Research Article

Ethnobotanical Knowledge and Therapeutic Uses of *Ormenis mixta* and *Citrus limon* in the Taza Region of Morocco

Hajar Kodad[1]*, Oussama Chauiyakh[2], Hammadi El Farissi[3], Safae El Aammouri[4], Smail Amalich[5], Malika Tiskar[6], Sana El Moutaouakil[1] and El Mahjoub Aouane[1]

[1]Natural Resources and Sustainable Development Laboratory, Faculty of Sciences, Ibn Tofail University; [2] Mohammed V University in Rabat, Higher School of Technology, Materials, Energy and Acoustics Team; [3]Chemical Engineering for Resources Valorization Group -UAE/L01FST, Faculty of Sciences and Technology Abdelmalek Essaadi University, Tangier 90002, Morocco.; [4]Plant, Animal, and Agro-Industry Production Laboratory, Faculty of Sciences, Ibn Tofail University; [5]Laboratory of Phytochemistry, National Agency of Medicinal and Aromatic Plants-Taounate; [6]Laboratory of Organic Chemistry, Catalysis and Environment, Faculty of Sciences, Ibn Tofail University..

Abstract | The erosion of traditional knowledge in Morocco, coupled with the limited scientific validation of medicinal plants, poses a threat to both cultural heritage and sustainable healthcare practices. This ethnobotanical study examines the traditional uses of *Ormenis mixta* and *Citrus limon* in the Taza region of Morocco, based on structured interviews conducted with 120 participants, comprising 25 herbalists and 95 consumers. The findings reveal distinct patterns of usage: *O. mixta* is predominantly utilised for digestive disorders (reported by 100% of respondents), skin conditions (87.5%), and anxiety (87.5%), whereas *C. limon* is primarily favoured for respiratory ailments (92.5%). The study also highlights gender disparities, age-related variations in dosage practices, and cultural applications. These findings underscore the richness of local knowledge while emphasising the necessity for scientific validation of the properties of local ecotypes, the urgent documentation of this vulnerable heritage, and the development of sustainable applications that integrate traditional medicine with modern innovations.

Received | Aug 15, 2025; **Accepted** | Sep 24, 2025; **Published** | December 26, 2025
***Correspondence** | Hajar Kodad; Natural Resources and Sustainable Development Laboratory, Faculty of Sciences, Ibn Tofail University, PB 133-14050, Kenitra, Morocco; **Email:** hajarkodad7@gmail.com
Citation |Kodad, H., O. Chauiyakh, H.El Farissi, S.El Aammouri, S.Amalich, M.Tiskar, S.El Moutaouakil and EM.Aouane. 2025. Ethnobotanical knowledge and therapeutic uses of *Ormenis mixta* and *Citrus limon* in the Taza region of Morocco. *Sarhad Journal of Agriculture*, 41(5): 195-209.
DOI | https://dx.doi.org/10.17582/journal.sja/2025/41.5.195.209
Keywords | Ethnobotany, Medicinal plants, Traditional medicine, *Ormenis mixta*, *Citrus limon*, Morocco.

Copyright: 2025 by the authors. Licensee ResearchersLinks Ltd, England, UK.
This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (https://creativecommons.org/licenses/by/4.0/).

Introduction

Ethnobotany, a discipline at the interface of the natural and social sciences, studies the complex relationships between human societies and plants, documenting their medicinal, cultural, and economic uses (Sihombing and Nugraha, 2025). In regions like Morocco, where floristic biodiversity is exceptional and traditional knowledge deeply rooted, this approach is crucial for the preservation of biocultural heritage and the development of modern therapeutic applications (Lahyaoui *et al*., 2025). Morocco, characterised by remarkable ecological diversity, including the Atlas and Rif massifs, the arid Saharan zones, and the

Mediterranean and Atlantic coastlines, has more than 4,200 plant species, of which approximately 600 are endemic (Chauiyakh *et al.*, 2022b). This floristic richness, recognised as one of the most important in the Mediterranean basin (Chauiyakh *et al.*, 2022a), constitutes a reservoir of resources for traditional medicine but also for the pharmaceutical, cosmetic and agri-food industries (Cherrat *et al.*, 2024). Traditional Moroccan medicine, or Tibb al-'Adwiya, is based on empirical knowledge transmitted orally for centuries, particularly in rural areas where access to modern healthcare remains limited (Lefrioui *et al.*, 2024). Approximately 80% of the Moroccan population would resort to medicinal plants for primary care, highlighting their socio-economic and cultural importance. However, this oral transmission weakens the sustainability of knowledge, particularly in the face of urbanisation and changing lifestyles (Ninich *et al.*, 2024). Recent studies have also documented the use of traditional plants in managing febrile illnesses in urban areas such as Casablanca (Radi *et al.*, 2022), demonstrating the persistence of ethnomedicinal practices across diverse ecological and social contexts. Among the most used plants are *Ormenis mixta* (L.) Dumort. (Asteraceae), commonly called Tihoudrine or Moroccan chamomile, and *Citrus limon* (L.) Osbeck (Rutaceae), the lemon tree. These species perfectly embody the link between biodiversity and traditional knowledge: *Ormenis mixta* is renowned for its anti-inflammatory, digestive and sedative properties (Farid *et al.*, 2024; Radi *et al.*, 2022). Its traditional uses include the treatment of gastrointestinal disorders and dermatological conditions (Elouaddari *et al.*, 2019; Idm'hand *et al.*, 2022). Recent pharmacological studies have confirmed its antioxidant and antimicrobial activities, attributed to its phenolic compounds and essential oils (Kamari *et al.*, 2025). *Citrus limon*, meanwhile, is widely exploited for its antiseptic, antimicrobial and digestive virtues (Boutaj, 2024). Its zest, rich in limonene and flavonoids, presents demonstrated pharmacological activities against respiratory infections and metabolic disorders (Posadino *et al.*, 2024; Purba and Suswati, 2025).

This research focuses on the Taza region, an area at the crossroads of diverse ecosystems and cultural influences, in order to: Document traditional uses of *Ormenis mixta* and *Citrus limon* in medicinal, culinary and ritual practices, using standardised ethnobotanical methods (semi-structured questionnaires and interviews with healers and herbalists). Analyse the intergenerational dynamics of knowledge by evaluating the potential erosion of knowledge among younger generations (Sule and Hidayat, 2025). Scientifically validate traditional uses through a systematic review of available pharmacological data, identifying bioactive molecules responsible for alleged therapeutic effects. This study contributes to enriching Moroccan ethnobotanical databases, which remain fragmentary in certain regions. It supports the in-situ conservation of species threatened by overcollection and climate change. It also opens avenues for pharmaceutical research by targeting underexploited active principles. Therefore, this work establishes a bridge between local knowledge and modern science, with a view to the sustainable valorization of Moroccan natural resources.

Materials and Methods

Study area

The study was conducted in the city of Taza, located in northeastern Morocco, at the junction between the eastern Rif and the Middle Atlas (Figure 1). This strategic region forms a unique biogeographical corridor between Mediterranean and Atlas influences, creating a mosaic of ecosystems conducive to diversified medicinal flora (Bencheikh *et al.*, 2024). Taza region presents remarkable plant diversity, with more than 800 species recorded, of which nearly 15% are endemic (Chauiyakh *et al.*, 2023).

