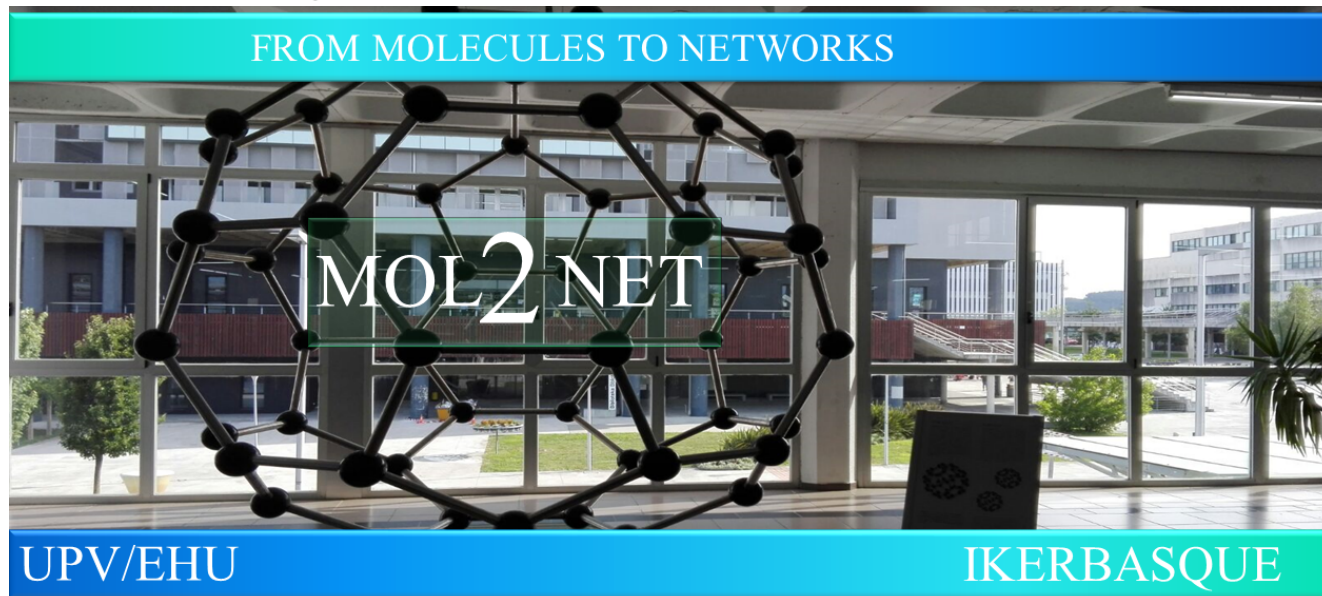




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## Inventory of medicinal and aromatic plants used to treat diverse ailments in the Al Haouz Region of the High Atlas Mountains, Morocco.

