Ethnobotanical study of *Tetraclinis articulata* in western Algeria: traditional uses and therapeutic potential

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Ethnobotany Research and Applications 33:21 (2026) - http://dx.doi.org/10.32859/era.33.21.1-18
Manuscript received: 25/10/2025 – Revised manuscript received: 21/01/2026 - Published: 23/01/2026

Research

Abstract

Background: This ethnobotanical survey, carried out in four wilayas of western Algeria (Bechar, El Bayadh, Tlemcen and Ain Temouchent), was based on interviews with specialists in traditional phytotherapy (herbalists and traditional healers) to identify and document the popular uses associated with *Tetraclinis articulata (T. articulata)*, locally known as **arar** tree.

Methods: Information was collected using a semi-structured questionnaire, enabling the investigation of the therapeutic uses of *T. articulata* across several clearly defined dimensions, including medical indications (ailments targeted by traditional treatments), plant parts used (leaves, wood, cones, etc.), preparation and administration methods (infusion, decoction, inhalation, external application, etc.), types of treatments practiced, and potentially reported side effects.

Results: The study reveals a widespread integration of the **arar** tree in local folk medicine, with a usage rate of 99.09 % among participants. A total of 42 ailments were recorded, including digestive disorders (e.g., gastric ulcers), respiratory conditions (e.g., cough), and urological diseases (e.g., urinary tract infections). Two quantitative indicators confirm the importance of the species, with a Use Value (UV) of 2.7 and a Cultural Importance Index (CI) of 1.76.

Conclusions: These results demonstrate the major role of *T. articulata* in traditional local healthcare, as well as its strong cultural value. The study highlights the richness of orally transmitted knowledge surrounding this species and emphasizes the need to integrate it into a scientific framework for the sustainable development and rational conservation of this plant resource from the Mediterranean region.

Keywords: *Tetraclinis articulata*, Ethnobotanical survey, Traditional medicine, Therapeutic properties

Background

Since ancient times, medicinal plants have played a central role in health care. This practice was based on instinct, experience and observation of natural effects. In addition to plants, the ancients also used animal and mineral substances, outside the food framework, to treat various conditions (Organisation Ouest-Africaine de la Santé 2013).

Today, about 75% of the African population depends exclusively on local plants for their care, due to a lack of access to modern medicines (Pousset 1989). In the Maghreb, and particularly in North Africa, phytotherapy has remained deeply rooted in traditional practices, constituting a valuable alternative to the formal medical system (Gharib 2022).

Tetraclinis articulata (Vahl) Masters (*T. articulata*), also known as **arar** tree, is a species of the Cupressaceae family, which occupies a major ecological role in North African forests, covering more than one million hectares (Benabid 1977). In traditional medicine, this plant is valued for its many therapeutic properties: its different parts are used to relieve gastric pain, respiratory diseases, intestinal infections, as well as to treat diabetes, hypertension and fever (Zahir & Rahmani 2020). Although this species has a wide variety of uses, the ethnobotanical knowledge associated with it remains fragmented and poorly structured due to a lack of written sources, which hinders its academic and institutional recognition.

In a context of rehabilitation of traditional medicines and rediscovery of local plant resources, how can the empirical knowledge relating to *T. articulata*, collected in four wilayas of western Algeria, be systematized and highlighted, in order to identify the main medicinal uses, evaluate their cultural importance and pave the way for their scientific recognition from a sustainable health perspective?

In light of this observation, the present study aims to:

- Document and organize popular knowledge associated with *T. articulata* through a field survey conducted among herbalists and traditional healers from four wilayas in western Algeria.
- Promote traditional medicinal uses by comparing them with available scientific data.
- Explore the prospects for integrating this plant into public health policies, taking into account its accessibility and local popularity.

Materials and Methods

In order to address this issue, the present study relies on an ethnobotanical approach combining field surveys and descriptive analysis. This approach makes it possible to explore popular knowledge related to *T. articulata* and to extract key structural elements, both medicinal and cultural. The methodology implemented thus aims to collect, organize, and evaluate the empirical knowledge gathered from local practitioners, with the goal of producing a contextualized scientific interpretation.

Study area

The study was conducted in four provinces of western Algeria: Bechar, El Bayadh, Tlemcen and Ain Temouchent. The geographical location of the study area is illustrated in Figure 1.

Bechar Province

Located in the southwest of the country (31°36’60” N, 2°12’60” W), about 1000 km from the capital Algiers, Bechar is a Saharan province dominated by rocky plateaus, sand dunes, and scattered oases. The climate is arid, typical of the Sahara, with high summer temperatures and relatively mild winters. Rainfall is scarce and irregular (Bouziane 2021). It shares borders with:

- Morocco to the west;
- Adrar to the east;
- Naâma and El Bayadh to the north;
- Tindouf to the south.

El Bayadh Province

This steppe region of southwestern Algeria covers an area of 71697 km². It features a heterogeneous landscape made up of high plateaus, mountains, and desert expanses. The region is dominated by the Ksour Mountains, a range that forms part of the Saharan Atlas. Its semi-arid climate is marked by cold winters, very hot summers, and low precipitation. Temperatures vary greatly depending on the season and altitude (Forest Conservation Department of El Bayadh Province 2018). It is bordered by:

- Saida and Tiaret to the north;
- Laghouat and Ghardaïa to the east;
- Bechar and Adrar to the south;
- Naama and Sidi Bel Abbes to the west.

Tlemcen Province

Located in the northwest of the country (between 1°27′ and 1°51′ West longitude and 34°27′ and 35°18′ North latitude), Tlemcen occupies a strategic position and covers an area of 9018 km² (Arbadi *et al.* 2018). It is characterized by diverse topography, including the Tell Atlas Mountains, fertile plains, and lush valleys. Benefiting from a Mediterranean climate, the region experiences hot, dry summers and mild, wet winters. It is bordered by:

- The Mediterranean Sea to the north;
- Morocco to the west;
- Ain Temouchent to the east;
- Naama and Sidi Bel Abbes to the south (Arbadi *et al.* 2018).

Ain Temouchent Province

Located on the northwest coast of Algeria, 520 km from the capital (Latitude: Approximately 35.2973° North, Longitude: Approximately -1.1404° West, Average Altitude: Approximately 200 to 300 m), this Mediterranean province covers 2376.89 km². Its proximity to the sea favors a temperate climate, with hot, dry summers and mild, rainy winters. The landscape alternates between agricultural plains, hills, and low-lying terrain. It is bordered by:

- The Mediterranean Sea to the north;
- Tlemcen to the west;
- Oran to the east;
- Sidi Bel Abbes to the south.

