Ethnomedicinal uses, quantitative analysis, and therapeutic potential of *Punica granatum* peel in Tunisia: An ethnobotanical study

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Ethnobotany Research and Applications 34:61 (2026)- http://dx.doi.org/10.32859/era.34.61.1-13
Manuscript received: 08/04/2026- Revised manuscript received: 04/06/2026 - Published: 05/06/2026

Research

Abstract

Background: *Punica granatum* L. peel is widely used in Tunisian traditional medicine for the treatment of various ailments. Despite its extensive use, comprehensive ethnobotanical studies integrating quantitative indices and statistical approaches remain limited.

Methods: Ethnobotanical data were collected through semi-structured interviews with local informants. The ethnomedicinal importance of *P. granatum* peel was assessed using Relative Frequency of Citation (RFC), Fidelity Level (FL), and Informant Consensus Factor (ICF). Statistical analyses were performed to examine associations between informant characteristics and knowledge distribution. Cluster-robust logistic regression was applied to investigate relationships between socio-demographic factors, usage patterns, and reported disease categories.

Results: *P. granatum* peel was mainly used for gastrointestinal and dermatological disorders. High ICF values indicated strong agreement among informants regarding plant use, while elevated FL values reflected specific and well-defined therapeutic applications. Knowledge distribution varied across socio-demographic groups, with reported knowledge appearing higher among older participants, although this trend should be interpreted cautiously due to their limited representation in the online survey sample.

Conclusion: This study highlights the ethnomedicinal relevance of *P. granatum* peel in Tunisia. The strong consensus among informants supports its traditional therapeutic relevance and provides a scientific basis for future pharmacological and phytochemical investigations.

Keywords: Punica granatum peel; ethnobotany; quantitative ethnobotany; traditional medicine; gastrointestinal disorders; Tunisia.

Background

Throughout history, human societies have developed extensive knowledge of natural resources, particularly medicinal plants, which play a central role in traditional healthcare systems. This knowledge is shaped by socio-cultural factors such as age, gender, and occupation, and is transmitted across generations (Silva *et al.* 2011). In this context, ethnobotany has emerged as a multidisciplinary field that explores the complex relationships between humans and plants, encompassing therapeutic, cultural, economic, and symbolic dimensions (Oran and Al-Eisawi, 2015). Ethnobotanical surveys are essential for documenting traditional knowledge, preserving cultural heritage, and identifying plant species with potential pharmacological value (Ford *et al.* 1994).

Medicinal plants continue to serve as a primary source of healthcare for a large proportion of the global population, particularly in developing countries (WHO, 2013). Consequently, the scientific investigation of traditional plant-based remedies has gained increasing attention, aiming to bridge indigenous knowledge with modern pharmacological research. Among these plants, *Punica granatum* L. (pomegranate), belonging to the Lythraceae family, is an ancient species originating from Central Asia and widely cultivated across diverse climatic regions (Ferrante, 2017). The species is well known for its rich phytochemical composition, including phenolic compounds, flavonoids, ellagitannins, and punicic acid, which are associated with numerous biological activities (Fakudze *et al.* 2022; Valero-Mendoza *et al.* 2023).

While the edible parts of pomegranate, particularly seeds and juice, have been extensively studied, increasing attention has recently been directed toward the peel, which represents approximately 40-50% of the fruit and constitutes a major agro-industrial by-product (Stefanou *et al.* 2020; Pirzadeh *et al.* 2021). Recent studies have highlighted the physicochemical properties and bioactive potential of pomegranate peel in functional food and nutraceutical applications. The peel is particularly rich in bioactive compounds such as punicalagin, ellagic acid, and gallic acid derivatives, which confer antioxidant, antimicrobial, and anti-inflammatory properties, thereby supporting its growing use as a functional dietary ingredient (Bennour *et al.* 2026a).

Historically, pomegranate peel has been employed in various traditional medical practices, including Chinese and Ayurvedic medicine, for the treatment of gastrointestinal disorders, infections, and inflammatory conditions (Siddiqui *et al*. 2024; Bennour *et al.* 2026b). In Tunisia and across Mediterranean and North African regions, traditional knowledge of medicinal plants remains deeply rooted in local culture. However, despite the recognized pharmacological importance of *P. granatum*, ethnobotanical studies specifically focusing on the peel and its traditional applications in these regions remain limited.

This gap highlights the need for systematic documentation and quantitative analysis of indigenous knowledge related to *P. granatum* peel, particularly regarding its therapeutic uses, preparation methods, and socio-cultural distribution. Moreover, the application of quantitative ethnobotanical indices provides a robust framework for evaluating the relative importance and consensus of medicinal plant use among local populations (Tardío and Pardo-de-Santayana, 2008). In addition, statistical modeling approaches can further help explore associations between informant characteristics and knowledge distribution.