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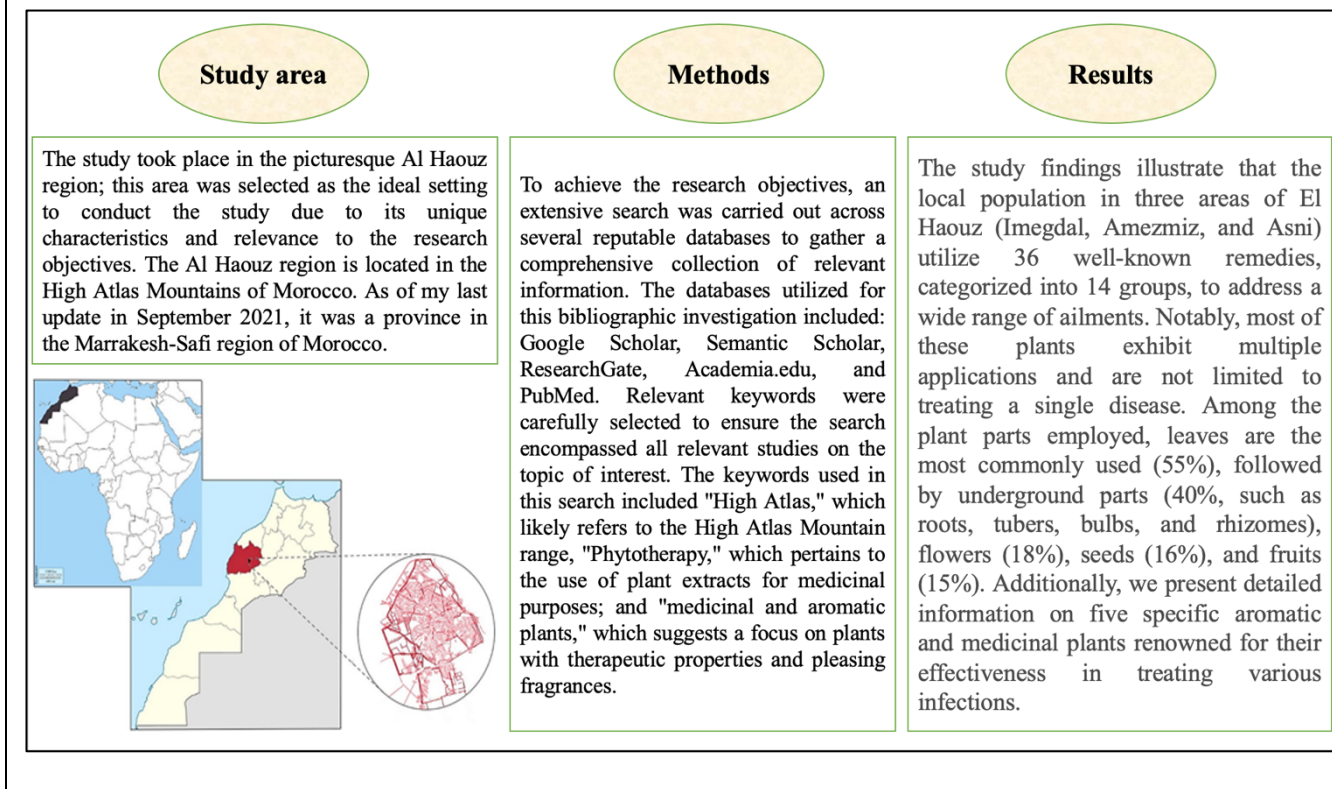
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### Abstract.

Traditional herbal medicine has been deeply rooted in the El Haouz region of the High Atlas Mountains in Morocco, where phytotherapy, using medicinal plants for disease prevention and treatment, has been widely practiced for many years. The local community has heavily relied on herbal remedies to alleviate various health conditions, including digestive issues, respiratory infections, joint discomfort, and skin disorders. The primary objective of our study is to meticulously document the specific medicinal plants employed by the region's inhabitants to address prevalent ailments. To achieve this, an extensive search was conducted across various reputable databases, such as Google Scholar, Semantic Scholar, ResearchGate, Academia.edu, and PubMed. Relevant keywords, such as "High Atlas," "Phytotherapy," and "medicinal and aromatic plants," were employed to ensure comprehensive coverage. Our bibliographic investigation reveals abundant aromatic and medicinal plants in the El Haouz region. The study findings illustrate that the local population in three areas of El Haouz (Imegdal, Amez Miz, and Asni) utilize 36 well-known remedies, categorized into 14 groups, to address a wide range of ailments. Notably, most of these plants exhibit multiple applications and are not limited to treating a single disease. Among the plant parts employed, leaves are the most commonly used (55%), followed by underground parts (40%, such as roots, tubers, bulbs, and rhizomes), flowers (18%), seeds (16%), and fruits (15%). Additionally, we present detailed information on five specific aromatic and medicinal plants renowned for their effectiveness in treating various infections. These plants include *Rubia tinctorum* L., *Ziziphus lotus* (L.) Lam., *Ridolfia segetum* (L.) Moris

(used for anemia), *Thymus saturejoides* Coss., and *Rosmarinus officinalis* L. (used for diabetes). The study delves into the specific utilization methods for each of these plants. The results of our inquiry provide substantial evidence of the local knowledge about plant species in the Al Haouz region, which have been traditionally employed for diverse ailments. Further exploration is warranted to investigate these documented plants' phytochemical, pharmacological, and toxicological aspects, with the potential to discover novel medications derived from them.

## Graphical Abstract



## Introduction

Throughout history, medicinal plants have played a vital role in traditional herbal medicine systems across the globe, serving as remedies for various disorders and ailments for thousands of years. This usage can be traced back to ancient civilizations on every continent, highlighting its enduring significance [1]. Despite advancements in pharmacology, the therapeutic application of plants remains prevalent in some countries, particularly in developing nations [2]. The World Health Organization estimates that approximately 80% of people in developed and developing countries rely on traditional medicines, significantly emphasizing plant-based treatments in primary healthcare [3].