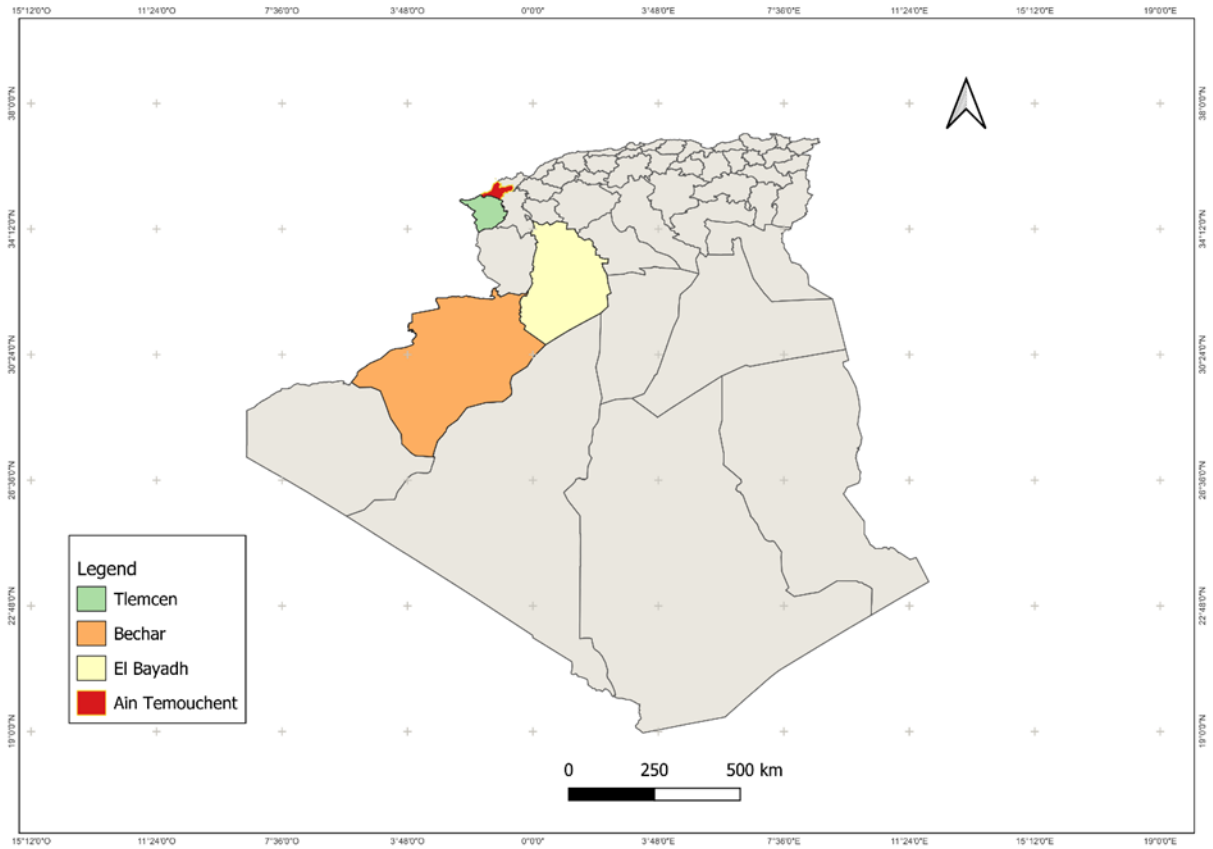

Figure 1. Geographical location of the study area in western Algeria (map generated using QGIS).

Plant material and taxonomic identification

The ethnobotanical study focused exclusively on *Tetraclinis articulata* (Vahl) Mast., which was the only species collected and documented for this study. Plant material was harvested from a natural stand located in the Zerdeb forest, in Ouled Mimoun. The collection site was georeferenced, and voucher specimens were prepared in accordance with standard herbarium preservation procedures.

Species identification was carried out by the authors, one of whom is a forestry specialist with more than thirty-six years of professional experience, and was confirmed in the field by the head of the Ouled Mimoun forestry district, an officer with

over forty years of experience in the sector. A voucher specimen was subsequently deposited in the herbarium of the Laboratory of Ecology and Management of Natural Ecosystems (LECGEN No. 13), Abou Bekr Belkaid University of Tlemcen, 13000, Algeria, where it was verified by comparison with an authenticated reference specimen preserved in the collection.

Ethnobotanical survey

Data collection

In this region, where traditional herbal medicine practices are still widespread, a purposive sample was compiled, including those considered to be the main conservators of traditional medicinal knowledge:

- Herbalists with a registered or locally recognized business.
- Traditional healers working in a community setting.
- A diversity of ages, genders and geographical areas to reflect the plurality of practices.

The data collection was based on a semi-structured questionnaire designed to gather detailed information while allowing respondents freedom of expression. It consisted of two main sections:

1. Socio-economic profiles: age, gender, level of education.
2. Ethnobotanical data: which allowed for targeted documentation of the therapeutic uses of *T. articulata*, including:
   - Medical indications: pathologies targeted by traditional treatments
   - Exploited plant parts: leaves, wood, cones, ...
   - Preparation and administration practices: These are concrete techniques for transforming and using the plant:
     - How it is prepared: infusion, decoction, etc.
     - How it is administered: inhalation, external application...
   - Types of care practiced: we talk about the therapeutic logic (function) or the type of medical intervention according to the reported knowledge:
     - Preventive, curative, comfort care.
     - Use to treat an acute or chronic pathology.
     - Ritual, symptomatic or systemic use.
   - Possible side effects.

The questionnaire was administered through face-to-face interviews and was intentionally designed to minimize interviewer and confirmation bias. All questions were formulated in an open-ended manner, allowing respondents to express their knowledge freely without being guided toward predefined answers. The interviewer avoided suggesting therapeutic indications, plant parts or preparation methods, and probing questions were used only to clarify the information provided by the informants.

Surveyed population

The survey targeted herbalists and traditional healers across four provinces in western Algeria, with a total of 110 participants, ensuring broad regional representation (Table 1).

Herbalists were selected for their local renown in working with medicinal plants and their familiarity with traditional uses. These individuals operate established shops that are well known in their communities.

Traditional healers were identified through local networks, including recommendations from herbalists, community members, and family contacts. Only practitioners with a long-standing reputation for their knowledge and the effectiveness of their remedies were included. Some traditional healers work in formal practice spaces, while others receive patients in their homes; in all cases, only widely trusted and locally acknowledged practitioners were approached for the survey.

Participant recruitment employed a purposive, location-based sampling strategy. The primary unit of analysis was the cultural region of Western Algeria, with the wilaya used as a practical geographic framework to ensure coverage of its major ecological zones (coastal/Tellian, steppe, and Saharan). The uneven distribution of participants across wilayas (detailed in Table 1) reflects the study's ethnobotanical focus on depth and regional variation rather than demographic proportionality.

A larger number of practitioners were interviewed in Tlemcen region, where the research team is based, allowing for more extensive, multi-location sampling within this primary study site. In Bechar, a recognized center for Saharan ethnomedicine, fieldwork was extended over several days due to both the richness of the tradition and the availability of willing participants. For Ain Temouchent and El Bayadh, targeted short-term visits (1-2 days) were sufficient to capture the core traditional

knowledge in those zones, as the number of accessible and identifiable practitioners was inherently lower. This approach efficiently captured the breadth of traditional medicinal knowledge across Western Algeria's diverse landscapes.

Table 1. Distribution of study participants (n=110) across the four selected wilayas.

Wilaya (Province)	Number of Participants	Primary Data Collection Rationale
Bechar	32	Major center for Saharan ethnomedical traditions. Extended fieldwork (>3 days) with local connections ensured deep access to specialized knowledge.
El Bayadh	17	Targeted sampling during a 2-day visit to document practices specific to the steppe region, where fewer formal practitioners were identified.
Tlemcen	46	In-depth, multi-city sampling within the wilaya due to researcher base, as it is a primary cultural center with a high density of practitioners.
Ain Temouchent	15	Focused sampling to capture the coastal/agricultural zone's practices, amid a lower observed density of practitioners.
Total	**110**	

Inclusion and Exclusion Criteria

In this study, all interviews were conducted face-to-face, and all 110 questionnaires were fully completed, resulting in a 100% response rate among the participants who agreed to take part. All approached individuals recognized *T. articulata*; however, only those who demonstrated sufficient knowledge of its traditional uses and benefits were included in the survey. A few individuals (mostly shop assistants temporarily working in herbalist stores) recognized the species but were not familiar with its uses, and these were therefore excluded. A small number of herbalists (four) declined participation due to being occupied during working hours; these were considered non-responses. Apart from these cases, all approached herbalists and traditional healers were willing to contribute to the study.

Data organization and analysis

The data collected was entered into a Microsoft Excel spreadsheet and then processed using SPSS software to perform statistical analyses and produce graphical representations illustrating the main trends.

In order to quantify and interpret ethnobotanical knowledge relating to *T. articulata*, two indicators were used:

Ethnobotanical indices

To quantify the traditional importance and versatility of *T. articulata* in the local knowledge system, we employed two standard ethnobotanical indices: the Use-Value (UV) and the Cultural Importance (CI) index. These indices were selected because they provide direct, complementary measures of a species' role, the UV indicating its relative importance based on reported uses, and the CI reflecting the diversity and cultural integration of its applications across different domains.

