Medicinal plants used traditionally for Urolithiasis management in Tunisia: An ethnobotanical survey

Asma Chaibni, Marwa Tabouii, Yassine M'rabet, Nedra Bennour, Sana Medimagh, Imene Ben Salah, Chedia Aouadhi, Hela Mahmoudi

Correspondence

Asma Chaibni[1], Marwa Tabouii[2], Yassine M'Rabet[1], Nedra Bennour[1], Sana Medimagh[3], Imene Ben Salah[1], Chedia Aouadhi[2,4], Hela Mahmoudi[1,2,*]

[1]Laboratoire des Substances Naturelles, Institut National de Recherche et d'Analyse Physico-Chimique, Sidi Thabet, Tunisie.
[2]Higher Institute of Biotechnology of Beja, Jendouba University BP 382 Cedex Beja,9000, Tunisia
[3]University de Carthage, Laboratoire des Grandes Cultures, Institut National de la Recherche Agronomique de Tunisie
[4]University of Tunis El Manar (UTM), Pasteur Institute of Tunisia, Laboratory of Epidemiology and Veterinary Microbiology. Group of Bacteriology and Biotechnology, BP 74, 13 place Pasteur, Belvedere, 1002 Tunis, Tunisia

*Corresponding Author: mahmoudihela@yahoo.fr

Ethnobotany Research and Applications 35:27 (2026) - http://dx.doi.org/10.32859/era.35.27.1-15
Manuscript received: 13/04/2026 - Revised manuscript received: 07/07/2026 - Published: 11/07/2026

Research

Abstract

Background: Urolithiasis is a major global health concern due to its high recurrence rate and significant impact on patients' quality of life. Documenting traditional knowledge of medicinal plants is essential for identifying potential alternative therapies. This study aimed to investigate plant-based remedies traditionally used for the treatment of urolithiasis in Tunisia.

Methods: An ethnobotanical survey was conducted among 270 participants using semi-structured questionnaires. Quantitative indices, including Relative Frequency of Citation (RFC), Use Value (UV), and Informant Consensus Factor (ICF), were calculated. Sociodemographic characteristics were also analyzed.

Results: Women represented 80% of the survey respondents, while among participants reporting previous experience with urolithiasis, 69.2% were women. Individuals aged 20-40 years (53.8%) constituted the main users of medicinal plants. A total of 27 plant species were identified, with *Petroselinum crispum*, *Ammi visnaga*, and *Herniaria hirsuta* being the most frequently cited. Decoction (36.2%) and infusion were the predominant preparation methods. The ICF value for urolithiasis was 0.95, indicating a strong agreement among informants. Most treatments lasted less than three weeks, and adverse effects were rarely reported.

Conclusions: The findings highlight the richness of ethnobotanical knowledge related to anti-urolithiatic plants in Tunisia. The high ICF values suggest promising candidates for further pharmacological validation. Standardization of preparation methods and clinical investigations are necessary to support their integration into modern therapeutic practices.

Keywords: Ethnobotany; Medicinal plants; Urolithiasis; Anti-urolithiatic activity; Traditional knowledge; Herbal medicine

Background

Medicinal plants represent one of the oldest forms of healthcare used by human populations worldwide. They remain a fundamental component of traditional medicine systems and continue to play an important role in primary healthcare, particularly in developing countries. Their therapeutic potential is largely attributed to their richness in bioactive compounds such as flavonoids, alkaloids, and phenolic acids. Kidney stone disease (KSD), also referred to as urolithiasis or nephrolithiasis, is a common disorder of the urinary tract characterized by the formation of crystalline deposits within the kidneys or anywhere along the urinary system (Bargagli et *al*. 2025). Over recent decades, the incidence of KSD has increased markedly, making it a major global public health concern. This rising trend is associated with high recurrence rates and a substantial negative impact on patients' quality of life. Clinically, KSD is typically manifested by severe flank pain, hematuria, urinary obstruction, and recurrent urinary tract infections.

Epidemiological data indicate a significant global burden of KSD, with prevalence rates ranging from 1-5% in Asia, 5-9% in Europe, and 7-13% in North America (Khan et al 2016; Scales *et al.* 2012; Thongprayoon 2020). In China, approximately one in seventeen adults is affected, with calcium oxalate (CaOx) stones accounting for nearly two-thirds of all reported cases (Zhangqun *et al*. 2020). Among the various types of urinary stones, CaOx stones are the most prevalent and represent a major clinical challenge due to their chronic nature and high recurrence rate, which can reach up to 90% within ten years (Morgan & Pearle 2016; Rivera *et al.* 2017). This imposes a considerable economic and healthcare burden.

Despite substantial progress in surgical techniques and pharmacological treatments, recurrence after intervention remains frequent, and current preventive strategies are often insufficient. Multiple factors contribute to stone formation, including demographic variables (age, sex, and ethnicity) and lifestyle-related factors such as dietary habits and physical activity (Ziemba & Matlaga 2017; Romero *et al.* 2010; Sorokin *et al.* 2017). Moreover, metabolic disorders, including obesity, diabetes mellitus, and metabolic syndrome, are strongly associated with an increased risk of KSD, although the underlying mechanisms remain incompletely understood (Daudon & Jungers 2007; Spatola *et al.* 2018; Obligado & Goldfarb 2008).

The pathogenesis of urolithiasis is complex and multifactorial, involving interactions between metabolic imbalances, genetic predisposition, and anatomical or functional abnormalities of the urinary tract. Among these factors, diet plays a pivotal role by influencing urinary composition and promoting supersaturation of lithogenic substances, thereby increasing both the risk of stone formation and recurrence (Siener & Hesse 2002; Siener *et al.* 2005).

Although conventional therapeutic approaches are widely used, their high cost, potential side effects, and limited efficacy in preventing recurrence have stimulated growing interest in alternative and complementary therapies. While some pharmacological agents facilitate stone expulsion, effective long-term preventive strategies remain a major unmet clinical need (Sekkoum *et al.* 2011).

In this context, traditional medicine offers valuable insights, as medicinal plants have long been used in the management of urolithiasis across various cultures (Itoh *et al.* 2005). Urolithiasis affects nearly 12% of the global population, and several plant species, including *Pistacia lentiscus* L., *Punica granatum* L., and *Ziziphus lotus* L., are recognized as rich sources of bioactive compounds such as quercetin, a flavonoid known for its protective role against urolithaisis formation (Aboufatima *et al.* 2019; Kachkoul *et al.*2020; Baddade *et al.* 2019). Consequently, medicinal plants traditionally used for the prevention and treatment of urolithiasis have attracted increasing scientific interest. Ethnobotanical surveys play a crucial role in documenting indigenous knowledge, identifying frequently used anti-urolithiatic species, and providing a foundation for further phytochemical, pharmacological, and clinical investigations. Therefore, the present study aimed to document medicinal plants traditionally used in the management of urolithiasis in Tunisia, to describe their modes of preparation and administration, and to evaluate their perceived efficacy and safety among the surveyed population.

Materials and Methods

Study Design

A descriptive cross-sectional ethnobotanical study was conducted across different regions of Tunisia to document medicinal plants traditionally used for the prevention and treatment of urolithiasis. A total of 270 participants were included in the survey. Data were collected using a structured questionnaire prepared in both French and Arabic to facilitate participant comprehension and improve data reliability.

A geographical map illustrating the distribution of the surveyed regions is presented in Figure 1.