The Al Haouz region stands out as one of the most biologically diverse areas in the Mediterranean, boasting rare biogeographical zones and a wealth of primary importance in biodiversity, with numerous plants holding therapeutic potential. Consequently, the region serves as a significant source of many medicinal plants traded within Morocco and abroad, and the utilization of plants in herbal medicine remains deeply ingrained in local practices. However, data on medicinal plants in this region are scarce and inadequate.

An ethnopharmacological study was carried out in the Al Haouz region to address this need. Given its diverse lithological, structural, and floristic plant characteristics, the study aimed to establish a comprehensive catalog of medicinal plants used in traditional disease treatments, mainly herbal

medicine. The goal was to enhance, preserve, and rationally utilize these valuable natural resources as alternatives for healthcare and therapeutic purposes.

## **Materials and Methods**

### **Study area**

The study took place in the picturesque Al Haouz region; this area was selected as the ideal setting to conduct the study due to its unique characteristics and relevance to the research objectives. The Al Haouz region is located in the High Atlas Mountains of Morocco. As of my last update in September 2021, it was a province in the Marrakesh-Safi region of Morocco. However, please note that administrative divisions and names may change over time, so double-checking with more recent sources for the latest information is always a good idea. The High Atlas Mountains are a stunning mountain range that stretches across central Morocco, forming part of the Atlas Mountains system. The region is known for its rugged landscapes, beautiful valleys, and traditional Berber villages. It's a popular destination for outdoor activities such as hiking, trekking, and exploring the local culture.

Marrakesh, one of Morocco's major cities, is often used as a starting point for travellers who wish to explore the Al Haouz region and the High Atlas Mountains. From Marrakesh, you can embark on various excursions to visit nearby valleys like Ourika Valley, Asni, Imlil, and other scenic areas. Visitors to the Al Haouz region can experience traditional Berber hospitality, enjoy local cuisine, and witness the unique architecture of the Berber villages, many of which cling to the mountainsides.

### **Data collection**

To achieve the research objectives, an extensive search was carried out across several reputable databases to gather a comprehensive collection of relevant information. The databases utilized for this bibliographic investigation included: Google Scholar, Semantic Scholar, ResearchGate, Academia.edu, and PubMed. Relevant keywords were carefully selected to ensure the search encompassed all relevant studies on the topic of interest. The keywords used in this search included "High Atlas," which likely refers to the High Atlas Mountain range, "Phytotherapy," which pertains to the use of plant extracts for medicinal purposes; and "medicinal and aromatic plants," which suggests a focus on plants with therapeutic properties and pleasing fragrances.

By using these keywords and searching the specified databases, the researchers aimed to cover a broad spectrum of academic literature related to the medicinal and aromatic plants in the El Haouz region. This approach allowed them to compile a comprehensive list of relevant studies, articles, and papers, which served as a foundation for their research and provided valuable insights into the abundance of aromatic and medicinal plants in the region under investigation. The El Haouz region likely refers to a geographical area, and the results of the bibliographic study revealed a substantial number of aromatic and medicinal plants in this area. The research findings have significant implications for understanding these plants' potential benefits and applications in phytotherapy, traditional medicine, or other related fields.

## **Results and Discussion**

The provided text describes a bibliographic investigation focusing on aromatic and medicinal plants in the El Haouz region. The study presents various findings related to the local population's traditional knowledge and use of these plants to address different health conditions.

### *Utilization of Medicinal Plants*

The abundance of medicinal plants in the region has been a valuable resource for traditional healing practices and natural medicine. Unlike pharmaceutical drugs that often target specific diseases, most of the medicinal plants in this area boast multiple applications and offer a wide range of therapeutic benefits. This characteristic highlights the remarkable diversity and versatility of these plants' medicinal properties. One key aspect of these medicinal plants is their holistic approach to healing. Many contain various bioactive compounds that interact with the human body in multifaceted ways. These compounds may affect different organ systems and physiological processes, allowing them to address multiple health conditions simultaneously [4].