Therefore, the present study aims to (i) document the traditional uses of *P. granatum* peel in Tunisia, (ii) analyze preparation methods and perceived therapeutic applications, and (iii) assess its ethnobotanical significance using quantitative indices such as Relative Frequency of Citation (RFC), Fidelity Level (FL), and Informant Consensus Factor (ICF), together with statistical modeling approaches. By integrating ethnobotanical knowledge with quantitative and statistical analyses, this work contributes to the valorization of pomegranate peel and supports future pharmacological, nutraceutical, and cosmetic investigations.

Materials and Methods

Ethnobotanical Survey

An ethnobotanical survey was conducted to document the traditional uses of *P. granatum* peel among Tunisian populations. Data were collected using an online semi-structured questionnaire distributed between February and March 2026.

A total of 100 informants participated, recruited through purposive sampling targeting individuals with knowledge of traditional medicine. Participants were selected based on self-reported familiarity with medicinal plant use and through snowball sampling within local social networks, ensuring the inclusion of respondents with relevant ethnobotanical knowledge.

The survey was disseminated via social media platforms to reach a broad respondent base. The questionnaire included both closed- and open-ended questions to collect socio-demographic data (age, gender, education, occupation) and

ethnobotanical information, including local plant names, parts used, preparation methods, routes of administration, and reported ailments.

Each specific use mentioned by an informant was recorded as a Use Report (UR). Ailments were classified into standardized disease categories to facilitate quantitative analysis. Responses were screened for completeness and consistency, and incomplete or ambiguous entries were excluded.

The questionnaire was developed based on previous ethnobotanical studies and validated by experts in ethnobotany to ensure content validity. A pilot test was conducted on a small sample to assess clarity and refine the survey instrument prior to full data collection.

However, the exclusive use of an online survey may have introduced selection bias by underrepresenting elderly, rural, and digitally marginalized populations, who may possess substantial traditional medicinal knowledge. This limitation is considered in the interpretation of the results.

Ethical Considerations

Participation was voluntary, and informed consent was obtained from all respondents. The study complied with ethical guidelines for research involving human participants, ensuring anonymity and confidentiality.

Quantitative Ethnobotanical Indices

To evaluate the ethnomedicinal importance of *P. granatum* peel and measure the specificity of reported therapeutic applications, three quantitative ethnobotanical indices were calculated: Relative Frequency of Citation (RFC), Fidelity Level (FL), and Informant Consensus Factor (ICF).

Relative Frequency of Citation (RFC) measures the local importance of the species based on the number of informants citing its use: **RFC=FC/N**

where *FC* is the number of informants mentioning *P. granatum* peel and *N* is the total number of informants (N = 100). RFC values range from 0 to 1, with higher values indicating greater cultural importance.

Fidelity Level (FL) quantifies the percentage of informants claiming the use of the plant for a specific ailment, reflecting the specificity of use: **FL (%) =Np/N×100**

where *Np* is the number of informants citing the plant for a particular ailment, and *N* is the total number of informants who cited the plant for any use. High FL values indicate a strong preference for a specific therapeutic application.

Informant Consensus Factor (ICF) assesses the degree of agreement among informants for a given disease category:
ICF= N_{ur}–N_t/N_{ur}-1

where N_{ur} is the total number of use reports for a category and *Nt* is the number of plant taxa used for that category.
Because the present study focused exclusively on a single plant species (*P. granatum* peel), the number of taxa used per disease category (N_t) was necessarily equal to 1. Consequently, ICF values mathematically approached 1 across all categories. Therefore, ICF results should be interpreted cautiously, as this index is less informative in single-species ethnobotanical studies.

Use Value (UV) was calculated to assess the relative importance of each therapeutic use. It is expressed as: **UV=∑Ui/N**

where ΣUi represents the total number of use reports cited for a given therapeutic indication and N is the total number of informants (N = 100). For example, a ΣUi value of 65 for stomach ulcer indicates that 65 use reports were recorded for this indication, resulting in a UV of 0.65 (65/100).

Data Processing and Statistical Analysis

Data were analyzed using SPSS (v.20). Associations between sociodemographic variables (age, gender, education level, and occupation) and medicinal knowledge were evaluated using Fisher's exact test. Exact cell frequencies and percentages were reported, together with Odds Ratios (OR) and 95% confidence intervals (CI).

Cluster-robust logistic regression analyses were performed in RStudio (v.2026.01.1) using the *sandwich* and *lmtest* packages. Informant ID was used as the clustering variable to account for potential intra-individual correlation.

Disease category was operationalized as the dependent variable and classified into four groups: gastrointestinal, infectious/parasitic, metabolic/chronic, and dermatological conditions. Independent variables included preparation form, administration route, and treatment duration.

The regression analysis was conducted at the level of informants (n = 100), corresponding to the total number of survey participants.

Results

Sociodemographic profile of respondents

A total of 100 individuals participated in the survey. The age distribution was relatively balanced, with respondents aged 20-40 years constituting the largest group (41.3%), followed by those aged 40-60 years (36.7%), >60 years (12.8%), and <20 years (9%) (Fig. 1a). Female participants were more represented than males, accounting for 58.7% and 41.3% of the sample, respectively, corresponding to a sex ratio of 0.7 (Fig. 1b).

