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Ethnobotanical Treasures of Khénifra in Morocco: Medicinal Plants for Relieving Respiratory Problems

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ABSTRACT

Traditional healing practices in Khénifra, Morocco, have been passed down through generations, utilizing the region's diverse local flora to treat various ailments. This study focuses on documenting the ethnobotanical knowledge related to the treatment of respiratory issues, an area where medicinal plants play a significant role. The aim is to identify the plant species used by local healers, examine their therapeutic properties, and analyze their potential contributions to modern medicine. Through fieldwork and interviews with traditional healers, combined with botanical analysis, the research reveals a wide variety of plant species employed to address respiratory conditions. The findings underscore the importance of preserving this traditional knowledge, not only as a cultural heritage but also as a valuable resource for developing sustainable healthcare solutions. In doing so, the study contributes to the understanding of how indigenous practices can inform scientific advancements, particularly in pharmacology and the search for new treatments. Statistical analysis using Usage Value (UV) and Relative Frequency of Citation (RFC) revealed that rosemary (UV = 0.16, RFC = 0.05) and celery (UV = 0.12, RFC = 0.08) were the most versatile and frequently cited plants. Additionally, leaves were identified as the most commonly used part of the plants. In contrast, plants like eucalyptus and tansy had low UV and RFC values, indicating limited use and knowledge.The conservation of this knowledge is crucial, as it provides insights that could lead to the discovery of novel therapeutic agents and promote sustainable development initiatives.

Keywords: Respiratory problems; Traditional medicine; Sustainable healthcare; Khénifra; Morocco

Introduction

The Khénifra province in Morocco is renowned for its rich cultural heritage and diverse natural landscapes. Among its many traditions, the use of medicinal plants for treating health issues, particularly respiratory problems, stands out as a significant aspect of local knowledge. This ethnobotanical practice, passed down through generations, reflects a deep understanding of the therapeutic properties of the region's flora, which includes a wide variety of plant species with potent medicinal benefits.[1,2,3] Respiratory issues, ranging from common colds and coughs to more severe conditions such as asthma and bronchitis, represent a significant health burden globally.

In Khénifra, traditional healers have long relied on the local flora to address these ailments, utilizing a vast array of plants known for their expectorant, anti-inflammatory, and antimicrobial properties. The integration of such traditional medicine into contemporary healthcare could offer sustainable and culturally sensitive solutions to these pervasive health challenges.[4,5,6 ,7] This study aims to document and analyze the medicinal plants used in Khénifra for respiratory ailments. Through comprehensive fieldwork, including interviews with local healers and botanical surveys, we seek to identify the plant species involved and understand their specific applications and preparation methods. By preserving and scientifically validating this traditional knowledge, we hope to contribute to the broader field of ethnobotany and explore new avenues for natural and holistic healthcare. Additionally, this research endeavors to highlight the importance of conserving indigenous knowledge and biodiversity, which are crucial for the sustainability of both the local culture and the environment. In the face of increasing global health challenges and the limitations of modern medicine, traditional practices such as those found in Khénifra offer a valuable complement to conventional treatments. By bridging the gap between traditional knowledge and scientific research, this study aspires to foster a deeper appreciation and integration of ethnobotanical practices in the quest for effective and accessible healthcare solutions.

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Materials and Methods

Study area

The study is conducted in the Khénifra province (Figure 1), located in the Middle Atlas region of Morocco. This area is characterized by its diverse topography, ranging from mountainous terrains to lush valleys, which contributes to its rich biodiversity. The province's unique climatic conditions, with a mix of Mediterranean and mountainous influences, create an ideal environment for a wide variety of plant species, many of which have been utilized for their medicinal properties. Khénifra is inhabited by a mix of Berber communities, known for their deep connection to the land and extensive knowledge of local flora. Traditional practices and lifestyles are well-preserved in this region, making it a rich repository of ethnobotanical knowledge. The local population relies heavily on natural resources for their healthcare needs, particularly in rural areas where access to modern medical facilities may be limited. [8,9,10,11]