For example, some plants may possess both anti-inflammatory and analgesic properties, effectively alleviating pain associated with ailments such as arthritis, headaches, and muscle strains. Similarly, certain plants may have antimicrobial and immune-boosting properties, enabling them to combat various infections and bolster the body's defences against pathogens. Furthermore, these medicinal plants often exhibit adaptogenic properties, meaning they can help the body adapt to stress and restore balance [5]. This can be beneficial in treating various health issues related to chronic stress or imbalances in the body's systems. Another fascinating aspect of these plants is their ability to address not only physical health but also mental and emotional well-being [5]. Some plants may have anxiolytic and calming effects, assisting with conditions like anxiety and stress-related disorders. Others might enhance cognitive function, memory, and concentration.

The traditional knowledge passed down through generations has played a crucial role in understanding the diverse medicinal applications of these plants. Local healers and traditional medicine practitioners have accumulated a wealth of information about the specific uses of each plant and how to prepare them for different conditions. It's essential to note that while these medicinal plants offer significant therapeutic potential, they are not substitutes for modern medical treatments in all cases. Instead, they can complement conventional medicine and provide additional options for healthcare [6].

Given the vast array of medicinal properties found in the region's plants, ongoing research and scientific studies are essential to validate their efficacy and safety. By combining traditional knowledge with modern scientific methods, there is an opportunity to harness the full potential of these plants for the benefit of human health. Furthermore, sustainable practices in harvesting and using these medicinal plants are crucial to ensure their preservation for future generations.

### *Versatility of Medicinal Plants*

The medicinal plants in the Al Haouz region have shown a remarkable ability to address various health issues. Unlike modern pharmaceutical drugs that often target one specific condition, these plants have been observed to offer holistic benefits, affecting multiple bodily systems simultaneously. From gastrointestinal disorders to respiratory ailments, from skin conditions to neurological disorders, these plants exhibit an impressive spectrum of therapeutic effects. The key to medicinal plants' versatility lies in their rich reservoir of bioactive compounds. These compounds are natural plant chemicals responsible for their medicinal properties. Medicinal plants often contain a complex blend of alkaloids, flavonoids, terpenoids, phenols, and other secondary metabolites, each with unique pharmacological

actions. The bioactive compounds in medicinal plants seldom act in isolation; instead, they engage in synergistic interactions that amplify their therapeutic potential [7]. This synergy allows the plants to exert multifaceted effects on the body, targeting various biochemical pathways simultaneously.

Consequently, this combination of compounds creates a more robust and adaptable therapeutic response. Medicinal plants have evolved over millennia to withstand environmental stressors and microbial threats. This resilience is mirrored in their medicinal properties as they adapt to various health challenges humans face. The ability of these plants to adapt to changing conditions translates into a broad range of therapeutic effects that can cater to different individuals and their unique health needs. The region's indigenous communities have passed down their knowledge of medicinal plants from generation to generation. Their traditional wisdom has often guided the use of these plants for diverse health issues. In recent times, scientific research has begun to corroborate the efficacy of these medicinal plants through rigorous studies [8]. Modern validation confirms the ancient wisdom, adding credibility to the versatility of these natural remedies.

The medicinal plants found in the region represent a treasure trove of therapeutic potential, boasting a versatility that extends beyond traditional pharmaceutical interventions. Their ability to address multiple health issues can be attributed to diverse bioactive compounds, synergistic interactions, and adaptability to different health challenges. Embracing these medicinal plants in healthcare practices can open up new possibilities for holistic and personalized healing approaches, integrating traditional medicine's ancient wisdom with modern scientific advancements [9-12]. However, further research and conservation efforts are crucial to fully understand and harness the vast benefits that these versatile medicinal plants can offer to humanity.

#### ***Plant Parts Used***

The information details the percentage distribution of plant parts commonly used for various purposes. These plant parts are utilized for multiple purposes, including culinary, medicinal, and cultural practices. The percentages represent the proportion of each plant part's usage to the total use of all plant parts.

