Medicinal plants used in the traditional management of wounds and hypertension: An ethnoecological survey in Ouled Moussa, Algeria

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Research

Abstract

Background: In Algeria, many communities rely on traditional knowledge of medicinal plants for daily healthcare. In Ouled Moussa, Boumerdes, local plants are still used to treat burns, wounds, and manage hypertension. However, scientific documentation in this region is limited. This study aims to document medicinal plants used in Ouled Moussa for wound care and hypertension, including their uses and ecological characteristics.

Methods: Structured interviews with 44 herbalists in Ouled Moussa documented medicinal plants, their preparation, and uses. Ethnobotanical indices assessed species importance. Chorology was analyzed using Takhtajan's classification, and conservation status was evaluated via the IUCN Red List. Principal Component Analysis (PCA) and Hierarchical Agglomerative Clustering (HAC) were applied to quantitative and binary data to identify groups of species.

Results: The herbalists shared knowledge on 48 plant species across 26 families, with Lamiaceae and Asteraceae most frequently cited. Herbs were the predominant life form, with leaves as the main plant part used, followed by seeds and roots. Preparations included infusions, mixtures, and ointments. Most species are native to the Mediterranean or Euro-Siberian regions, and the majority are not currently threatened according to the 2024 IUCN Red List, though *Saussurea costus* is Critically Endangered and *Marrubium vulgare* Near Threatened. Notably, species such as *Teucrium polium*, *Punica granatum*, *Carthamus caeruleus*, and *Hibiscus sabdariffa* were widely cited for both wound care and managing blood pressure, reflecting a practical overlap valued by the community.

Conclusions: These findings highlight a living tradition of using local plants for health needs in Ouled Moussa. Preserving this knowledge is essential, especially as some of these plants face pressures from environmental changes. Beyond cultural preservation, these practices may guide researchers in identifying plants with potential for developing new wound-healing and antihypertensive treatments. Further studies should explore the pharmacological properties of these plants to confirm their safety and effectiveness.

Keywords: Ethnoecological, wound healing, hypertension, medicinal plants, PCA.

Background

Plants have been integral to human healthcare since ancient times, with their systematic use notably advanced by scholars like Al-Razi during the Islamic Golden Age (8th–13th century), laying the groundwork for modern pharmacology. Today, approximately 80% of the global population still relies on plant-based medicines for primary healthcare, while around 25% of modern pharmaceuticals are derived from medicinal plants (Steel, Gallego-Perez *et al*. 2025). Globally, interest in traditional medicine continues to rise, with medicinal plants recognized not only for their therapeutic potential but also as valuable resources for the discovery of new pharmaceutical compounds (Süntar 2020).

Algeria, located within the Mediterranean basin, is distinguished by its remarkable biodiversity, encompassing approximately 3,139 plant species, of which 6.3% are endemic to the country (Meddour, Sahar *et al*. 2023). This rich floristic diversity supports a wide range of endemic and naturalized plant species across diverse ecosystems. (Boughrara and Belgacem 2016). The region of Ouled Moussa in Boumerdes benefits from this ecological wealth, where traditional knowledge of medicinal plants is still actively preserved and transmitted across generations. This traditional knowledge is deeply rooted in Islamic teachings, particularly the hadiths of the Prophet Muhammad (peace and blessings be upon him), which highlight the use of plants for healing purposes. Beyond its religious foundation, this knowledge is also shaped and enriched by the oral traditions of the local inhabitants, who have passed down their practical experiences and understanding of medicinal plants across generations within the community.

Wounds, injuries, and burns represent a significant public health concern globally, with millions of individuals affected each year, potentially leading to severe complications or death if left untreated (Falanga, Isseroff *et al*. 2022). Hypertension, a major non-communicable disease, affects over 1.28 billion adults worldwide and is considered a leading contributor to morbidity and mortality (Organization 2023). The prevalence of hypertension continues to rise, particularly in low- and middle-income countries, where approximately two-thirds of cases are reported due to factors such as lifestyle changes, dietary habits, and limited access to healthcare services (Mills, Stefanescu *et al.* 2020). Importantly, hypertension has been identified as a significant factor that impairs wound healing, primarily due to its association with reduced blood flow, microvascular dysfunction, and impaired oxygen delivery to the wound site (Stanley, Lounsbury *et al.* 2005, Ahmed, Mooar *et al.* 2011). Chronic hypertension can delay the inflammatory phase and disrupt collagen synthesis, which are essential processes for effective tissue repair. Conventional antihypertensive therapies, including beta-blockers, ACE inhibitors, and calcium channel blockers, are widely used to manage blood pressure and reduce cardiovascular risks. However, these medications can also influence wound healing processes. For instance, beta-blockers such as propranolol have been reported to impair wound healing by reducing peripheral blood flow, which may lead to delayed epithelialization and collagen deposition. Similarly, while ACE inhibitors like enalapril can improve vascular function, they may interfere with the inflammatory phase and delay wound closure under certain conditions (Stuermer *et al.* 2019) . These potential adverse effects on wound healing highlight the need to monitor blood pressure closely during wound care. Using medicinal plants with blood pressure-lowering properties may help maintain control while supporting recovery. In this context, plants with dual antihypertensive and wound-healing actions offer a promising option, helping manage blood pressure while promoting faster healing for safer, more effective patient recovery.

Therefore, in populations with a high burden of hypertension, such as in many regions of Africa and the Mediterranean (Parati, *et al.* 2022), effective wound management strategies must consider the impact of hypertension on the healing process, emphasizing the need for integrative approaches, including the use of medicinal plants with potential antihypertensive and wound-healing properties. However, this dual therapeutic potential remains underexplored within Algerian ethnomedicine. Although, some medicinal plants may offer dual therapeutic benefits for wound healing and blood pressure regulation, this potential remains largely underexplored within Algerian traditional medicine.

This study documents plants used by the Ouled Moussa community for wound care and hypertension, highlighting their ecological characteristics. It aims to preserve traditional knowledge and support future pharmacological and ecological research.

Material and Methods

Study area

Ouled Moussa is a commune located in Boumerdes Province, Algeria, situated within the Daïra of Khemis El Khechna. It is positioned approximately 32 km southeast of Algiers, extending from Ouled El Hadj in the west to the Bouzegza Mountains in the east, covering a total area of 29 km² (Figure 1). According to the 2022 municipal census, the total population of Ouled

Moussa was recorded at 97,000 residents, with males accounting for 52% and females 48% of the population. The study area is characterized by a Mediterranean climate, with a mean annual precipitation of 789.9 mm. Winters are generally cool and wet, whereas summers are warm and dry. Climatic data were collected between 1998 and 2008 and obtained from the National Meteorological Office. The region also exhibits considerable biodiversity, largely supported by its pronounced topographic heterogeneity. From north to south, the landscape encompasses coastal zones, coastal plains, hills, valleys, and mountainous areas. Elevation ranges from sea level to 1,032 m above sea level at Mount Bouzegza, contributing to the diversity of habitats and ecosystems found throughout the region (Souiher *et al.* 2025), which supports the practice of traditional medicine within the community.

During this ethnobotanical survey, information was collected through structured and semi-structured interviews with local informants across different sectors of the commune, focusing on the medicinal plants used for wound healing and hypertension management within the context of local cultural practices and Islamic traditions.

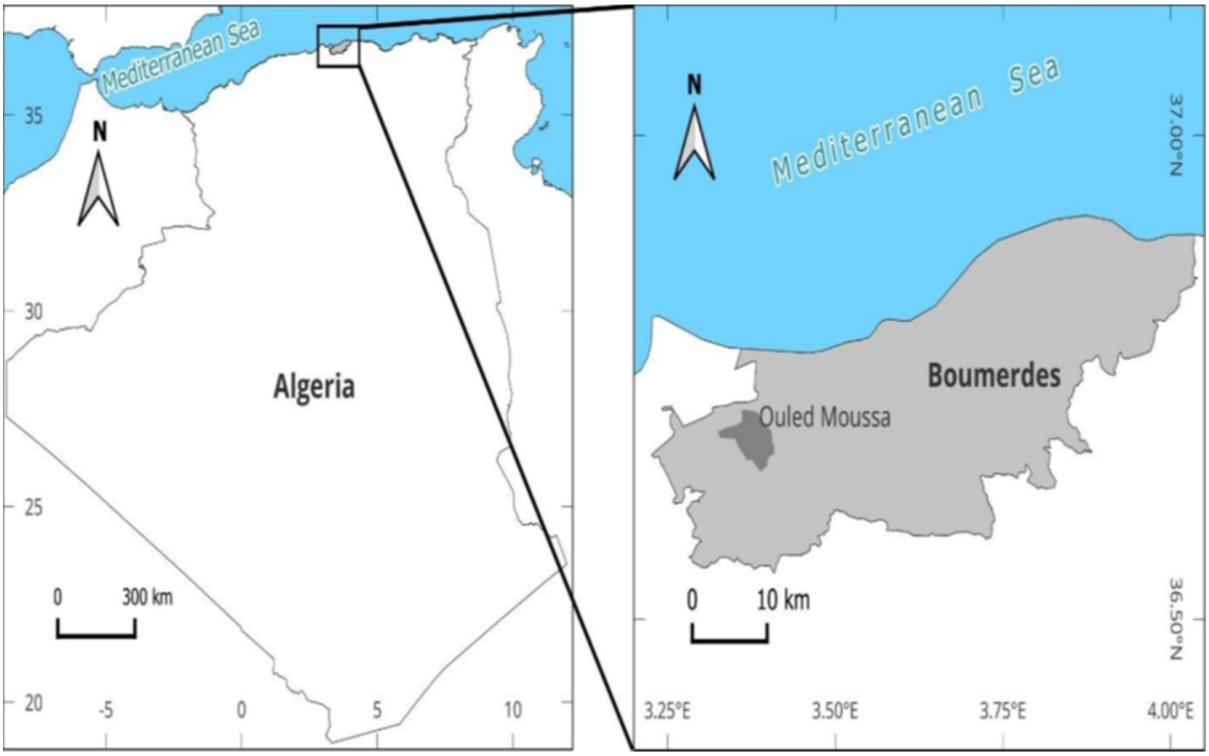

Figure 1. Map of Ouled Moussa province, Boumerdes, showing the study area (Administrative boundaries downloaded from DIVA-GIS Data website, https://diva-gis.org/data.html)

Therapeutic plants collection

A descriptive, cross-sectional, and declarative ethnobotanical study was carried out over a period of three months in 2024, focusing on traditional medicine practitioners actively engaged in the use and recommendation of medicinal plants for the treatment of superficial wounds, internal injuries, burns, and hypertension. The survey specifically targeted healers known within their communities for their herbal knowledge and practices. Data were collected through structured face-to-face interviews conducted in the national language, each lasting between 15 and 35 minutes, allowing participants to share detailed information about the plants they use and the therapeutic practices they follow.