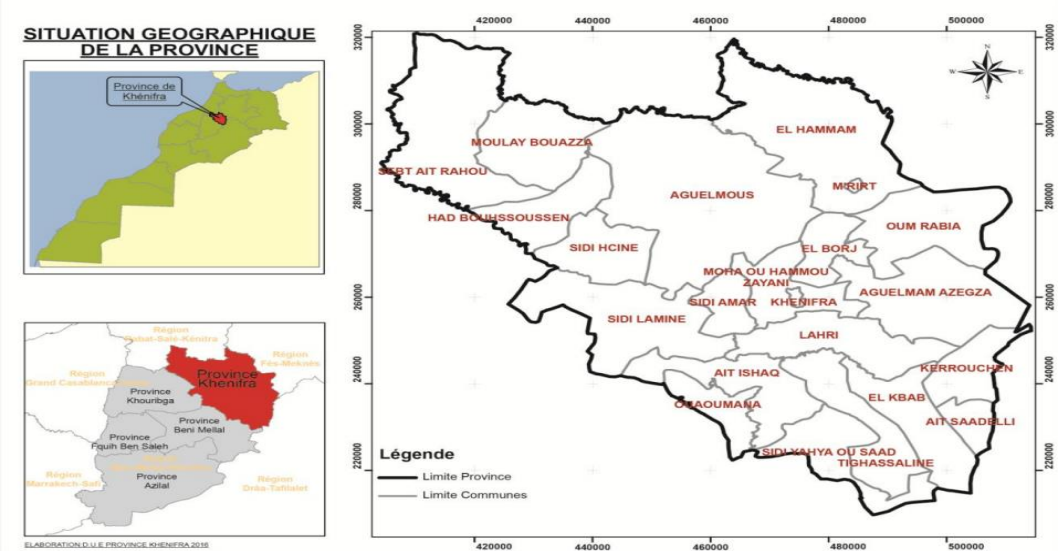

Figure 1: Khénifra Province and geographical location of the different studies

Survey method

The study was conducted in the province of Sefrou from September 2022 to October 2023. The research involved conducting open-ended interviews with local residents to identify various medicinal and aromatic plants (MAPs). Following the interviews, surveys were administered to gather detailed information on the therapeutic uses and preparation methods of these plants. The surveys included questions on respondents' gender, age, education level, and family situation, as well as specific details about the plant parts used and methods of administration. A total of 100 surveys were collected, and the data were analyzed using XLSTAT and Minitab software to generate tables and graphs. Plant species identification was conducted at the Laboratory of Engineering, Electrochemistry, Modeling, and Environment (LIEME). This is situated at the Faculty of Science, Sidi Mohamed Ben Abdellah University in Fes, Morocco

Statistical analysis

Relative Citation Frequency (RFC)

The relative citation frequency index (RFC) indicates the significance of each species based on informant usage. The formula for RFC is:

$$\mathrm{RFC} = \frac{\mathrm{FC}}{\mathrm{N}} \quad \text{(Eqn. 1)}$$

where FC is the number of informants citing a particular species and N is the total number of informants. The value of RFC ranges from 0 to 1.[12,13]

Fidelity level (FL)

The fidelity level (FL) is used to identify the most suitable species for treating a specific condition. It is calculated as follows:

$$FL = \frac{N_p}{\mathrm{N}} \text{ (Eqn. 2)}^{14,15}$$

where Np represents the number of informants who recommend a specific remedy and N is the total number of informants mentioning the use of that species.

Use Value (UV)

The use value (UV) measures the relative importance of a local species, particularly plants. The formula for UV is:

$$\mathrm{UV} = \frac{\mathrm{U}}{\mathrm{N}} \text{ (Eqn. 3)}^{16,17}$$

where U is the number of uses mentioned by each informant and N is the total number of informants.