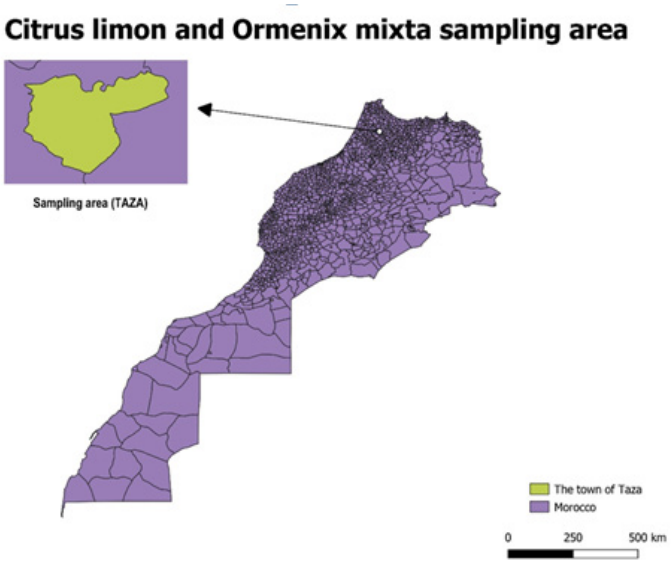

Figure 1: *Citrus limon and Ormenis mixta sampling area*

Origin and selection of studied plants

The specimens of *Ormenis mixta* and *Citrus limon*

(Figure 2) analysed in this study were systematically collected in the Taza region at 34°43'15"N 4°02'23"W (altitude of 1,324 m), an area recognised as a centre of excellence for traditional Moroccan phytotherapy. The plant materials used in this research were taxonomically validated by Professor Zidane, a botanist at the Faculty of Sciences, Ibn Tofail University, Kenitra/Morocco. A voucher was deposited in the Herbarium of the Department of Biology, Faculty of Sciences-Kenitra, under number 82/2025 for *C. limon* and 83/2025 for *O. mixta*.

Figure 2: *Studied plants; a) Ormenis mixta; b) Citrus limon (by author, Jun 2024)*

The choice of these two species is based on regional ethnopharmacological importance: *O. mixta* is traditionally used for digestive disorders, and *C. limon* is used by the population for preparations against respiratory ailments. Availability and accessibility: Presence in 3 key ecological strata of Taza (forest, cultivated area, and riparian forest). Identified research gaps: Only 2 specific studies on *O. mixta* from Taza. Economic valorisation potential: Growing demand in national markets.

Sampling

The sampling within the framework of this ethnobotanical study was developed according to internationally recognised methodological standards, relying mainly on the recommendations of Albuquerque *et al.* (2014), who insist on the need to choose a relevant and representative sample for the analysis of traditional knowledge related to the use of medicinal plants. To achieve this objective, the reasoned sampling strategy, or purposive sampling, was privileged in order to identify key informants with specialised knowledge, often transmitted orally within rural communities (Albuquerque *et al.*, 2014). This ethnobotanical survey was conducted in June and July 2024, which is the harvest period for most aromatic and medicinal plants after flowering for therapeutic use. In this study, 120 participants were interviewed; these respondents represent the number of people who have an interest in using these two plants in phytotherapy in this region. They agreed to answer our questions, unlike another category of people who refused to participate in this ethnobotanical survey for personal reasons. A purposive sampling strategy was adopted to identify key informants such as herbalists, traditional healers, and elders, who play a central role in preserving and transmitting plant-based knowledge. This approach ensured that the collected information was both relevant and representative.

Data collection relied on structured interviews guided by a standardized questionnaire, pre-tested for clarity and reliability (Radi *et al.*, 2024). The questionnaire was divided into four sections: sociodemographic profiles of participants, therapeutic uses of plants, methods of preparation and dosage, and the modes of transmission of ethnobotanical knowledge within communities.

To strengthen the scientific analysis, quantitative indices were incorporated. The Cultural Importance Index (CI) measured the relative value of each plant, the Use Value (UV) reflected the versatility of species across multiple uses, and the Fidelity Level (FL) assessed consensus regarding specific therapeutic indications. Together, these metrics provided a robust evaluation of both plant significance and reliability of reported practices.

For each recorded species, variables included plant parts used, preparation methods, therapeutic contexts, and frequency of use, along with cultural aspects such as rituals and intergenerational transfer. This integrative approach not only documents contemporary ethnobotanical practices in Taza but also highlights the cultural dynamics shaping their evolution in response to social and environmental changes.

Ethical considerations and consent of participants

Ethics Committee approval for this research was secured from the Biology Department at Ibn Tofail University. Initially, informed oral agreement was obtained in the field, commencing at the community level and thereafter on an individual basis before to each interview. Participants were apprised that the study was exclusively academic and devoid of any commercial intent. Their involvement was completely

voluntary, and they had the right to withdraw or request the deletion of their information at any moment. The responders explicitly consented to the disclosure of specific personal data in this publication.

Statistical analyses

Data processing was performed using SPSS software for Windows (Statistical Package for the Social Sciences, version 25). The analyses focused on: Descriptive statistics: Calculation of frequencies and percentages for qualitative variables. Determination of means and standard deviations for quantitative variables for inferential analyses: The Chi-square test (x^2) was applied to evaluate associations between different categorical variables; the statistical significance threshold was set at $p \leq 0.05$.

Results and Discussion

The data from our ethnobotanical survey are presented as relative frequencies (percentages) and absolute frequencies (number of respondents). An important methodological particularity should be noted: participants could provide several responses simultaneously for the same question, thus reflecting the complexity of traditional uses. This multidimensional approach explains why the sum of percentages may exceed 100% for certain variables, since a single informant can be counted in several usage categories.

Distribution of target population

In this study, we surveyed 39 men, of whom 25 are herbalists who sell medicinal plants for phytotherapy, and 81 women, who are all consumers of these two plants. In total, the number of consumers in this survey is 95 people. Figure 3 presents the distribution of people who participated in this survey according to sex (male or female) and status (herbalist or consumer).

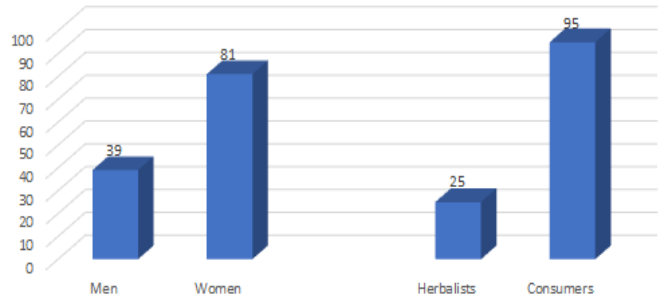

Figure 3: *Distribution of the target population by sex and status*

To ensure that the survey targets a heterogeneous population, the surveyed people were from different age groups and categories. This study targeted young people from the age of 20, single and married, as well as elderly people up to the age of 78 (Figure 4). Population heterogeneity is crucial for ensuring reliable results, as differences in age groups, sex, and status can lead to varied findings in ethnobotanical studies.

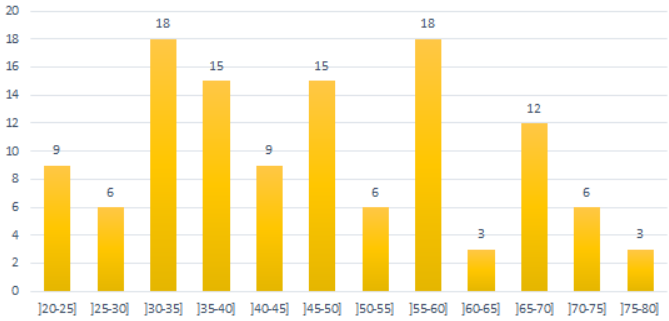

Figure 4: *Age distribution of respondents*

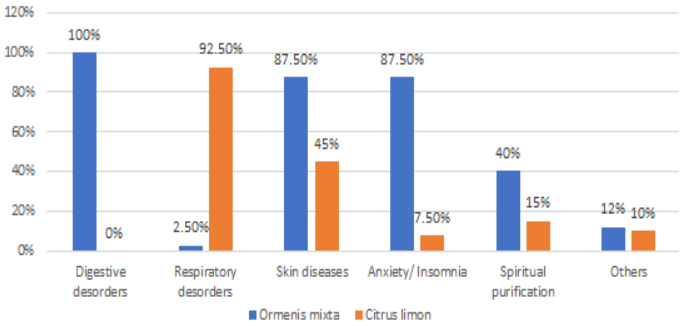

Figure 5: *Therapeutic use of Ormenis mixta and Citrus limon*

Therapeutic use and frequency of use of Ormenis mixta and Citrus limon

Analysis of structured interviews revealed trends concerning the use of *Ormenis mixta* and *Citrus limon* for medicinal purposes (Figure 5).