Identification and Preservation of Therapeutic Plants

Plant specimens were collected during their flowering stage to allow for accurate taxonomic identification. Following collection, the samples were carefully dried, pressed, and mounted on standard herbarium sheets (11.5 × 17.5 inches) for long-term preservation and record-keeping. Identification was carried out by specialists at the National High School of Agronomy (ENSA), El Harrach, Algeria. Once verified, each specimen was assigned a unique voucher number and deposited in the Biodiversity, Biotechnology, Environment, and Sustainable Development Laboratory (BioDev) for future reference and consultation.

Ecological considerations

Life forms

In this study, the frequencies of life forms of the recorded species were determined according to the Raunkiaer classification system (Cain 1950). The Raunkiaer system categorizes plants into five classes based on the position of their renewal buds. When the buds are located below the ground surface, the species are classified as Geophytes; at the ground level, as Hemicryptophytes; and above ground, as Chamaephytes and Phanerophytes, which are both woody plants. Finally, annual herbaceous species are classified as Therophytes (Cain, 1950). This classification is highly useful, as it reflects the ecological adaptations of species(Irl *et al.* 2020). Geophytes are able to tolerate recurrent forest fires due to the protection of their regenerative buds, which are buried in the soil. Hemicryptophytes are adapted to very cold climates, as the snow cover protects their ground-level buds from subzero air temperatures. Therophytes are well adapted to harsh climatic conditions, such as prolonged droughts, or to ecosystems disturbed by anthropogenic activities such as agriculture. Indeed, these species have very short life cycle, they produce a large number of seeds each season, which can remain viable for several years and germinate when environmental conditions become more favorable.

In this study, our approach is not ecological in nature; rather, we aim to understand the preferences of herbalists for certain species over others. More specifically, we seek to determine whether herbalists tend to favor particular groups of species according to their life forms and, if so, which life forms are preferred and why. To address this question, a chi-square test was conducted using a dataset comprising the frequencies of each life form.

Chorology

The percentage of species according to their biogeographic origin was analyzed based on Takhtajan's world floristic biogeographic subdivision(Takhtajan 1986). Overall, the recorded species are originated from eighteen floristic regions that express the spontaneous distribution of taxon as follow; Amazonian (Ama), Atlantic cost (Atl-Cot), Caribbean (Car), Circumtropical (Cir-Tro), Cosmopolite (Cos), East Asia (E-Asi), West Asia (W-Asi), Euro-Siberian (Eu-Sib), Guinean (Gua), Himalayan (Him), Indian (Ind), Irano-Turanian (Ira-Tur), Madrean (Mad), Malesian (Mal), Mediterranean (Med), North African (N-Afr), Saharo-Arabian (Sah-Arb), Sudanian (Sou). When the taxon is communally distributed over the world, the taxon is considered as Cosmopolite (Cos), when it is endemic to the North Africa, taxon is noted (N-Afr).

The IUCN red list of threatened species

As we study the use of plants in healthcare, we also examined their threatened extinction risk status according to the International Union for Conservation of Nature's (IUCN) Red List of Threatened Species. This organization classify species according to nine extinction risk categories. The categories that indicate an extinction risk are, vulnerable (VU), Endangered (EN) and Critically Endangered (CR).

Data Analysis

Quantitative ethnobotanical indices were employed to analyse the collected data and evaluate the relative importance and consensus regarding the medicinal plants reported by informants.

The Relative Frequency of Citation (RFC)

The Relative Frequency of Citation (RFC) was calculated to assess the local importance of each medicinal plant based on the perspectives of herbalists. RFC was determined by dividing the number of herbalists who mentioned a particular species (FC) by the total number of participating herbalists (N) according to the formula (Boudjelal, Henchiri et al. 2013).

$$\mathrm{RFC} = \frac{\mathrm{FC}}{\mathrm{N}} \quad (0<\mathrm{RFC}<1)$$

Where

FC= represents the number of informants citing the species.

N= Total number of herbalists in the survey

The Use Value (UV)

It's a relative measure of the importance of each locally known plant species used as an herbal remedy. This value is calculated using the following formula:

$$\mathrm{UV} = \frac{\sum u}{\mathrm{N}}$$

Where

U = The total number of use-reports for a species across all informants.
N= The total number of informants.

The Fidelity Level (FL%)

It's a measure used to identify the most important medicinal plant species in the treatment of various ailments. It's calculated with this equation: FL = (Ns / N) × 100

$$\mathrm{FL} = \frac{\mathrm{Np}}{\mathrm{N}} \times 100$$

Where
Np= Number of records of a particular plant for a specific ailment
N= Whole number of respondents mentioned the plant species for any disorder

Informant consensus factor (ICF)

It was calculated to identify the agreement of informants on the reported use reports for different types of diseases, by the formula:

$$\mathrm{ICF} = \frac{\mathrm{Nur} - \mathrm{Nt}}{\mathrm{Nur} - 1}$$

Where
Nur= The number of use reports for a particular ailment category and
Nt= The number of taxa used for the given ailment category.

Family use value (FUV)

It was calculated to identify the essential medicinal plant families in the study area, by the following formula:

$$\mathrm{FUV} = \frac{\mathrm{UVs}}{\mathrm{Ns}}$$

Where UVs represents the cumulative use values of all species belonging to a particular family, and Ns denotes the total number of species recorded for that family.

The Multivariate Analysis

In this study, the Principal Component Analysis (PCA) was used to identify groups of species that are homogeneous with respect to the studied variables. The PCA was performed on a dataset of dimension $n \times p = 48 \times 49$, where n represents the number of species (rows) and p the total number of variables (columns). To respect the mathematical assumptions of the PCA, the principal components were constructed solely based on the 12 quantitative variables (active variables). The remaining 37 qualitative variables were included as supplementary (or illustrative) variables, ensuring they did not influence the axis construction while allowing for post-hoc interpretation using Wilks' test. All the qualitative variables take two levels "true" or "false" coded "1" and "0" respectively. The Wilks lambda test which is a commonly used statistic in Multivariate Analysis of Variance (MANOVA) was used to identify which qualitative variables best explain the variance of groups differences (Haase & Ellis 1987) . In other word, which variables best separate the groups of species with respect to the qualitative variables in the factor map. The species of each group that best explain the axis are cited in the text in descending order of the contribution rate and the square cosine ($\cos^2$) which express the (i) contribution rate of the species to the definition of the principal component and (ii) the quality of representation of that species in the principal component respectively.

The PCA was performed using "FactoMineR" R package which is dedicated to the multivariate analysis created by Lê, Josse, and Husson (2008). The PCA results analysis was plotted using "factoextra" R package. All the data analysis were performed using R software (R Development Core Team, 2025).

Clustering

For this purpose, we applied Hierarchical Agglomerative Clustering (HAC), an unsupervised clustering method based on similarities among individuals. Euclidean distances were computed using the coordinates of individuals on the principal components obtained from the PCA previously done.

Cluster aggregation was performed using Ward's linkage method. The results are represented as a dendrogram, and the final number of clusters was determined by cutting the tree at an appropriate height. The main advantages of this method are that

(i) it does not require the number of clusters to be specified a priori; (ii) it performs well when applied to multivariate analysis results; and (iii) it provides an intuitive and easily interpretable graphical representation of group structure.

The HAC analysis was conducted using the FactoMineR package in the R software environment (Lê *et al*. 2008).

Results

Demographic Data

A total of 44 herbalists participated in this survey, with the majority being male (84.1%). Most participants were between 40 and 60 years of age, reflecting the active age group in herbal practice within the region. Regarding educational background, over half of the herbalists had attained at least a middle or high school education, indicating a relatively good level of formal education among participants. Herbal knowledge was mainly acquired through professional practice and family traditions, highlighting the importance of both community transmission and hands-on experience in sustaining herbal practices. In terms of experience, the majority of herbalists had been practicing for less than 15 years, reflecting a growing interest in herbal medicine within the community.

Table 1. Socio-demography of informants in the research area.

Characteristics	Category	Percentage (%)
Age (years)	20–30	20.5%
	30–40	20.5%
	40–50	22.7%
	50–60	27.3%
	60–70	9.0%
Gender	Female	15.9%
	Male	84.1%
Academic Level	None	4.5%
	Primary school	6.8%
	Middle school	27.3%
	High school	31.8%
	Licence (Bachelor's)	13.6%
	Master's degree	13.6%
	Doctorate	2.3%
Source of Experience	Family	34.1%
	Commerce	43.2%
	Books & Social Media	2.3%
	Educational Courses	20.5%
Years of Experience	0–15	59.1%
	15–30	29.5%
	30–45	6.8%
	45–60	4.5%

Ecological considerations

Life forms

All life forms are equally represented except the geophyts (Figure 2). This result was expected as it is well known that under a temperate sub-humid Mediterranean climate, the geophytes are less frequented than the others according to (Cain,1950). It is also well known that the Therophytes are well adapted to the summer drought even that characterize the Mediterranean climate (Cain, 1950; Irl et al, 2020). No trend can be identified on the use of the recorded species according to their life forms (χ^2=0.325, df = 4, p-value = 0.98).