Use Value index – UV

Commonly used in ethnobotany, The Use Value (UV) index is used to assess the frequency and diversity of use of a species based on citations reported by informants (Table 2). There are several methods for calculating it. The method used is that proposed by Tardío and Pardo-de-Santayana (2008):

$$UV=\Sigma U/N$$

U: Total number of reported uses for the species (sum of all specific use-citations by all informants).
N: Number of informants interviewed.

Table 2. Interpretation of UV values according to thresholds established in the literature.

UV value	Interpretation
$UV \leq 0.5$	Marginal use (rarely cited, limited functions)
$0.5 < UV \leq 1.0$	Moderate use (regular use without predominance)
$UV > 1.0$	Significant use (high cultural and therapeutic value)

Cultural Importance Index – CI

The CI is a quantitative indicator that measures the extent of reported uses across all categories, reflecting the overall cultural importance of a species within a community (Tardío & Pardo-de-Santayana 2008). The interpretation of CI values is presented in Table 3. The formula applied is as follows:

$$CI=\Sigma URi/N$$

URi: Total number of use-reports provided by each informant (summed across all categories).
N: Total number of informants.

To detail the contribution of each domain, the index was also calculated per use-category (CI_c), using the same formula where URi represents use-reports within a single category.

Table 3. Interpretation of CI values.

CI value	Interpretation
CI < 0.5	Low importance (rare or specialized use)
0.5 ≤ CI < 1.0	Moderate importance (regular use but not dominant)
CI ≥ 1.0	High importance (high medicinal, symbolic or economic value)

Validity and limits

Although based on targeted interviews and a semi-structured methodology, the ethnobotanical approach adopted relies on spontaneous testimonies from specific socio-cultural contexts. These data, rich in empirical information, may contain a degree of subjectivity linked to individual perceptions or local traditions.

Furthermore, although the results of this survey indicate regional trends, they cannot be extrapolated to the entire country without further study. However, they offer valuable insight into traditional medicinal knowledge relating to *T. articulata*, revealing uses that are deeply rooted in popular phytotherapeutic practices.

Results and Discussion

The analysis of the collected data, supported by graphical representations and quantitative processing, highlights several significant trends. The use of ethnobotanical indices (Use value Index (UV) and Cultural Importance Index (CI)) has made it possible to assess the frequency of use of *T. articulata* as well as its symbolic and therapeutic value in local practices. The interpretation of the results is part of a comparative approach, comparing the collected data with previous work to contextualize the observations and enrich the scientific and practical reading of the study.

Distribution by age

Respondents ranged in age from 19 to 83 years, with an average age of 40. The majority belonged to the 25–35 (22.73%) and 36–45 (23.64%) age groups (Fig. 2), while younger practitioners were less represented in the sample.

The predominance of middle-aged and older practitioners suggests that traditional herbal knowledge is largely maintained by individuals with long-standing experience within their communities. The low representation of younger participants may indicate limited intergenerational transfer of knowledge, potentially related to changing lifestyles, reduced interest among younger generations, or the absence of structured mechanisms for transmitting ethnobotanical practices. Conversely, the participation of older practitioners highlights the resilience of ancestral knowledge and underscores the importance of reinforcing knowledge preservation strategies, particularly in a sociocultural context undergoing rapid transformation.

Gender distribution

The analysis of gender distribution shows a marked male predominance among respondents, with 87.27% men and 12.73% women, corresponding to a gender ratio of 6.86: 1 (M: F) (Fig. 3). This imbalance indicates that men were significantly more represented in the surveyed group of herbalists and traditional healers.

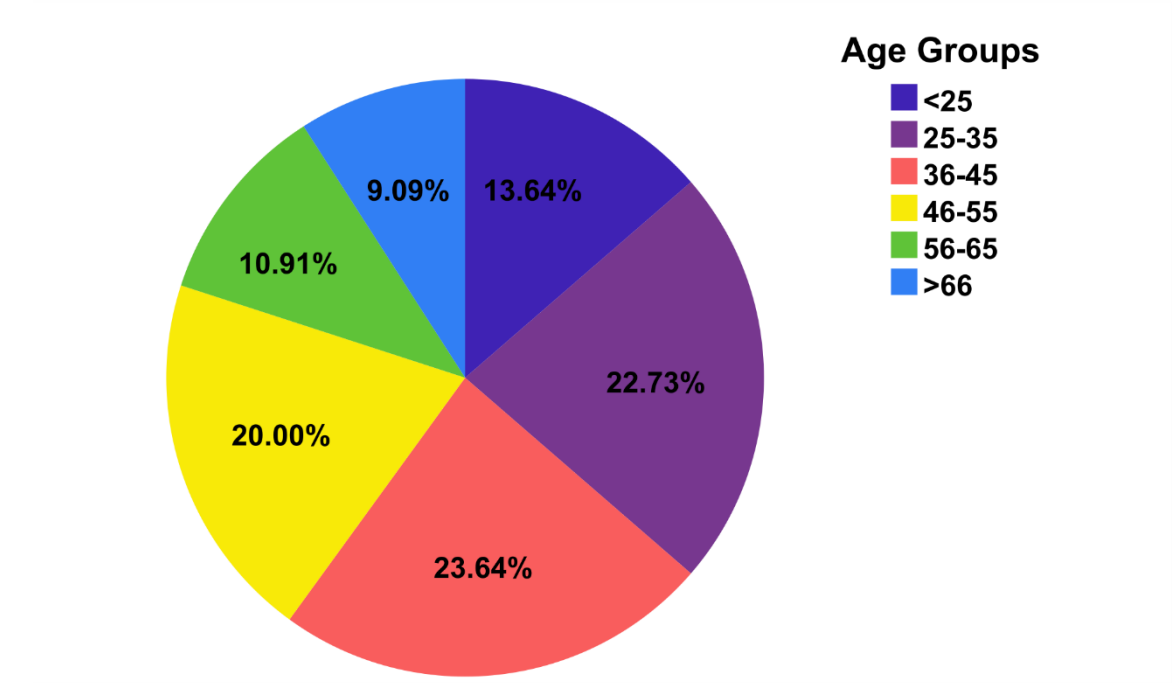

Figure 2. Age distribution of the surveyed herbalists and traditional healers.

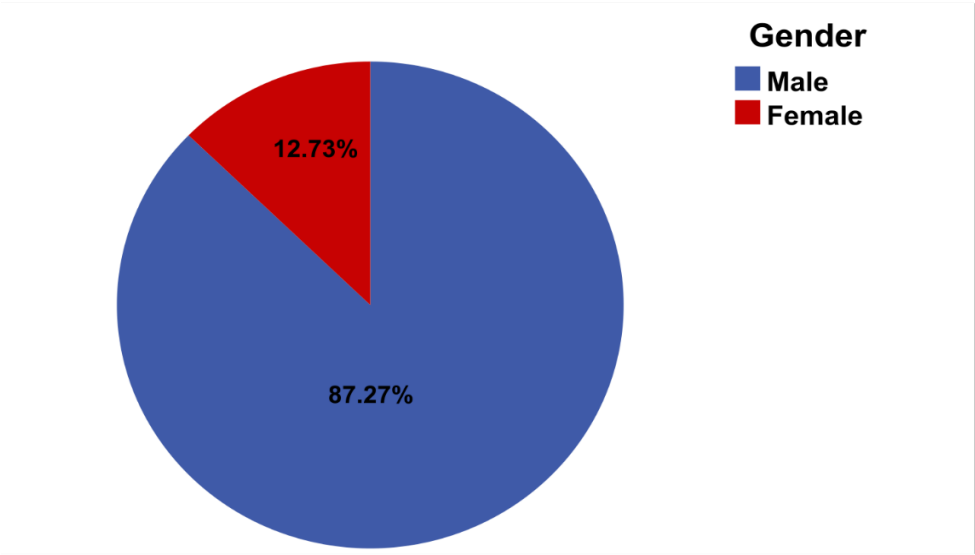

Figure 3. Gender distribution of the study participants.