Concerning educational attainment, most respondents possessed a university-level education (81%), while participants with secondary, primary, and no formal education represented 11%, 3%, and 5%, respectively (Fig. 1c). The surveyed population also included individuals from various socio-professional categories, reflecting the diversity of the study sample (Fig. 1).

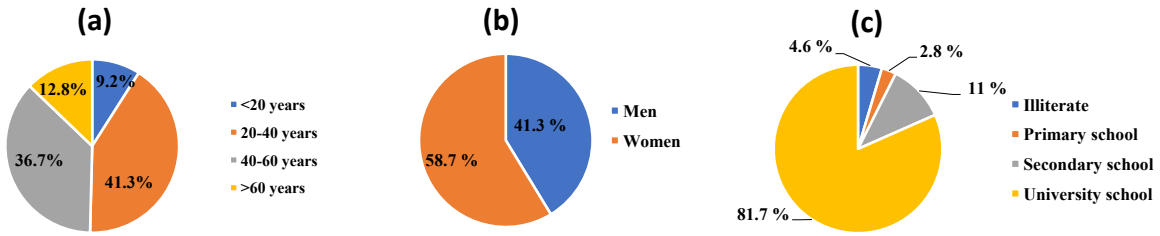

Figure 1. Sociodemographic profile of participants: age (a), sex (b) and level of education (c)

Knowledge and Cultural Significance of Pomegranate Peel

The Relative Frequency of Citation (RFC) calculated for *P. granatum* peel was 0.87, indicating its widespread recognition and frequent traditional use among respondents.

Overall, 87.2% of participants identified pomegranate peel as a medicinal resource, while 82.9% considered it an effective natural remedy (Fig. 2a-b). Knowledge regarding the medicinal use of the peel was slightly more frequently reported by men (91%) than by women (84.4%). However, no statistically significant association was observed between gender and reported knowledge (Fisher's exact test, p = 0.389, OR = 0.53, 95% CI: 0.11-2). Minor differences in percentages are attributable to rounding.

Awareness of the medicinal properties of pomegranate peel remained consistently high across all age categories, reaching 81.8% among respondents aged 20-40 years, 90% among those aged 40-60 years, and 100% among participants older than 60 years. Nevertheless, no significant association was detected between age group and medicinal knowledge of the peel (p = 0.219).

Similarly, educational attainment did not significantly influence participants' knowledge of medicinal uses (p = 0.9, OR = 0.57, 95% CI: 0.01-4.93), suggesting that this ethnobotanical knowledge is broadly distributed across different demographic groups.

Family transmission emerged as the principal source of knowledge (61.9%), followed by personal experience (19%) and traditional education (16.2%) (Fig. 2c). These findings highlight the major role of intergenerational knowledge transfer in preserving traditional ethnomedicinal practices and maintaining the cultural importance of pomegranate peel within the studied population.

Preparation and Preservation of Pomegranate Peel

Respondents reported that drying was almost equally performed by sun exposure (50%) and shade drying (49%), whereas oven drying was rarely used (1%) (Fig. 3a). After drying, the peel was mainly preserved in powdered form (80.2%), followed by storage as small pieces (12.6%) (Fig. 3b).