Coefficient of determination (R)

$$A = \frac{\sum_1^n (Xi-XB)(Yi-YB)}{\sum_1^n (Xi-XB)2} \text{ (Eqn. 4)}$$

$$A' = \frac{\sum_1^n (Xi-XB)(Yi-YB)}{(Yi-YB)2} \text{ (Eqn. 5)}$$

$R^2 = A * A'$

$(Xi - XB)$: represents the difference between the Use Value (UV) and the average UV

$(Yi - YB)$: represents the difference between Relative Frequency Citation (RFC) and the average of RFC

A: represents the directing coefficient of the linear function in the form Y =Ax + B

A′ : Represents the directing coefficient of the linear function in the form X =A' y + B'

R between 0 and 1 plus r close to 1 means a strong and perfect correlation.

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Results and Discussion

The total sample consists of 100 participants (Table 1), which is a reasonable size for basic statistical analysis. Participants have an average age of 50.55 years with a standard deviation of 14.6 years. This average indicates that the sample is mainly composed of middle-aged to older individuals. The relatively high standard deviation shows a significant dispersion in ages, suggesting a diversity of ages among the participants, likely ranging from young adults to elderly individuals. The participants are predominantly male, representing 73% of the sample, while females make up 27%. This gender disparity could influence the study results, especially if the issues being studied are likely to vary by gender. The majority of participants, 46%, have an informal level of education. Following that, 23% have completed primary school, 20% have a secondary education level, and only 11% have attained a university education.

Table 1: Demographic profile of botanical survey participants

Demographic profile	**N =100**	**Fi%**
Age (mean number of years ± SD)	50 .55 ± 14.6	
Gender		
Male	73	73
Female	27	27
Level of education		
Informal	46	46
Primary school	23	23
Secondary	20	20
University	11	11
Residence		
Aguelmous	40	40
Moulay Bouazza	12	12
Oum Errabiâ	11	11
Sidi Yahya Ou Saad	22	22
El Kbab	10	10
Ait Ishak	5	5
Years of experience		
2–5	30	30
6–9	10	10
10–19	10	10
20–29	8	8
30–39	12	12
40–49	11	11
50–59	19	19

This distribution indicates a predominance of low formal education levels among the participants, which could reflect specific socio-economic and geographic contexts. Participants mainly reside in Aguelmous (40%), followed by Sidi Yahya Ou Saad (22%), Moulay Bouazaa (12%), Oum Rabia (11%), El Kbab (10%), and Ait Ishak (5%). This distribution indicates a notable concentration in certain geographical areas, which could influence the results based on local characteristics. Participants have a wide range of years of experience. 30% have between 2 and 5 years of experience, making this the largest group. Additionally, 19% have between 50 and 59 years of experience Theinsights provided by this group serve as a baseline for validating the comments of others, 12% have between 30 and 39 years, 11% have between 40 and 49 years, 10% have between 6 and 9 years and between 10 and 19 years, and finally, 8% have between 20 and 29 years of experience. This diversity shows a balanced distribution between relatively new and very experienced professionals. This study's sample presents a predominantly male population, middle-aged, with mainly informal education levels and a wide range of professional experience. The geographical distribution indicates a concentration in specific areas, there are ancient studies that confirm our results. [18,19,20]. This study focuses on documenting and characterizing medicinal plants used in the treatment of respiratory problems in the Khénifra province of Morocco. The results of this survey, compiled in Table 2, describe the identified plants along with their specific applications for respiratory issues. This compilation provides valuable insight into local traditional medicine practices and serves as a foundation for future research aimed at scientifically validating these traditional remedies. The UV (Usage Value) and RFC (Relative Frequency of Citation) values help determine the importance and popularity of plants in traditional uses. Usage Value indicates how often a plant is used in different contexts. A higher UV value means the plant is used for a variety of purposes, reflecting its versatility and cultural significance. Relative Frequency of Citation measures the proportion of respondents who mention using a particular plant. A high RFC indicates that the plant is commonly used and well-known among the studied population.[21,22] Examining the data reveals that certain plants (Figure 2) stand out for their high usage value and frequency of citation. For example, rosemary (*Rosmarinus officinalis*) has a UV of 0.16 and an RFC of 0.05, indicating it is very versatile and frequently used, demonstrating its importance for multiple uses and its popularity among users. Similarly, celery (*Apium graveolens*), with a

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UV of 0.12 and an RFC of 0.08, is also widely used and often cited, reflecting its frequent use in various medicinal or culinary contexts. Some plants, although less frequently cited, are intensively used by those who know them. For instance, lemon balm (*Melissa officinalis*) has a UV of 0.14 and an RFC of 0.02, suggesting it is highly valued for specific uses.