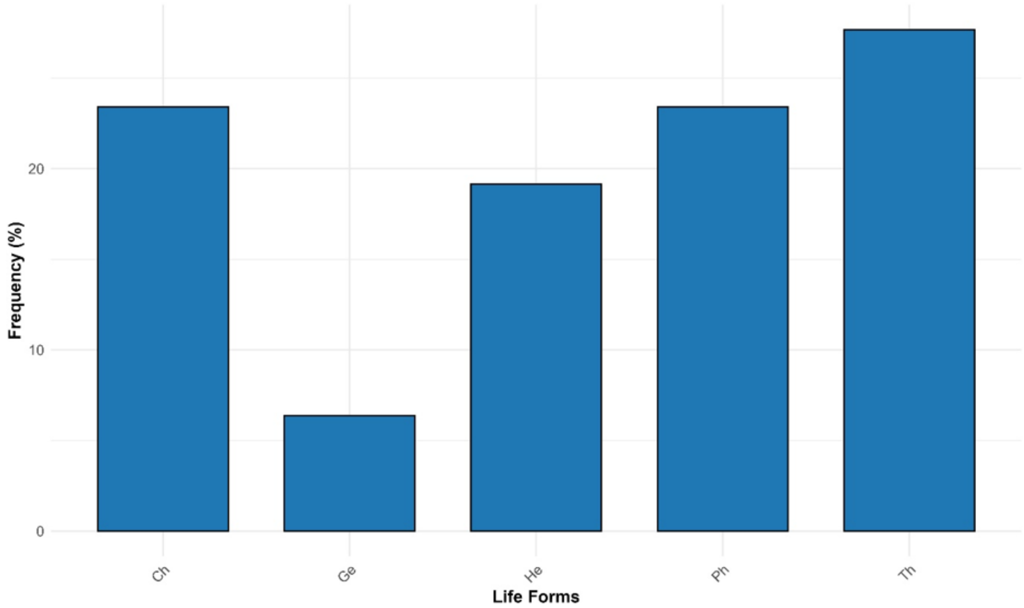

Figure 2. life forms frequencies (%) according to the Raunkiaer classification of 48 species counted in Ouled Moussa used for treating hypertension and wound-healing disorders. Th: Phanerophytes,, Ch: Chamaephytes, He: Hemicryptophytes, Ge: Geophytes, Th: Therophytes.

Chorology

45.83 % of the recorded species used in Ouled Moussa are native to the Mediterranean (Med) floristic region followed by the Euro-Siberian (Eu-Sib) region with 22.91 % (Figure 3). Overall, more than 68% of the studied species belong to either the Mediterranean or the Euro-Siberian biogeographical region, or to both.

The third most used species are native to the North of Africa (Morocco, Algeria and Tunisia) with 12.50 %. This finding highlight that's the healer promote the local species that grow naturally in their locality than the introduced and domesticated species like *Cucurbita moschata* which has Caribbean, Guinean highlands and Amazonian biogeographical origin or even *Hibiscus sabdariffa* which is circumtropical.

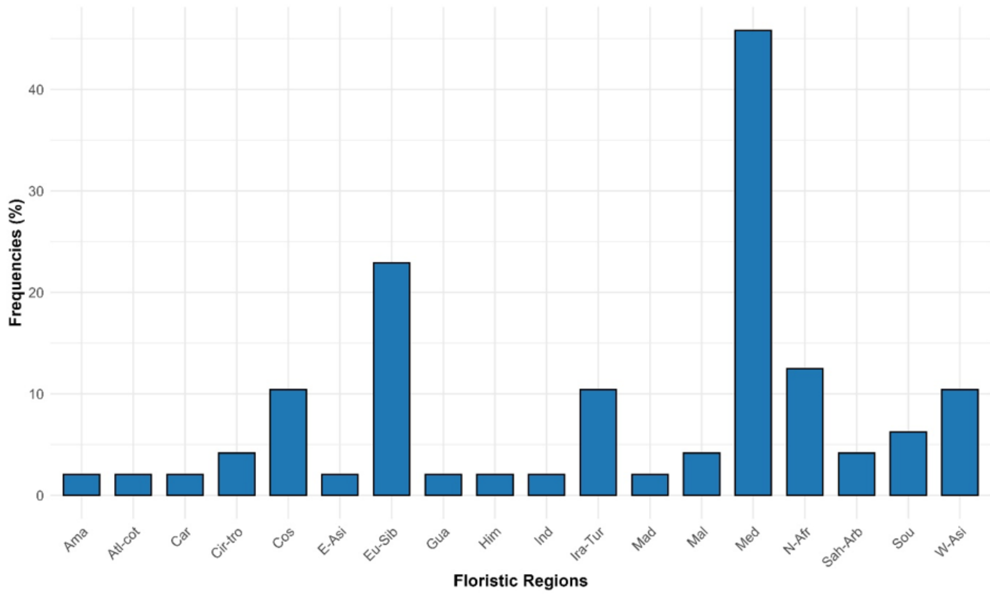

Figure 3. Biogeographical origin according to Takhtajan 1986 subdivision of counted species in Ouled Moussa used for treating hypertension and wound-healing disorders. Ama: Amazonian, Atl-Cot: Atlantic cost, Car: Caribbean, Cir-Tro: Circumtropical, Cos: Cosmopolite, E-Asi: East Asia, W-Asi: West Asia, Eu-Sib: Euro-Siberian, Gua: Guinean, Him: Himalayan, Ind: Indian, Ira-Tur: Irano-Turanian, Mad: Madrean, Mal: Malesian, Med: Mediterranean, N-Afr: North African, Sah-Arb: Saharo-Arabian, Sou: Sudanian

IUCN Red list

The hole of used species in Ouled Moussa is not threatened by disappearance according to the 2024 IUCN red list, where 56.25 % of theme are Not Evaluated (NE) (Figure 4). However, 31.25 % of the species are Least Concerned (LC) by disappearance among which 46.66 % are Mediterranean, 33.33 % are Euro-Siberian and 20 % are North African. In our study, we found one species which is Critically Endangered (CR) *Saussurea costus* which is a Himalayan taxon.

Among the Mediterranean, North African and Euro-Siberian Species (n=39, 81.25 % of species), only *Marrubium vulgare* is considered as Near Threatened (NT) by the IUCN classification.

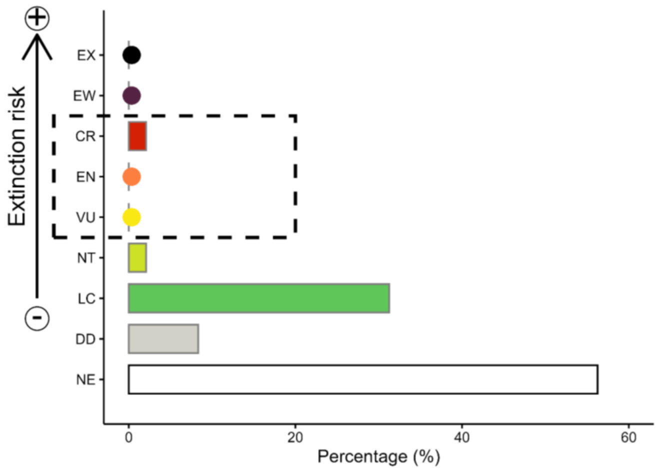

Figure 4. Percentage of studied species used to treat hypertension and wound-healing disorders in the Ouled Moussa district, according to the 2024 IUCN Red List categories. The dashed line indicates the threatened categories. NE: Not Evaluated, DD: Data Deficient, LC: Least Concern, NT: Near Threatened, CR: Critically Endangered, EW: Extinct in the Wild, EX: Extinct.

Data Analysis

In total, 48 plant species from 29 families were documented for their traditional use in treating wounds, burns, and hypertension. The data collected include therapeutic applications, preparation methods, and administration routes. Superficial and internal wounds were mostly treated topically or orally, respectively, while burns were managed with oils or ointments. Antihypertensive plants were generally prepared as infusions. A detailed presentation of the main species and their uses is provided in Table 2.

Growth Forms of Medicinal Plants Used for Wound Healing and Hypertension

The survey revealed a clear predominance of herbaceous species, which accounted for 82.2% of the medicinal flora, reflecting their accessibility and traditional importance in local healing practices. Shrubs (8.9%) and trees (4.4%) were less represented, while climbers and ferns, each constituting 2.2%, appeared only marginally. This pattern underlines the central role of herbs in the ethnopharmacological landscape (Figure 5).

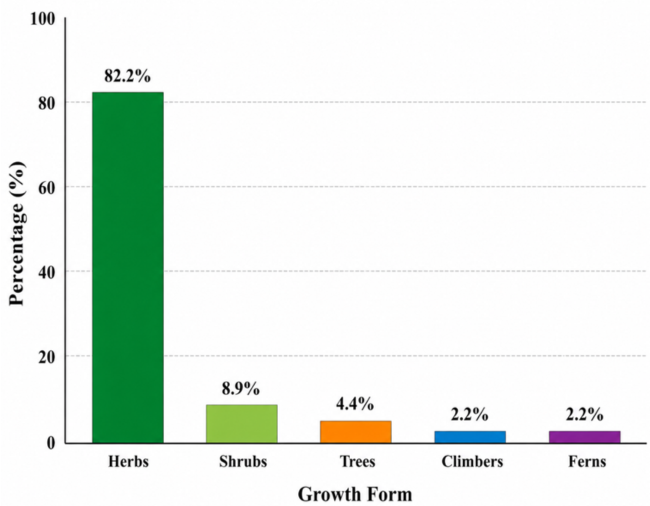

Figure 5. Growth forms of medicinal plants used locally.