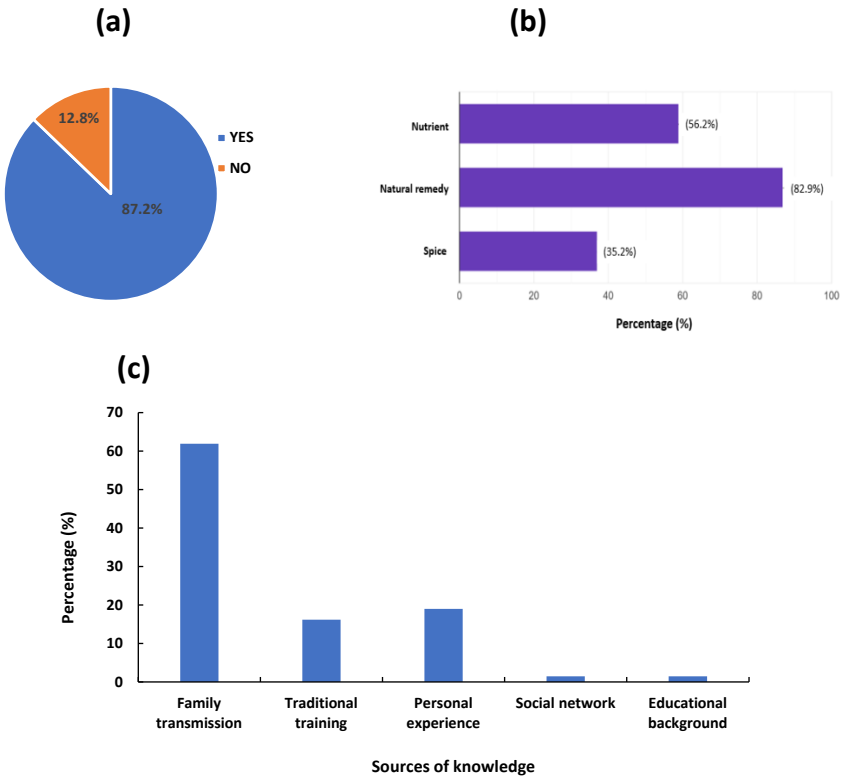

Figure 2: Knowledge of pomegranate peel and its uses

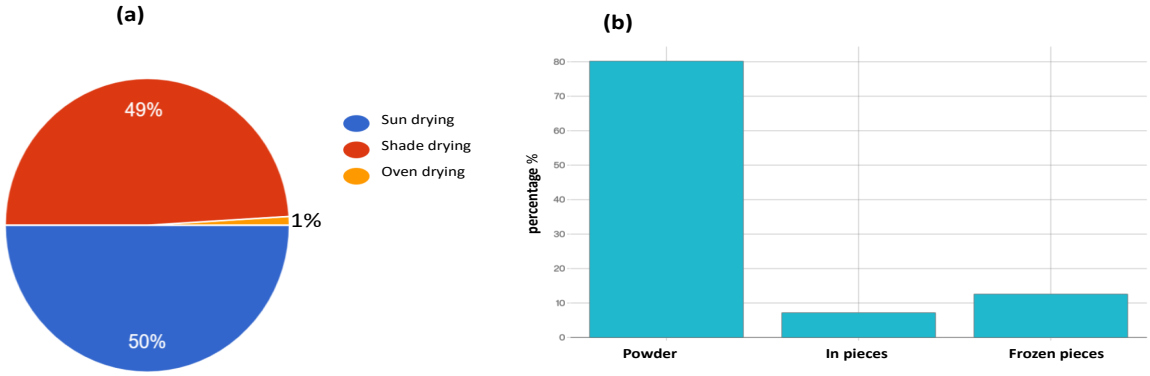

Figure 3. Different methods of drying (a) and preserving (b) of pomegranate peels.

Ethnobotanical Survey Results: Disease-Specific Uses of Pomegranate Peel

The ethnobotanical survey revealed a wide range of traditional therapeutic applications of *P. granatum* peel across several disease categories (Table 1). In the infectious and parasitic disorders category, bacterial infections were the most frequently reported use (UV = 0.44; FL = 9.0%), followed by parasitic infections and oral infections (UV = 0.30; FL = 6.1%). Vaginal infections (UV = 0.12; FL = 2.5%) and fungal skin infections (UV = 0.10; FL = 2.0%) were mentioned less frequently.

Regarding metabolic and chronic disorders, diabetes was moderately cited among respondents (UV = 0.30; FL = 6.1%), whereas high cholesterol showed lower citation values (UV = 0.10; FL = 2.0%). Dermatological applications mainly included wound healing (UV = 0.24; FL = 4.9%) and the treatment of minor burns (UV = 0.11; FL = 2.2%).

Oral and dental conditions also represented important therapeutic indications, particularly gingivitis (UV = 0.23; FL = 4.7%). Additional minor uses, including hemorrhoids, were less frequently reported (UV = 0.07; FL = 1.4%).

The Informant Consensus Factor (ICF) values were uniformly equal to 1.00 across all disease categories (Table 1). This outcome is expected in a single-species ethnobotanical survey, where only one taxon was evaluated within each therapeutic category..

Table 1. Ethnobotanical indices of *P. granatum* peel: Use Value (UV), Informant Consensus Factor (ICF), and Fidelity Level (FL) across disease categories

Category	Disease	∑Ui	UV	ICF	FL (%)	Interpretation
Gastro-intestinal	Stomach ulcer	65	0.65	1.00	13.3	Highly cited, primary use for digestive disorders
	Gastritis	62	0.62	1.00	12.7	Widely used for gastric complaints
	Intestinal colic	34	0.34	1.00	7.0	Moderate use for digestive discomfort
	Intestinal inflammation	32	0.32	1.00	6.5	Moderate use for inflammation
	Diarrhea	31	0.31	1.00	6.3	Symptomatic treatment of diarrhea
	Bloating	19	0.19	1.00	3.9	Limited use for mild digestive issues
	Vomiting	15	0.15	1.00	3.1	Low frequency of citation
Infectious/Parasitic	Bacterial infections	44	0.44	1.00	9.0	Notable use for antimicrobial purposes
	Parasitic infections	30	0.30	1.00	6.1	Moderate use for parasites
	Oral infections	30	0.30	1.00	6.1	Moderate use for oral health
	Vaginal infections	12	0.12	1.00	2.5	Low frequency, specific use
	Fungal skin infections	10	0.10	1.00	2.0	Limited use, potential antifungal activity
Metabolic / Chronic diseases	Diabetes	30	0.30	1.00	6.1	Moderate use, potential antidiabetic activity
	High cholesterol	10	0.10	1.00	2.0	Rarely cited, minor use
Dermatological / Wounds	Wounds	24	0.24	1.00	4.9	Moderate use for wound healing
	Minor burns	11	0.11	1.00	2.2	Limited, topical applications
Oral / Dental	Gingivitis	23	0.23	1.00	4.7	Moderate use for dental health
Others	Hemorrhoids	7	0.07	1.00	1.4	Low consensus, minor use

Modes of Preparation, Administration, Dosage, and Traditional Uses

Pomegranate peel was traditionally prepared using several methods, including decoction, infusion, maceration, and powder forms. Among these, decoction was the most frequently reported preparation method (44.7%), followed by powder (36.9%), infusion (16.5%), and maceration (5.8%) (Fig. 4a, Table 2).