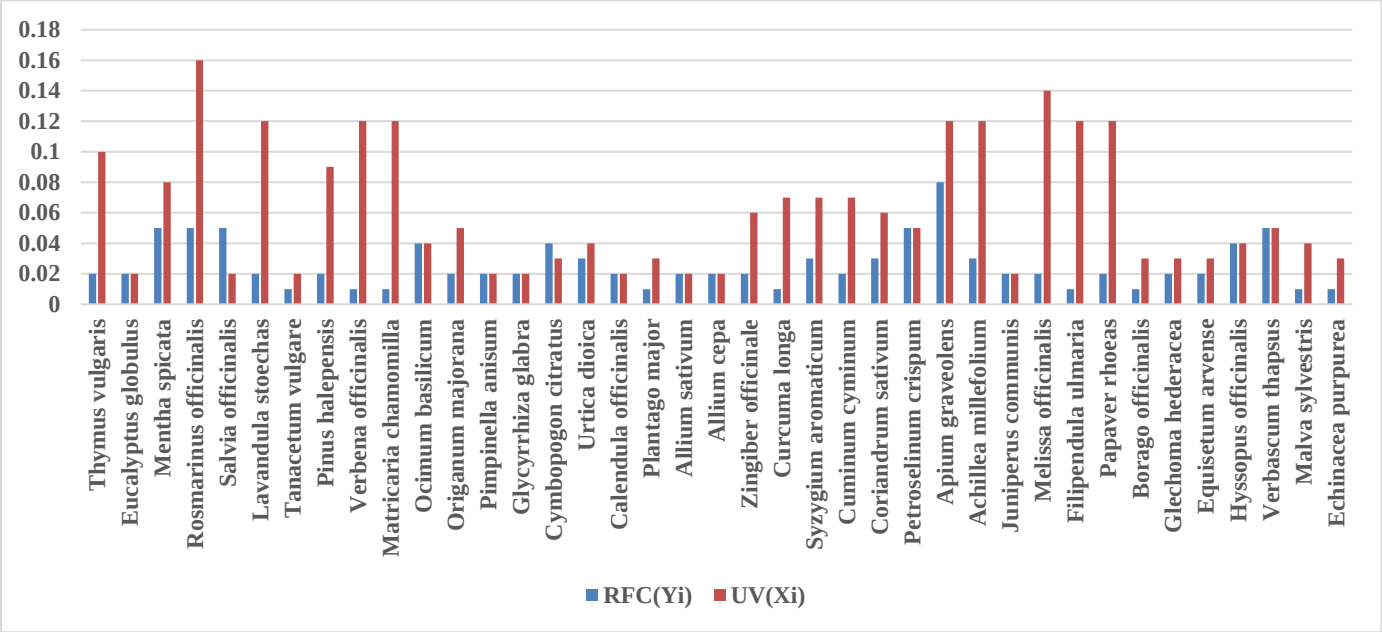

Figure 2: Graphical representation as a function of the use value (UV) and as a function of the relative frequency of citation (RFC)