The strong male predominance observed in the sample likely reflects socio-cultural dynamics specific to the region, where the practice of herbalism and traditional healing is traditionally carried out by men. Several factors may contribute to this pattern, including:

• the historical transmission of phytotherapeutic knowledge primarily through male family lines.
• social norms that may limit women's participation in visible, shop-based, or publicly recognized herbalist activities.
• the presence of women practitioners who operate informally within households and therefore remain less accessible for formal surveys.

This gender imbalance underlines the need for more inclusive sampling approaches in future studies to better capture the contribution of women who hold substantial knowledge yet may not be represented in conventional sampling contexts.

Level of education

The analysis of the informants' educational level shows a heterogeneous distribution. The majority had completed secondary education (63.64 %), while a notable proportion held university degrees (22.73%). A smaller share of respondents was

illiterate (8.18%) (Fig. 4). This distribution reflects a broad range of educational backgrounds among the surveyed herbalists and traditional healers.

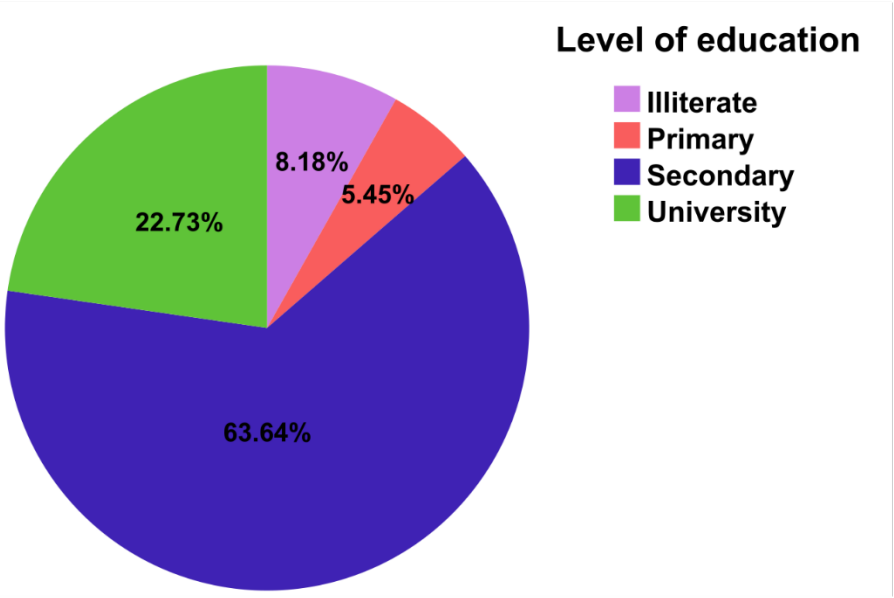

Figure 4. Distribution of participants according to their reported level of education.

The diversity of educational levels among participants challenges the common assumption that herbalism is mainly practiced by individuals with limited formal education. The substantial representation of respondents with secondary and higher education indicates a coexistence between traditional knowledge systems and formal academic backgrounds. This suggests that phytotherapeutic practices in the region are shaped by a pluralistic knowledge base, where empirical experience and formal learning can complement each other. Such diversity provides promising opportunities for strengthening dialogue between traditional practitioners and scientific institutions, particularly in the context of validating and promoting local medicinal knowledge.

Source of information

The results show that family transmission is the main source of learning therapeutic knowledge related to *T. articulata*. Indeed, 55.45% of respondents indicated that they had received their knowledge from their parents or other family members (Fig. 5), often as part of a legacy practice or a business passed down over several generations.

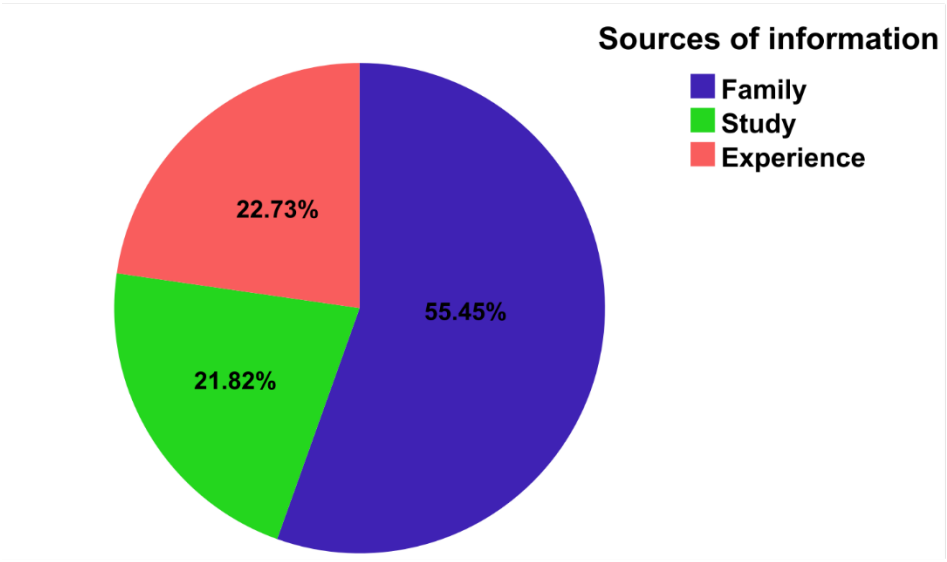

Figure 5. The source of information for respondents on the uses of the plant.

This predominance of family origins highlights the central role of oral tradition in the perpetuation of phytotherapeutic knowledge. It illustrates a mode of transfer based on lived experience, where medicinal practices are shared through observation, storytelling and the reproduction of gestures. This transmission mechanism, although informal, remains essential for the preservation of traditional knowledge within local communities. It also highlights the vulnerability of such knowledge, which depends heavily on intergenerational transfer.

Areas of use of the plant

Analysis of participant responses reveals a functional diversity in the uses of *T. articulata*, as summarized in Figure 6. A very large majority (99.09 %) of informants identified it primarily as a medicinal resource. Other significant use categories included cosmetics (32.73%), primarily through its essential oils for skin and hair care, and crafts (24.55%), utilizing the prized wooden burl for art objects, high-end furniture, and specialized tools. Geographic-specific uses, such as tar production (*katran*) and leather tanning, were particularly reported by informants in southern (Saharan) regions. In contrast, uses in construction (6.364%) and as livestock forage (2.727%%) were reported only anecdotally.

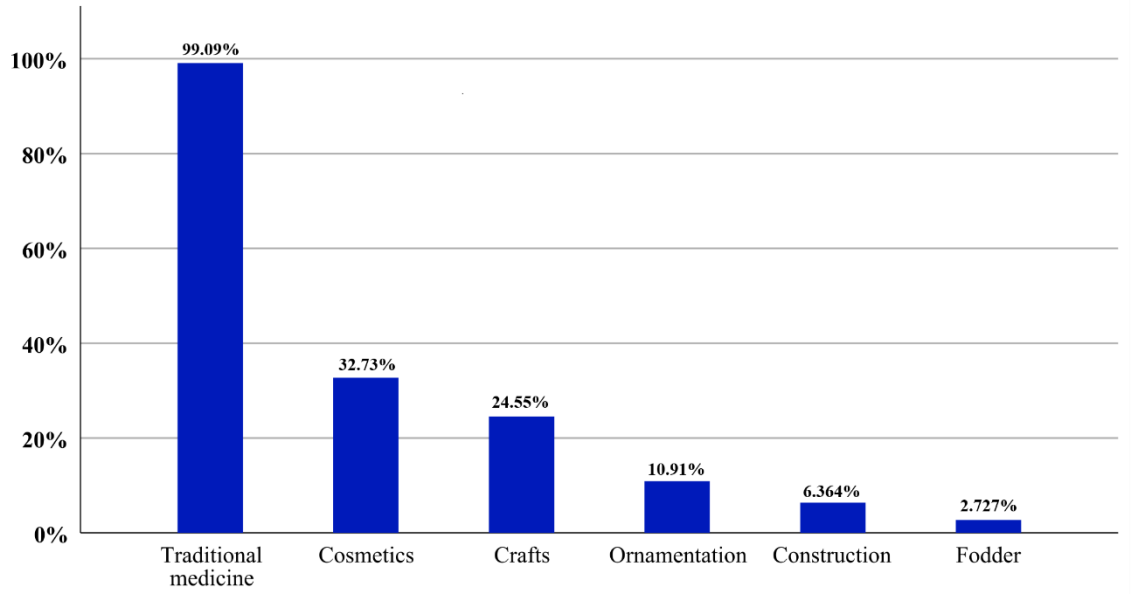

Figure 6. Areas of use of *T. articulata.*

The identified use pattern underscores the multifunctional value of *T. articulata* in western Algeria, with medicine constituting its primary cultural domain. The notable craft and cosmetic applications highlight its economic and artisanal importance, consistent with previous findings (Bellakhdar 1997, El Mouridi 2011).