Preparation Methods and Plant Parts Used

Infusion was the most frequently employed preparation method, accounting for approximately 42% of the documented uses, followed by mixture (18%) and ointment (13%). Other preparation methods, including maceration, oil extraction, and powder, were less frequently reported. Regarding the plant parts used, leaves were the most commonly utilized across preparations, reflecting their accessibility and phytochemical abundance, followed by roots, flowers, and fruits (Figure 6). The prevalence of infusion and the widespread use of leaves indicate a reliance on simple water-based extraction techniques in traditional practices, aiming to maximize the yield of bioactive constituents while maintaining ease of preparation.

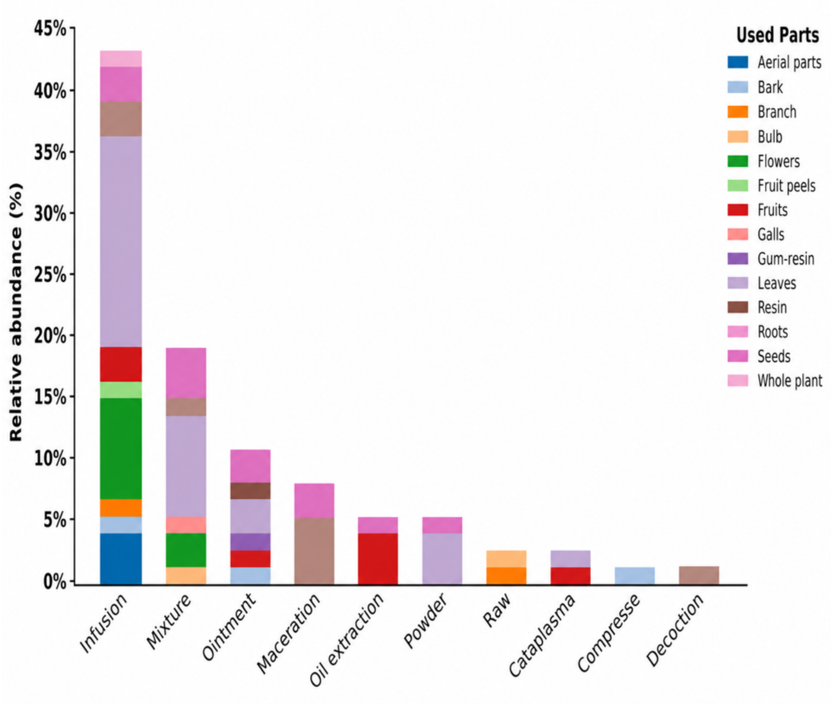

Figure 6. Medicinal Plant Parts by Preparation Method

Family Use Value (FUV) and Species Percentage by Family

The analysis of the Family Use Value (FUV) and the relative percentage of species per family revealed a marked predominance of Malvaceae (FUV = 0.61; 2% of species), followed by Anacardiaceae (0.52; 2%), Lythraceae (0.39; 2%), and Pinaceae (0.34; 2%). Although Lamiaceae presented the highest proportion of recorded species (25%), its FUV was comparatively moderate (0.14). Asteraceae, with 15% of the species and an FUV of 0.10, also demonstrated a notable ethnobotanical presence. These findings indicate that certain families, despite having a lower number of species, exhibit higher reported usage values, suggesting a specific ethnobotanical relevance (Figure 7).

Informant consensus factor (ICF)

The Informant Consensus Factor (ICF) values varied across ailment categories, with the highest consensus observed for internal wounds (ICF = 0.80), followed by burns (0.79), hypertension (0.74), and superficial wounds (0.71). Hypertension exhibited the highest number of use reports (Nur = 95) and taxa (Nt = 25), reflecting its prominence in the surveyed communities, while internal wounds had a relatively high consensus despite fewer taxa (Nt = 14) (Figure 8). These findings indicate targeted and consistent use of medicinal plants within the community for wound-related ailments and hypertension management.

The Multivariate Analysis

In the aim to create homogenous groups of species with respect to the studied variables we performed a PCA. The interpretation of the PCA results will be restricted to the four first dimensions that express 88.8 % of the inertia. This result indicates that the PCA results are highly significant. All of the remaining axes exhibit an inertia bellow to the reference value.

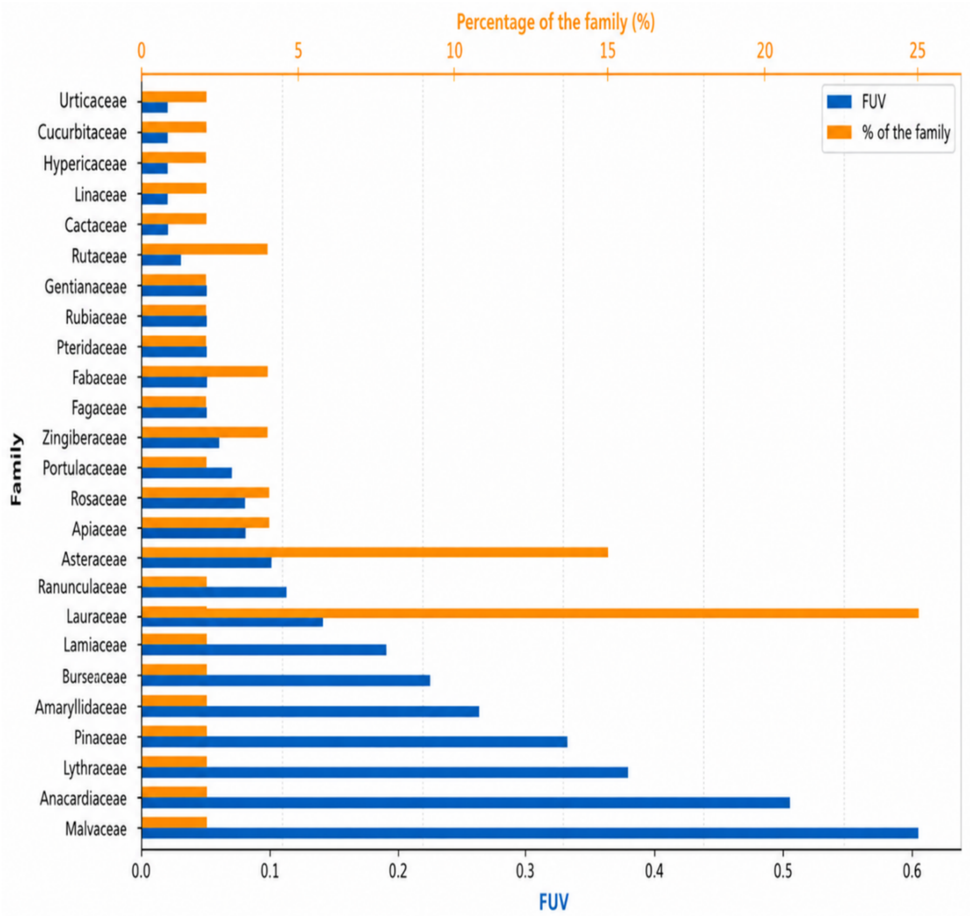

Figure 7. Family Use Value (FUV) and Species Percentage by Family

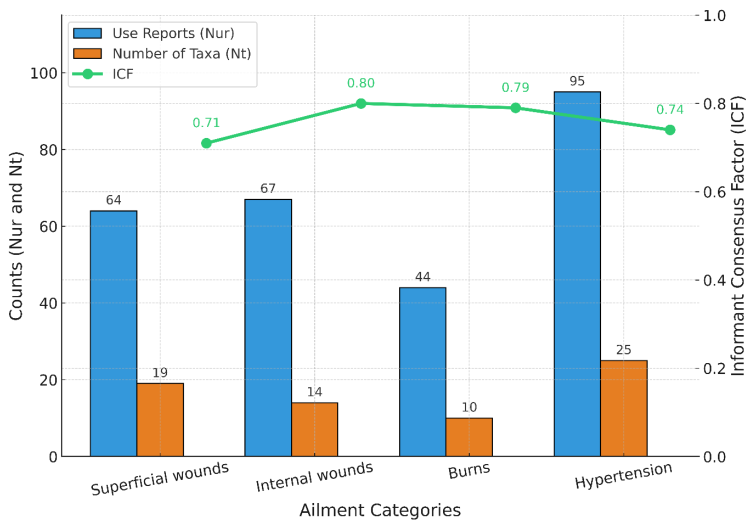

Figure 8. Informant Consensus Factor (ICF), Use Reports, and Taxa Count across Ailment Categories

First plan 1/2

The PCA results obtained by the first plan are highly significant in so far as it's express 65.81 % of the inertia. The best qualitative variables to explain the two first axis are the treat hypertension (Wilks p-value = 8.02e-14) Figure 9.

In the positive side of the dimension 1 and according to the highest to the lowest species contribution and cos², we find *Teucrium polium, Pistacia lentiscus, Carthamus caeruleus, Hibiscus sabdariffa, Phlomis crinite, Punica granatum and Pinus halepensis* (Figure 9). In the negative side, we find *Hypericum perforatum, Ocimum basilicum, Salvia officinalis, Urtica membranacea, Adiantum capillus-veneris, Centaurium erythraea, Citrus limon, Mentha spicata and Pimpinella anisum*. The first group of species shares high values of UV, FC, citation in total and RFC indices while the second group exhibit very low values (coefficient of correlation R ≈ + 0.97, p-value < 0.001 for all cited variables (Figure 9, b). According to the highest species contribution and cos², the dimension 2 groups the species *Hibiscus sabdariffa, Allium sativum, Laurus nobilis, Olea europaea, Crataegus monogyna and Petroselinum crispum* in the positive side of axis (figure 9, a). These species share high value of fidelity level of hypertension (FL_HTN) and high number of us reports for the HTN.