The mode of administration was predominantly oral, accounting for 64.1% of reported uses, whereas external application represented 34% of cases. Combined oral and topical administration was less common, reported by only 2% of respondents (Fig. 4b).

Regarding dosage, the most commonly reported amount was approximately 5 g (equivalent to one teaspoon), cited by 63.6% of participants. Treatment duration generally ranged from 3 to 15 days (67.4%), while higher doses (>10 g) and prolonged treatment periods (>1 month) were less frequently mentioned (Table 2, Fig. 4c-d).

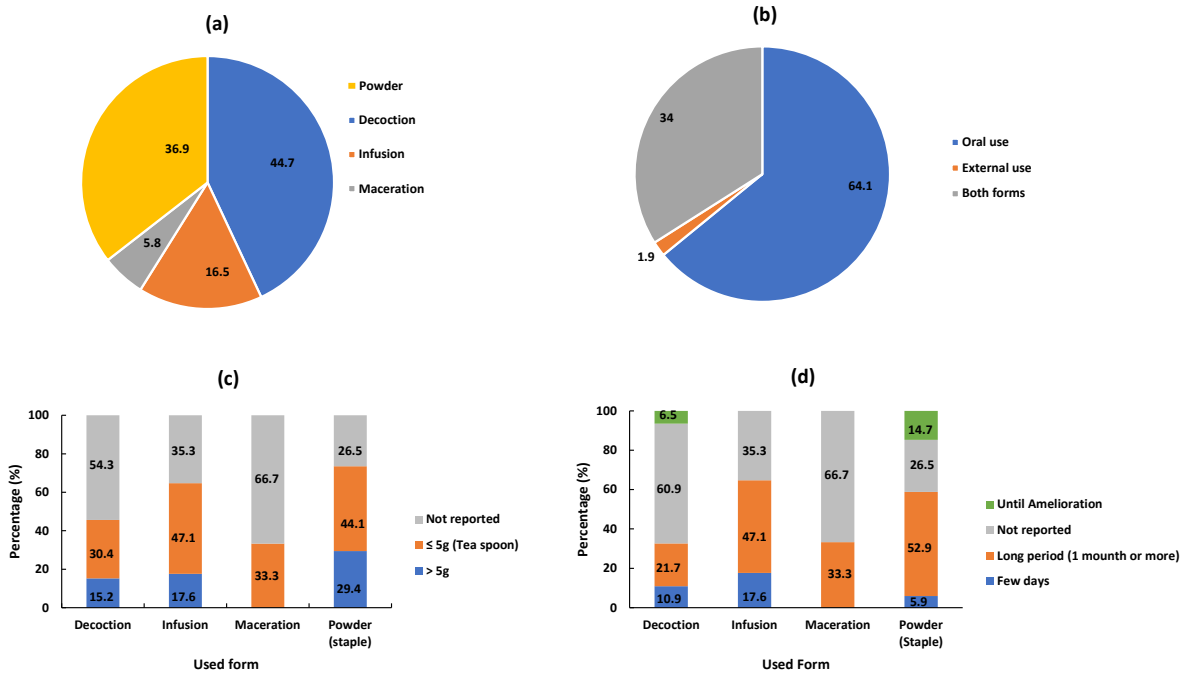

Figure 4. *Punica granatum* peel usage forms, routes, dosage and duration. (a) Traditional preparation forms, (b) administration route, (c) doses and (d)duration according to different forms

Table 2. Dosage and duration of *P. granatum* peel use among respondents

Parameter	Category	Percentage (%)
Dosage	Teaspoon (5 g)	63.6
	10 g	18.2
	> 10 g	9.0
	Not reported	9.2
Duration	3-15 days	67.4
	1 month	23.9
	> 1 month	8.7

Statistical Analysis: Logistic Regression

Cluster-robust logistic regression analysis revealed that disease category and route of administration were significantly associated with the traditional therapeutic use of *P. granatum* peel (Table 3). Compared with dermatological conditions used as the reference category, gastrointestinal disorders exhibited a markedly strong positive association with peel use (OR = 146.84, 95% CI: 27.34-788.62, $p < 0.001$). Infectious and parasitic diseases were also significantly associated with peel use (OR = 7.09, 95% CI: 2.78-18.09, $p < 0.001$), whereas metabolic disorders showed no statistically significant association (OR = 1.17, 95% CI: 0.37-3.65, $p = 0.784$).