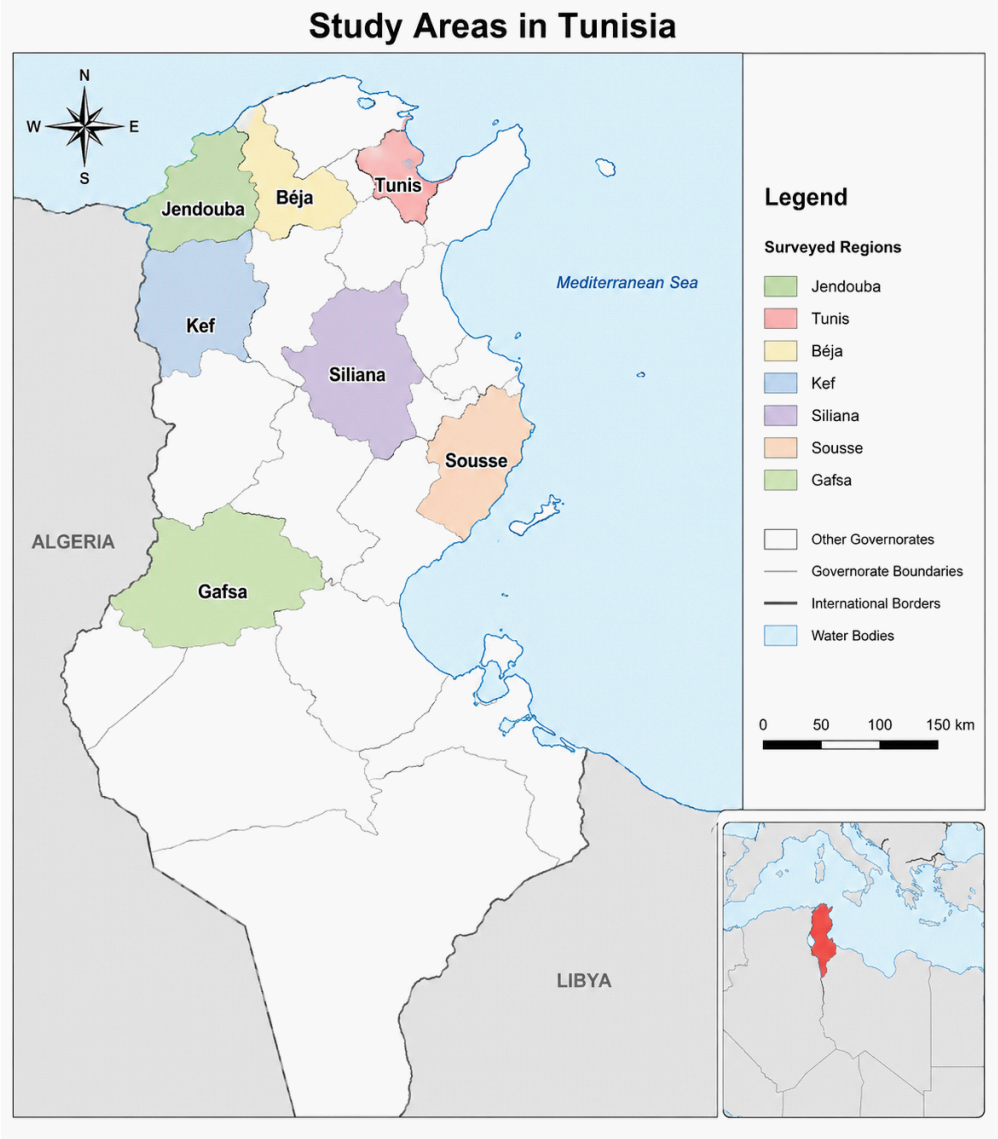

Figure 1. Map showing the distribution of study areas across different regions of Tunisia

The study covered several Tunisian regions, including Jendouba, Béja, Tunis, Kef, Siliana, Sousse, and Gafsa, representing northern, central, and southern parts of the country. Tunisia is geographically located in North Africa along the southern Mediterranean coast, between latitudes 30° and 38° N and longitudes 7° and 12° E. The surveyed regions exhibit diverse climatic and ecological characteristics, ranging from humid and sub-humid conditions in northwestern areas such as Jendouba and Béja to semi-arid environments in central and southern Tunisia. This geographical diversity may influence both the availability of medicinal plant species and their traditional ethnomedicinal uses.

Study Population

The study population consisted of volunteer participants of both sexes, representing diverse age groups (<20, 20-40, 40-60, and >60 years), professions (healthcare professionals, farmers, students, employees, traders, housewives, and others), educational levels (illiterate, primary, secondary, and university), and geographic regions. Participants were eligible if they had personal or familial experience with urolithiasis and/or knowledge of medicinal plant use. Participants were recruited using a convenience sampling strategy through online dissemination of the questionnaire via social media platforms and personal networks. Consequently, the study population may not fully represent all Tunisian social categories, particularly elderly, rural, and illiterate individuals with limited internet access.

Data Collection

Data were collected using a structured online questionnaire designed and distributed via Google Forms. The questionnaire was available in both French and Arabic to ensure accessibility and comprehension among participants. It consisted of closed-

and open-ended questions addressing socio-demographic characteristics (sex, age, profession, region, and education level), participants' knowledge of urolithiasis, sources of information, and perceived symptoms associated with the disease.

Participants were also asked about their knowledge and use of medicinal plants against urolithiasis. For each cited plant, information was collected on the local name, plant parts used (leaves, roots, seeds, fruits, whole plant, or others), methods of preparation (infusion, decoction, powder, or fresh plant), and modes of administration (oral intake as a beverage or food). Additional data included the duration of use, traditionally perceived therapeutic effectiveness (good, moderate, or weak), reported adverse effects, and the origin of the plant (wild-harvested or cultivated). Because the questionnaire was distributed online through Google Forms, the study population may be biased toward younger, educated, and digitally connected participants. Consequently, elderly, rural, and illiterate individuals, who may possess substantial traditional ethnobotanical knowledge, were likely underrepresented. Therefore, the findings should be interpreted as reflecting the knowledge of the accessible surveyed population rather than the entire Tunisian population.

Ethical Considerations

Participation in the study was voluntary and anonymous. Electronic informed consent was obtained from all participants prior to completing the questionnaire. No personally identifiable information was collected, ensuring confidentiality and compliance with ethical standards for ethnobotanical research.

Data Analysis

The collected data were analyzed using descriptive and inferential statistical methods. Medicinal plant species were categorized according to frequency of citation, plant parts used, preparation methods, and traditionally perceived therapeutic effectiveness. Results were expressed as frequencies and percentages.

Statistical analyses were performed using IBM SPSS Statistics software version 26.0 (IBM Corp., Armonk, NY, USA). Frequencies and percentages were calculated for categorical variables. Associations between sociodemographic characteristics and awareness of medicinal plants were assessed using the Chi-square test. Odds ratios (OR) and 95% confidence intervals (CI) were calculated to estimate the strength of associations. Statistical significance was established at $p < 0.05$.

Ethnobotanical Indices

Quantitative ethnobotanical indices were used to assess the relative importance of the recorded plant species.

The Relative Frequency of Citation (RFC) was calculated as RFC = FC/N, where *FC* is the number of participants citing a species and *N* is the total number of respondents; higher RFC values indicate greater local importance.

The Use Value (UV) was calculated as UV = ∑U/N, where *U* represents the number of uses reported per species and *N* is the total number of respondents; higher UV values reflect a broader range of traditional uses.

Informant Consensus Factor (ICF) was used to quantify agreement among informants regarding plants used for the investigated ailment category (urolithiasis) and was calculated as: ICF= (Nur– Nt)/(Nur – 1)

Where (Nur) is the number of use reports in a category and (Nt) the number of taxa used. Ailments were grouped following ICD-11.

In the present study, the number of use reports (Nur) for urolithiasis was 270, while the number of recorded taxa (Nt) was 27, resulting in an ICF value of 0.95, indicating a high level of agreement among informants.

Results and Discussion

Sociodemographic profile of respondents

As part of this study, an ethnobotanical survey was conducted across various regions of Tunisia to identify the primary medicinal plants employed in the treatment of urolithiasis. A total of 270 individuals were interviewed. The data on the gender of medicinal plant users for the treatment of urolithiasis revealed a striking imbalance, with women accounting for an overwhelming majority of 80%, in contrast to only 20% of men. The sex distribution differed significantly from an equal distribution ($\chi^2 = 97.20$, $p < 0.001$), indicating a clear predominance of female participants. This resulted in a sex ratio of 4:1 (female to male), which may reflect women's traditionally greater involvement in family healthcare and their broader

knowledge of medicinal plants, as observed in other ethnobotanical studies (see Table 1). This finding is consistent with studies conducted in Tunisia and the Maghreb, where women are often recognized as key holders of traditional medicinal knowledge (Bouasla & Bouasla 2017; Bencheikh *et al.* 2021, Bennour et *al*. 2026; Tabouii et *al*. 2026). The superior familiarity of women with conventional phytotherapy knowledge may be attributed to their roles within the family unit; they are frequently responsible for childcare and maintaining family health using accessible and cost-effective remedies. The importance of gender in the preservation and transmission of ethnopharmacological knowledge across generations is underlined by their central role in plant collection, preparation, and administration. The predominance of female respondents (80%) may be explained by greater engagement of women in health-related surveys and their traditionally recognized role in household healthcare management. In addition, the online distribution of the questionnaire may have favored participation from individuals with higher digital accessibility, potentially contributing to gender imbalance in the sample.