Table 2: Medicinal and aromatic plants used to treat respiratory problems

Scientific name	Family	Local name	Parts used	Method of preparation and application
Thymus vulgaris – ***TV001-10-22***	Lamiaceae	zaatar	Leaves, flowering tops	Infuse 1-2 teaspoons of dried thyme in a cup of hot water for 10 minutes. Drink 2-3 times a day or inhale as steam.
Eucalyptus globulus – ***EG002-10-22***	Myrtaceae	Kaleptus	Leaves	Infuse a few leaves in a cup of hot water or use steam inhalation. Drink or inhale 2-3 times a day. Also use essential oil for inhalation.
Mentha spicata – ***MS003-10-22***	Lamiaceae	Na3na3	Leaves	Infuse fresh or dried mint leaves in hot water. Drink 2-3 times a day or use for steam inhalation.
Rosmarinus officinalis – ***RO004-11-22***	Lamiaceae	Iklil jabal	Leaves	Infuse 1-2 teaspoons of dried rosemary in a cup of hot water. Drink 2-3 times a day or use for inhalations.
Salvia officinalis – ***SO005-11-22***	Lamiaceae	Salmia	Leaves	Infuse sage leaves in hot water. Drink 2-3 times a day or use as a gargle for sore throat.
Lavandula stoechas – ***LS006-11-22***	Lamiaceae	Khzama	Flowers	Infuse dried lavender flowers in a cup of hot water. Drink once a day or use essential oil for inhalations.

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Tanacetum vulgare – ***TV007-4-23***	Asteraceae	kisom	Flowering tops	Infuse leaves in hot water. Drink in moderation, as tansy can be toxic in large quantities.
Pinus halepensis – ***PH008-11-22***	Pinaceae	Sanwbar	Needles, buds	Infuse pine needles or bark in hot water. Drink 1-2 times a day or use for inhalations.
Verbena officinalis – ***VO009-1-23***	Verbenaceae	Ra3y hmam	Leaves	Infuse verbena leaves in hot water. Drink 2-3 times a day.
Matricaria chamomilla – ***MC010-1-23***	Asteraceae	Babounj	Flowers	Infuse chamomile flowers in hot water. Drink 2-3 times a day.
Ocimum basilicum – ***OB011-6-23***	Lamiaceae	7ba9	Leaves	Infuse basil leaves in hot water. Drink 2-3 times a day or use for inhalations.
Origanum majorana – ***OM012-1-23***	Lamiaceae	Mardadouch	Leaves	Infuse dried marjoram leaves in hot water. Drink 2-3 times a day.
Pimpinella anisum – ***PA013-1-23***	Apiaceae	Yansoun	Seeds	Infuse anise seeds in hot water. Drink 2-3 times a day.
Glycyrrhiza glabra – ***GG014-3-23***	Fabaceae	3ra9 sous	Roots	Infuse dried licorice roots in hot water. Drink in moderation, as licorice can raise blood pressure.
Cymbopogon citratus – ***CC015-3-23***	Poaceae	Hachichat laymoun	Leaves	Infuse lemongrass leaves in hot water. Drink 2-3 times a day or use for inhalations
Urtica dioica – ***UD016-3-23***	Urticaceae	9aras	Leaves	Infuse nettle leaves in hot water. Drink 2-3 times a day.
Calendula officinalis – ***CO017-4-23***	Asteraceae	9tefa	Flowers	Infuse dried marigold flowers in hot water. Drink 2-3 times a day or use as a gargle.
Plantago major – ***PM018-2-23***	Plantaginaceae	Lsan haml	Leaves	Infuse leaves in hot water. Drink 2-3 times a day.
Allium sativum – ***AS019-2-23***	Amaryllidaceae	Toum	Bulbs	Infuse crushed garlic cloves in hot water. Drink once a day or consume raw for its antimicrobial properties.
Allium cepa – ***AC020-4-23***	Amaryllidaceae	Basla	Bulbs	Infuse or decoct onion in hot water. Drink 1-2 times a day.
Zingiber officinale – ***ZO021-4-23***	Zingiberaceae	Zanjabil	Rhizome	Infuse fresh ginger slices in hot water. Drink 2-3 times a day.
Curcuma longa – ***CL022-5-23***	Zingiberaceae	karkam	Rhizome	Infuse turmeric powder in hot water or add to warm milk (golden milk). Drink 1-2 times a day.
Syzygium aromaticum – ***SA023-5-23***	Myrtaceae	Kranfal	Flower buds	Infuse cloves in hot water. Drink in moderation, once a day.