The second group of species placed in the negative side composed by the species, *Trigonella foenum-graecum*, *Opuntia ficus-indica* and *Nigella sativa*, is characterized by low citation in total, UV, FC, and RFC. This group exhibits high fidelity level of superficial wound (SuW) that reaches 100 % (RFL_SW = – 0.56 p-value = 3.25e-5). Overall, the variable that best separates the individual for the first plan is treat hypertension (treat _HTN) (Wilks p-value = 1.07e-13).

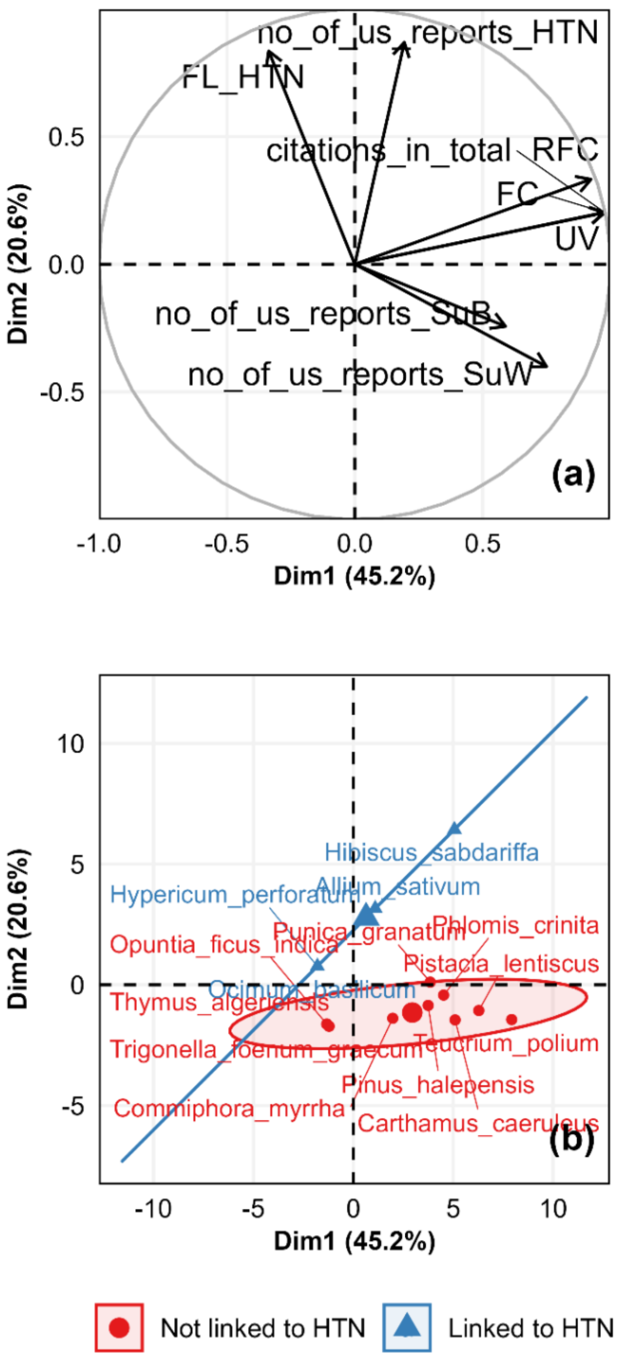

Figure 9. Variables factor map (a) and individuals factor map (b) on axes 1 and 2, related to the Hypertension (HTN), with confidence ellipses.

Second plan ¾

Dimension 3 groups species like *Punica granatum, Curcuma longa, Pinus halepensis, Carduus nutans, Haplophyllum tuberculatum and Linum usitatissimum* in the negative side (Figure 10,a). According to the highest Wilks test, the best qualitative variable is treating IW (p-value = $1.34e^{-8}$), and this dimension is highly and negatively correlated to FL_IW (R = – 0.848, p-value = $2.62e^{-14}$) and number of citation report for IW (R = – 0.634, p-value = $1.29e^{-6}$) Figure 10, b. The positive side of third dimension groups species related to FL_SW and previously cited above. The dimension 4 explains 9.6 % of inertia. It groups species related to FL_SB and number of us reports for superficial burn (SB) ailment (R = – 0.567, p-value = 2.54e– 5 and R = – 0.517, p-value = $1.66e^{-4}$ respectively). From these species we can cite, *Pistacia lentiscus*, *Rubus fruticosus*, *Curcubita moschata* and *Carthamus caeruleus* which exhibit the highest contribution to the fourth dimension.

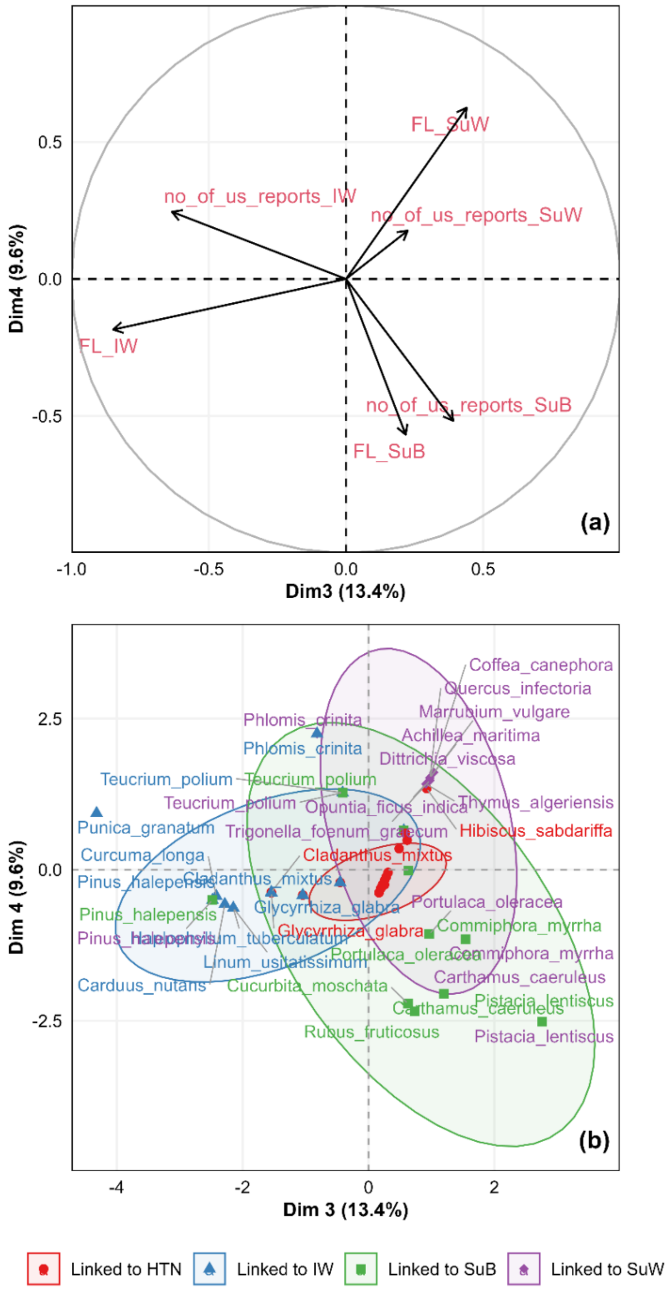

Figure 10. Variables factor map (a) and individuals factor map (b) on axes 3 and 4, with confidence ellipses related to the four ethnobotanical use categories: hypertension (HTN), internal wounds (IW), superficial burns (SB), and superficial wounds (SW). Species may appear more than once if they are used to treat multiple ailments.

Clustering

In this study, we performed a clustering analysis using Hierarchical Agglomerative Clustering (HAC). The HAC grouped the species into six clusters (Figure 11). The first cluster comprised species used to treat hypertension (Table 2), among which some can be considered exclusive for this ailment. The most frequently cited species used exclusively for hypertension in this survey were *Allium sativum*, cited by more than a quarter of the surveyed herbalists, followed by *Laurus nobilis*, *Crataegus monogyna*, and *Petroselinum crispum* (Table 2).

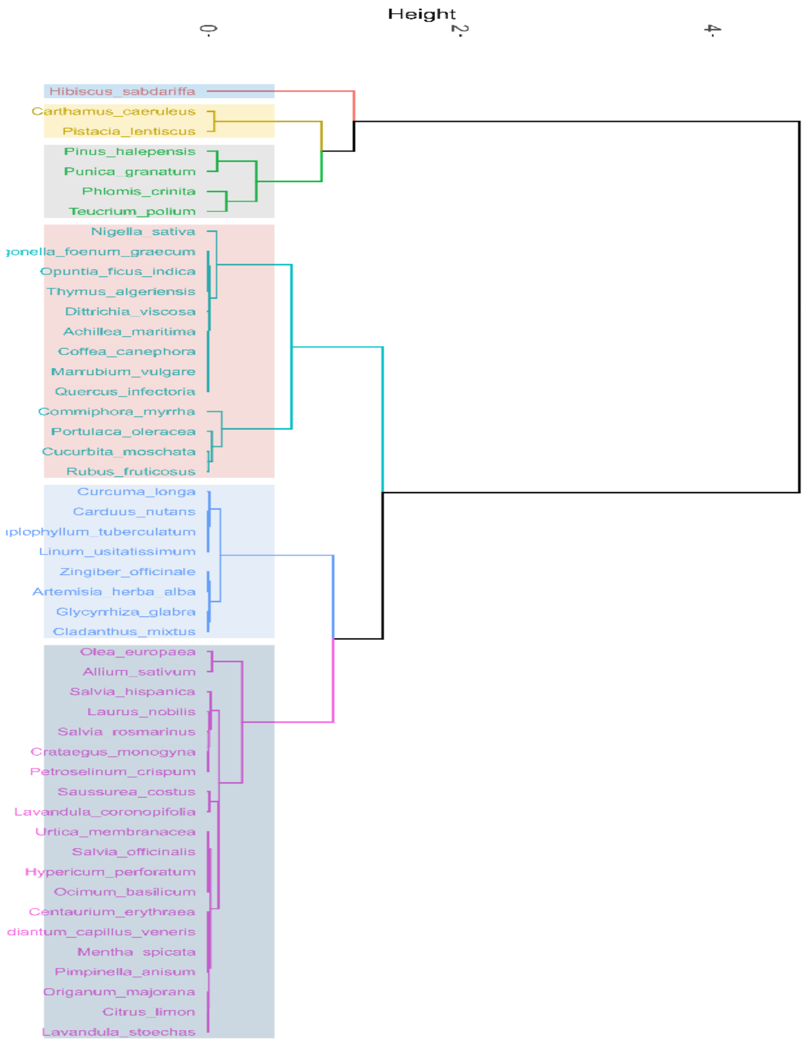

Figure 11. Dendrogram-Based Classification of Medicinal Plants According to Therapeutic Uses.