The age distribution of participants was significantly different across categories ($\chi^2 = 295.87$, $p < 0.001$), with the 20-40-year age group being the most represented (68.1%), followed by those aged 40-60 years (23.7%), while individuals under 20 years old accounted for only 3.7% and those over 60 years old represented 4.4% of the sample (Table 1). Similar findings have been reported in other studies, highlighting variations in responses across different age groups. This suggests that both young adults and middle-aged individuals are actively involved in the use of medicinal plants, while the lower proportion of older respondents may reflect limited participation in the survey or a gradual erosion of traditional knowledge, possibly due to weakening intergenerational transmission within families and local communities. Comparable age-related patterns have been reported by other researchers, where middle-aged and younger participants constitute the majority of informants (Hamrouni *et al.* 2026; Nouri *et al.* 2025). The predominance of the 20-40-year age group (68.1%) is likely related to the online dissemination of the questionnaire, which tends to reach younger, more digitally active individuals. Older age groups may have been underrepresented due to lower internet accessibility.

Educational level distribution also differed significantly ($\chi^2 = 358.29$, $p < 0.001$), as most participants had university education (73.3%). In terms of education level, followed by secondary (20%) and primary (6.3%) levels. Illiterate individuals represented only 0.4% of the sample (Table 1). These findings suggest that educational attainment may influence the use and perception of medicinal plants. Higher education levels may be associated with improved access to information and a greater ability to integrate traditional knowledge with scientific understanding. However, ethnobotanical knowledge has also been reported among both illiterate and highly educated individuals, as observed in Tabarka and Ain Draham (Jdaidi *et al.* 2022). The high proportion of university-educated participants (73.3%) may be explained by the online nature of the survey, which facilitated participation among younger and educated individuals with internet access. Consequently, certain population groups, particularly elderly and illiterate individuals traditionally considered important holders of ethnobotanical knowledge, were probably underrepresented. This sampling limitation should be considered when interpreting the representativeness of the reported ethnobotanical data.

Table 1. Demographic characteristics of participant

Variable	Category	Number of informants (N=270)	%	Test	P
Sex	Male	54	20.0	X^2 =97,20	P< 0,001
	Female	216	80.0		
Age	<20	10	3.7	X^2 =295,87	P< 0,001
	20-40	184	68.1		
	40-60	64	23.7		
	>60	12	4.4		
Education level	Illiterate	1	0.4	X^2 =358,29	P< 0,001
	Primary	17	6.3		
	Secondary	54	20.0		
	University	198	73.3		

The distribution of participants by profession (Figure 2) shows that knowledge of medicinal plants is widespread across different social groups. The largest groups were students (35.93%) and employees (33.33%), indicating that the use of medicinal plants is maintained among younger and working-age individuals. The important role of housewives (19.26%) reflects their traditional involvement in family healthcare. In contrast, healthcare professionals (5.56%) and farmers (1.48%) were underrepresented. The low representation of farmers (1.48%) and rural populations may be attributed to the online

nature of the survey, which likely favored participation from students, employees, and individuals with higher education levels who are more active on digital platforms.

Overall, the findings indicate that the use of medicinal plants in different regions of Tunisia is widespread and inclusive, spanning diverse age groups, educational backgrounds, genders, and occupations. This highlights that ethnobotanical knowledge is widely shared and not limited to any specific social group.

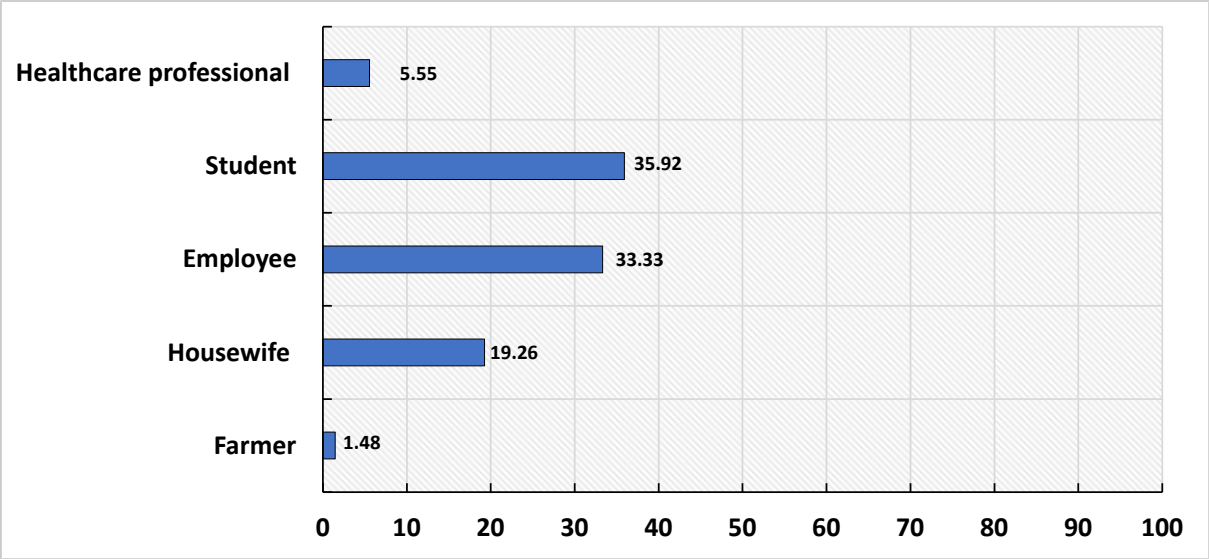

Figure 2. Sociodemographic profile of participants: Profession

Geographical distribution of participants across the studied localities in different regions of Tunisia

The distribution of participants across Tunisia's regions shows that the highest numbers of respondents were recorded in the northern regions of Jendouba (24.8%) and Tunis (24.1%), possibly due to higher population density or easier access to participants. Béja (18.1%) also showed a relatively high level of participation. In contrast, other localities such as Kef, Siliana, Sousse, and Gafsa had lower participation rates (Figure 3). These differences may be explained by geographical distance, accessibility constraints, or lower population density. This uneven distribution suggests that knowledge of medicinal plants may be more representative of highly sampled areas. Therefore, the overrepresentation of certain regions may influence the overall findings, particularly regarding plant diversity and traditional uses. Consequently, it is important to consider this spatial variability when interpreting the results and to emphasize the need for a more balanced sampling strategy.

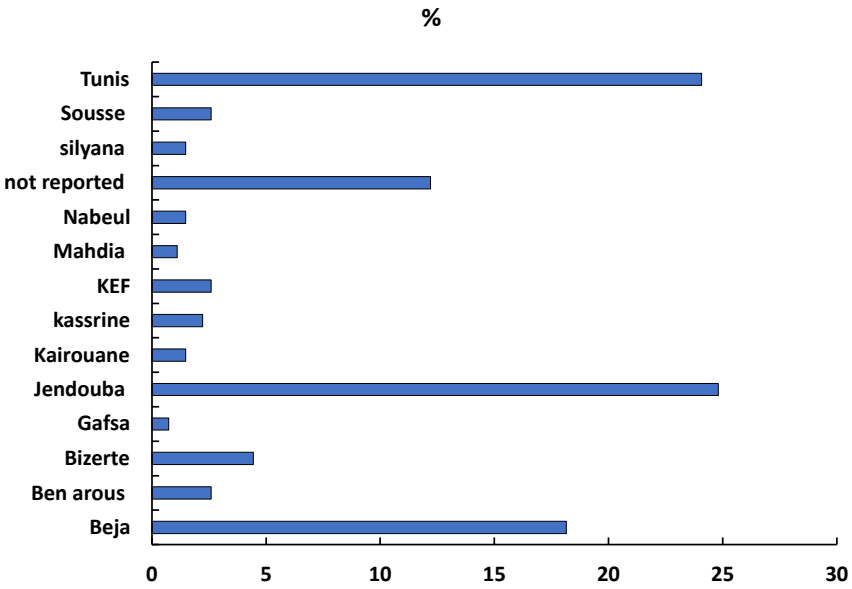

Figure 3. Geographical distribution of participants

Awareness of urolithiasis disease

A total of 270 respondents participated in this survey, of which 66% reported being aware of urolithiasis, while 34% declared having no knowledge of this condition (Figure 4a). The main sources of information about urolithiasis disease (Figure 4b) show that indirect information is the most common, with 51.5% of participants reporting that they had heard about or read about the condition. This suggests that knowledge is primarily acquired through informal channels such as media, education, and community discussions. Additionally, 47% of respondents reported that a family member had experienced urolithiasis, making family experience the second most important source of knowledge. In contrast, only 9.6% of participants reported having experienced the condition themselves. The most commonly reported symptoms (Figure 4c) were difficulty urinating (70%), followed by lower back pain (57.8%) and hematuria (32.6%). Similar trends have been reported in previous studies (Almaghlouth *et al.* 2023; Sorokin *et al.* 2017).