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Cuminum cyminum – ***CC024-5-23***	Apiaceae	Kamoune	Seeds	Infuse cumin seeds in hot water. Drink 2-3 times a day.
Coriandrum sativum – ***CS025-5-23***	Apiaceae	Lakzira	Leaves, seeds	Infuse coriander seeds in hot water. Drink 2-3 times a day.
Petroselinum crispum – ***PC026-5-23***	Apiaceae	Ba9dnous	Leaves	Infuse fresh or dried parsley leaves in hot water. Drink 2-3 times a day.
Apium graveolens – ***AG027-6-23***	Apiaceae	Krafas	Seeds	Infuse celery seeds or leaves in hot water. Drink 2-3 times a day.
Achillea millefolium – ***AM028-6-23***	Asteraceae	Akhil chajar	Aerial parts	Infuse dried yarrow leaves or flowers in hot water. Drink 2-3 times a day.
Juniperus communis – ***JC029-6-23***	Cupressaceae	3ar3ar	Berries	Infuse juniper berries in hot water. Drink in moderation, 1-2 times a day.
Melissa officinalis – ***MO030-6-23***	Lamiaceae	Tranjan	Leaves	Infuse fresh or dried lemon balm leaves in hot water. Drink 2-3 times a day.
Filipendula ulmaria – ***FU031-7-23***	Rosaceae	3ochb malik	Flowers	Infuse dried meadowsweet flowers in hot water. Drink 2-3 times a day.
Papaver rhoeas – ***PR032-7-23***	Papaveraceae	Khachkhach	Petals	Infuse poppy petals in hot water. Drink 1-2 times a day.
Borago officinalis – ***BO033-7-23***	Boraginaceae	Lsan tour	Flowers, leaves	Infuse borage leaves or flowers in hot water. Drink 2-3 times a day.
Glechoma hederacea – ***GH034-7-23***	Lamiaceae	3ochbat bira	Leaves	Infuse ground ivy leaves or stems in hot water. Drink 2-3 times a day or use as a gargle.
Equisetum arvense – ***EA035-7-23***	Equisetaceae	Danb khayl	Stems	Infuse dried horsetail stems in hot water. Drink 2-3 times a day.
Hyssopus officinalis – ***HO036-7-23***	Lamiaceae	Zofa	Flowers	Infuse hyssop leaves or flowers in hot water. Drink 2-3 times a day.
Verbascum thapsus – ***VT037-7-23***	Scrophulariaceae	Bousir	Flowers	Infuse mullein flowers or leaves in hot water. Drink 2-3 times a day or use for inhalations.
Malva sylvestris – ***MS038-5-23***	Malvaceae	khabiza	Leaves	Infuse mallow flowers or leaves in hot water. Drink 2-3 times a day or use for gargling.
Echinacea purpurea – ***EP039-5-23***	Asteraceae	9onfodia	Flowers	Infuse dried roots or aerial parts in hot water. Drink 2-3 times a day.

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Meadowsweet (*Filipendula ulmaria*), with a UV of 0.12 and an RFC of 0.01, shows a high usage value despite a low frequency of citation, which may indicate specialized knowledge of this plant. On the other hand, some plants, such as eucalyptus (*Eucalyptus globulus*) and tansy (*Tanacetum vulgare*), have relatively low UV and RFC values. *Eucalyptus*, with a UV of 0.02 and an RFC of 0.02, is relatively less used and less cited, suggesting limited importance or lesser knowledge among users. Tansy, with similar values, also reflects marginal use or limited knowledge. Lastly, some plants are well-known and widely used, such as parsley (*Petroselinum crispum*) and mint (*Mentha spicata*). *Parsley*, with a UV of 0.05 and an RFC of 0.05, and mint, with a UV of 0.08 and an RFC of 0.05, indicate common plants with regular uses. In conclusion, the UV and RFC values help determine which plants are the most versatile and popular among users. For example, rosemary and celery stand out for their high usage value and frequency of citation, while plants like lemon balm and meadowsweet are intensively used by a smaller group of connoisseurs [23,30] There are ancient studies that confirm our results [26,27,28,29]. The analysis of the Relative Frequency of Citation (RFC) and Usage Value (UV) of medicinal plants reveals important insights (Table 3) and (Figure 5).