- Leaves (55%): Leaves are the most commonly used part of plants, comprising the most significant percentage of plant usage. Leaves are rich in nutrients, flavor, and medicinal properties, making them popular for cooking, herbal remedies, and other applications.
- Underground parts (roots, tubers, bulbs, and rhizomes) (40%): The underground parts of plants are also highly utilized, accounting for a significant portion of plant usage. Roots, tubers (such as potatoes), bulbs (like onions), and rhizomes (e.g., ginger) store essential nutrients and energy for the plant, making them valuable as food sources and for their medicinal properties.
- Flowers (18%): Though not as commonly used as leaves and underground parts, flowers still hold substantial importance in various cultures and cuisines. Edible flowers add flavor, color, and aesthetic appeal to dishes, salads, and beverages.
- Seeds (17%): Seeds are valuable for their high nutritional content and are used in many culinary preparations, such as spices, oils, and snacks. Additionally, some seeds have medicinal properties and are used in traditional medicine.
- Fruits (15%): While delicious and widely consumed, they have a slightly lower overall usage percentage than other plant parts. Fruits are eaten fresh, dried, or processed into jams, juices, and preserves.

It's essential to note that the percentages provided are approximate and may vary depending on factors such as regional cuisines, cultural practices, and traditional medicinal uses of plants [5, 7, 13]. Additionally, the usage percentages of plant parts may change over time due to shifts in dietary preferences, food trends, and advancements in plant-based research.

#### ***Five Specific Aromatic and Medicinal Plants***

Aromatic and medicinal plants have been used as traditional remedies for various ailments for centuries. This investigation focuses on five specific plants renowned for their effectiveness in treating

infections and health conditions. Each plant possesses unique therapeutic properties and has been traditionally employed in various cultures worldwide. The following is a detailed account of these plants and their medicinal uses [14-19].

- *Rubia tinctorum* L.: Commonly known as Madder, it is a perennial herbaceous plant belonging to the Rubiaceae family. Its roots contain biologically active compounds, including anthraquinones, which give the plant its medicinal properties. Madder has been traditionally used as an antimicrobial agent, particularly in treating skin infections and wounds. The plant's antibacterial and antifungal properties are effective against various pathogenic microorganisms. Additionally, it is known to possess anti-inflammatory characteristics, making it helpful in alleviating skin inflammation and related conditions [20].
- *Ziziphus lotus* (L.) Lam.: commonly known as Jujube, belongs to the Rhamnaceae family. This deciduous shrub or small tree is valued for its edible fruits and medicinal properties. The fruits are rich in vitamins, minerals, and antioxidants. They have been traditionally used to enhance immune function, boost energy, and improve overall health. Additionally, Jujube exhibits anti-inflammatory and antimicrobial activities, which have made it effective in treating digestive disorders and respiratory infections [11, 21-27].
- *Ridolfia segetum* (L.) Moris (used for anemia): also known as Corn Mignonette or Mignonette des champs, is an annual herb belonging to the Apiaceae family. This plant is particularly renowned for treating anemia due to its iron-rich composition. The leaves and seeds of *Ridolfia segetum* contain significant amounts of iron, which plays a crucial role in red blood cell formation and oxygen transport. As a result, it is often utilized as a natural remedy for individuals with iron-deficiency anemia or other blood-related disorders [25-28].
- *Thymus saturejoides* Coss.: a member of the Lamiaceae family, is commonly known as Thyme. This aromatic herb is known for its antiseptic and antimicrobial properties. Thyme essential oil, extracted from the plant, is rich in thymol, a potent compound with antimicrobial solid effects. Thyme has been used traditionally to combat respiratory infections, including bronchitis and sore throat. Its antimicrobial properties also extend to topical use, effectively treating skin infections and wounds [20, 29].
- *Rosmarinus officinalis* L. (used for diabetes): Rosemary, is an evergreen shrub belonging to the Lamiaceae family. Besides its culinary uses, Rosemary is valued for its medicinal properties. It has been traditionally used to manage diabetes due to its potential to improve insulin sensitivity and lowering blood glucose levels. The plant contains various bioactive compounds, including rosmarinic acid and carnosol, which exhibit antioxidant and anti-inflammatory effects. Additionally, Rosemary has shown promise in protecting against diabetic complications, such as nephropathy and neuropathy [8, 30-34].

Each of the five aromatic and medicinal plants discussed above possesses unique therapeutic properties that have been utilized for centuries to treat various infections and health conditions. From the antimicrobial properties of *Rubia tinctorum* and *Thymus saturejoides* to the iron-rich content of *Ridolfia segetum* for anemia treatment and the potential antidiabetic effects of *Rosmarinus officinalis*, these plants offer a natural and traditional approach to improving health and well-being. However, it is crucial to note that while these plants have shown promising results, consulting with healthcare professionals before using them for medicinal purposes is essential to ensure safety and proper dosage.