These findings indicate that knowledge about urolithiasis is primarily acquired through indirect sources rather than personal experience. This highlights the important role of social interactions in the transmission of health-related knowledge, particularly in traditional communities. The high prevalence of urinary symptoms reported suggests that local herbal practices may prioritize plants with diuretic properties.

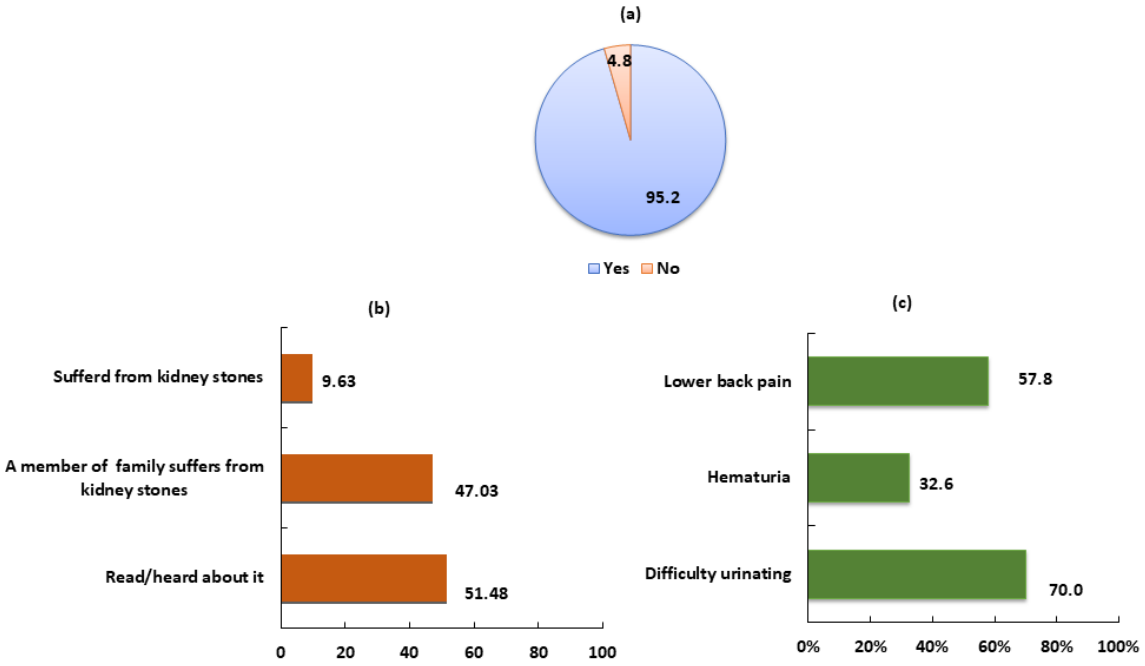

Figure 4**.** Awareness of urolithiasis disease (a), sources of knowledge regarding urolithiasis (b), and the main symptoms of this condition (c)

A specific analysis of individuals who have experienced urolithiasis reveals a predominance of women, accounting for 69.2% of cases compared to 30.8% for men (Figure 5a). Although global data often indicate a higher prevalence in men, this trend may reflect greater participation of women in surveys or a higher reliance on traditional medicine among women in Tunisia (Alaya *et al.* 2012). In terms of age distribution (Figure 5b), the condition was most prevalent among individuals aged 20-40 years (53.8%), followed by those aged 40-60 years (42.3%). This distribution highlights the potential socio-economic impact of the disease on the active population.

Use of medicinal plants for the treatment of urolithiasis

The survey results reveal a marked homogeneity in the distribution of ethnobotanical knowledge within the study population (Figure 6). Although women represent most informants, statistical analysis shows no significant association between gender and the awareness of medicinal plants ($p = 0.65$). The Odds Ratio (OR = 0.87), being very close to unity, along with the 95% confidence interval (CI: 0.47-1.61) which includes the value 1, confirms that the probability of possessing this knowledge is nearly identical for both men and women. These findings suggest that the knowledge of natural remedies, particularly for the treatment of urolithiasis, constitutes a shared cultural foundation. Similar to other studies where demographic factors such as age or educational level do not significantly influence the recognition of medicinal properties, our data indicate that

the transmission of this traditional knowledge occurs uniformly across different social groups, regardless of the informant's gender.

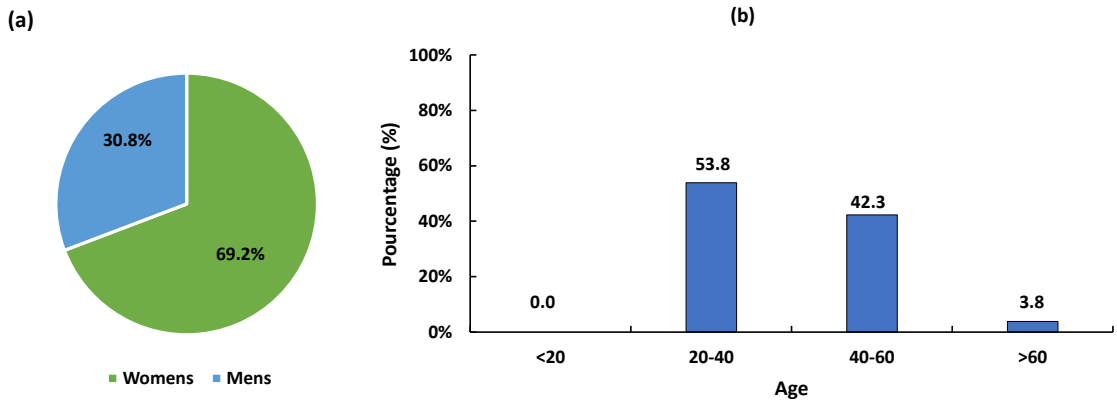

Figure 5. Distribution of sex (a) and age (b) of people who suffered from urolithiasis.

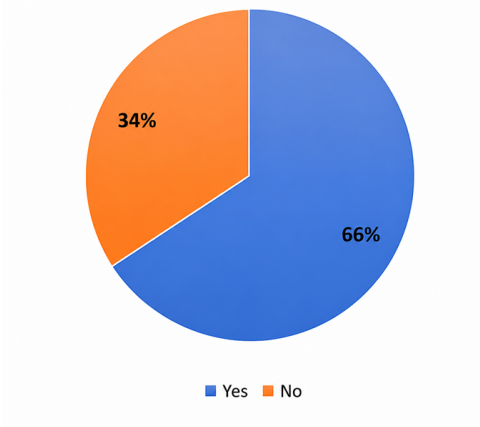

Figure 6. Awareness about medicinal plants

Ethnobotanical investigation

The ethnobotanical investigation revealed a variety of medicinal plants used by local populations in Tunisia for treating urolithiasis (Table 2). Among these, *P. crispum* was the most frequently cited species, with a Relative Frequency of Citation (RFC) of 0.267 and a Use Value (UV) of 0.344. *E. japonica* followed with RFC = 0.141 and UV = 0.056, while *A. visnaga* (RFC = 0.119, UV = 0.141), *H. hirsuta* (RFC = 0.056, UV = 0.063), and *H. vulgare* (RFC = 0.041, UV = 0.056) were less frequently mentioned. Furthermore, *U. dioica*, *T. aucheriana*, *P. granatum*, and *B. vulgaris* exhibited low citation frequencies and use values (RFC = 0.02, UV = 0.02) and (RFC = 0.01, UV = 0.01), while other species were cited fewer than three times.