The geographic specificity of uses like tar production reflects a direct adaptation to local environmental and cultural contexts. Conversely, the marginality of construction and forage uses can be explained by economic and practical factors: competition with more accessible, industrial materials and the reported low palatability of the tree to livestock, leading farmers to prefer other forage species. Overall, this use distribution highlights a significant opportunity: despite its recognized value, structured agroforestry practices centered on the species remain underdeveloped, pointing to a clear need for initiatives that could enhance its sustainable management and economic potential.

Used parts of the plant

The survey results indicate that leaves are the most frequently used plant part of *T. articulata*, cited by 100% of respondents (Fig. 7). Cones are the second most cited part, mentioned by 55.45% of participants.

The strong preference for leaves can be explained by their year-round accessibility, versatility of use (e.g., in infusions or powders), and their entrenched role in local medicinal practices. This empirical preference is supported by phytochemical analyses, which attribute a high concentration of bioactive compounds—including α-pinene, camphor, borneol, and various esters—to the leaves (Bourkhiss *et al.* 2007, Djouahri *et al.* 2015, Larabi *et al.* 2015). These compounds are known for

antiseptic, expectorant, and anti-inflammatory effects, chemically justifying the leaves' central role in treating respiratory, skin, and digestive disorders. Although cones are more seasonally available, their reported use aligns with their recognized high essential oil content (Boussaid *et al.* 2016), making them particularly valued for specific remedies in the form of extracts or concentrated powders.

The predominance of leaves as the most utilized part in western Algeria is consistent with findings from Morocco, where leaves are also the most cited part for both therapy and cosmetics (Zahir *et al.* 2020a), underscoring their recognized phytochemical value. A key difference lies in the broader material use documented in Morocco, including significant artisanal and industrial applications of wood and resin. This contrast highlights a more pharmacologically specialized use in our region compared to a wider socioeconomic utilization elsewhere.

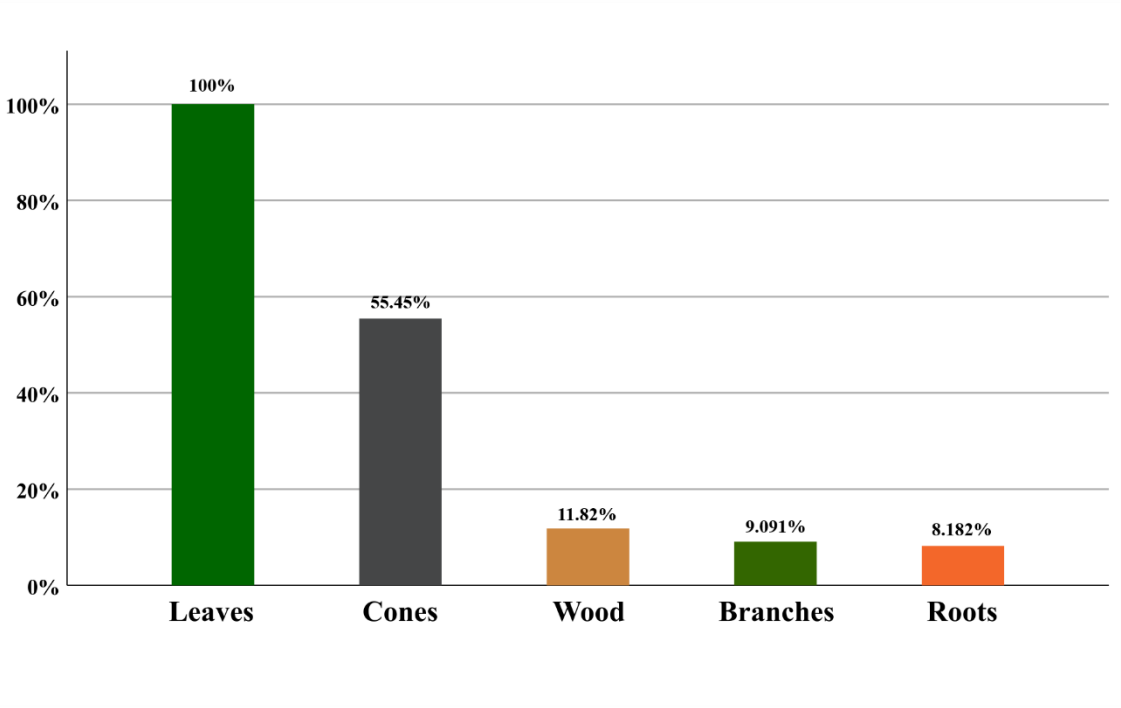

Figure 7. Used parts of *T. articulata* in traditional medicine.

Diseases treated by *T. articulata*

The results of the survey confirm the central role of *T. articulata* in traditional medicine in western Algeria. A wide range of pathologies is concerned (Table 4), illustrating the therapeutic versatility of this medicinal species (Fig. 8). The majority of respondents cited the use of *T. articulata* for the treatment of stomach ulcers (53.63%), followed by gastrointestinal infections (20%), pulmonary infections (15.45%), and cough (14.54%).

Other notable applications include the treatment of sunstroke (10%), urinary tract infections (9.09%), irritable bowel syndrome (9.09%), and the relief of fever and pain (8.18%). Dermatological conditions such as eczema (5.45%), burns (2.72%), and various wounds were also reported. In addition to its medicinal properties, *T. articulata* is sometimes associated with spiritual and mystical uses, as mentioned by 33.63% of participants.

The reported uses highlight the therapeutic versatility of *T. articulata*, spanning gastrointestinal, respiratory, dermatological, and systemic conditions. These empirical applications are corroborated by previous pharmacological studies, which attribute antimicrobial and anti-inflammatory properties to the species, largely due to its high content of bioactive compounds such as α-pinene, camphor, borneol, and esters (Bourkhiss *et al.* 2010b, El Jemli *et al.* 2016).

The primary therapeutic uses for *T. articulata* in our study, specifically gastrointestinal, respiratory, and febrile conditions, closely align with the core applications reported in central Morocco, where it is also predominantly used for gastrointestinal disorders, fever, and headaches (Zahir *et al.* 2020a). This indicates a shared foundational knowledge across the Maghreb. Notable regional distinctions exist, however, such as the reported use for sunstroke in western Algeria and for vertigo and eye inflammation in Morocco, reflecting localized adaptations of traditional practice.