Table 3: Descriptive Statistics (Quantitative Data)

Statistics	RFC (Yi)	UV (Xi)
No. of observations	39	39
Minimum	0.010	0.020
Maximum	0.080	0.160
1st Quartile	0.020	0.030
Median	0.020	0.050
3rd Quartile	0.030	0.095
Mean	0.026	0.062
Variance (n-1)	0.000	0.002
Standard deviation (n)	0.015	0.041
Standard deviation (n-1)	0.016	0.042

With 39 observations, the mean RFC is 0.026, indicating a low frequency of citation, while the mean UV of 0.062 suggests that certain plants are highly valued for their medicinal properties, particularly in addressing respiratory issues. The low variance in RFC shows that most plants are cited infrequently, whereas the higher variance in UV indicates a broader recognition of specific plants for their therapeutic uses. Notably, the correlation coefficient between RFC and UV is 0.15(Figure 4), indicating a weak positive relationship; as the frequency of citation increases, the usage value tends to rise slightly. However, the low correlation suggests that factors other than citation frequency may play a more significant role in determining the perceived value of these plants.

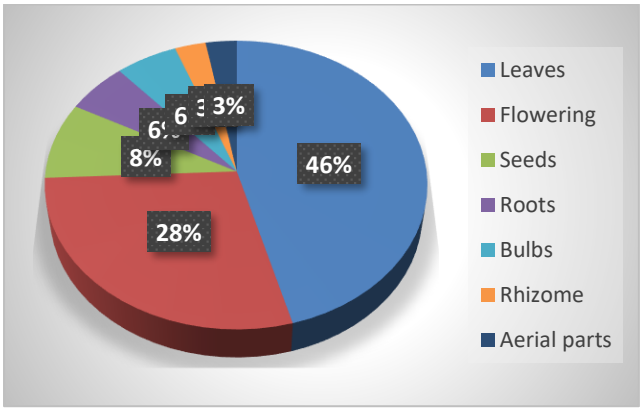

Figure 3: Breakdown of the different parts used of the medicinal plants in Khénifra provinc

This highlights the community's reliance on certain medicinal plants while underscoring the need for further research to validate their efficacy and standardize their use in traditional medicine.

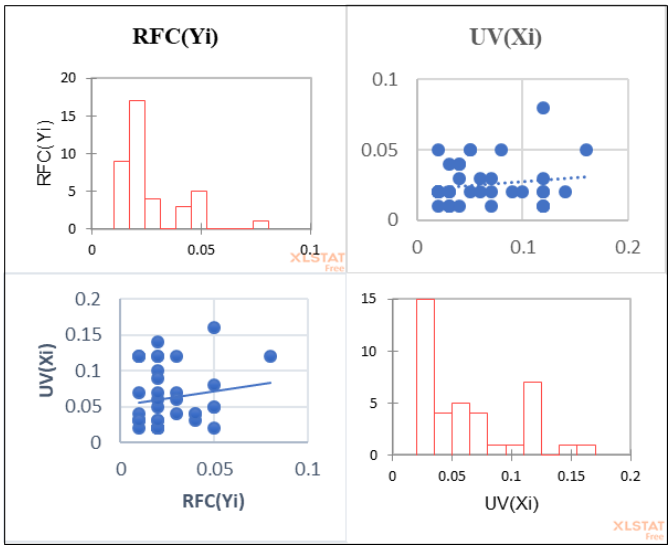

Figure 4: Correlation between UV(Xi) and RFC(Yi)