### ***Evidence of Local Knowledge***

The Al Haouz region, located in the High Atlas Mountains of Morocco, is renowned for its rich biodiversity and diverse flora. The local communities in this region have a deep-rooted relationship with nature and possess a profound knowledge of medicinal plants and their applications. Over generations, they have accumulated knowledge about these plants' properties, preparation, and usage for various health ailments [18, 35-37]. This article explores the evidence of local expertise in using medicinal plants in the Al Haouz region. Ethnobotanical studies conducted in the Al Haouz region have revealed a wealth of information about local communities' traditional use of medicinal plants. These studies involve interviews, surveys, and observations with traditional healers, herbalists, and

community members. The collected data shed light on the plants' names, parts used, preparation methods, and their therapeutic applications [38-40].

In the Al Haouz region, traditional healing practices are significant in the healthcare system. Local healers, often referred to as "tabibs," "herborists," or "raqqas," possess an intimate understanding of medicinal plants and their healing properties. They use various plants to treat ailments such as digestive disorders, respiratory issues, skin conditions, and more [41-43]. These healers have passed down their knowledge orally from one generation to another, making it an essential part of the local cultural heritage. The Al Haouz region's diverse ecological settings, ranging from lush valleys to arid plateaus, contribute to the abundance of medicinal plant species. Traditional healers have developed an intricate knowledge of the specific environments where these plants thrive and how to harvest them sustainably. This knowledge is crucial for conserving medicinal plant species and maintaining the region's biodiversity. Local communities in the Al Haouz region often integrate medicinal plant usage into their cultural and spiritual practices. Certain plants are considered sacred, and their usage is intertwined with rituals and beliefs. For instance, specific plants might be used in ceremonies to ward off evil spirits or to bless individuals during important life events. Information about medicinal plants is passed down through an informal and oral tradition [44, 13]. Children often accompany their elders during plant gathering excursions, learning to identify, collect, and utilize various medicinal plants from an early age. This knowledge transfer fosters a deep connection between people and their natural environment. Despite the prevalence of traditional healing practices, the Al Haouz region's communities also embrace modern medicine. However, there is still a preference for traditional remedies due to factors like accessibility, cultural beliefs, and trust in the effectiveness of medicinal plants [45-50].

The Al Haouz region exemplifies a remarkable display of local knowledge in the usage of medicinal plants. The deep-rooted relationship between people and their environment has fostered a sustainable and effective healthcare system based on traditional healing practices. As the region faces modernization and potential challenges to its traditional knowledge, efforts to document and preserve this valuable wisdom become crucial for the local communities' well-being and the conservation of the region's biodiversity [50-54]. In summary, the bibliographic investigation in the El Haouz region reveals the rich diversity of aromatic and medicinal plants and their traditional use by the local population. The study presents valuable information on specific plants and their applications, shedding light on the significance of traditional herbal knowledge in addressing various health conditions in the area.

## Conclusions

The Al Haouz Region in the High Atlas Mountains of Morocco has a diverse inventory of medicinal and aromatic plants, which hold significant cultural value for local communities. These plants have been relied upon for generations to treat various ailments, and traditional healers, known as "Tabibs," play a crucial role in administering these herbal remedies. The region's unique geographical location and diverse ecosystems contribute to the abundance of medicinal flora.

The inventory showcases various plant species with distinct healing properties, such as lavender, thyme, chamomile, and rosemary, prized for their aromatic and therapeutic benefits. Studying these traditional practices provides valuable insights into the harmonious blend of culture and nature in the region, with many remedies deeply rooted in Berber traditions, reflecting the rich cultural heritage of the local communities. The Al Haouz Region's medicinal plant inventory is not only a valuable resource for ethnobotanical research and sustainable conservation efforts but has also caught the

attention of researchers exploring the potential of these plants for modern pharmaceutical applications. However, the over-harvesting of certain species threatens the delicate ecological balance of the High Atlas Mountains.

To address this concern, collaborative efforts between researchers, local communities, and authorities are essential to promote responsible harvesting and conservation. As the global interest in traditional medicine grows, preserving the knowledge of these medicinal plants becomes increasingly crucial. The Al Haouz Region serves as a living laboratory of ancient healing practices and the resilience of traditional knowledge. Understanding and preserving these medicinal and aromatic plants will benefit the local population and contribute to the broader field of natural medicine worldwide.

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