In fact, *P. crispum* has a long history of use in traditional medicine, mainly due to its strong antioxidant activity associated with the presence of various bioactive compounds, including tocopherols, flavonoids, and carotenoids. The plant is also recognized for its diuretic and anti-inflammatory properties. It is widely recommended for the treatment of urinary tract infections and urolithiasis, as its diuretic effect facilitates toxin elimination and helps prevent Urolithiaisi formation (Bauer Petrovska 2012; Rezazad & Farokhi 2014). When compared to conventional medications, ethnomedicinal plants provide significant therapeutic advantages. They can synthesize a wide range of secondary metabolites, such as alkaloids, terpenoids, flavonoids, carotenoids, phenolic acids, isoprenoids, and phytoestrogens. These compounds have been linked to a variety of biological activities, including antioxidant, anti-inflammatory, anticarcinogenic, and hypoglycemic properties. Consequently, medicinal plants are a valuable natural resource for treating various diseases, including kidney disorders. Commonly cited species include *A. visnaga*, *P. crispum*, and *H. vulgare* (Abu-Serie *et al.* 2019).

E. japonica is esteemed for its nutritional value, with a low caloric content enhanced by antioxidants, fructose, and citric acid. Its leaves also exhibit multiple biological activities and display a broad spectrum of pharmacological properties, encompassing antidiabetic, immunomodulatory, and nephroprotective characteristics. It has been linked to enhanced renal function through improved filtration and toxin removal, as well as beneficial effects on digestive and visual health. In addition, it may help to regulate blood pressure, ease symptoms of gastrointestinal disturbances such as constipation and colic, and reduce nasal congestion. Moreover, it has been found to have therapeutic potential in the treatment of urolithiasis (Huang *et al.* 2007; Liu *et al.* 2016; El-aouni *et al.* 2025).

*A. visnaga (*Khella Baldi*)* and *H. hirsuta* are two plants that are well known in traditional medicine for their ability to treat urolithiasis, as they exhibit complementary pharmacological activities. The long-standing use of *A. visnaga* as a diuretic and antispasmodic agent is attributed to the bioactive constituents of the plant, including essential oils, flavonoids, and ɣ-pyrones such as khellin and visnagin. These compounds protect renal epithelial cells against calcium oxalate crystal-induced damage and may reduce hypercalciuria by increasing the soluble fraction of urinary calcium through chelation, thereby inhibiting crystal formation and promoting oxalate excretion.

Concurrently, H. hirsuta, a plant endemic to the Mediterranean region with a long history of traditional use, has been shown to possess notable antilithiasic and lithotriptic properties. It facilitates the dissolution and expulsion of urinary stones, as evidenced by ethnobotanical practices and *in vitro* studies demonstrating its inhibitory effect on calcium oxalate crystallization. The traditionally reported anti-urolithiatic potential of *H. hirsuta* is largely associated with its antioxidant and anti-inflammatory metabolites, which help to mitigate the processes involved in stone formation. Previous *in vitro* studies have demonstrated that aqueous extracts of *H. hirsuta* inhibit calcium oxalate crystallization (Gerstenbluth & Resnik 2004; Atmani & Khan 2000; Aly Mohammed 2025).

Furthermore, the anti-urolithiatic activity of the other plants cited in this study has been confirmed by many *in vivo* and *in vitro* studies. For example, *H. vulgare* (Shah 2012), *U. dioica* (Belmamoun *et al.* 2022; Keleş *et al.* 2020), *P. granatum* (Arra *et al.* 2024; Kachkoul *et al.* 2020), and *B. vulgaris* (Jyothilakshmi *et al.* 2013) have been shown to reduce and prevent the formation and growth of urinary stones. These effects are likely attributed to their diuretic, antioxidant, and nephroprotective properties.

A strong cultural consensus regarding the traditionally therapeutic effectiveness of *P. crispum*, *E. japonica*, *A. visnaga*, and *H. hirsuta* is reflected by these findings, which is likely associated with their ecological availability and longstanding empirical validation. These medicinal plants may represent promising candidates for further pharmacological investigation. However, although several experimental studies support their biological activities, their traditional anti-urolithiatic uses remain largely based on ethnomedicinal knowledge and require additional pharmacological and clinical validation before therapeutic application.

The predominance of *P. crispum*, *A. visnaga*, and *H. hirsuta* in the present survey is consistent with ethnobotanical studies conducted in other North African and Mediterranean countries. Similar anti-urolithiatic uses of *A. visnaga* and *H. hirsuta* have been reported in Morocco and Algeria, where these species are traditionally employed for their diuretic and litholytic properties (Bencheikh *et al.* 2021; Bouasla & Bouasla 2017). Likewise, *P. crispum* has been frequently cited in Mediterranean traditional medicine as a preventive remedy for urinary disorders due to its recognized diuretic activity. These similarities suggest a shared ethnopharmacological heritage across Mediterranean populations and reinforce the cultural importance of these species in traditional urinary disease management.

Table 2. Ethnobotanical data of medicinal species identified for anti-urolithiasic use in Tunisia

Species	Local name	Family	FC	FC (%)	RFC	ΣU	U (%)	UV	ICF
Petroselinum crispum (Mill.) Fuss	*Persil (maadnous)*	Apiaceae	72	26.67	0.267	93.00	34.44	0.344	0.95
Eriobotrya japonica (Thunb.) Lindl.	*Néflier du Japon (mespilier)*	Rosaceae	38	14.07	0.141	15.00	5.56	0.056	
Ammi visnaga (L.) Lam.	*Khella / Bisnaga*	Apiaceae	32	11.85	0.119	38.00	14.07	0.141	
Herniaria hirsuta L.	*Herniaire / Herbe à rupture*	Caryophyllaceae	15	5.56	0.056	17.00	6.30	0.063	
Hordeum vulgare L.	*Orge (chaîr)*	Poaceae	11	4.07	0.041	15.00	5.56	0.056	
Urtica dioica L.	*Ortie (harriga)*	Urticaceae	5	1.85	0.019	6.00	2.22	0.022	
Tamarix aucheriana Decne. & Bunge	*Tamaris*	Tamaricaceae	5	1.85	0.019	5.00	1.85	0.019	
Punica granatum L.	*Grenadier (roman)*	Lythraceae	4	1.48	0.015	6.00	2.22	0.022	
Berberis vulgaris subsp. *cicla*	*Épine-vinette*	Berberidaceae	4	1.48	0.015	4.00	1.48	0.015	
*Citrullus lanatus (*Thunb.*) Matsum. & Nakai*	*Pastèque (della3 / batikh)*	Cucurbitaceae	3	1.11	0.011	4.00	1.48	0.015	
Pistacia lentiscus L.	*Lentisque (dharw)*	Anacardiaceae	3	1.11	0.011	3.00	1.11	0.011	
Mentha spicata L.	*Menthe verte (na'naa)*	Lamiaceae	2	0.74	0.007	2.00	0.74	0.007	
Arbutus unedo L.	*Arbousier (seddra)*	Ericaceae	2	0.74	0.007	2.00	0.74	0.007	
Olea europaea subsp. *europaea*	*Olivier (zitoun)*	Oleaceae	2	0.74	0.007	2.00	0.74	0.007	
Salvia officinalis L.	*Sauge (salmiya)*	Lamiaceae	2	0.74	0.007	2.00	0.74	0.007	
Myrtus communis subsp. *communis*	*Myrte (rayhan)*	Myrtaceae	2	0.74	0.007	2.00	0.74	0.007	
Globularia alypum L.	Tasse d'argent (zriga)	Plantaginaceae	1	0.37	0.004	1.00	0.37	0.004	
Origanum majorana L.	*Marjolaine (mardgouch)*	Lamiaceae	1	0.37	0.004	1.00	0.37	0.004	
Zea mays L.	*Maïs (dhra)*	Poaceae	1	0.37	0.004	1.00	0.37	0.004	
Ricinus communis L.	*Ricin (kharwaa)*	Euphorbiaceae	1	0.37	0.004	1.00	0.37	0.004	
Laurus nobilis L.	*Laurier (wrak rih)*	Lauraceae	1	0.37	0.004	1.00	0.37	0.004	
Daucus carota subsp. *carota*	*Carotte sauvage (khizrouna)*	Apiaceae	1	0.37	0.004	1.00	0.37	0.004	
Polygonum aviculare L.	*Renouée (lissane el ard)*	Polygonaceae	1	0.37	0.004	1.00	0.37	0.004	
Spinacia oleracea L.	*Épinard (sabeneh)*	Amaranthaceae	1	0.37	0.004	1.00	0.37	0.004	
Cichorium intybus var. *intybus*	*Chicorée sauvage (hindiba)*	Asteraceae	1	0.37	0.004	1.00	0.37	0.004	
Phoenix dactylifera L.	*Palmier dattier (nakhla)*	Arecaceae	1	0.37	0.004	1.00	0.37	0.004	
Cynodon dactylon (L.) Pers.	*Chiendent (njem)*	Poaceae	1	0.37	0.004	1.00	0.37	0.004	