Another species cited exclusively for hypertension, but grouped alone in cluster 4, was *Hibiscus sabdariffa*, mentioned by two-thirds of the surveyed herbalists (Table 2). *Olea europaea*, cited by 18% of herbalists as a remedy for hypertension, was also occasionally recommended for treating superficial wounds and burns (Table 2).

The second cluster groups species used to treat both internal wounds and hypertension. These dual therapeutic properties were observed in *Cladanthus mixtus*, *Glycyrrhiza glabra*, *Artemisia Herba alba*, and *Zingiber officinale*. However, these findings require further investigation with a larger number of herbalists, as the cited species showed low overall citation frequencies (ranging from 2 to 3) and very few use reports related specifically to hypertension (Table 2). The remaining species in this cluster were cited exclusively for their properties in treating internal wounds. The most frequently cited species was *Curcuma longa*, with a fidelity level of 100% and three citations in total (Table 2).

Table 2 Six clusters according to the HAC analysis. Species are sorted in descending order according to the citations in total. HTN: Hypertension, SuW: Superficial Wounds, IW: Internal Wounds, SuB: Superficial Burns.

Common	Species	Family	UV	RFC	Citation in total	Number of us report	Therapeutic uses	FL(%)	Used Parts	Preparation
	Cluster 1									
الثوم	*Allium sativum* L. As-05-24-BioDev	*Amarylidaceae*	0.27	0.27	12	12	HTN	100	Bulb	Raw
الزيتون	*Olea europaea* L. Oe-03-24-BioDev	*Oleaceae*	0.20	0.18	9	7	HTN	78	Leaves	Infusion
						1	SuW	11	Fruits	Oil extraction
						1	SuB	11	Fruits	Oil extraction
الرند	*Laurus nobilis* L. Ln-08-24-BioDev	*Lauraceae*	0.14	0.14	6	6	HTN	100	Leaves	Infusion
الزعرور البري	*Crataegus monogyna* Jacq. Cm-05-24-BioDev	*Rosaceae*	0.11	0.11	5	5	HTN	100	Fruits	Infusion
المعدنوس	*Petroselinum crispum* (Mill.) Fuss. Pc-03-24-BioDev	*Apiacieae*	0.11	0.11	5	5	HTN	100	Aerial parts	Infusion
الشيا	*Salvia hispanica* L. Sh-04-24-BioDev	*Lamiaceae*	0.09	0.11	4	3	HTN	75	Seeds	Infusion
						1	IW	25	Seeds	Maceration
اكليل الجبل	*Salvia rosmarinus* Spenn. Ro-04-23-BioDev	*Lamiaceae*	0.09	0.09	4	4	HTN	100	Leaves	Infusion
الخزامى	*Lavandula coronopifolia* Poir. Lc-03-24-BioDev	*Lamiaceae*	0.07	0.07	3	2	HTN	67	Leaves, Flowers	Mixture
						1	SuW	33	Leaves, Flowers	Infusion
البردقوش	*Origanum majorana* L. Om-03-24-BioDev	*Lamiaceae*	0.07	0.07	3	3	HTN	100	Leaves	Mixture
كزبرة البئر	*Adiantum capillus-veneris* L. Ac-03-24-BioDev	*Pteridaceae*	0.05	0.05	2	2	HTN	100	Seeds	Infusion
مرارة الحنش	*Centaurium erythraea* Rafn. Ce-03-24-BioDev	*Gentianaceae*	0.05	0.05	2	2	HTN	100	Aerial parts	Infusion
الليمون	*Citrus limon* L.	*Rutaceae*	0.05	0.05	2	2	HTN	100	Fruits,	Infusion

	Cl-03-24-BioDev								Leaves	Infusion
الحلحال	*Lavandula stoechas* L. Ls-04-26-BioDev	*Lamiaceae*	0.05	0.05	2	2	HTN	100	Leaves, Flowers	Mixture
النعناع	*Mentha spicata* L. Pc-03-24-BioDev	*Lamiaceae*	0.05	0.05	2	2	HTN	100	Leaves	Infusion
حبة الحلاوة	*Pimpinella anisum* L. Pa-03-24-BioDev	*Apiaceae*	0.05	0.05	2	2	HTN	100	Seeds	Mixture
حشيشة القلب	*Hypericum perforatum* L. Hp-03-24-BioDev	*Hypericaceae*	0.02	0.02	1	1	HTN	100	Leaves	Infusion
الريحان	*Ocimum basilicum* L. Ob-03-24-BioDev	*Lamiaceae*	0.02	0.02	1	1	HTN	100	Leaves	Infusion
سواك النبي	*Salvia officinalis* L. So-06-23-BioDev	*Lamiaceae*	0.02	0.02	1	1	HTN	100	Leaves	Hypertension
القراص	*Urtica membranacea* Poir. ex Savigny Um-03-24-BioDev	*Urticaceae*	0.02	0.02	1	1	HTN	100	Flowers	Infusion
	Cluster 2									
البابونج	*Cladanthus mixtus* L. Cm-03-24-BioDev	*Astercaceae*	0.07	0.07	3	2	IW	67	Flowers	Infusion
						1	HTN	33	Leaves	Infusion
الكركم	*Curcuma longa* L. Cl-03-24-BioDev	*Zingiberaceae*	0.07	0.07	3	3	IW	100	Roots	Maceration
عرق السوس	*Glycyrrhiza glabra* L. Gg-03-24-BioDev	*Fabaceae*	0.07	0.07	3	2	IW	67	Branches	Infusion
						1	HTN	33	Raw	–
الشيح	*Artemisia herba alba* Asso. Ah-03-24-BioDev	*Asteraceae*	0.05	0.05	2	1	IW	50	Aerial parts	Infusion
						1	HTN	50	Flowers	Infusion
الزنجبيل	*Zingiber officinale* Roscoe. Zo-03-24-BioDev	*Zingiberaceae*	0.05	0.05	2	1	IW	50	Roots	Decoction
						1	HTN	50	Roots	Infusion
شوك الحمير	*Carduus nutans* L.	*Asteraceae*	0.02	0.02	1	1	IW			
المسيكا	*Haplophyllum tuberculatum* (Forssk.) A.Juss. Ht-03-24-BioDev	*Rutaceae*	0.02	0.02	1	1	IW	100	Whole Plant	Infusion
الكتان	*Linum usitatissimum* L. Lu-03-24-BioDev	*Linaceae*	0.02	0.02	1	1	IW	100	Seeds	Maceration

	Cluster 3									
ام الناس	*Commiphora myrrha* (T.Nees) Engl. Cm-03-23-BioDev	*Burseracea*	0.23	0.16	10	4	SuW	40	Resin	Ointment
						6	SuB	60	Gum-Resin	Ointment
شونيز	*Nigella sativa* L. Ns-03-24-BioDev	*Rnunculaceae*	0.11	0.09	5	3	SuW	60	Leaves, Seeds	Mixture
						1	IW	20	Leaves	Infusion
						1	SuB	20	Seeds	Oil Extraction
مقرمان	*Dittrichia viscosa* (L.) Greuter. Dv-03-24-BioDev	*Asteraceae*	0.07	0.07	3	3	SuW	100	Leaves	Powder
الرجلة	*Portulaca oleracea* L. Po-03-24-BioDev	*Portulacaceae*	0.07	0.07	3	2	SuB	67	Seeds	Ointment
الاخيليا	*Achillea maritima* (L.) Ehrend. & *Y.P.Guo* Am-07-25-BioDev	*Asteraceae*	0.05	0.05	2	2	SuW	100	Flowers	Infusion
القهوة	*Coffea canephora* L. Cc-03-24-BioDev	*Rubiaceae*	0.05	0.05	2	2	SuW	100	Seeds	Powder
مريوت	*Marrubium vulgare* L. Mv-03-24-BioDev	*Lamiaceae*	0.05	0.05	2	2	SuW	100	Leaves	Powder
العفصة	*Quercus infectoria* G.Olivier. Qi-03-24-BioDev	*Fagaceae*	0.05	0.05	2	2	SuW	100	Galls	Mixture
عليق أسود	*Rubus fruticosus*	*Rosaceae*	0.05	0.05	2	2	SuB	100	Leaves	Cataplasm
القسط الهندي	*Saussurea costus* (Falc.) Lipsch. Sc-03-24-BioDev	*Asteraceae*	0.05	0.05	2	1	SuW	50	Roots	Mixture
						1	HTN	50	Roots	Maceration
اليقطين	*Cucurbita moschata* Duchesne. Cm-03-24-BioDev	*Cucurbitaceae*	0.02	0.02	1	1	SuB	100	Fruits	Cataplasm
الصبار	*Opuntia ficus-indica* (L.) Mill. Of-03-24-BioDev	*Cactaceae*	0.02	0.02	1	1	SuW	100	Bulb	Mixture
الزعتر	*Thymus algeriensis* Boiss. & Reut. Ta-03-24-BioDev	*Lamiaceae*	0.02	0.02	1	1	SuW	100	Leaves	Powder
الحلبة	*Trigonella foenum-graecum* L. Tf-03-24-BioDev	*Fabaceae*	0.02	0.02	1	1	SuW	100	Seeds	Mixture
	Cluster 4									
الكركدية	*Hibiscus sabdariffa* L. Hs-06-26-BioDev	*Malvaceae*	0.61	0.61	27	27	HTN	100	Flowers	Infusion