The plant *Ormenis mixta* is used by 100% of respondents to relieve digestive disorders, 87.5% to treat skin problems and anxiety problems and 2.5% to treat respiratory diseases. Concerning *Citrus limon*, this plant is not used for the treatment of digestive system disorders (0%); however, it is very widespread in phytotherapy for respiratory ailments (92.5%), followed by skin diseases (45%) and finally for the treatment of insomnia by a proportion of 7.5% of the population. For spiritual purification, we found that *Ormenis mixta* is used by 40% of respondents, and *Citrus limon* plays a minor role in this field, with 15% of participants integrating it into certain domestic practices. Several surveyed people declared that they

use these two plants in other medicinal practices, such as 12% of respondents using *Ormenis mixta* for other varied applications, notably in infusion to strengthen immunity. And 10% declare using *Citrus limon* for various uses, such as indoor air purification or hair care.

These results highlight the diversity of applications of these two plants, with a marked prevalence of *Ormenis mixta* for digestive disorders and anxiety, while *Citrus limon* is mainly used for respiratory ailments. The results of our study confirm and enrich existing knowledge about the traditional uses of *Ormenis mixta* and *Citrus limon*. The specialisation of *O. mixta* in treating digestive disorders (100% of respondents) and anxiety (87.5%) joins previous observations while revealing higher usage frequencies than those reported in other regions of Morocco (Kamari *et al*., 2025). The well-documented antispasmodic and sedative properties of this plant scientifically explain these uses. Similarly, the predominance of *C. limon* for respiratory ailments (92.5%) corroborates literature data (Posadino *et al*., 2025), based on its richness in vitamin C and limonene with immunostimulant effects (Kostyuk and Prytychenka, 2025; Posadino *et al*., 2024) and its antibacterial properties against respiratory pathogens (Mahjaf *et al*., 2024).

However, the total absence of digestive use of lemon in our sample contrasts with practices reported elsewhere (Vujčić Bok *et al*., 2022), suggesting local cultural specificities. The dermatological applications of both plants appear more marked in Taza, while the innovative use of lemon against insomnia (7.5%) and more frequent spiritual practices than elsewhere (40% for *O. mixta*) highlight regional particularities deserving further investigation. These results underline both the universality of certain medicinal uses and the importance of local contexts in the evolution of ethnopharmacological practices.

Other previous studies show that citrus fruits such as lemon exhibit a wide range of therapeutic effects due to their richness in flavonoids, phenolic acids, and essential oils. Their antioxidant potential is particularly high in the peels, where compounds such as hesperidin, nobiletin, quercetin, and eriocitrin stabilise free radicals and surpass edible parts in terms of activity (Singh *et al*., 2020; Zahr *et al*., 2023). Beyond their antioxidant effects, citrus peels and juices exhibit strong antibacterial and antifungal properties: polymethoxylated flavonoids like nobiletin and tangeretin disrupt bacterial membranes (Yao *et al*., 2012), hesperidin and ferulic acid inhibit strains of Staphylococcus and Bacillus (Liang *et al*., 2023), while orange and lemon extracts act against Gram-positive and Gram-negative bacteria as well as fungi, notably Candida albicans and Aspergillus species (Bashir *et al*., 2020; Shehata *et al*., 2021). Citrus essential oils, dominated by limonene, further inhibit foodborne pathogens such as Listeria monocytogenes and Salmonella (Zahr *et al*., 2023). Their anticancer activity has also been demonstrated: hesperetin and naringenin trigger apoptosis via the p53 and caspase pathways (Alshatwi *et al*., 2013), while eriocitrin from lemon induces ROS-mediated apoptosis in breast and liver cancer cells (Yuan *et al*., 2022). Moreover, the essential oils of C. sinensis and *C. limon* are cytotoxic against various human cancer cell lines and inhibit angiogenesis and metastasis (Zahr *et al*., 2023). Clinical studies confirm these effects, showing that daily consumption of orange juice increases the antioxidant capacity of plasma (Constans *et al*., 2015), that citrus juices modulate the composition of the gut microbiota (Brasili *et al*., 2019), that lemon juice treats oral candidiasis in HIV-infected patients, and that D-limonene accumulates in breast tissues, reducing tumour proliferation without major toxicity (Zahr *et al*., 2023). Epidemiological data also associate high citrus consumption with a reduced risk of mouth and pharynx cancers (Cirmi *et al*., 2017).

Studies have shown that biological extracts of *O. mixta* have long been used in traditional medicine for circulatory disorders such as hypo- and hypertension and blood sugar regulation, for digestive problems including stomach pain, diarrhea, intestinal gas, and constipation, as well as for skin care in the treatment of burns, wounds, eczema, and for cosmetic purposes (Elouaddari *et al*., 2019). They are also recommended as anxiolytics, helping to rebalance the central nervous system and relieve nervous depressions, liver and stomach weaknesses, as well as colitis caused by colibacillus (Elouaddari *et al*., 2019). their richness in monoterpenes and sesquiterpenes explains much of their biological activity (Tarik *et al*., 2014). Experimentally, the biological extracts of *O. mixta* have demonstrated powerful antibacterial effects against Escherichia coli, Bacillus subtilis, Staphylococcus aureus, and Micrococcus luteus, as well as antifungal activity against Penicillium parasiticus, Aspergillus niger, and Trametes pini; Additional antimicrobial

studies have confirmed significant activity against Citrobacter freundii, Enterococcus faecalis, Listeria monocytogenes, and Klebsiella pneumoniae (Elouaddari *et al.*, 2019; Kamari *et al.*, 2025). The combination of fatty acids, such as propionic acid, with *O. mixta* oil enhanced the antifungal activity, while the coumarins isolated from its roots (corfin and 3'-hydroxycorfin) showed strong inhibition of the rice blast fungus Pyricularia grisea (Elouaddari *et al.*, 2019). Cytotoxic assays revealed that methanolic extracts exhibit moderate activity against human cervical cancer cell lines SiHa and HeLa, likely due to bioactive compounds with anti-growth potential (Merghoub *et al.*, 2009). Moreover, given its medicinal and aromatic value, micropropagation protocols have been developed for in vitro germination and regeneration, while variations in yield and chemical composition between leaves and flowers highlight the importance of optimized harvesting (Anass *et al.*, 2015; Harras and Ahmed, 2014).

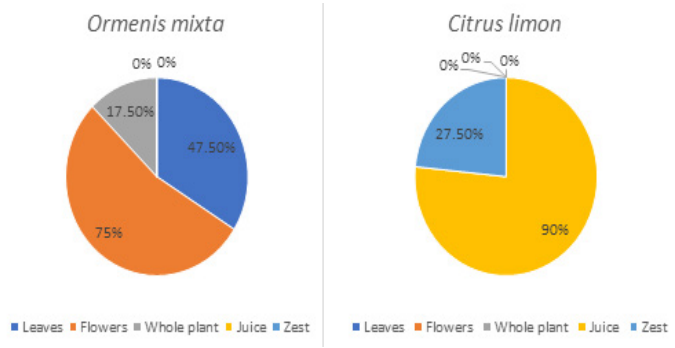

Figure 6: *Different parts of O. mixta and C. limon used by the population*

Plant parts used

The results of our study concerning the parts used by *Ormenis mixta* and *Citrus limon* present both similarities and differences with scientific literature data (Figure 6). For *O. mixta*, the predominance of flowers (75% in medicinal preparations) (Benkhaira *et al.*, 2021), who report the use of flower heads in 68% of cases in Morocco, mainly for digestive infusions. However, our study reveals more frequent use of leaves (47.5%) compared to 35% documented by Idm'hand *et al.* (2022), particularly for dermatological applications (Idm'hand *et al.*, 2022). The use of the whole plant (17.5%) in purification rituals is also more marked than elsewhere, perhaps reflecting traditional practices specific to the Taza region.