Perceived efficacy

The evaluation of perceived efficacy (Figure 7) shows that the species most frequently cited benefit from strong empirical validation by users. Notably, *A. visnaga* (89.7%) and *H. hirsuta* (88.2%) exhibit the highest satisfaction rates, consistent with their long-standing traditional use in dissolving calcium oxalate crystals. Over 50% of users consider the effect of *P. crispum* to be significant, while approximately 45.2% report a "moderate" effect, confirming its primary role as a diuretic and preventive agent within the local pharmacopoeia.

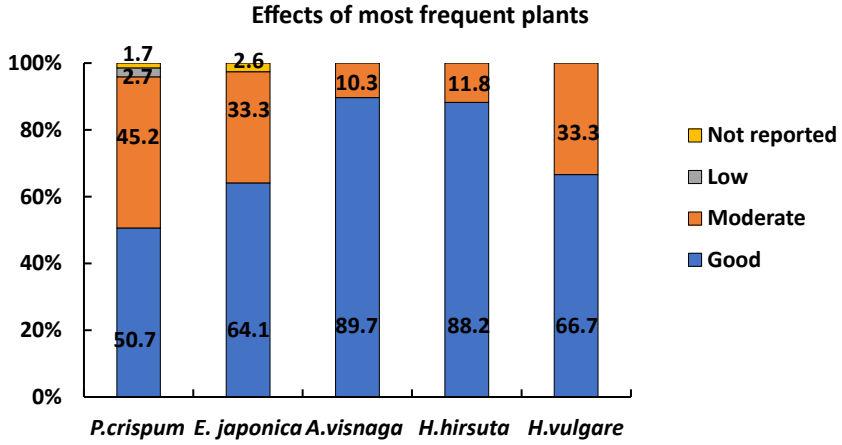

Figure 7. Perceived therapeutic efficacy of the most frequently cited medicinal plants

Distribution of preparation methods of medicinal plants used by respondents

The analysis of preparation methods revealed that decoction was the most commonly used method among respondents (Table 3). It was reported in most cases, either alone or in combination with other preparation forms. Infusion was the second most frequently cited method, while powder and the use of fresh plants were less commonly reported. Responses including multiple preparation methods were counted separately for each category. Some respondents indicated the use of combined preparation methods, particularly decoction associated with infusion or fresh plant usage, reflecting a diversity of traditional practices. The predominance of decoction suggests a cultural preference for thermal extraction methods, which are often considered more effective for extracting bioactive compounds from plant materials.

Table 3. Frequency and Percentage of Medicinal Plant Preparation Methods

Preparation method	Frequency (n)	Percentage (%)
Decoction	139	51.48
Infusion	48	17.78
Fresh plant	15	5.56
Powdered	4	1.48

The survey revealed significant knowledge gaps regarding the standardization of herbal medicine preparation. Notably, practitioners lack precise information regarding the appropriate weight and proportions of plant materials, as well as the optimal preparation time required for different plant parts. Despite these limitations, decoction (51.48%) remained the most widely used method, followed by infusion (17.78%), fresh plant (5.56%), and powdered plant (1.48%) (Table 3). The local population's preference for decoction and infusion is often attributed to their perceived ability to provide higher concentrations of active compounds, enhanced therapeutic efficacy, and antimicrobial properties (Fotakis *et al.* 2016; Guimarães *et al.* 2011; Martins *et al.* 2015).

Cross-analysis of preparation methods and treatment duration (Figure 8) reveals distinct usage patterns among the population. Decoction, the predominant method, is largely associated with short-term cycles of less than one week (30.7%) or one to three weeks (36.2%), suggesting its use for managing acute symptoms such as renal colic. In contrast, infusion is often not reported in terms of duration (55.9%), which may correspond to more irregular or long-term preventive consumption. Furthermore, the use of powdered plants is almost exclusively reported without a precise timeline (83.3%), highlighting a significant lack of standardization in the administration of these herbal remedies.

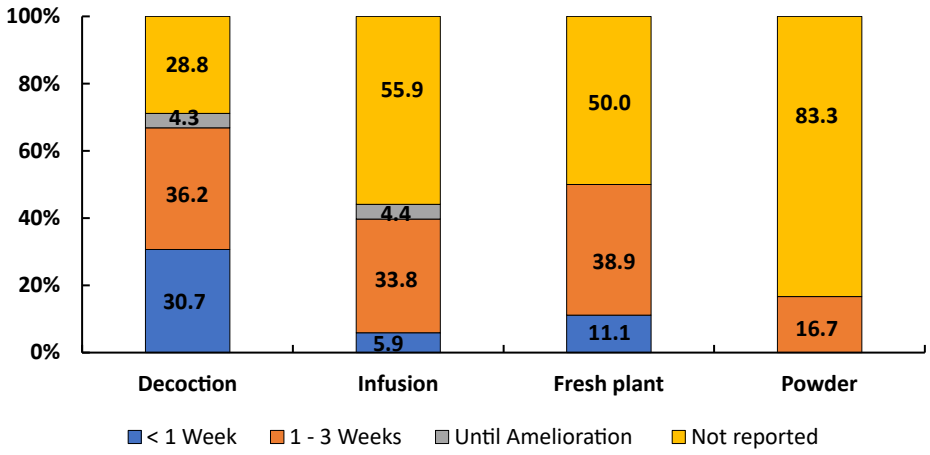

Figure 8. Distribution of treatment duration according to the different preparation methods.

Safety and origin

The survey results indicate a high perceived safety profile for the medicinal plants used in the treatment of urolithiasis, as no adverse effects were reported by the majority of respondents (69.3%). In contrast, only a small proportion of participants (9.3%) experienced adverse reactions associated with certain plant species (Figure 9a). Among these, *A. visnaga* was the most frequently mentioned species, with a limited number of participants reporting self-perceived dental problems potentially associated with its prolonged use. However, this observation was not clinically verified and should therefore be interpreted with caution. This perceived safety likely contributes to the continued reliance on traditional phytotherapy in these Tunisian communities. However, it is important to note that the low reporting of adverse effects may be due to the lack of clinical monitoring, highlighting the need for further pharmacological and toxicological studies.

Regarding the acquisition of medicinal resources, the data show a clear preference for cultivated plants (54.5%) compared to wild-harvested species (35.2%) (Figure 9b). This reliance on cultivated plants suggests that key species used for urolithiasis, such as *P. crispum* and *H. vulgare*, are readily available in local agriculture or home gardens. This trend may also reflect reduced availability of wild flora or a shift toward more sustainable practices. However, the continued use of wild plants highlights the importance of regional biodiversity and traditional harvesting practices in Northern Tunisia. In addition, the safety data reported in this study were based exclusively on self-declared participant perceptions and were not supported by clinical evaluation or toxicological monitoring. Therefore, underreporting, recall bias, or misinterpretation of adverse effects cannot be excluded.