	Cluster 5									
الخياطة	*Teucrium polium* L.	*Lamiaceae*	0.66	0.39	29	15	SuW	52	Leaves	Ointment
	Tp-06-24-BioDev					12	IW	41	Leaves	Infusion
						2	SuB	7	Leaves	Mixture
خياطة الجراح	*Phlomis crinita* Cav.	*Lamiaceae*	0.45	0.32	20	12	IW	60	Leaves	Infusion
	Pc-06-24-BioDev					8	SuW	40	Leaves	Mixture
الرمان	*Punica granatum* L.	*Lythraceae*	0.39	0.39	17	17	IW	100	Fruit peels	Infusion
	Pg-06-24-BioDev									
دباغة	*Pinus halepensis* Mill.	*Pinaceae*	0.34	0.32	15	12	IW	80	Bark	Infusion
	Ph-06-24-BioDev									
						2	SuW	13	Bark	Ointment
						1	SuB	7	Bark	Compress
	Cluster 6									
الضرو	*Pistacia lentiscus* L.	*Anacardiaceae*	0.52	0.41	23	16	SuB	70	Fruits	Oil extraction
	Cc-06-24-BioDev					7	SuW	30	Fruits	Ointment
مورس قورص	*Carthamus caeruleus* L. C.Presl.	*Asteraceae*	0.43	0.34	19	12	SuB	63	Roots	Maceration
	Cc-04-22-BioDev					7	SuW	37	Roots	Maceration

Abbreviations: RFC= Relative Citation of Frequency, FL=Fidelity Level, UV=Use Values

The third cluster includes species used to treat either superficial wounds or superficial burns. However, two species were reported by herbalists to treat both conditions. *Commiphora myrrha* is mainly used to treat superficial burns rather than superficial wounds, with fidelity levels of 60% and 40%, respectively. *Nigella sativa* exhibits three therapeutic properties: although it was primarily cited for the treatment of superficial wounds (FL = 60%), it was also reported for the treatment of internal wounds and superficial burns, each with a fidelity level of 20%. Within this cluster, *Saussurea costus* shows dual therapeutic properties in treating both superficial wounds and hypertension. Nevertheless, further investigation is required, as this species was cited only twice overall (Table 2). The remaining species in this group were cited exclusively for their properties in treating either superficial wounds, such as *Ditrichia viscosa*, or superficial burns, such as *Portulaca oleracea*. Cluster 4 contains only *Hibiscus sabdariffa*, which was the most frequently cited species used exclusively for the treatment of hypertension. This species was cited 27 times and exhibited a fidelity level of 100% for hypertension treatment. Given its therapeutic profile, *H. sabdariffa* could also be grouped with the first cluster.

Cluster 5 groups species that mainly exhibit properties for treating superficial wounds, internal wounds, or both, and that show high use values and relative frequencies of citation. Among these species are *Teucrium polium* (UV = 0.66, RFC = 0.39) and *Pinus halepensis* (UV = 0.34, RFC = 0.32), which are also used to treat superficial burns in addition to the two previously cited conditions, as well as *Phlomis crinita* (UV = 0.45, RFC = 0.32). In cluster 6, species with high use values and high relative frequencies of citation are mainly associated with the treatment of superficial burns, followed by superficial wounds. These species include *Pistacia lentiscus* and *Carthamus caeruleus* (Table 2). Overall, in line with the objective of identifying the most commonly used species for wound and burn treatment and for the management of hypertension, seven species emerge as strong candidates for in-depth future studies. These include *Olea europaea* and *Salvia hispanica*, which are primarily used to manage hypertension and are also employed in wound and burn treatment; *Cladanthus mixtus*, *Glycyrrhiza glabra*, *Artemisia herba alba*, and *Zingiber officinale*, which are mainly used for treating internal wounds and managing hypertension; and finally, *Saussurea costus*, which is primarily used to treat superficial wounds and manage hypertension.

Medicinal plants with dual effect

Figure 12 shows the relative percentages of ethnomedicinal uses for six plant species across four therapeutic categories: hypertension, internal wounds, superficial wounds, and superficial burns. While hypertension remains the predominant use for most species, several *particularly Saussurea costus*, *Lavandula coronopifolia*, *Artemisia herba-alba*, and *Zingiber officinale* demonstrate a notable dual role in both wound healing and cardiovascular management. *Olea europaea* and *Salvia hispanica* are mainly cited for hypertension, with limited wound-related applications. Overall, the figure highlights the dual therapeutic potential of certain species while confirming a strong ethnomedical focus on cardiovascular health.

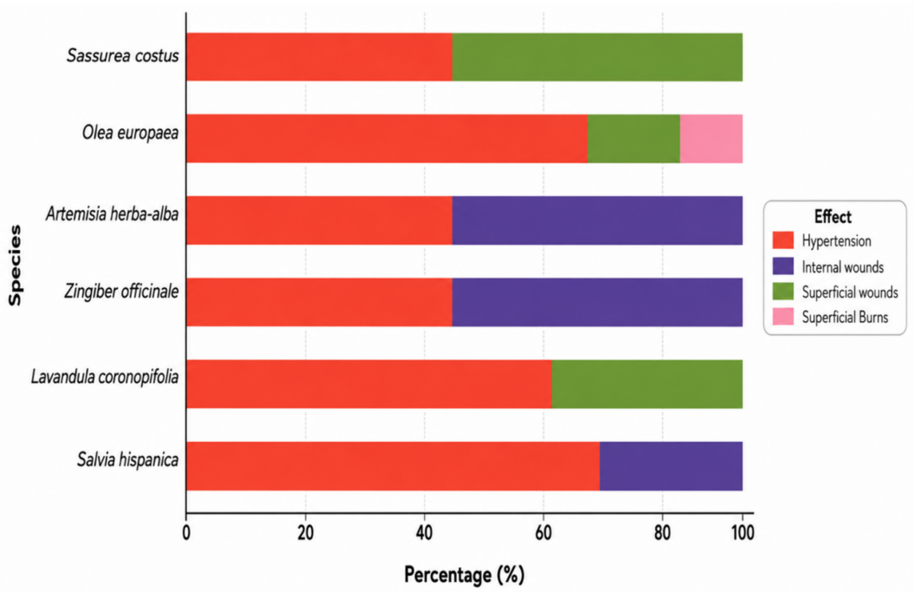

Figure 12. Fidelity Level (FL) of Medicinal Plants with Dual Effects (Wound healing & Hypertension)

Discussions

The traditional use of medicinal plants for treating hypertension and wound-healing disorders remains an important component of local healthcare and cultural heritage. Our survey documented 48 therapeutic plant species across 26 families, used for managing hypertension and promoting wound healing. Most traditional healers interviewed were adults aged 40 to

70 years, indicating that ethnobotanical knowledge is largely held by a mature generation. Engaging younger practitioners will be essential to ensure the continuity of this valuable heritage. Plant life-form analysis further contextualized the medicinal flora documented in this survey. Therophytes predominated, followed by phanerophytes and chamaephytes, whereas hemicryptophytes were moderately represented and geophytes were least frequent. This dominance of herbaceous forms is commonly reported in ethnobotanical studies and is often attributed to their accessibility, rapid regeneration, and richness in bioactive secondary metabolites (Ullah *et al.* 2025).The floristic-region spectrum further complements these findings by showing that Mediterranean elements dominate the medicinal flora, with Euro-Siberian chorotypes in second position, while other regional affiliations such as Saharo-Arabian and Irano-Turanian are less represented. This pattern is consistent with biogeographical gradients in North African and Mediterranean ecosystems, where climatic seasonality, historical connections with Eurasia, and long-term human land use favor species with Mediterranean and temperate affinities. Similar chorological trends have been documented in vascular plant surveys across Mediterranean-climate regions, reflecting how regional biogeography shapes the pool of available medicinal species and influences traditional plant selection (Chust *et al.* 2006). Assessment of conservation status further contextualized the medicinal flora recorded in this survey. Most species used for treating hypertension and wound-healing disorders fall within the Least Concern category, while a smaller proportion are classified as Near Threatened, Data Deficient, or Not Evaluated, and only a few taxa appear in threatened categories. This pattern is frequently reported in ethnobotanical inventories, where commonly harvested medicinal plants tend to be widespread species, whereas rarer or poorly studied taxa highlight important gaps in conservation knowledge. Reliance on Data Deficient and non-evaluated species underscores the need for targeted ecological assessments to prevent future population declines linked to harvesting pressure and habitat change. Such integration of ethnobotanical surveys with IUCN Red List evaluations is increasingly emphasized as a key step for guiding sustainable use and conservation priorities (Edgar 2025) . In the Ouled Moussa district, herbs constituted the predominant growth form used in local medicine, likely reflecting their widespread availability, ease of collection, and richness in bioactive secondary metabolites. Leaves were the most commonly harvested plant part, ahead of roots, seeds, and flowers, probably because they are easily accessible and concentrate many active compounds. Preparation methods were dominated by infusions, followed by mixtures, ointments, and macerations, reflecting common practices of traditional healers in Ouled Moussa and the need for rapid, practical remedies in everyday healthcare. Family-level analysis further clarified patterns of medicinal plant use in Ouled Moussa by distinguishing between taxonomic richness and cultural importance.