Concerning *C. limon*, the preference for juice (90%) is consistent with the work of Badiche-El Hilali al. (2024), who emphasise its majority use in various cultures for its antiseptic and vitamin properties (Badiche-El Hilali *et al.*, 2024). The use of zest (27.5%) is, however, less widespread in our sample than in certain studies, which could be explained by lesser transmission of knowledge relating to the use of peels in the studied region (Meryem *et al.*, 2023). The low use of other parts of the plant (leaves, flowers) corresponds to general observations, although certain studies report more frequent use of leaves in subtropical regions (15–20% vs. less than 5% in our sample). These variations could reflect both differences in the availability of plant parts according to the seasons and cultural specificities in preparation practices. These results indicate that the most used plant parts are those that concentrate the most sought-after active principles, such as *Ormenis mixta* flowers rich in flavonoids and *Citrus limon* juice rich in vitamin C and antioxidants.

Preparation methods

The preparation methods of *Ormenis mixta* and *Citrus limon* vary according to treated ailments and local traditions. The Figure 7 below illustrates the main methods used by respondents.

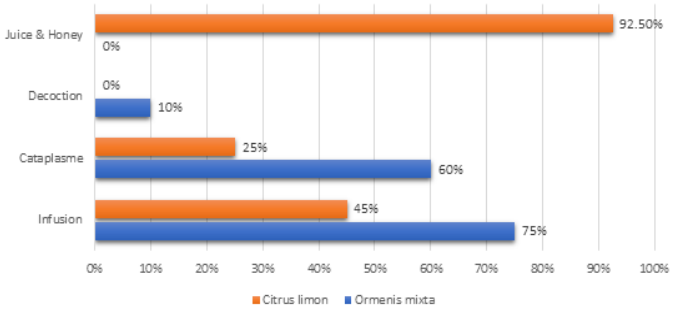

Figure 7: *Methods of preparing plants*

Our results reveal marked differences in preparation methods between *Ormenis mixta* and *Citrus limon*, reflecting empirical adaptation to the pharmacological properties of each plant. For *O. mixta*, infusion (75%) dominates, optimising extraction of digestive and sedative compounds. This method allows effective extraction of active principles, notably flavonoids and essential oils, and it is easy to prepare and widely integrated into medicinal and daily habits, while poultice (60%) is privileged for anti-inflammatory skin applications. Conversely, *C. limon* is mainly consumed as juice mixed with honey (92.5%); this juice is very consumed because honeyed lemon acts as a natural flavour enhancer, a traditional synergy fully

exploiting its antibacterial and immunostimulant properties against respiratory infections. The more moderate popularity of infusion for *C. limon* (45%) could be explained by thermal degradation of vitamin C, while poultice (25%) finds more limited application in dermatological care. Decoction, marginal for both plants (10% for *O. mixta*), seems reserved for specific uses requiring more advanced extraction requiring higher concentrations of active ingredients.

These results, globally consistent with scientific literature, nevertheless highlight certain local particularities, such as exceptionally high use of honey-lemon mixture, suggesting cultural optimisation of therapeutic practices. The low adoption of decoction contrasts with certain studies, possibly due to loss of volatile compounds or preference for faster preparations. These observations underline the importance of both biochemical factors (preservation of active principles) and cultural factors (transmission of knowledge) in the choice of preparation methods in traditional medicine.

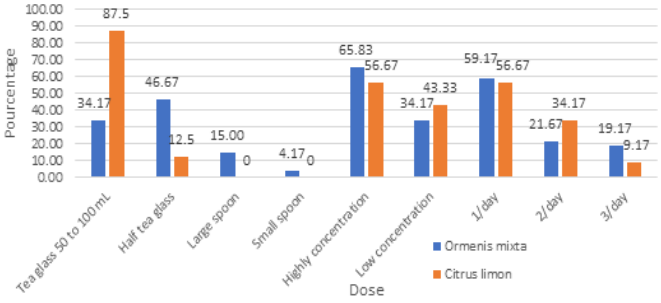

Figure 8: *The dose consumed of each plant by the population*

Administered dose

The graph (Figure 8) illustrates usage doses for two plants, *Ormenis mixta* and *Citrus limon*, according to different administration modalities. Data are expressed as percentages and represent responses from people interviewed about their mode of use of these plants.

First, regarding volume used, results show that 87.5% of people prefer to use *Citrus limon* as half a tea glass, while only 46.67% adopt this same format for *Ormenis mixta*. Conversely, for a whole tea glass (50 to 100 mL), 34.17% of participants declare using *Ormenis mixta*, against a higher percentage for *Citrus limon* (87.5%). When it comes to small quantities, such as a large spoon or small spoon, both plants are much less used, with rates below 15%.

The influence of concentration on usage habits is also notable. High concentration is privileged for *Ormenis mixta* (65.83%), while low concentration is more often adopted for *Citrus limon* (43.33%, against 34.17% for *Ormenis mixta*). This suggests that users perceive *Ormenis mixta* as more effective or better adapted in a more concentrated form.

Finally, the effect of usage frequency reveals intriguing trends. Administration once a day is most common for both plants (59.17% for *Ormenis mixta* and 56.67% for *Citrus limon*). However, when usage frequency increases to twice a day, 34.17% of people declare using *Citrus limon*, while only 21.67% consume *Ormenis mixta*. For three-times-a-day use, rates decrease further, reaching 19.17% for *Ormenis mixta* and only 9.17% for *Citrus limon*.

In conclusion, the survey shows that *Citrus limon* is mainly used as half a tea glass, while *Ormenis mixta* is consumed more in concentrated form. Moreover, single daily use is most widespread for both plants, while increased administration frequency is less common. These results highlight consumer habits and preferences regarding the use of these plants in their daily life.

Cultural and spiritual importance

In addition to their medicinal uses, *Ormenis mixta* and *Citrus limon* possess strong cultural and spiritual significance. These plants are integrated into various rituals and traditional practices, emphasising their role within local communities.

Our results (Table 1) reveal that in Taza, *Ormenis mixta* plays a predominant spiritual role, with 40% of respondents using it in purification rituals by fumigation – a proportion superior to the 30–35% reported by Benkhaira *et al.* (2021) for other Moroccan regions – while its incorporation into religious ceremonies (15%) also exceeds observations of Lahyaoui *et al.* (2025) in Berber environments (~10%) (Benkhaira *et al.*, 2021; Lahyaoui *et al.*, 2025). This increased prevalence could reflect more dynamic cultural transmission or particular valorisation of its purifying properties, corroborated by recent phytochemical analyses highlighting its active volatile compounds. For *Citrus limon*, its ritual use in Taza is distinguished by two aspects: strong integration into domestic cleaning practices, and an unprecedented role

in festive offerings (20%), not documented elsewhere, where it symbolises prosperity and conviviality. These gaps suggest local adaptation of knowledge, potentially influenced by synergies between Arab and Amazigh traditions, while confirming the common Mediterranean base of purifying uses related to these plants. The combination of our data with existing literature thus underlines both the persistence of ancestral practices and the emergence of cultural innovations anchored in specific socio-ecological contexts.

Table 1: *Cultural and spiritual importance of plants*

Plant	Cultural Practice	Percentage of respondents (%)
Ormenis mixta	Burned for spiritual purification	40%
Ormenis mixta	Used in religious rituals	15%
Citrus limon	Used in domestic cleaning rituals	30%
Citrus limon	Used in culinary offerings during festivals	20%

Knowledge transmission

The study also explored how ethnobotanical knowledge about *Ormenis mixta* and *Citrus limon* is transmitted from generation to generation. It appears that this knowledge is mainly shared orally, although other transmission channels exist as complements.