No significant relationships were observed between the different preparation forms, including infusion, maceration, and powder, compared with decoction (all $p > 0.15$). Likewise, treatment duration was not significantly associated with therapeutic use patterns (all $p > 0.5$).

Regarding the route of administration, exclusive oral use (OR = 0.061, 95% CI: 0.019-0.201, $p < 0.001$) and exclusive topical use (OR = 0.040, 95% CI: 0.006-0.264, $p < 0.001$) were both significantly associated relative to combined oral and topical administration.

The very large odds ratio observed for gastrointestinal disorders may reflect sparse data structure or partial separation within the regression model and should therefore be interpreted cautiously despite its statistical significance.

Table 3. Cluster-robust logistic regression model showing factors associated with the traditional use of *P. granatum* peel according to disease category (n = 100 informants)

Variable	OR	95% CI	p-value
Intercept	3.33	0.75-14.72	0.103
Disease category (ref. = Dermatological)			
Gastrointestinal	146.84	27.34-788.62	<0.001
Infectious/Parasitic	7.09	2.78-18.09	<0.001
Metabolic	1.17	0.37-3.65	0.784
Form (ref. = Decoction)			
Infusion	0.76	0.31-1.84	0.528
Maceration	2.32	0.71-7.61	0.154
Powder	0.75	0.29-1.92	0.537
Administration (ref. = Both)			
Oral	0.061	0.019-0.201	<0.001
Topical	0.04	0.006-0.264	<0.001
Duration (ref. = Ameliorate/Other)			
Long	0.79	0.25-2.55	0.69
Short	0.66	0.17-2.53	0.535

Perceived efficacy and reported side effects of *P. granatum* peel

Participants generally reported high perceived efficacy of *P. granatum* peel across different disease categories (Fig. 5). Dermatological conditions received the highest efficacy ratings, followed by infectious/parasitic diseases, whereas gastrointestinal and metabolic disorders were mainly described as moderately effective.

The association between disease category and dichotomized efficacy (moderate/excellent versus lower ratings) approached statistical significance (Fisher's exact test, simulated $p = 0.056$). Pairwise comparisons using dermatological conditions as the reference showed a non-significant trend toward higher perceived efficacy for gastrointestinal disorders (OR = 1.77, 95% CI: 0.97-3.26, $p = 0.063$). Infectious/parasitic diseases presented a weaker trend (OR = 1.48, 95% CI: 0.81-2.72, $p = 0.197$), whereas metabolic conditions showed no significant difference (OR = 1.04, 95% CI: 0.56-1.93, $p = 1.000$).

Safety Profile of Pomegranate Peel

The majority of participants (96.2%) reported no adverse effects associated with the traditional use of pomegranate peel, suggesting a favorable perceived safety profile based on self-reported observations. However, these findings remain subjective and do not constitute clinical evidence of safety. Self-reported data obtained through online surveys may be subject to recall bias, reporting bias, and the absence of medical validation, which limits the reliability of safety-related conclusions.

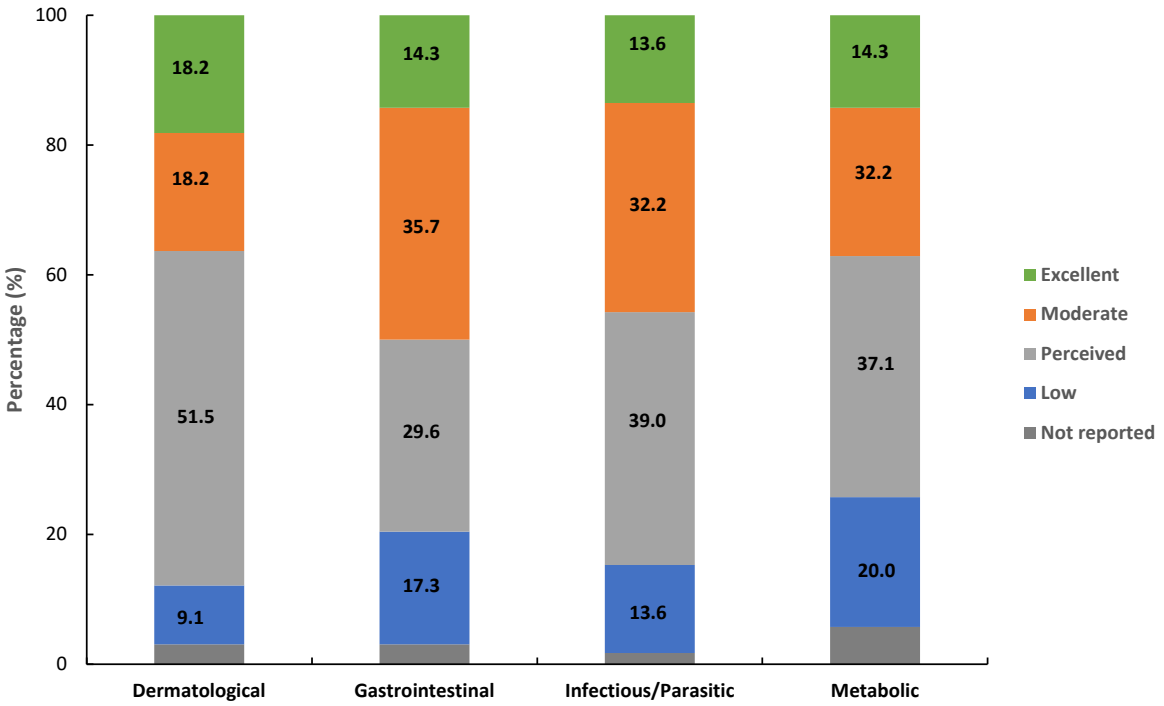

Figure 5. Participants described efficacy of *P. granatum* traditional treatment according to diseases categories.