Although some families contributed a high number of recorded species, the highest Family Use Values were observed for Malvaceae and Anacardiaceae, followed by Lythraceae and Pinaceae, indicating that a limited number of culturally prominent taxa can strongly influence local therapeutic practices. This contrast between floristic representation and use frequency has been widely reported in ethnobotanical research, where perceived efficacy, availability, and tradition often outweigh simple species abundance in shaping medicinal plant selection. The distribution of informant consensus across ailment categories reflects the organization of traditional therapeutic knowledge within the community. High consensus values indicate the preferential use of a limited number of culturally validated plant species, suggesting shared empirical experience and perceived efficacy. Similar patterns have been reported in recent ethnobotanical studies, where high consensus values were associated with strong agreement among informants regarding plant selection for specific ailments. Conversely, lower consensus values generally indicate greater diversity of remedies, which may reflect ecological availability, the complexity of certain conditions, or adaptive knowledge transmission within the community (Ralte *et al.* 2024). The hierarchical clustering analysis revealed coherent therapeutic groupings that reflect the internal structure of local ethnomedicinal knowledge. Species grouped for hypertension, particularly *Allium sativum*, *Crataegus monogyna*, *Laurus nobilis*, and *Hibiscus sabdariffa*, correspond to plants widely recognized for their antihypertensive properties. For instance, clinical and experimental studies have demonstrated significant blood-pressure-lowering effects of *Allium sativum* and *Hibiscus sabdariffa* (Ried 2016). Similarly, the clustering of species used for wound and burn treatment, such as *Pistacia lentiscus*, *Pinus halepensis*, *Carthamus caeruleus* and *Nigella sativa*, aligns with their documented antimicrobial, anti-inflammatory, and tissue-healing properties (Dahmani *et al.* 2018, Elakremi *et al.* 2023). The occurrence of species with multiple therapeutic roles across clusters (e.g., *Zingiber officinale* or *Glycyrrhiza glabra*) highlights the polyvalent nature of traditional remedies, a pattern frequently reported in quantitative ethnobotanical studies(Heinrich, Kufer *et al.* 2006). Overall, the clustering approach helps identify culturally salient species with potential pharmacological relevance for further investigation.

Conclusion

This study highlights the role of traditional medicinal plants in Ouled Moussa (Algeria) for treating hypertension and wound-healing disorders. Forty-eight species from 26 families were documented, with herbs and leaves predominating, reflecting practical and accessible remedies. Informant consensus and hierarchical clustering identified culturally important species with pharmacological potential, such as Allium sativum, Hibiscus sabdariffa, Pistacia lentiscus, and Carthamus caeruleus. Most species are categorized as Least Concern, but some are Data Deficient or Near Threatened, underscoring the need for sustainable harvesting and ecological monitoring. The concentration of knowledge among older practitioners also highlights the importance of transmitting ethnobotanical knowledge to younger generations and guiding future pharmacological research.

Declarations

List of abbreviations:

Ethics approval and consent to participate: All participants provided prior informed consent before taking part in the ethnobotanical surveys.

Consent for publication: Not applicable

Availability of data and materials: The data supporting this study are available from the corresponding author upon reasonable request

Competing interests: The authors declare no conflicts of interest

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Author contributions: M.M.D. conceived and designed the study, performed data interpretation, and led the discussion. B.L. contributed to the ethnoecological aspects of the study. M.H. contributed to the ethnobotanical results. All authors reviewed and approved the final manuscript.

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Literature cited

Ahmed AA, Mooar PA, Kleiner M, Torg JS, Miyamoto CT. 2011. Hypertensive Patients Show Delayed Wound Healing following Total Hip Arthroplasty. PLoS ONE 6(8): e23224. doi: 10.1371/journal.pone.0023224

Boudjelal A, Henchiri C, Sari M, Sarri D, Hendel N, Benkhaled A, Ruberto G.2013. Herbalists and wild medicinal plants in M'Sila (North Algeria): An ethnopharmacology survey. Journal of Ethnopharmacology 148: 395-402. doi: 10.1016/j.jep.2013.03.082.

Boughrara B, Belgacem L. 2016. Ethnobotanical study close to the population of the extreme north east of Algeria: the municipalities of El Kala National Park (EKNP). Industrial Crops and Products 88: 2-7. doi: 10.1016/j.indcrop.2016.03.009.

Cain, S A. 1950. Life-Forms and Phytoclimate. Botanical Review 16: 1–32. doi: 10.1007/BF02879783

Chust G, Pérez-Haase A, Chave J, Pretus, J L. 2006. Floristic patterns and plant traits of Mediterranean communities in fragmented habitats. Journal of Biogeography 33: 1235-1245. doi: 10.1111/j.1365-2699.2006.01492.x

Dahmani M M, Laoufi R, Okba S S, Arab K. 2018. Gas chromatography coupled to mass spectrometry characterization, anti-inflammatory effect, wound-healing potential, and hair growth-promoting activity of Algerian Carthamus caeruleus L (Asteraceae). Indian Journal of Pharmacology 50: 123-129. doi: 10.4103/ijp.IJP_65_17.

Edgar G J. 2025. IUCN Red List criteria fail to recognise most threatened and extinct species, Biological Conservation 301: 110880. doi: 10.1016/j.biocon.2024.110880.

Elakremi M, Sillero L, Salem R B, Labidi J, Moussaoui Y. 2023. Chemical Composition and Biological Activities of *Pistacia vera* L. Leaves oil. Chemistry Africa 6: 2393-2400. doi: 10.1007/s42250-022-00558-3

Falanga V, Isseroff R R, Soulika A M, Romanelli M, Margolis D, Suzanne K, Granick M, Harding K. 2022. Chronic wounds. Nature Reviews Disease Primers 8: 50. doi: 10.1038/s41572-022-00377-3

Haase R F, Ellis M V. 1987. Multivariate analysis of variance. Journal of Counseling Psychology. 34: 404-413. doi: 10.1037/0022-0167.34.4.404

Heinrich M, Kufer J, Leonti M, Pardo-de-Santayana M. 2006. Ethnobotany and ethnopharmacology—Interdisciplinary links with the historical sciences. Journal of Ethnopharmacology. 107: 157-160. doi: 10.1016/j.jep.2006.05.035.

Irl SDH, Obermeier A, Beierkuhnlein C, Steinbauer MJ. 2020. Climate controls plant life-form patterns on a high-elevation oceanic island. Journal of Biogeography 47: 2261-2273. doi: 10.1111/jbi.13929

Meddour R, Sahar O, Jury S. 2023. New analysis of the endemic vascular plants of Algeria, their diversity, distribution pattern and conservation status. Willdenowia. 53: 25-43. doi: 10.3372/wi.53.53102.

Mills KT, Stefanescu A, He J. 2020. The global epidemiology of hypertension. Nature Reviews Nephrology 16: 223-237. doi: 10.1038/s41581-019-0244-2

Organization WH .2023. Global report on hypertension: the race against a silent killer, World Health Organization.

Parati G, Lackland DT, Campbell NRC, Owolabi MO, Bavuma C, Beheiry HM, Dzudie A, Ibrahim MM, El Aroussy W, Singh S, Varghese CV, Whelton PK, Zhang XH .2022. How to improve awareness, treatment, and control of hypertension in Africa, and how to reduce its consequences: a call to action from the world hypertension league. Hypertension 79(9): 1949-1961. doi: 10.1161/HYPERTENSIONAHA.121.18884.

Ralte L, Sailo H, Singh YT .2024. Ethnobotanical study of medicinal plants used by the indigenous community of the western region of Mizoram, India. Journal of Ethnobiology and Ethnomedicine 20(1): 2.doi: 10.1186/s13002-023-00642-z.

Ried, K. 2016. Garlic lowers blood pressure in hypertensive individuals, regulates serum cholesterol, and stimulates immunity: an updated meta-analysis and review. The Journal of Nutrition 146(2): 389S-396S. doi: 10.3945/jn.114.202192.

Stanley AC,Lounsbury KM, K Corrow, PW Callas, R Zhar, AK Howe, MA Ricci .2005. Pressure elevation slows the fibroblast response to wound healing.Journal of Vascular Surgery 42(3): 546-551. doi: 10.1016/j.jvs.2005.04.047.

Steel A, Gallego-Perez DF, Ijaz N, Gall A, Bangpan M, Boeira LDS, Schveitzer MC, Chutaputti N, Mahlanza-Langer L, Pillai GKG, Posayanonda T, Sungchol K, Shankar D, Kuchenmüller T, .2025. Integration of Traditional, Complementary, and Integrative Medicine in the Institutionalization of Evidence-Informed Decision-Making: The World Health Organization Meeting Report. Journal of Integrative and Complementary Medicine 31(4): 388-394. doi: 10.1089/jicm.2024.0837.

Stuermer EK , Besser M, Terberger N, Bachmann HS, Severing AL. 2019. Side effects of frequently used antihypertensive drugs on wound healing in vitro. Skin Pharmacology and Physiology 32(3): 162-172. doi: 10.1159/000499433

Süntar, I. 2020. Importance of ethnopharmacological studies in drug discovery: role of medicinal plants. Phytochemistry Reviews 19(5): 1199-1209. doi: 10.1007/s11101-019-09629-9.

Takhtajan A. 1986. Floristic regions of the world. Univ. California press, London.

Yang, HS (1995) Studies of environmental responses in interspecific competition of ecotypes of Taraxacum officinale. Korean Journal of Environmental Biology 13(2): 107-120.

Ullah I, Akhtar S, Adnan M, Nawab J, Ullah S, Al-Wadud MA .2025. Ethnobotanical knowledge and ethnomedicinal uses of plant resources by urban communities of Khyber Pakhtunkhwa, Pakistan: a novel urban ethnobotanical approach. Journal of Ethnobiology and Ethnomedicine 21(1): 13. doi: 10.1186/s13002-025-00766-4.