Table 2: *Transmission of ethnobotanical knowledge*

Transmission method	Percentage of respondents (%)
Oral transmission (family)	75%
Community elders (healers)	50%
Written sources (books/ manuals)	10%
Formal education (courses)	5%

Our results (Table 2) reveal that 75% of respondents in Taza acquired their knowledge about *Ormenis mixta* and *Citrus limon* through family oral transmission, a figure superior to the 60–65% reported by Lahyaoui *et al.* (2025) in the High Atlas, perhaps reflecting a stronger anchoring of local traditions (Lahyaoui *et al.*, 2025). Healers and elders play a key role (50%), a proportion similar to observations of Hachi *et al.* (2022) in a rural Moroccan environment, confirming their status as knowledge guardians (Hachi *et al.*, 2022). Conversely, learning through written sources (10%) or formal education (5%) remains marginal, contrary to regions like India, where certain states integrate traditional medicine into school curricula (Shi *et al.*, 2021). This dependence on orality, while weakening long-term preservation, allows dynamic adaptation of knowledge to local needs, as shown by the work of Ninich *et al.* (2022) on the resilience of family practices (Ninich *et al.*, 2022). The low institutionalisation of this knowledge in Morocco contrasts with countries like China, where traditional medicine has been formalised for decades, highlighting the urgency of documentation programmes, such as those initiated by the National Institute of Aromatic and Medicinal Plants (INPAM). This data highlights a paradox: living but vulnerable intergenerational transmission facing urbanisation, requiring hybrid strategies (orality + digital archiving) to safeguard this heritage.

Statistical analyses

Usage Status of Ormenis mixta and Citrus limon in Taza

Statistical analysis (Table 3) reveals a significant association between gender and status ($p = 0.00$), highlighting an extremely asymmetric distribution: all individuals identified as herbalists are male (24 men, 0 women), while all females are consumers (81 women, 0 herbalists). This distribution suggests a strong gender influence on status within this sample, highlighting those men have a significantly higher probability of exercising as herbalists, while women are exclusively present in the consumer role. This significant disparity requires in-depth analysis, particularly by examining social, cultural or structural factors that could justify it.

Table 3: *Distribution of status (herbalist vs consumer) by gender with significance test (n=120)*

Status	P value			
	Herbalist	Consumer		
Gender	Man	24	15	0.00
	Woman	0	81	0.00

Variations in dosage practices of Ormenis mixta: influence of age and mode of administration

This analysis highlights a significant relationship between user age and dosological patterns of *Ormenis mixta* in the Taza region. Results show a predominance of the standard dose (tea glass) among 30-60-year-olds, with particularly marked usage peaks among 30-35-year-olds and 55-60-year-olds. Young adults (20-25 years) and forty-year-olds rather

favour half-glasses, while a remarkable concentration of large spoon usage is observed specifically among 45-50-year-olds (Table 4). These differentiated usage patterns according to age present both similarities and gaps with data reported in other regions of Morocco. While certain studies like that of Choneva *et al.* (2025) noted relative standardisation of doses (Choneva *et al.*, 2025), our results reveal local particularities, notably the exclusive association of a large spoon with the 45-50 age group.

Table 4: *Association between age group and type of dose used in consumption of O. mixta*

Age		Dose of *O. mixta*				P value
		Tea glass	Half tea glass	Large spoon	Small spoon	
[20-25]	Effectif	3	6	0	0	0.000
[25-30]	Effectif	0	3	0	3	
[30-35]	Effectif	9	3	6	0	
[35-40]	Effectif	3	9	3	0	
[40-45]	Effectif	6	3	0	0	
[45-50]	Effectif	0	12	0	3	
[50-55]	Effectif	3	3	0	0	
[55-60]	Effectif	6	9	3	0	
[60-65]	Effectif	0	0	0	3	
[65-70]	Effectif	6	3	3	0	
[70-75]	Effectif	3	3	0	0	
[75-80]	Effectif	0	0	3	0	

Table 5: *Daily frequency of doses according to age*

Age	Dose/Day of *O. mixta*				P value
		1/day	2/day	3/day	0.00
[20-25]	Effectif	9	0	0	
[25-30]	Effectif	3	0	3	
[30-35]	Effectif	12	0	6	
[35-40]	Effectif	12	0	3	
[40-45]	Effectif	9	0	0	
[45-50]	Effectif	3	9	3	
[50-55]	Effectif	3	3	0	
[55-60]	Effectif	6	9	3	
[60-65]	Effectif	0	0	3	
[65-70]	Effectif	9	0	3	
[70-75]	Effectif	3	3	0	
[75-80]	Effectif	0	0	3	

These dosological variations could reflect both specific therapeutic needs at certain life periods and preparation traditions specific to the Taza region. All these observations underline the importance of considering demographic and cultural factors in the study of traditional medicinal practices, while highlighting the need to more systematically document this local knowledge for better understanding of their therapeutic rationality.

This Table 5 reveals distinct dosological patterns for *Ormenis mixta* according to age, with predominantly single administration among 30-40 year-olds (12 cases), double among 45-60 year-olds (9 cases) and triple at age extremes (25-35 years and >60 years). These results, although partially aligned with Mekonnen *et al.* (2022) concerning dose increase with age, diverge from observations of Mekonnen *et al.* (2022) on dosological uniformity, thus highlighting the influence of regional specificities (Mekonnen *et al.*, 2022). Intensive use among young adults and seniors could be explained by acute therapeutic needs or local traditions (Korotkiy and Skornyakova, 2025). These dosological variations, significantly correlated with age ($p < 0.05$), highlight the importance of adapting therapeutic recommendations to demographic and cultural contexts, while underlining the need for complementary pharmacological studies to evaluate the impact of these differences on the efficacy and safety of *O. mixta* use.

Table 6: *Distribution of doses according to mode of use (infusion vs poultice) and their statistical association*

		Dose of *O. mixta*				P value
		Tea glass	Half tea glass	Large spoon	Small spoon	
Infusion	Yes	33	36	12	9	0.055
	No	6	18	6	0	
Poultice	Yes	27	39	9	0	0.000
	No	12	15	9	9	

This analysis reveals significant differences in *O. mixta* dosological patterns according to administration mode (Table 6). For infusions, although association with administered quantities is not statistically significant ($p=0.055$), marked preference of consumers for tea glass (33 cases) and half-glass (36 cases) is observed, contrary to non-consumers who mainly use half-glass (18 cases). Conversely, poultice administration shows a highly significant association ($p = 0.000$) with specific doses; users systematically favour a glass and half-tea glass, while non-users present greater variability, including small spoon use (9 cases). These results

partially corroborate observations of Mekonnen *et al.* (2022) concerning dose standardisation for external applications but diverge from those of Ninich *et al.* (2022), who did not report dosological differences according to administration mode (Mekonnen *et al.*, 2022; Ninich *et al.*, 2022). The clear distinction observed in our study, particularly for poultices, suggests the existence of well-established usage protocols for skin applications, probably linked to therapeutic efficacy considerations or specific local traditions. These results underline the importance of considering administration mode in the evaluation of traditional dosological practices.

Table 7: *Association between frequency of daily doses and use of infusion or poultice*

		Dose/Day of *O. mixta*			P value
		1/day	2/day	3/day	
Infusion	Yes	54	15	21	0.286
	No	15	9	6	
Poultice	Yes	42	24	9	0.000
	No	27	0	18	

This Table 7 highlights notable differences in *O. mixta* administration patterns according to mode of use. While infusion frequency shows no significant correlation with usage status (p=0.286), revealing homogeneous distribution of daily intakes, poultice application conversely presents a highly significant association (p=0.000) with specific dosological patterns. Poultice users favour moderate administrations (1-2 times/day in 66 combined cases), while non-users mainly opt for increased frequency (3 times/day in 18 cases). These observations diverge from the conclusions of Elharas (2025), who did not report variations according to administration mode (Elharas, 2025). The specificity of dosological patterns for poultices could be explained by practical considerations (application time) or therapeutic ones (local action duration), as suggested by Chaachouay *et al.* (2019) in their analysis of traditional topical practices (Chaachouay *et al.*, 2019). These results underline the importance of adapting dosological recommendations to administration mode in ethnopharmacological studies.