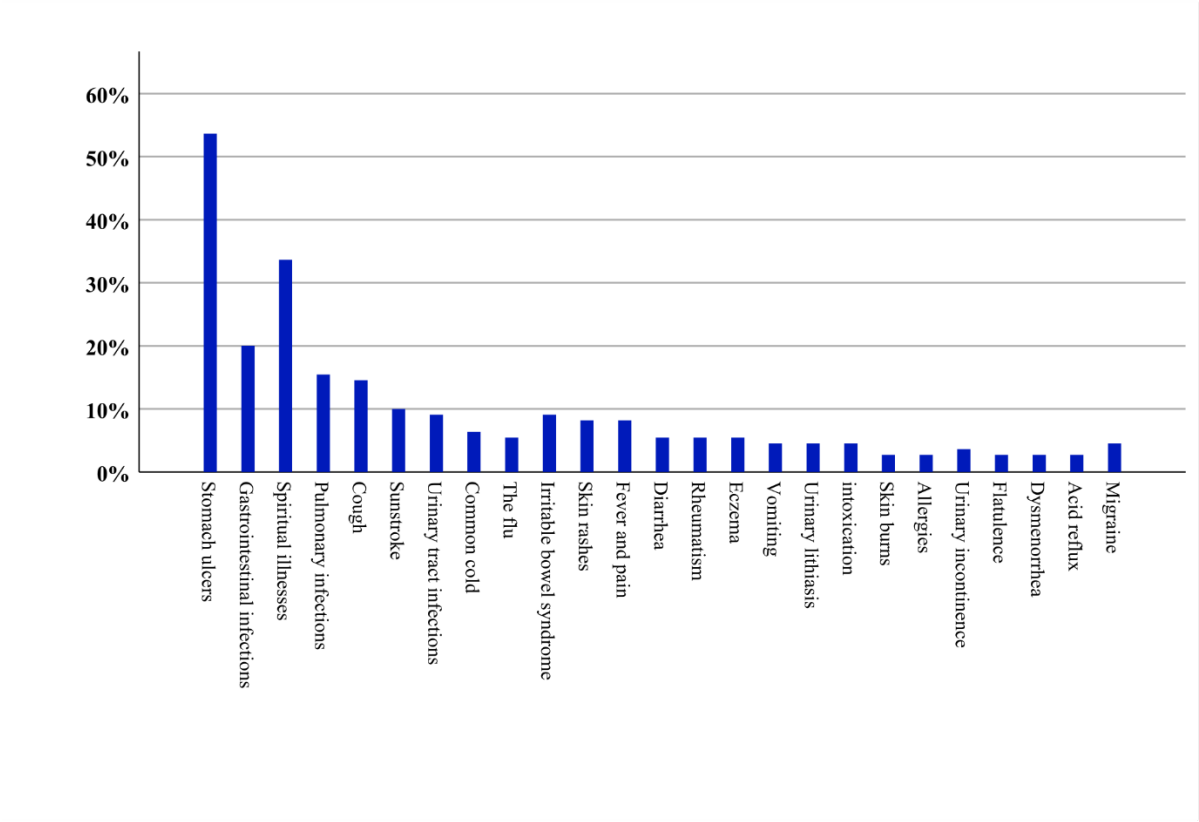

Figure 8. The diseases treated by *T. articulata.*

Table 4. Reported therapeutic ailments treated with *T. articulata* and their citation frequency among informants.

Category of Ailment	**Specific Ailment (Use-Report)**	**Number of Citations (Frequency)**
Gastrointestinal Disorders	Stomach ulcer	59
	Gastrointestinal infections	22
	Irritable bowel syndrome	10
	Vomiting	5
	Diarrhea	6
	Bloating / Flatulence	3
	Gastric reflux	3
	Food poisoning	5
	Dyspepsia / Indigestion	4
	Hemorrhoids	2
	Intestinal Parasitosis / Stomach worms	3
Genitourinary & Renal Disorders	Urinary infections	10
	Urinary lithiasis / Kidney stones	5
	Urinary incontinence	4
	Dysmenorrhea - painful menstruation	3
Respiratory Disorders	Lung infections	17
	Cough	16
	Common cold	6
	Influenza	7
Dermatological Conditions	Skin rashes	9
	Eczema	6
	Skin burns	3
	Diaper Dermatitis / Nappy rash	2
	Hair loss	7
	Dandruff	1

	Heel fissures	3
Dental & Oral Health Disorders	Dental and oral pain	2
Metabolic, Nutritional & Endocrine Disorders	Gout	1
	Anemia	1
	Diabetes Mellitus	2
	Osteomalacia (Nutrient deficiency)	2
Musculoskeletal & Pain Disorders	Fever and Pain	9
	Rheumatism	6
	Migraine	5
Psychosomatic Disorders	Mystical Diseases	37
Hepatic Disorders	Liver diseases / Hepatic disorders	1
Cardiovascular Disorders	Heart diseases / cardiovascular diseases	2
Oncological Disorders	Cancer	2
Neurological & Cognitive Disorders	Memory Impairment	2
Immunological & Allergic Disorders	Allergies	3
Infectious & Systemic Disorders	Toxicity / Toxin Exposure	5
Environmental Disorders	Heatstroke / Sunstroke	11

Among the most frequently cited traditional applications, the treatment of gastrointestinal disorders is supported by pharmacological evidence indicating an effect on digestive function. An in vivo study reported that a butanol extract of *T. articulata* significantly reduced gastrointestinal motility, with an inhibition rate of 68.18%, suggesting an antidiarrheal and antispasmodic effect consistent with its traditional use in digestive complaints (Ababsa *et al.* 2019).

Similarly, the traditional use for urinary tract infections (UTI) is pharmacologically plausible due to its demonstrated broad-spectrum antibacterial activity against various Gram-positive and Gram-negative bacteria (Bourkhiss *et al.* 2007; El Jemli *et al.* 2016), a relevant property given the bacterial origin of most UTIs (Flores-Mireles *et al.* 2015).

The application for pulmonary infections is supported by the essential oil's anti-inflammatory activity (El Jemli *et al.* 2016) and the expectorant and bronchodilatory properties of constituents like camphor and α-pinene.

Beyond these common uses, a variety of less frequently mentioned conditions demonstrates the wide range of applications for *T. articulata*, including rheumatism, urinary lithiasis, diabetes, dysmenorrhea, migraine, and even cancer. While these could be linked to the plant's general antibacterial or bioactive properties, further scientific studies are needed to confirm these hypotheses.

Dermatological uses, often relying on resin extracts or leaf decoctions, are similarly supported by the documented healing and antiseptic effects of its terpenes and flavonoids (Bourkhiss *et al.* 2010a). Extending beyond physical applications, participants also described spiritual and mystical uses, including in amulets, fumigations, or rituals for spiritual protection. This reflects a holistic cultural perception of *T. articulata*, regarded not only as a therapeutic resource but also as a sacred element capable of restoring balance between body and mind, thereby integrating therapeutic and spiritual dimensions within traditional practice.

Beyond its immediate medicinal applications, the cultural and economic importance of *T. articulata* raises important concerns regarding the sustainability of its use and its conservation at the local level. Previous studies have highlighted increasing anthropogenic pressures on natural stands, including illicit cutting and overexploitation (Kermouni Serradj *et al.* 2022). These pressures are consistent with the high demand for the species documented in our survey. Together, these observations emphasize the need for rational conservation strategies that regulate harvesting practices and promote sustainable use in order to preserve both the species and the traditional knowledge associated with it.

Forms of use of *T. articulata*

The data collected indicate a diversity of use patterns of *T. articulata*, each adapted to specific uses and associated with distinct benefits (Fig. 9). Powder (43.14%) is the most common form, made from dried and ground leaves. Herbal tea (37.91%) is prepared by infusing the leaves in hot water. Direct consumption (raw) (12.42%) consists of ingesting the fresh plant in small quantities. Essential oil (6.54%%) is extracted from its aromatic parts.