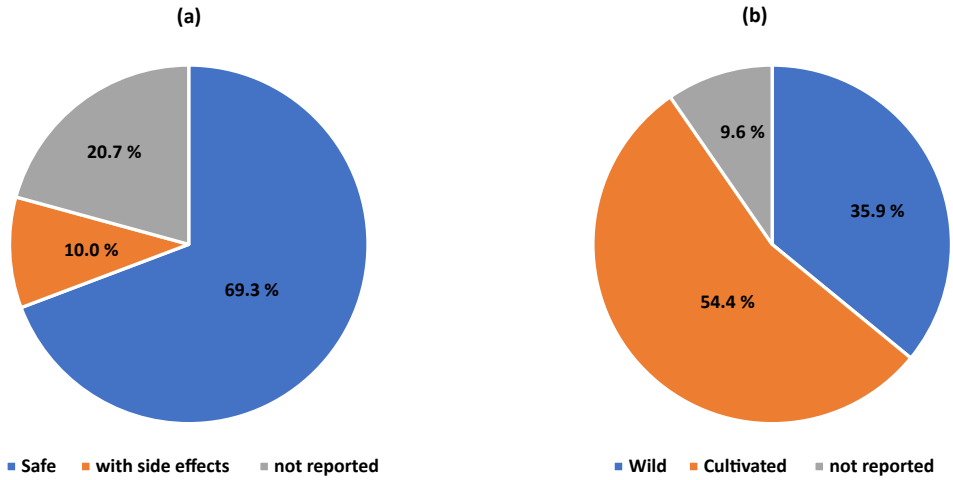

Figure 9. Perceived safety profile of medicinal plants used for urolithiasis management (a) and origin of the reported plant species (b).

A major limitation of this study is the exclusive use of an online survey, which may have introduced selection bias toward younger, educated, and digitally connected participants. Indeed, university-educated respondents represented 73.3% of the

sample, whereas illiterate individuals accounted for only 0.4%. Elderly and rural populations, traditionally considered important holders of ethnobotanical knowledge, were likely underrepresented. Therefore, the findings should be interpreted cautiously and may not fully reflect the complete diversity of traditional medicinal knowledge in Tunisia. Future ethnobotanical investigations should incorporate direct field interviews and rural sampling strategies to improve representativeness.

Conclusion

In conclusion, this study documents for the first time at a national level the richness of phytotherapeutic practices against urolithiasis in Tunisia. Nevertheless, the use of an online survey represents a significant methodological limitation, inducing a sampling bias toward a young, connected, and highly educated population, to the detriment of rural or illiterate demographics who are often the primary holders of traditional ethnobotanical knowledge. Quantitative analysis identified *P. crispum*, *A. visnaga*, and *H. hirsuta* as the most significant species, based on their high Relative Frequency of Citation (RFC) values and perceived therapeutic success. The predominance of decoction as a preparation method and the preference for short-term treatments reflect standardized traditional practices passed down through generations. While the perceived efficacy of these plants is high, there is a clear lack of standardization regarding dosage and long-term safety. This study provides a valuable foundation for future research. We recommend that the species highlighted here, particularly those with high RFC and UV values for each ailment, undergo rigorous phytochemical and pharmacological investigations. Such investigations are essential to validate their safety, elucidate their mechanisms of action, and potentially integrate these traditional remedies into modern therapeutic protocols for managing urolithiasis.

Declarations

Ethics approval and consent to participate: Verbal informed consent was obtained from all participants prior to survey administration. The study was conducted in accordance with ethical guidelines for ethnobotanical research involving human participants. As the research was non-invasive, non-clinical, and conducted for academic purposes under Tunisian national regulations, formal institutional ethics approval was not required.

Access and Benefit-Sharing (Nagoya Protocol): This study involved documentation of traditional knowledge and collection of plant specimens in Tunisia. The research was non-commercial and conducted solely for academic purposes. No genetic resources were transferred outside Tunisia. The study complies with national regulations on access to genetic resources and traditional knowledge under the Nagoya Protocol.

Consent for publication: Not applicable

Availability of data and materials: Not applicable

Competing interests: Not applicable

Funding: Not applicable

Author contributions: Chaibni A; Tabouii M; M'Rabet Y; Bennour N: Conceptualization, data curation, investigation, software, writing - original draft.; Ben Salah I; Aouadhi C: Formal analysis, review & editing; Mahmoudi H: Supervision, visualization, review & editing.

Acknowledgements

The authors acknowledge the support provided by Tunisian Ministry of Higher Education and Scientific Research.

Literature cited

Aboufatima R, Laadraoui J, Laaradia MA, Bezza K, El Guebbas Z, Oufquir S, Ferehan H, El Alami A, Sokar Z, Chait A. 2019. Study of protective effects of *Pistacia lentiscus* leaves aqueous extract against gastric ulcer and renal stone formation in rats. European Journal of Pharmaceutical and Medical Research 6(2):41-47 https://www.ejpmr.com/home/abstract_id/4665

Abu-Serie MM, Habashy NH, Maher AM. 2019. *In vitro* anti-nephrotoxic potential of *Ammi visnaga, Petroselinum crispum*, *Hordeum vulgare*, and *Cymbopogon schoenanthus* seed or leaf extracts by suppressing necrotic mediators, oxidative stress and inflammation. BMC Complementary and Alternative Medicine 19:149. doi: 10.1186/s12906-019-2559-8

Alaya A, Nouri A, Belgith M, Saad H, Jouini R, Najjar MF. 2012. Changes in urinary stone composition in the Tunisian population: A retrospective study of 1,301 cases. Annals of Laboratory Medicine 32(3):177-183. doi:10.3343/alm.2012.32.3.177

Almaghlouth AK, Alqutayfi HM, Bohamad AH, et al. 2023. Urolithiasis symptoms and risk factors among the general population of Alahsa, Saudi Arabia. Cureus 15(5):e39645. doi:10.7759/cureus.39645

Aly Mohammed MS. 2025. Traditional medicinal plants for kidney disease. EC Orthopaedics 16(6):1-9.

Arra K, Pasupula R, Anandam S. 2024. *In vivo* assessment of *Punica granatum* leaf extract: Anti-urolithiatic and nephroprotective effects. Natural Product Sciences 30(2):80-92. doi:10.20307/nps.2024.30.2.80

Atmani F, Khan SR. 2000. Effects of an extract from *Herniaria hirsuta* on calcium oxalate crystallization *in vitro*. BJU International 85(6):621-625. doi:10.1046/j.1464-410x.2000.00485.x

Baddade L, Mbarki MEM, Elhadri I, Berkani M. 2019. *Zizyphus lotus* anti-lithiasis activity *in vitro* of aqueous extracts of pulp fruit in human urine. Journal of Materials and Environmental Sciences 10(6):520-525. https://www.jmaterenvironsci.com/Document/vol10/vol10_N6/54-JMES-Baddade-2019.pdf

Bargagli M, Scoglio M, Howles SA, Fuster DG. 2025. Kidney stone disease: Risk factors, pathophysiology and management. Nature Reviews Nephrology 21:794-808. doi: 10.1038/s41581-025-00990-x

Bauer Petrovska B. 2012. Historical review of medicinal plants' usage. Pharmacognosy Reviews 6:11. doi: 10.4103/0973-7847.95849

Belmamoun AR, Ammam A, Chadli R, Mhamdia C, Bakdi A. 2022. Phytotherapy of urinary calculi: Mass reduction of calcium oxalate stones *in vitro* by aqueous extract of *Urtica dioica*. International Journal of Minor Fruits, Medicinal and Aromatic Plants 8(2):36-42. doi:10.53552/ijmfmap.8.2.2022.36-42

Bencheikh N, Elbouzidi A, Kharchoufa L, Ouassou H, Alami Merrouni I, Mechchate H, Es-safi I, Hano C, Addi M, Bouhrim M. 2021. Inventory of medicinal plants used traditionally to manage kidney diseases in north-eastern Morocco: Ethnobotanical fieldwork and pharmacological evidence. Plants 10:1966. doi: 10.3390/plants10091966

Bennour N, Chaibni A, M'Rabet Y, Tabouii M, Aouadhi C, Hosni K, Mahmoudi H. 2026. Ethnomedicinal uses, quantitative analysis, and therapeutic potential of *Punica granatum* peel in Tunisia: An ethnobotanical study. *Ethnobotany Research and Applications* 34:61. doi:10.32859/era.34.61.1-13.