Variations in dosage practices of Citrus limon: influence of age and mode of administration

This analysis reveals a significant correlation (p<0.05) between age and *Citrus limon* dosage (Table 8), with a predominance of tea glass among 30-70-year-olds (15-18 cases) contrasting with more moderate use of half-glass at age extremes (20-30 years and >60 years, 3-9 cases). These variations probably reflect adaptations related to physiological needs, usage experience and local traditions, partially corroborating the work of Ninich *et al.* (2022) while presenting regional specificities distinct from the Mediterranean observations of Bencheikh *et al.* (2024) (Bencheikh *et al.*, 2024; Ninich *et al.*, 2022). The bell-shaped distribution of dosages suggests therapeutic rationality anchored in the cultural and demographic context of Taza.

Table 8: *Variation of Citrus limon doses according to age*

Age		Dose of *Citrus limon*		P value
		Tea glass	Half tea glass	0.00
[20-25]	Effectif	9	0	
[25-30]	Effectif	0	6	
[30-35]	Effectif	15	3	
[35-40]	Effectif	15	0	
[40-45]	Effectif	9	0	
[45-50]	Effectif	12	3	
[50-55]	Effectif	6	0	
[55-60]	Effectif	18	0	
[60-65]	Effectif	0	3	
[65-70]	Effectif	12	0	
[70-75]	Effectif	6	0	
[75-80]	Effectif	3	0	

Table 9: *Association between age and daily frequency of citrus limon administration*

Age		Dose/Day of *Citrus limon*			P value
		1/day	2/day	3/day	
[20-25]	Effectif	3	6	0	0.000
[25-30]	Effectif	0	3	3	
[30-35]	Effectif	3	9	6	
[35-40]	Effectif	6	6	3	
[40-45]	Effectif	6	3	0	
[45-50]	Effectif	12	0	3	
[50-55]	Effectif	6	0	0	
[55-60]	Effectif	15	3	0	
[60-65]	Effectif	3	0	0	
[65-70]	Effectif	9	3	0	
[70-75]	Effectif	3	3	0	
[75-80]	Effectif	0	3	0	

This study highlights a significant relationship (p<0.05) between age and frequency of *Citrus*

limon administration (Table 9), revealing distinct dosological patterns according to age groups. Subjects aged 45 to 70 years mainly favour single daily intake (peaking at 15 cases among 55–60-year-olds), while young adults (20-40 years) rather opt for two daily intakes. Three-times-daily administration, although less frequent, is mainly observed among 25-35-year-olds, suggesting more intensive use in this age group. These dosological variations could reflect differences in therapeutic needs, tolerances, or perceptions of efficacy according to age, as also observed by Chaachouay *et al*. (2019) in their work on traditional medicinal practices (Chaachouay *et al*., 2019). These results underline the importance of considering demographic factors in the evaluation of dosological patterns in ethnopharmacology.

Analysis reveals notable differences in consumption patterns according to preparation type. For natural juice, no significant correlation is observed with ingested quantity (p=0.238), although a clear preference for a whole glass (96 cases) rather than a half-glass (15 cases) is noted. Conversely, "Juice/Honey" preparation shows significant association (p=0.049) with larger doses, where 99 out of 102 users systematically opt for a whole glass, against only 3 cases of half-glass among non-users. These results suggest that honey addition could influence dosological practices, possibly due to (1) better taste tolerance allowing larger doses, (2) specific therapeutic indications requiring standardised quantities, or (3) local traditions systematically associating this mixture with complete doses. The difference in statistical significance between both preparation types (p=0.238 vs p=0.049) underlines the importance of preparation mode in the evaluation of traditional dosological patterns (Table 10).

Table 10: *Association between juice type and dose of Citrus limon used*

Dose of *Citrus limon*		**P value**		
		Tea glass	Half tea glass	
Juice	Yes	96	15	0.238
	No	9	0	
Juice/ honey	Yes	99	12	0.049
	No	6	3	

This Table 11 analyses the correlation between the daily frequency of *Citrus limon* consumption and two different consumption modes: simple juice (juice) and juice with honey (juice/honey). Both p-values (0.482) signal the absence of a statistically significant association between consumption modality (with or without honey) and administration frequency (1, 2 or 3 times per day). In other words, whether *Citrus limon* is consumed as simple juice or juice with honey, this has no impact on daily usage frequency. Furthermore, distribution is similar in both situations: the majority of participants consume juice once a day (60 cases), then twice a day (36 cases), while three-times-daily frequency remains less common (15 cases) and is found exclusively among consumers. Conversely, individuals who do not consume are in the minority and concentrate mainly on low frequencies. This uniformity of practices suggests that the preparation method does not affect users' dosage patterns.

Table 11: *Frequency of Citrus limon consumption according to preparation method*

		Dose/Day of *Citrus limon*			**P value**
		1/day	2/day	3/day	
Juice	Yes	60	36	15	0.482
	No	6	3	0	
Juice/ honey	Yes	60	36	15	0.482
	No	6	3	0	

Conclusions and Recommendations

This ethnobotanical survey conducted with 120 informants in the Taza region highlights a robust and differentiated knowledge base around two key species. *Ormenis mixta* is primarily used for digestive disorders and anxiety, while *Citrus limon* is mainly associated with respiratory ailments; these uses are accompanied by distinct preparation preferences (infusion and poultice for *O. mixta*; juice, often combined with honey, for *C. limon*) and dosage patterns modulated by age. Beyond the therapeutic sphere, both plants hold a significant cultural and ritual place, and knowledge is mostly transmitted orally, highlighting both its vitality and vulnerability. These results converge with the literature while revealing local specificities and call for targeted pharmacological validations of regional ecotypes (chemical profiling, activity assays, safety studies), clinical trials comparing traditional preparations and standardised forms, as well as integrated conservation and valorisation strategies (sustainable cultivation, quality supply chains, digital archiving of knowledge). The limitations of the study-reasoned sampling, self-declarations, and geographical

focus-call for multicentric and longitudinal work. Overall, the integration of local knowledge with modern methods opens promising perspectives for natural health and sustainable development, while contributing to the preservation of a threatened biocultural heritage.

Acknowledgements

We are more grateful to ANPMA National Agency for Medicinal and Aromatic Plants–Sahel Boutaher Taounante, Morocco, who gave me the golden opportunity to do this wonderful project, which also helped me in doing a lot of research and I come to know about so many new things. Secondly, I would also like to extend my gratitude to Dr. CHAOUCH Abdelaziz and Sir Madam. MEZIANE Touriya for providing me and support me with all the facility that was required.

Novelty Statement

This learns about will make a contribution to enriching Moroccan ethnobotanical databases, nonetheless fragmentary for positive regions. Supporting in situ conservation of these species, threatened through overcollection and local weather change.

Opening avenues for pharmaceutical research, with the aid of concentrated on underexploited lively principles. Therefore, this work targets to set up a bridge between nearby know-how and cutting-edge science, with a view to sustainable valorization of Moroccan herbal resources.

Authors' Contribution

Hajar Kodad: Conceptualization and writing of this manuscript
Oussama Chauiyakh: methodology and Analysis
Safae El Aammouri: validation for research,
Hammadi El Farissi: investigation Malika Tiskar &
Smail Amalich: helped in revision of the manuscript.
Sana El moutaouakil: helped in writing and revision of the manuscript.
El Mahjoub Aouane: supervision

Generative AI or AI assisted technology statement
The authors declare that they haven't used generative AI.

Conflict of interest
The authors declare no conflicts of interest.

References

Albuquerque, U., L.V.F.C. Cunha, R. Lucena and R. Alves. 2014. Methods and Techniques in Ethnobiology and Ethnoecology. Springer.