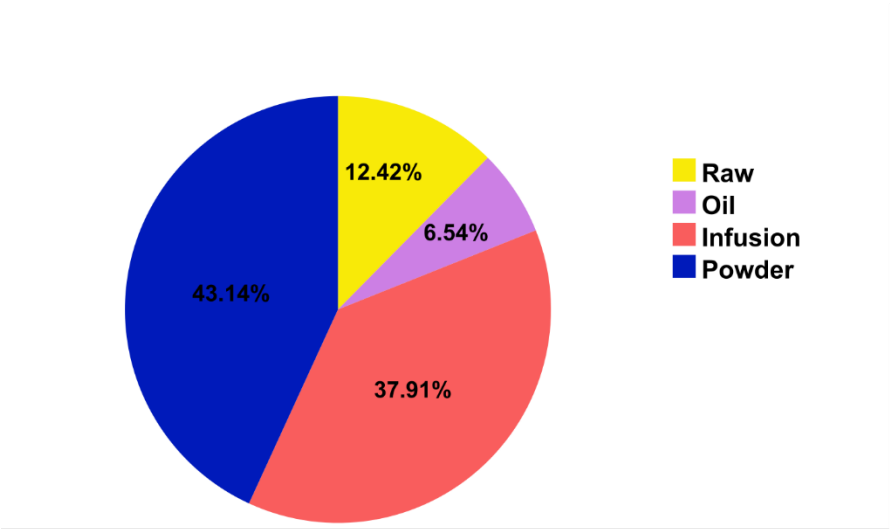

Figure 9. The forms of use of *T. articulata* in traditional medicine.

The distribution of these forms reflects a varied appropriation of the plant according to the preferences of the practitioners and the intended therapeutic purposes. Powder is favored in medicinal and cosmetic preparations due to its ease of use, durable preservation, and richness in active ingredients. Herbal tea is appreciated for its soothing and digestive effects and is commonly used in gastrointestinal care or daily well-being practices. Although marginal, direct consumption is sought for its immediate effect but remains limited by the plant's intense and bitter taste. Essential oil is used in the treatment of skin and hair conditions and in aromatherapy for its relaxing properties; however, its benefits are less scientifically documented than other, more widely studied essential oils. Overall, this diversity demonstrates the adaptability of traditional knowledge to modern needs in health and well-being.

Traditional Remedies Based on *T. articulata*: Preparations and Uses

The interviewees shared numerous traditional remedies using *T. articulata*, still widely used today to treat a range of ailments. These recipes illustrate the cultural and therapeutic importance of the plant in the local pharmacopoeia. Among these recipes we cite:

Traditional treatment for sunstroke

Sunstroke, common in arid regions such as Bechar, is caused by prolonged exposure to the sun and manifests itself in headaches, dizziness and excessive elevation of body temperature. Faced with this problem, respondents in Bechar shared a traditional remedy made from natural ingredients, renowned for its cooling and soothing effects.

- Composition of the remedy: This remedy is based on three components:
  - Red onion
  - Powder of *T. articulata* leaves
  - Orange blossom water
- Preparation and administration:
  - Blend a red onion with a tablespoon of *T. articulata* leaf powder.
  - Add about 60 mL of orange blossom water until a smooth paste is obtained.
  - Spread this paste over the entire scalp.
  - Cover the head with medical gauze to keep the mixture in place.
  - Leave on for at least six hours to allow the cooling properties to take effect.
  - Rinse thoroughly with warm water after the application time.

This remedy is used as a complementary treatment, alongside recommended medical treatments such as hydration, rest in the shade and cooling the body. It is part of a local empirical practice that highlights the antioxidant properties of onions, the anti-inflammatory effects of *T. articulata* (Bourkhiss *et al.* 2010b), and the soothing properties of orange blossom.

Traditional cough treatment

A traditional remedy frequently reported by respondents in the Tlemcen region consists of a homemade syrup to relieve coughs and respiratory tract irritation. Based on an empirical approach, this practice is fully integrated into the local therapeutic repertoire, reflecting the oral transmission and cultural roots of the medicinal uses of *T. articulata* in the region.

- Composition of the remedy:
  - Dried *T. articulata* leaves
  - Rock sugar (Lump sugar)
- Preparation and administration:
  - Pour water into a suitable saucepan.
  - Add equal quantities of rock sugar and dried *T. articulata* leaves.
  - Ensure that the leaves are completely submerged in the liquid.
  - Bring to the boil and continue cooking until the volume has significantly reduced, obtaining a syrupy texture.
  - Strain the mixture to remove any plant residue.
  - Allow to cool to room temperature before administration.

The syrup obtained is consumed at a rate of one tablespoon, morning and evening, to reduce cough symptoms and promote gradual soothing of the respiratory mucous.

Although the pharmacological literature on this syrup is limited, the properties of *T. articulata*, notably its high content of compounds such as borneol, camphor and α-pinene, have been associated with expectorant, antiseptic and anti-inflammatory effects (Bourkhiss *et al.* 2010b, El Jemli *et al.* 2016). These data support the traditional use of the species in respiratory diseases.

Treatment of respiratory infections

Relief from respiratory conditions is also a practice frequently reported by respondents. Two methods are preferred for clearing the airways and improving breathing comfort: by smoke or by steam.

- Fumigation method:
  - A small quantity of *T. articulata* leaves, carefully cleaned and perfectly dry, is used for combustion.
  - The leaves are placed in a heat-resistant container (incense burner or terracotta bowl) and then lit to produce a light, steady smoke.
  - The patient gently inhales this smoke, remaining at a safe distance to avoid eye or respiratory irritation.

This method is similar to a fumigation practice traditionally used to clear the bronchial tubes or calm coughs. It also evokes the aromatic practices mentioned by El Jemli *et al.* (2016), associating the volatile compounds of *T. articulata* with decongestant effects.

- Steam inhalation method:
  - *T. articulata* leaves are boiled in water.
  - Once the steam begins to rise, the patient sits over the container, covering their head with a towel to concentrate the vapors around them.
  - Inhalation is done with caution, avoiding direct contact with the hot water.

This process allows to benefit from the expectorant and antiseptic properties of aromatic compounds contained in the leaves, particularly terpenes such as camphor, borneol, and α-pinene (Bourkhiss *et al.* 2010b), known for their effectiveness in the treatment of mild to moderate pulmonary conditions.

Traditional treatment of gastroduodenal ulcer

Among the traditional remedies for gastroduodenal ulcer reported by informants, one of the most frequently cited consisted of a simple preparation in which one teaspoon (approximately 3–4 g) of dried leaf powder of *T. articulata* is mixed into a single serving of plain yogurt (approximately 110 g). This preparation is typically consumed once or twice daily and is traditionally perceived as effective in relieving gastric discomfort and ulcer-related symptoms.

From a scientific perspective, this traditional use is supported by phytochemical and pharmacological evidence. Several studies have demonstrated that *T. articulata* contains a diverse range of bioactive compounds, particularly essential oils rich in monoterpenes such as α-pinene and limonene. These constituents are well recognized for their antimicrobial, anti-

inflammatory, and antioxidant properties (Bourkhiss *et al.* 2007; Bourkhiss *et al.* 2010b), which are relevant mechanisms in the prevention and healing of gastric mucosal damage.

Experimental investigations further substantiate the use of *T. articulata* in traditional remedies targeting ulcer-related disorders. Ababsa *et al.* (2019) demonstrated that a butanol extract administered at 400 mg/kg produced a 77.4% inhibition of ulcer formation in an acetic acid–induced colitis model in mice. This gastroprotective effect was comparable to that of the reference drug aspirin (81.39%), supporting the therapeutic relevance of the plant's phytochemical constituents and validating its use in specific anti-ulcer formulations.

In addition to the medicinal properties of the plant itself, the use of yogurt as a vehicle in this traditional preparation appears scientifically justified. Yogurt has been shown to exert protective effects on the gastric mucosa, acting as a buffering and soothing medium that may enhance mucosal defense. Notably, Uchida and Kurakazu (2004) demonstrated that probiotic yogurt containing *Lactobacillus gasseri* significantly reduced gastric lesions and ulcer formation, highlighting its intrinsic gastroprotective properties.

Taken together, these findings provide a coherent scientific rationale for this traditional remedy. Yogurt not only facilitates the administration of *T. articulata* leaf powder but may also synergistically contribute to gastric healing, thereby reinforcing the therapeutic relevance of this ethnomedicinal practice in the management of gastroduodenal ulcers.

Side effects (complications)

Although the vast majority of respondents (Fig. 10) agreed that the use of *T. articulata* has no side effects (77.27%), they clarified that it must be used rationally. They specified that the dose should not exceed 20 to 30 g per day, divided into two doses at least six hours apart, for a maximum treatment period of five days.