Bouasla A, Bouasla I. 2017. Ethnobotanical survey of medicinal plants in northeastern Algeria. Phytomedicine. 1:36:68-81. doi: 10.1016/j.phymed.2017.09.007

Daudon M, Jungers P. 2007. Diabetes and nephrolithiasis. Current Diabetes Reports 7(6):443-448. doi: 10.1007/s11892-007-0075-6

El-Aouni N, Dahmani W, Ali A, Evariste Akissi ZL, Dib I, Legssyer A, Sahpaz S, Ziyyat A. 2025. *Eriobotrya japonica* (Thunb.) Lindl.: Ethnomedicinal uses, phytochemical contents and pharmacological properties: A review. Ethnobotany Research and Applications 31:38. doi:10.32859/era.31.38.1-43

Fotakis C, Tsigrimani D, Tsiaka T, Lantzouraki DZ, Strati IF, Makris C, Tagkouli D, Proestos C, Sinanoglou VJ, Zoumpoulakis P. 2016. Metabolic and antioxidant profiles of herbal infusions and decoctions. Food Chemistry 211:963-971. doi: 10.1016/j.foodchem.2016.05.124

Gerstenbluth RE, Resnick MI. 2004. Medical management of calcium oxalate urolithiasis. Medical Clinics of North America 88(2):431-442. doi: 10.1016/S0025-7125(03)00171-8

Guimarães R, Barros L, Carvalho AM, Ferreira ICFR. 2011. Infusions and decoctions of mixed herbs used in folk medicine: Synergism in antioxidant potential. Phytotherapy Research 25(8):1209-1214. doi: 10.1002/ptr.3366

Hamrouni S, Ben Salem J, Jaffali C, Khadhri A, Aouadhi C. 2026. Traditional use of medicinal plants for gastrointestinal disorders: An ethnobotanical study in Northern Tunisia. Ethnobotany Research and Applications 30:50. doi:10.32859/era.30.50.1-10

Huang Y, Li J, Wang R, Wu Q, Li YH, Yu SC, Cheng WM, Wang YY. 2007. Effect of triterpene acids of *Eriobotrya japonica* leaf on inflammatory cytokine and mediator induction from alveolar macrophages of chronic bronchitic rats. Journal of Ethnopharmacology 56:76-82. doi: 10.1007/s00011-006-5185-0

Itoh Y, Yasui T, Okada A, Tozawa K, Hayashi Y, Kohri K. 2005. Preventive effects of green tea on renal stone formation and the role of oxidative stress in nephrolithiasis. Journal of Urology 173:271-275. doi: 10.1097/01.ju.0000141311.51003.87

Jdaidi N, Selmi H, Aloui F, Chaabane A. 2022. Ethno botanical study of some rare medicinal species in Tunisia: Case *of Laurus nobilis* L. Comprehensive Research and Reviews in Science and Technology 1(1):30-36. doi: 10.57219/crrst.2022.1.1.0024

Jyothilakshmi V, Thellamudhu G, Kumar A, Khurana A, Nayak D, Kalaiselvi P. 2013. Preliminary investigation on ultra-high diluted *Berberis vulgaris* in experimental urolithiasis. Homeopathy 102:172-178. doi: 10.1016/j.homp.2013.05.004

Kachkoul R, Houssaini TS, Mohim M, El Habbani R, Lahrichi A. 2020. Chemical compounds identification and antioxidant and calcium oxalate anticrystallization activities of *Punica granatum*. Evidence-Based Complementary and Alternative Medicine 2020:9424510. doi: 10.1155/2020/9424510

Keleş R, Şen A, Ertaş B, Kayalı D, Eker P, Şener TE, Doğan A, Çetinel Ş, Şener G. 2020. Effects of *Urtica dioica* ethanolic extract against urinary calculi in rats. Journal of Research in Pharmacy 24(2):205-217. doi: 10.35333/jrp.2020.137

Khan SR, Pearle MS, Robertson WG, Gambaro G, Canales BK, Doizi S, et al. 2016. Urolithiasis. Nature Reviews Disease Primers 2:16008. doi: 10.1038/nrdp.2016.8

Liu Y, Zhang W, Xu C, Li X. 2016. Biological activities of extracts from *Eriobotrya japonica*: A review. International Journal of Molecular Sciences 17:1983. doi: 10.3390/ijms17121983

Martins N, Barros L, Santos-Buelga C, Silva S, Henriques M, Ferreira ICFR. 2015. Decoction and infusion of thyme: Antioxidant and antibacterial activities. Food Chemistry 167:131-137. doi: 10.1016/j.foodchem.2014.06.094

Morgan MS, Pearle MS. 2016. Medical management of renal stones. BMJ 352:i52. doi: 10.1136/bmj.i52

Nouri J, Selmi H, El Baher Dhafer C, Chaabane A. 2025. Ethnobotanical study of *Prunus avium* in Tunisia. Ethnobotany Research and Applications 30:46. doi:10.32859/era.30.46.1-12

Obligado SH, Goldfarb DS. 2008. Association of nephrolithiasis with hypertension and obesity. American Journal of Hypertension 21(3):257-264. doi: 10.1038/ajh.2007.62

Rezazad M, Farokhi F. 2014. Protective effect of *Petroselinum crispum* extract in renal dysfunction. Avicenna Journal of Phytomedicine 4(5):312-319.

Rivera M, Jaeger C, Yelfimov D, Krambeck AE. 2017. Risk of chronic kidney disease in stone formers. Urology 99:23-26. doi: 10.1016/j.urology.2016.08.041

Romero V, Akpinar H, Assimos DG. 2010. Urolithiasis: Global epidemiology. Reviews in Urology 12(2-3):e86-e96.

Scales CD Jr, Smith AC, Hanley JM, Saigal CS. 2012. Prevalence of urolithiasis in the United States. European Urology 62(1):160-165. doi: 10.1016/j.eururo.2012.03.052

Sekkoum K, Cheriti A, Taleb S, Bourmita Y, Belboukhari N. 2011. Traditional phytotherapy for urinary diseases. Electronic Journal of Environmental, Agricultural and Food Chemistry 10:2616-2622.

Shah JG, Patel BG, Patel SB, Patel RK. 2012. Antiurolithiatic and antioxidant activity of *Hordeum vulgare*. Indian Journal of Pharmacology 44(6). doi: 10.4103/0253-7613.103237

Siener R, Hesse A. 2002. The effect of different diets on urine composition and the risk of calcium oxalate crystallisation in healthy subjects. European Urology 42:289-296. doi: 10.1016/s0302-2838(02)00316-0

Siener R, Schade N, Nicolay C, von Unruh GE, Hesse A. 2005. The efficacy of dietary intervention on urinary risk factors for stone formation in recurrent calcium oxalate stone patients. Journal of Urology 173:1601-1605. doi: 10.1097/01.ju.0000154626.16349.d3

Sorokin I, Mamoulakis C, Miyazawa K, Rodgers A, Talati J, Lotan Y. 2017. Epidemiology of stone disease across the world. World Journal of Urology 35(9):1301-1320. doi: 10.1007/s00345-017-2008-6

Spatola L, Ferraro PM, Gambaro G, Badalamenti S, Dauriz M. 2018. Metabolic syndrome and uric acid nephrolithiasis: insulin resistance in focus. Metabolism 83:225-233. doi: 10.1016/j.metabol.2018.02.008

Tabouii M, Mahmoudi H, Aouadhi C. 2026 Ethnobotanical survey of *Artemisia vulgaris* and *Laurus nobilis* in the Treatment of Microbial Gastroenteritis in Northwestern Tunisia. Ethnobotany Research and Applications 33:35. doi:10.32859/era.33.35.1-10

Thongprayoon C, Krambeck AE, Rule AD. 2020. Determining the true burden of kidney stone disease. Nature Reviews Nephrology 16(12):736-746. doi: 10.1038/s41581-020-0320-7

Zhangqun Ye , Zeng, Yang H, Li J, Tang K, Wang G, Wang S, Yu Y, Wang Y, Zhang T, Long Y, Li W, Wang C, Wang W, Gao S, ShanY, Huang X, Bai Z, Lin X, Cheng Y, Wang Q, Xu Z, Xie L, Yuan J, Ren S, Fan Y, PanT, Wang J, Li X, Chen X, Xiaojian Gu X. 2020. The Status and Characteristics of Urinary Stone Composition in China. BJU International 125(6):801-809. doi: 10.1111/bju.14765

Ziemba JB, Matlaga BR. 2017. Epidemiology and economics of nephrolithiasis. Investigative and Clinical Urology 58(5):299-306. doi: 10.4111/icu.2017.58.5.299