Alshatwi, A.A., E. Ramesh, V.S. Periasamy and P. Subash-Babu. 2013. The apoptotic effect of hesperetin on human cervical cancer cells is mediated through cell cycle arrest, death receptor, and mitochondrial pathways. Fundam. Clin. Pharmacol. 27: 581-592. https://doi.org/10.1111/j.1472-8206.2012.01061.x

Anass, E., A. El Amrani and J.J. Eddine. 2015. Effect of the parts of plant material (flowers and leaves) on essential oil chemical composition of *Ormenis mixta* from Morocco. J. Essent. Oil Bear. Plant., 18:v398-408. https://doi.org/10.1080/0972060X.2014.935022

Badiche-El Hilali, F., B. Medeiros-Fonseca, J. Silva, A.C. Silvestre-Ferreira, M.J. Pires, R.M. Gil da Costa, F. Peixoto, P.A. Oliveira and D. Valero. 2024. The effect of lemon juice (*Citrus limon* L.) treated with melatonin on the health status and treatment of K14HPV16 mice. Antioxidan., 13: 588. https://doi.org/10.3390/antiox13050588

Bashir, L.U., A. Abdulkadir, M.M. Shah, A. Hamisu, U. Sharif and A.A. Kamalu. 2020. Phytochemical screening and antifungal potentials of *Citrus limon* peels against Fusarium oxysporum and Rhizopus stolonifer causing rots in watermelon (*Citrullus lanatus* L.). J. Exp. Sci., 17-21. https://doi.org/10.25081/jes.2020.v11.6206

Bencheikh, N., A. Elbouzidi, A. Baraich, M. Bouhrim, A. Azeroual, M. Addi, R.A. Mothana, H.M. Al-Yousef, B. Eto and M. Elachouri. 2024. Ethnobotanical survey and scientific validation of liver-healing plants in northeastern Morocco. Front. Pharmacol., 15. https://doi.org/10.3389/fphar.2024.1414190

Benkhaira, N., N. Ech-chibani and K. Fikri-Benbrahim. 2021. Ethnobotanical survey on the medicinal usage of two common medicinal plants in Taounate Region: Artemisia herba-alba Asso and *Ormenis mixta* (L.) Dumort. Ethnobot. Res. Appl., 22: 1-19.

Boutaj, H. 2024. A comprehensive review of Moroccan medicinal plants for diabetes management. Dis. Basel Switz., 12: 246.

https://doi.org/10.3390/diseases12100246

Brasili, E., N.M.A. Hassimotto, F. Del Chierico, F. Marini, A. Quagliariello, F. Sciubba, A. Miccheli, L. Putignani, F. Lajolo. 2019. Daily consumption of orange juice from Citrus sinensis L. Osbeck cv. Cara Cara and cv. Bahia differently affects gut microbiota profiling as unveiled by an integrated meta-omics approach. J. Agric. Food Chem., 67: 1381-1391. https://doi.org/10.1021/acs.jafc.8b05408

Chaachouay, N., O. Benkhnigue, M. Fadli, H.E. Ibaoui, R.E. Ayadi and L. Zidane. 2019. Ethnobotanical and ethnopharmacological study of medicinal and aromatic plants used in the treatment of respiratory system disorders in the Moroccan Rif. Ethnobot. Res. Appl., 18: 1-16.

Chauiyakh, O., E. El Fahime, S. Aarabi, O. Ninich, L. Ouchari, F. Bentata, A. Chaouch and A. Ettahir. 2023. In vitro biological control of Cedrus atlantica's lignivorous fungi by the extracted essential oils from the infected wood. Int. Wood Prod. J., 1-9. https://doi.org/10.1080/20426445.2023.2265249

Chauiyakh, O., A. Et-tahir, K. Kettani, A. Cherrat, A. Benayad and A. Chaouch. 2022a. Review on health status, chemical composition and antimicrobial properties of the four species of the genus Cedrus. Int. Wood Prod. J., 13: 272-285. https://doi.org/10.1080/20426445.2022.2118652

Chauiyakh, O., A. Et-Tahir, B. Satrani, M. Ghanmi, S. Cherrad, K. Kettani, A. Chaouch and M. Tiskar. 2022b. Chemical composition and evaluation of the antibacterial and antifungal activities of Pre-Rif Teucrium polium essential oil. Res. J. Pharm. Technol., 15: 1755-1760. https://doi.org/10.52711/0974-360X.2022.00294

Cherrat, A., H. Zerkani, I. Tagnaout, S. Amalich, O. Chauiyakh and T. Zair. 2024. Study of the phenolic compounds of the leaves and flowers of Anacyclus pyrethrum using HPLC-UV/SM and evaluation of their antioxidant, antibacterial, and antifungal activities. Vegetos. https://doi.org/10.1007/s42535-024-00891-7

Choneva, M., A. Bivolarska, D. Gyuzeleva, V. Turiyski, P. Stoyanov, T. Mladenova, K. Todorov, R. Mladenov, N. Prissadova, R. Ardasheva, V. Yotov, P. Denev, A. Topalova-Shishmanova, S. Bivolarski and I. Dimov. 2025. Putting ethnobotany into practice: In vitro antioxidant potential and impact on rat gastric smooth muscle reactivity of aqueous extracts of Marrubium friwaldskyanum Boiss. and Marrubium peregrinum L. Life., 15: 948. https://doi.org/10.3390/life15060948

Cirmi, S., A. Maugeri, N. Ferlazzo, S. Gangemi, G. Calapai, U. Schumacher and M. Navarra. 2017. Anticancer potential of Citrus juices and their extracts: A systematic review of both preclinical and clinical studies. Front. Pharmacol., 8. https://doi.org/10.3389/fphar.2017.00420

Constans, J., C. Bennetau-Pelissero, J.-F. Martin, E. Rock, A. Mazur, A. Bedel, C. Morand and A.M. Bérard. 2015. Marked antioxidant effect of orange juice intake and its phytomicronutrients in a preliminary randomized cross-over trial on mild hypercholesterolemic men. Clin. Nutr., 34: 1093-1100. https://doi.org/10.1016/j.clnu.2014.12.016

Elharas, K. 2025. An ethnobotanical survey of medicinal plants used in the Boujdour Province, Morocco. Bol. Latinoam. Caribe Plantas Med. Aromat., 24: 16-32. https://doi.org/10.37360/blacpma.25.24.1.2

Elouaddari, A., A.E. Amrani, J.A. Cayuela Sánchez, T.O. Bellahcen, A. Zouiten and J.J. Eddine. 2019. Chemical composition and biological activities of the Cladanthus mixtus essential oil: A review. Anal. Chem. Lett., 9: 649-663. https://doi.org/10.1080/22297928.2019.1682665

Farid, E.K., K. Kriri, E. Mohamed, C. Ouiaam, A. Chetto, T. Abdelhak, R. Benkirane and R. Benyahya. 2024. The serial mediating role of acidity content and total soluble solids in linking peel thickness to vitamin C content in some accessions of *Citrus limon* (L.) Burm. J. Glob. Innov. Agric. Sci., 12: 293-305. https://doi.org/10.22194/JGIAS/24.1233

Hachi, M., T. Hachi, H. Essabiri, A. Yaakoubi, L. Zidane and E.H. Abba. 2022. Ethnobotanical study of medicinal plants in the Central Middle Atlas region (Morocco). IOP Conf. Ser. Earth Environ. Sci., 1090: 012027. https://doi.org/10.1088/1755-1315/1090/1/012027

Harras, N. and L. Ahmed. 2014. In vitro germination and plantlet establishment of wild chamomile of Morocco Cladanthus mixtus (L.) Oberpr. and Vogt. Am. J. Plant Sci., 5: 2623-2632. https://doi.org/10.4236/ajps.2014.518277

Idm'hand, E., F. Msanda and K. Cherifi. 2022. A review of Moroccan medicinal plants used in the treatment of hypertension. Int. J. Nat. Life Sci., 6: 48-78. https://doi.org/10.47947/ijnls.1010197

Kamari, F.E.L., A. Bouchyoua, J. El Amrani, A. Harmouzi, N. El Houda Tahiri, A. Sbai, M. El-Shazly, S.H. Aly, A. El Moussaoui, B. Lyoussi and D. Ousaaid. 2025. Chemical composition, antioxidant, and antibacterial activities of Cladanthus mixtus essential oil. Biochem. Syst. Ecol., 123: 105076. https://doi.org/10.1016/j.bse.2025.105076

Korotkiy, V. and O. Skornyakova. 2025. Therapeutic approach to correct hematopoiesis and anemia in calves with nonspecific bronchopneumonia. J. Glob. Innov. Agric. Sci., 1069–1075. https://doi.org/10.22194/JGIAS/25.1633