Discussion

The results of this integrative ethnobotanical survey highlight the enduring cultural significance and therapeutic relevance of *P. granatum* L. peel in contemporary Tunisian traditional medicine. Ethnobotanical indices such as Use Value (UV), Relative Frequency of Citation (RFC), Fidelity Level (FL), and Informant Consensus Factor (ICF) provide quantitative evidence supporting the importance of this medicinal by-product within local healthcare practices.

The interpretation of ICF values in the present study is limited by the single-species design. Since only *P. granatum* peel was investigated, the number of taxa used per disease category was equal to one, resulting in uniformly maximal ICF values. Consequently, this index does not provide a discriminative measure of informant consensus in this context and should therefore not be overinterpreted.

The predominance of female participants observed in this study may reflect the traditionally important role of women in family healthcare practices and medicinal plant knowledge transmission within Tunisian households. Similar observations have been reported in ethnobotanical studies conducted in North African communities (Nouri *et al.* 2025). In addition, the predominance of university-educated respondents (81%) reflects a selection bias associated with online questionnaire distribution, which likely limited participation of rural and less digitally connected populations who may hold richer traditional knowledge. Consequently, the study population may not fully represent traditional knowledge holders, potentially skewing responses toward more educated or modernized interpretations of traditional medicine practices.

The elevated RFC and UV values indicate that *P. granatum* peel is not only widely recognized but also consistently integrated into primary healthcare practices, suggesting a stable transmission of ethnomedicinal knowledge within Tunisian households rather than sporadic or symbolic use. Historically, pomegranate has occupied an important place in Mediterranean civilizations, including Carthaginian, Roman, Arab, Persian, and Ottoman traditional medicinal systems, where different parts of the fruit were commonly used for therapeutic purposes.

The quantitative ethnobotanical analysis revealed that gastrointestinal disorders represented the principal therapeutic category associated with pomegranate peel use. The highest FL values were recorded for stomach ulcer (13.3%) and gastritis (12.7%), indicating a strong community preference for digestive applications. From a phytochemical perspective, these traditional uses are supported by the high concentration of hydrolysable tannins and polyphenolic compounds present in the peel, including punicalagin, punicalin, ellagic acid, and gallic acid derivatives. These compounds exhibit astringent, antioxidant, antimicrobial, and anti-inflammatory activities that may contribute to the protection of gastrointestinal mucosa

and the reduction of intestinal inflammation. Tannins are known to form protective complexes with mucosal proteins, thereby reducing intestinal secretion and limiting microbial proliferation.

The therapeutic importance of pomegranate peel in gastrointestinal disorders has also been reported in several traditional medical systems worldwide. The 2020 edition of the Pharmacopoeia of Traditional Medicine of the People's Republic of China describes pomegranate peel as an antidiarrheal, hemostatic, astringent, and anthelmintic agent. Similarly, Persian and Tibetan medicine traditionally employ the peel for the treatment of diarrhea, stomach pain, and intermittent fever (Boullard, 2001). In Egypt, pomegranate peel has historically been used as a vermifuge, tonic, and remedy for dysentery and gastrointestinal infections (Bayou *et al.* 2020).

In addition to digestive disorders, the present study identified diabetes mellitus as one of the frequently cited metabolic conditions associated with pomegranate peel use (UV = 0.30; FL = 6.1%). This observation is supported by previous pharmacological studies demonstrating that pomegranate polyphenols, particularly punicalagin and ellagic acid, may contribute to glycemic regulation through α-glucosidase inhibition, improvement of insulin sensitivity, and reduction of oxidative stress associated with diabetic complications.

While the ethnomedicinal importance of pomegranate peel is well documented in Asian and Mediterranean medicine, the present study also contributes to expanding knowledge concerning its use in North African traditional healthcare systems. In sub-Saharan Africa, particularly in East and South African traditional medicine, pomegranate rind is commonly used as an antiparasitic, anthelmintic, and antidiarrheal remedy.

In Europe, historical herbal medicine records indicate that dried pomegranate peel was traditionally used as an astringent gargle for aphthous ulcers and throat infections, as well as a topical preparation for dermatological lesions. In the Americas, pomegranate peel has progressively been integrated into traditional and complementary medicine for the management of respiratory inflammation and wound healing. More recently, its high antioxidant activity has promoted its incorporation into nutraceutical, pharmaceutical, cosmetic, and functional food industries as a natural preservative and bioactive ingredient.