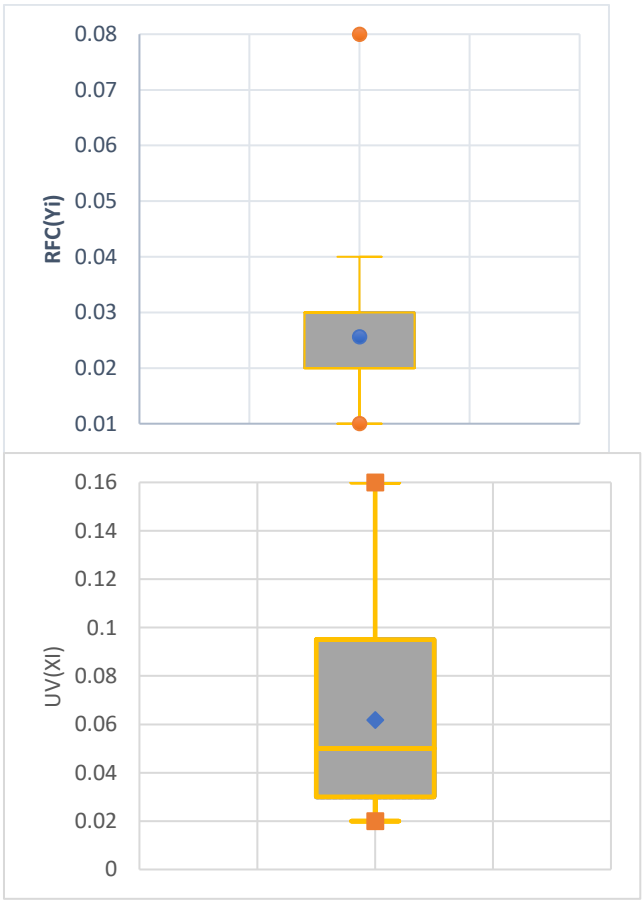

Figure 5: Box plot representations of the RFC (Yi) and UV (Xi) variable

Ethnic medicinal characteristics: growth form, plant parts

The data provides an overview of the usage distribution of different plant parts (Figure 3), likely for medicinal or botanical purposes. Leaves are the most frequently used part, representing 46% of the total usage. This high percentage suggests their significant importance, probably due to their accessibility and high concentration of active compounds. Leaves, frequently used to address respiratory issues, are particularly valued in traditional medicine due to their central role in photosynthesis. Their richness in bioactive compounds, such as flavonoids and essential oils, contributes to their anti-inflammatory and expectorant properties, which are essential for alleviating respiratory conditions. There are ancient studies that confirm our results.[31,32,33] Flowering parts come next, accounting for 29% of the usage. Their importance may be due to their aromatic properties or beneficial active ingredients. Seeds are used less frequently, at 9%. Although seeds are rich in nutrients and oils, their usage is lower compared to leaves and flowering parts. Roots and bulbs are also less commonly used, each representing 6% of the total. Roots contain potent compounds used for various therapeutic purposes, but their harvest or preparation may be more complex. Bulbs, while containing concentrated bioactive compounds, are used less frequently than leaves and flowers. Rhizomes and aerial parts are the least commonly used, each representing 3% of the total. Rhizomes, being underground stems with medicinal properties, are used infrequently, as are aerial parts of the plant. In conclusion, leaves and flowering parts are the most favored, together accounting for 75% of the total usage, due to their accessibility and beneficial compounds. The remaining 25% is made up of seeds, roots, bulbs, rhizomes, and aerial parts, indicating more specialized but less common applications. This distribution can guide future studies on the efficacy and accessibility of different plant parts for specific uses.[24,25]

Conclusion

In conclusion, the use of medicinal plants such as *Rosmarinus officinalis*, *Apium graveolens*, *Melissa officinalis*, *Filipendula ulmaria*, *Eucalyptus globulus*, and *Tanacetum vulgare* in the Khenifra province reflects a deep connection between local traditions and healthcare practices aimed at alleviating respiratory issues. The prevalence of leaves and flowers in these treatments underscores their accessibility and high concentration of beneficial compounds known for their therapeutic properties. Although roots, bulbs, and seeds are less commonly utilized, they still offer valuable contributions to overall treatment efficacy. This practice exemplifies the community's sustainable adaptation to its natural resources while preserving valuable botanical heritage. Ongoing research is essential to standardize these preparations and validate the effectiveness of these remedies, ensuring their safety and enhancing the preservation of traditional knowledge.

Conflict of Interest

Authors declare no conflict of interest

Authors' Declaration

The authors hereby declare that the work presented in this article is original and that any liability for claims relating to the content of this article will be borne by them.

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