Kostyuk, N. and A. Prytychenka. 2025. The use of adipose-derived mesenchymal stem cells in the treatment of claw lesions in cows. J. Glob. Innov. Agric. Sci., 333–342. https://doi.org/10.22194/JGIAS/25.1523

Lahyaoui, M., N. Dakka, N. El Menyiy, M. Sobeh, P. Razi, K.W. Goh, Y.M. Al-Worafi, M.J. Farrukh and A. Bouyahya. 2025. Ethnobotanical survey of medicinal and aromatic plants used by the population of Settat Province, Morocco. Heliyon., 11: e42323. https://doi.org/10.1016/j.heliyon.2025.e42323

Lefrioui, Y., M. Chebaibi, M.D. Bichara, I. Mssillou, H. Bekkari, J.P. Giesy and D. Bousta. 2024. Ethnobotanical survey of medicinal plants used in north-central Morocco as natural analgesic and anti-inflammatory agents. Sci. Afr., 25: e02275. https://doi.org/10.1016/j.sciaf.2024.e02275

Liang, Y., L. Zhang, C. Lai, Z. Ouyang and J. Zhang. 2023. Evaluation of antibacterial activity of compounds isolated from the peel of Newhall navel orange. Nat. Prod. Res., 37: 2060–2064. https://doi.org/10.1080/14786419.2022.2116580

Mahjaf, G.M., M.A.A. Mohammed, H.A.E. Ahmed and L.M.A. Abdelgader. 2024. In vitro assessment of antimicrobial activity of citrus lemon against selected clinical isolates from Shendi city, Sudan. J. Bacteriol. Mycol. Open Access., 12: 83–87. https://doi.org/10.15406/jbmoa.2024.12.00378

Mekonnen, A.B., A.S. Mohammed and A.K. Tefera. 2022. Ethnobotanical study of traditional medicinal plants used to treat human and animal diseases in Sedie Muja District, South Gondar, Ethiopia. Evid. Based Complement. Alternat. Med., 2022: 1–22. https://doi.org/10.1155/2022/7328613

Merghoub, N., L. Benbacer, S. Amzazi, H. Morjani and M. El Mzibri. 2009. Cytotoxic effect of some Moroccan medicinal plantextracts on human cervical cell lines. J. Med. Plants Res., 3: 1045–1050.

Meryem, S., D. Mohamed, C. Nour-eddine and E. Faouzi. 2023. Chemical composition, antibacterial and antioxidant properties of three Moroccan citrus peel essential oils. Sci. Afr., 20: e01592. https://doi.org/10.1016/j.sciaf.2023.e01592

Ninich, O., E. El Fahime, B. Satrani, S. Burri, M. Ghanmi, S. Aarabi, O. Chauiyakh, K. Kettani and A. Ettahir. 2024. Comparative chemical and biological analysis of wood and tar essential oils from Cedrus atlantica and Juniperus oxycedrus in Morocco. Trop. J. Nat. Prod. Res., 8: 6570–6581. https://doi.org/10.26538/tjnpr/v8i3.15

Ninich, O., A. Et-tahir, K. Kettani, M. Ghanmi, J. Aoujdad, S. El Antry, M. Ouajdi and B. Satrani. 2022. Plant sources, techniques of production and uses of tar: A review. J. Ethnopharmacol., 285. https://doi.org/10.1016/j.jep.2021.114889

Posadino, A.M., P. Maccioccu, A.H. Eid, R. Giordo, G. Pintus and G. Fenu. 2024. *Citrus limon* var. pompia Camarda var. nova: A comprehensive review of its botanical characteristics, traditional uses, phytochemical profile, and potential health benefits. Nutrient., 16. https://doi.org/10.3390/nu16162619

Posadino, A.M., P. Maccioccu, R. Giordo, Y. Spissu, A.H. Eid, A. Barberis, G. Pintus and G. Fenu. 2025. Exploring the medicinal potential of *Citrus limon* var. pompia Camarda var. nova: From phytochemicals to therapeutic applications. Food Biosci., 66: 106255. https://doi.org/10.1016/j.fbio.2025.106255

Purba, D. and S. Suswati. 2025. Profile of secondary metabolite compounds in soybean (Glycine max L.) leaves under different shading treatments. J. Glob. Innov. Agric. Sci., 193–202. https://doi.org/10.22194/JGIAS/25.1399

Radi, F.Z., H. Khamar, F. Remok, S. Amine, D.

Aziz, S. Aoudry, N. Zekri, A. Bouzoubaa and Z. Touria. 2022. Aromatic and medicinal plants in the Ifrane region (Morocco): Floristic diversity, with special emphasis on ethnobotanical and socioeconomic studies of six spontaneous plants. J. Pharm. Pharmacogn. Res., 10: 517–550. https://doi.org/10.56499/jppres21.1331_10.3.517

Radi, M., S. Benlakhdar, A. Ailli, F.Z. Ayyad, T. Balafrej, A.E.B.E. Alaoui, N. Hadi, H. Khamar, R. Asserraji and A.E. Imache. 2024. Ethnobotanical study of medicinal plants with therapeutic interest in the province of Khemisset, Morocco. Ethnobot. Res. Appl., 29: 1–22.

Shehata, M.G., T.S. Awad, D. Asker, S.A. El Sohaimy, N.M. Abd El-Aziz and M.M. Youssef. 2021. Antioxidant and antimicrobial activities and UPLC-ESI-MS/MS polyphenolic profile of sweet orange peel extracts. Curr. Res. Food Sci., 4: 326–335. https://doi.org/10.1016/j.crfs.2021.05.001

Shi, Y., C. Zhang and X. Li. 2021. Traditional medicine in India. J. Tradit. Chin. Med. Sci., 8: S51–S55. https://doi.org/10.1016/j.jtcms.2020.06.007

Sihombing, L. and S. Nugraha. 2025. The impact of halal certification in herbal medicine on Indonesia's agribusiness and pharma sectors: A review. J. Glob. Innov. Agric. Sci., 707–718. https://doi.org/10.22194/JGIAS/25.1579

Singh, B., J.P. Singh, A. Kaur and N. Singh. 2020. Phenolic composition, antioxidant potential and health benefits of citrus peel. Food Res. Int., 132:,109114. https://doi.org/10.1016/j.foodres.2020.109114

Sule, S. and K. Hidayat. 2025. Linking farmer knowledge and learning to agricultural sustainability: A study of apple farmers in Indonesia. J. Glob. Innov. Agric. Sci., 1021–1029. https://doi.org/10.22194/JGIAS/25.1772

Tarik, A., M. Elkouali, A. Ainane and M. Talbi. 2014. Moroccan traditional fragrance based essential oils: Preparation, composition and chemical identification. Pharma Chem., 6: 84–89.

Vujčić Bok, V., I. Šola and G. Rusak. 2022. Lemon juice formulations modulate in vitro digestive recovery of spinach phytochemicals. Food Technol. Biotechnol., 6: 293–307. https://doi.org/10.17113/ftb.60.03.22.7104

Yao, X., X. Zhu, S. Pan, Y. Fang, F. Jiang, G.O. Phillips and X. Xu. 2012. Antimicrobial activity of nobiletin and tangeretin against Pseudomonas. Food Chem., 132: 1883–1890. https://doi.org/10.1016/j.foodchem.2011.12.021

Yuan, C., G. Chen, C. Jing, M. Liu, B. Liang, G. Gong and M. Yu. 2022. Eriocitrin, a dietary flavonoid suppressed cell proliferation, induced apoptosis through modulation of JAK2/STAT3 and JNK/p38 MAPKs signaling pathway in MCF-7 cells. J. Biochem. Mol. Toxicol., 36: e22943. https://doi.org/10.1002/jbt.22943

Zahr, S., R. Zahr, R. El Hajj and M. Khalil. 2023. Phytochemistry and biological activities of Citrus sinensis and *Citrus limon*: an update. J. Herb. Med., 41: 100737. https://doi.org/10.1016/j.hermed.2023.100737