The preparation methods documented in this study, particularly decoction and powder formulation, may contribute to maximizing the extraction of bioactive compounds from the peel. The predominance of decoction observed in this study is consistent with previous ethnobotanical investigations, where hot aqueous extraction is traditionally preferred for improving the recovery of tannins and polar phenolic compounds from medicinal plants. Similar findings were reported by Ali et al. (2017), who observed frequent use of pomegranate peel powder in traditional remedies. Sanaa (2013) also demonstrated the beneficial effects of pomegranate peel powder in the management of gastric and intestinal ulcers.

The predominance of oral administration observed in the present study is consistent with the primary use of pomegranate peel for gastrointestinal and metabolic disorders. Previous ethnobotanical investigations conducted in Tunisia and neighboring North African regions similarly reported the frequent use of aqueous preparations administered orally for digestive ailments (Jedidi *et al.* 2018; Hassaïne *et al.* 2019; Hamrouni *et al.* 2026).

Pomegranate peel has traditionally been recognized for its astringent and vermifuge properties. Decoctions and powders are commonly used for dysentery, diarrhea, stomatitis, and inflammatory digestive conditions, and may be administered orally or used as mouthwashes and topical preparations (Lansky *et al.* 2000).

The logistic regression analysis highlighted the influence of disease category and administration route on traditional therapeutic use. Although no significant association was observed between preparation form and disease category, gastrointestinal and infectious/parasitic disorders remained the most strongly associated conditions with pomegranate peel use. The stronger reliance on traditional knowledge among older participants suggests intergenerational accumulation of ethnomedicinal experience, highlighting the importance of oral transmission in preserving traditional healthcare practices. The very large odds ratio observed for gastrointestinal disorders may reflect sparse data or partial separation and therefore should be interpreted cautiously despite statistical significance.

The high perceived efficacy reported by respondents was accompanied by a strong perception of safety, with the majority of participants reporting no adverse effects associated with traditional peel use. However, because these observations are based on self-reported perceptions, they should be interpreted cautiously. These findings are based on self-reported perceptions and are subject to recall and social desirability bias; therefore, they cannot be interpreted as clinical evidence

of safety**.** Previous toxicological studies demonstrated that pomegranate extracts are generally safe at therapeutic doses, whereas excessive or prolonged exposure to highly concentrated tannin-rich extracts may induce gastric irritation or hepatic stress (Vidal *et al.* 2003; Mehru *et al.* 2008; Jahromi *et al.* 2015). Additional studies further classified ethanolic peel extracts as non-toxic in experimental toxicity assays (Wibowo *et al.* 2018). More recent investigations have also reported selective cytotoxic effects of pomegranate peel extracts against cancer cells while preserving normal cells (Bakhti *et al.* 2024). However, these in vitro effects were observed at high concentrations and cannot be directly extrapolated to traditional therapeutic doses used in ethnomedicine.

Overall, the present findings support the important ethnomedicinal value of *P. granatum* peel in Tunisian traditional medicine and reinforce its potential as a promising source of bioactive compounds for future pharmaceutical, nutraceutical, and functional applications.

Conclusion

Punica granatum peel represents an important natural resource widely used in Tunisian traditional medicine. The present study highlights its high cultural relevance and broad spectrum of reported therapeutic applications, particularly for gastrointestinal and infectious conditions.

The integration of ethnobotanical knowledge with quantitative indices, especially RFC and UV, supports the traditional importance of pomegranate peel and reinforces growing scientific interest in its pharmacological potential. High FL values associated with gastrointestinal disorders suggest that future investigations should prioritize bioactive compounds such as punicalagin, ellagic acid, tannins, and related polyphenols, which are known to exhibit anti-inflammatory, antimicrobial, antioxidant, and gastroprotective properties. These compounds should be further investigated particularly in relation to gastrointestinal diseases such as diarrhea, gastric ulcers, intestinal inflammation, and microbial infections, which showed the highest ethnomedicinal relevance in this study.

Nevertheless, the findings should be interpreted in light of important methodological limitations, including the online-only recruitment strategy, which may have excluded older and rural populations, the predominance of highly educated respondents, and the limited interpretability of ICF values in a single-species ethnobotanical design, where consensus metrics may be artificially inflated and not fully informative.

Further pharmacological, toxicological, and clinical investigations are necessary to validate the therapeutic potential, efficacy, and safety of *P. granatum* peel and to support its integration into evidence-based pharmaceutical, nutraceutical, and functional food applications.

Declarations

Ethics approval and consent to participate:
Verbal informed consent was obtained from all participants prior to data collection. Participation was voluntary and anonymous.
Consent for publication: Not applicable
Availability of data and materials: Not applicable
Competing interests: Not applicable
Funding: Not applicable
Author contributions: Bennour Nedra; Chaibni A; M'Rabet Y; Tabouii M: Conceptualization, data curation, investigation, software, writing - original draft.; 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.

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