documented, with Asteraceae, Lamiaceae, and Asphodelaceae being prominently represented. Statistical analyses reveal strong correlations between plant usage patterns, geographic distribution, and informant profiles, emphasizing the dynamic interplay of cultural and ecological factors that shape traditional healing practices.

Particular attention is drawn to species such as *Dittrichia viscosa* (L.) Greuter*, Teucrium polium* (L.), and *Salvia officinalis* (L.), which are highly cited and reported to exhibit stage-specific therapeutic activities throughout the wound healing process. These species are therefore considered high-priority candidates for further pharmacological investigations. The study also validates traditional methods, most notably the use of fresh leaves in topical applications, while underscoring the Moroccan population's precise, experience-based selection of plants. This precision is evident in how wound characteristics, including color, depth, and appearance, guide the choice and preparation of phytotherapeutic agents.

Beyond documenting traditional approaches, the findings offer a strong foundation for future pharmacological research and the development of novel plant-derived therapies. They further highlight the pivotal role of traditional healers and herbalists in conserving and transmitting ethnopharmacological knowledge, even amid changing social and environmental contexts. Expanding ethnopharmacological surveys to neighboring regions would help elucidate regional variations and confirm the broader relevance and applicability of the insights gained from this study.

Ultimately, this comprehensive study serves as a key resource for promoting the conservation and sustainable use of medicinal plants. It also paves the way for pharmacological and biotechnological innovations that leverage the therapeutic potential of Morocco's rich botanical heritage.

Declarations

List of abbreviations: FC - Frequency of Citation; FIV - Family Importance Value; JI - Jaccard Index; MAPs - Medicinal and Aromatic Plants; MCA - Multiple Correspondence Analysis; NS - Number of Species; PPV - Plant Part Value; RFC - Relative Frequency of Citation; RSI - Rahman's Similarity Index; RU - Reported Uses; SPSS - Statistical Package for the Social Sciences; WHC - Wound Healing Continuum.

Ethics approval and consent to participate: This study complied with the Nagoya Protocol on Access and Benefit-Sharing. Verbal informed consent was obtained from participants and community leaders after clearly explaining the study's objectives. Traditional knowledge was collected according to national regulations, with no biological samples exported or commercial use intended.

Consent for publication: Not applicable.

Availability of data and materials: The datasets used and/or analysed during the current study available from the corresponding author on reasonable request.

Competing interests: The authors declare that they have no known competing financial, interests or personal relationships that could have appeared to influence the work reported in this paper.

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Authors' contributions: A.E.G. Writing – review & editing, Writing – original draft, Resources, Methodology, Formal analysis, Data curation. B.L. Writing – review & editing,Sofware, Data analysis, Data curation. K.S. Data curation, Writing – original draft. A.E.M. Data curation, Writing – original draft. S.I.S.K. Supervision, Validation, Resources. S.E. Conceptualization, Supervision, Validation, Resources, Writing – review & editing.

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