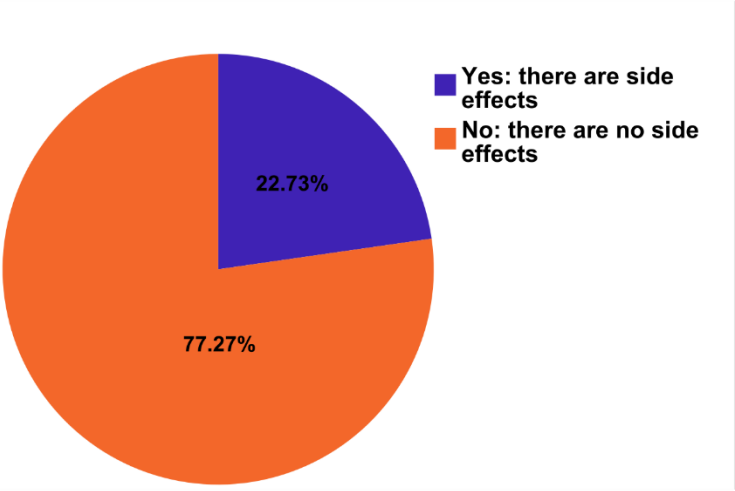

Figure 10. Side effects resulting from the use of *T. articulata* in traditional medicine.

All medicinal plants, even those traditionally used for their health benefits, can potentially cause side effects, especially if they are not used properly or if they are incorrectly dosed (Braun & Cohen 2015). Although many plants are considered safe when taken as recommended, it is important to recognize that even natural remedies are not risk-free. *T. articulata* is no exception. The respondents' conditional statement about its safety aligns with several studies that highlight the safety of *T. articulata*, particularly through experiments on mice (El Jemli *et al.* 2016) and rats (Sadiki *et al.* 2019).

Zahir *et al.* (2020b) confirm this relative safety, but note that toxicity depends on factors such as the plant part used, the dose consumed, and the duration of exposure. Despite the optimistic results from these studies, there are reported cases of adverse reactions, such as a first clinical case of contact eczema occurring after the application of a powder of leaves and branchlets of *T. articulata* (Zahir & Rahmani 2020). This indicates that although acute toxicity is rarely observed, prolonged exposure may lead to adverse effects, particularly dermatological ones. Thus, while current studies focus mainly on acute toxicity, it is crucial to expand research to include chronic toxicity to better understand the risks of prolonged use, whether with raw extract, essential oil, or specific compounds of the plant (Azzi *et al.* 2012). Therefore, a cautious approach remains necessary, especially in cosmetic and therapeutic applications.

Ethnobotanical indices

Use Value index (UV)

The Use Value (UV) index or Usage Value (UV = 2.7) indicates that *T. articulata* is a plant with intensive use, widely integrated into local medical practices. This high value clearly exceeds the indicative threshold for significant use (UV > 1.0), suggesting therapeutic versatility, but also interpersonal stability of knowledge: several respondents report identical or convergent uses.

This data corroborates the results of other studies conducted on medicinal species with dominant use (Bano *et al.* 2014, El-Ghazouani *et al.* 2024), where a high use value is often associated with intergenerational transmission, a solid empirical foundation, and local accessibility of plant resources. The importance of *T. articulata* in the treatment of digestive and respiratory ailments in particular reinforces its ethnopharmacological relevance.

Cultural Importance Index (CI)

A Cultural Importance Index (CI) of 1.76 reflects the strong cultural importance of *T. articulata*. The detailed breakdown per use-category is provided in Table 5. The predominance of medicinal use (CI_c = 0.99) in the citations confirms the species' established therapeutic role. However, the other categories, although less frequent, widen its functional and cultural influence, particularly in contexts of beauty, decoration and craft production.

Table 5. Cultural Importance Index (CI) values for *T. articulata* per use-category.

Category of use	Number of use-reports (U_s)	Number of respondents (N)	CI_c (Category-Specific)
Traditional medicine	109	110	0.990909091
Crafts	12	110	0.109090909
Ornamentation	27	110	0.245454545
Cosmetics	36	110	0.327272727
Construction	7	110	0.063636364
Fodder	3	110	0.027272727

The CI value highlights that *T. articulata* is recognized not only for its medicinal properties, but also for its artisanal, cosmetic and symbolic applications. This multifunctional profile is consistent with comparative studies, such as those by Senkardes *et al.* (2022) and Ahmed *et al.* (2023), which have highlighted species with high CI values (>1) often linked to therapeutic and ritual practices integrated into everyday life. The use of *T. articulata* in protective rituals or as a cosmetic ingredient reinforces this symbolic and holistic dimension, which is specific to traditional pharmacopoeias.

Conclusion

The ethnobotanical study conducted on *T. articulata* highlights the central role of this species in the therapeutic traditions of western Algeria (Bechar, El Bayadh, Tlemcen and Ain Temouchent). It bears witness to deeply rooted empirical knowledge, passed down from generation to generation, and still widely used today in informal healthcare.

Through cross-analysis of qualitative and quantitative data (UV = 2.7; CI = 1.76), the survey highlighted the high frequency of use, functional diversity and marked cultural value of this plant. These results are consistent with recent pharmacological studies, which attribute antimicrobial, antioxidant and anti-inflammatory properties to *T. articulata*, linked to its high flavonoid, terpene and polyphenol content. This scientific foundation reinforces the therapeutic relevance observed in the field and opens concrete prospects for valorization, highlighting the strong potential of this species for integration into modern phytotherapy research frameworks.

However, the persistent gap between contemporary scientific discoveries and the practices of local herbalists constitutes a barrier to the integration of this knowledge into formal health systems. Academic advances often remain unknown or inaccessible to those who hold traditional knowledge, which can limit the dialogue between empirical knowledge and scientific validation.

It therefore appears fundamental to strengthen the bridges between science and tradition: not to replace one with the other, but to enable mutual enhancement.

In this context, ethnobotanical documentation does not merely record traditional practices but also raises theoretical questions regarding the biological and pharmacological mechanisms underlying the recurrent uses of medicinal species such

as *T. articulata*. By integrating the knowledge of local practitioners into research and development protocols, this approach can help transform culturally grounded practices into testable scientific hypotheses, thereby promoting safer, more informed, and context-appropriate applications of medicinal plants within both research and public health frameworks.

This collaborative dynamic, based on respect for indigenous knowledge and openness to scientific methods, will contribute to the resilience of community health systems, the sustainability of plant genetic resources, and opens up prospects for in-depth study in the fields of phytopharmacology, conservation and sustainable therapeutic innovation.

Declarations

Ethical Approval and Participant Consent: All participants were informed about the objectives of the study, and their participation was entirely voluntary. Verbal informed consent was obtained from each respondent prior to the interviews, and all information was collected and analyzed anonymously, in accordance with ethical research standards. For this type of non-invasive ethnobotanical survey based on interviews with adult participants, ethical requirements in Algeria are fulfilled through informed consent.

Access and Benefit Sharing (ABS) Compliance: This study was conducted in accordance with the principles of the Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization. The research focuses on the documentation of non-commercial traditional knowledge. Prior informed consent was obtained from all participating practitioners for the collection and use of this knowledge for academic publication.

Consent for publication: Not applicable.

Availability of data and materials: Not applicable.

Competing interests: The authors declare that they have no conflicts of interest.

Funding: This research received no funding.

Author contributions: Chaima Narimane Nesrallah was responsible for the fieldwork, data preparation and analysis, methodology, and for writing, reviewing, and editing the manuscript. Sabiha Bouchaour-Djabeur supervised the work, contributed to the review and editing of the manuscript, and improved the overall writing quality. All authors have read, revised, and approved the final version of the article prior to submission.

Acknowledgements

We express our sincere gratitude to all participants who kindly contributed to this ethnobotanical survey and generously devoted their time to share their valuable knowledge. We also wish to thank everyone who, in any capacity, supported and contributed to the accomplishment of this research.

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