Contemporary ethnobotany of *Opuntia ficus-indica* in Algeria: perceptions, practices, and trust across sociodemographic groups

Amina Bouras, Rym Aissaoui, Fares Hamoud, Youssouf Driouche, Amina Dridi, Ali Becheker, Meriem Ferfar, Abderachid Slimani, Zihad Bouslama

Correspondence

Amina Bouras[1], Rym Aissaoui[1,2], Fares Hamoud[2*], Youssouf Driouche[2], Amina Dridi[2], Ali Becheker[2], Meriem Ferfar[2], Abderachid Slimani[3], Zihad Bouslama[2]

[1]Laboratory of Ecology of Terrestrial and Aquatic Systems (EcoSTAq), Department of Biology, Faculty of Sciences, Badji Mokhtar University, BP. 12, 23005 Annaba, Algeria.
[2]Environmental Research Centre (CRE), Alzon, 23000, Annaba, Algeria.
[3]Department of Biology, Faculty of Sciences, Badji Mokhtar University, BP. 12, 23005 Annaba, Algeria

*Corresponding Author: fares_hamoud26@yahoo.fr; f.hamoud@cre.dz

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Research

Abstract

Background: The aim of this study was to document the ethnobotanical uses and perceptions of *Opuntia ficus-indica* (prickly pear) in Algeria, a country where traditional knowledge of this multipurpose plant remains underexplored despite its ecological and economic significance.

Methods: Ethnobotanical data were collected from 525 respondents via a structured, anonymous online questionnaire between May and July 2023. The survey covered sociodemographic profiles, plant parts used, forms and frequency of use, sources of acquisition, preparation methods, perceived benefits, and adverse effects. Data analysis included descriptive statistics, chi-square tests, Cramer's V, and network analysis, performed using RStudio (v4.2.2) with the igraph, ggraph, and tidygraph packages).

Results: The study revealed that women, university-educated individuals, and younger age groups (18-35) were the primary users of *Opuntia ficus-indica*. The fruit was the most used part, followed by seeds and cladodes. Uses ranged from cosmetics and food to herbal remedies. Modern processed forms (e.g., oils, capsules) were preferred by educated users, while traditional preparations remained popular among older adults. Strong associations were found between usage patterns and variables such as age, gender, education, and profession. Network analysis confirmed key relationships between plant use, form, frequency, and expected effects.

Conclusions: This study highlights the rich and dynamic role of *Opuntia ficus-indica* in Algerian ethnobotanical practices. It underlines the influence of sociodemographic factors on knowledge and use patterns and supports future strategies for sustainable development, health promotion, and cultural preservation involving this species.

Keywords: *Opuntia ficus-indica*; Prickly pear; Ethnobotany; Algeria; Sociodemographic factors; Traditional knowledge

Background

Ethnobotany, as an interdisciplinary field bridging anthropology, botany, and pharmacology, seeks to document and analyze traditional plant knowledge within cultural contexts. This knowledge serves as a vital resource for sustainable agriculture, biodiversity conservation, and phytotherapy (Moshobane *et al.* 2022, Patti *et al.* 2025). However, the erosion of traditional knowledge systems, driven by modernization, urbanization, and changing lifestyles, has raised concerns among researchers and conservationists (Tesfay *et al.* 2020).

Algeria, situated within the Mediterranean basin, a recognized biodiversity hotspot, encompasses a remarkable range of bioclimatic zones, from humid coastal areas to arid Saharan landscapes. This ecological variability contributes to the country's rich ethnobotanical traditions, particularly in rural and semi-urban communities where plant-based knowledge is integrated into daily life and healthcare practices (Adli *et al.* 2017, Adli *et al.* 2019, Samir *et al.* 2023).

Among the culturally and economically important species in Algeria, *Opuntia ficus-indica* (L.) Mill. (Cactaceae), commonly known as prickly pear, occupies a prominent position. Valued for its drought tolerance and ability to thrive in marginal soils, the plant plays a significant role in erosion control, livestock fodder, and dryland agriculture (Neffar *et al.* 2014, Samir *et al.* 2023). It also holds considerable therapeutic value, attributed to its rich phytochemical profile, including flavonoids, polyphenols, and mucilage compounds, which have been associated with antioxidant, anti-inflammatory, and antidiabetic properties (Benramdane 2022, Bouaouich *et al.* 2023, Chougui *et al.* 2013a, 2013b, Zeghbib *et al.* 2024).

Traditionally, various parts of *Opuntia ficus-indica* are used to treat a wide range of conditions, including digestive disturbances, skin inflammation, and blood sugar imbalances. These practices are often rooted in oral transmission and community-specific experiences, reflecting a blend of empirical efficacy and cultural belief (Barache *et al.* 2020, Moshobane *et al.* 2022, Patti *et al.* 2025).

In recent years, the plant's applications have expanded into commercial domains, with growing interest in nutraceutical, cosmetic, and pharmaceutical industries (Bouaouich *et al.* 2023, Patti *et al.* 2025). However, the shift from informal household use to industrial processing introduces challenges regarding standardization, safety perception, and the potential marginalization of traditional knowledge holders (Patti *et al.* 2025, Tesfay *et al.* 2020).

In Algeria, despite its ecological abundance and widespread use, *Opuntia ficus-indica* remains under documented in terms of sociocultural perception, usage patterns, and consumer trust dynamics. This gap underscores the need for updated, multidimensional ethnobotanical assessments that reflect not only biological aspects, but also how demographic factors such as age, gender, education, and profession influence plant use, knowledge transfer, and market behavior (Moshobane *et al.* 2022, Patti *et al.* 2025, Tesfay *et al.* 2020).

This study seeks to address that gap by analyzing how *Opuntia ficus-indica* is perceived and utilized across Algerian society, with particular attention to form of use, sourcing behavior, risk perception, and sociodemographic determinants. Through a combination of descriptive statistics, chi-square association tests, and network-based visual analysis, we aim to map the evolving relationships between traditional plant use and contemporary health, trust, and sustainability frameworks.

Materials and Methods

Study area

Algeria is the largest country in Africa, spanning a wide range of ecological zones from Mediterranean coastal plains to the arid Sahara Desert. Its diverse bioclimatic zones, including humid, semi-arid, arid, and hyper-arid regions, contribute to the richness of ethnobotanical knowledge across its 58 wilayas (provinces) (Benchohra *et al.* 2025, Brahmi *et al.* 2023, Gherairia *et al.* 2025, Meddour *et al.* 2022). The current study covered respondents from across the national territory, including both rural and urban populations

Study Design and Data Collection

A structured, anonymous online survey using non-probability sampling was conducted between May and July 2023 to investigate the ethnobotanical uses and sociocultural perceptions of *Opuntia ficus-indica* across Algeria (Vehovar *et al.* 2016, Wardropper *et al.* 2021) The questionnaire combined closed and semi-open questions and was organized into two main sections: (i) sociodemographic information (including gender, age, marital status, education level, profession, and wilaya (province), and (ii) 17 thematic questions addressing traditional knowledge, plant parts used, forms and frequency of use,

sources of acquisition, preparation methods, perceived therapeutic benefits, and reported adverse effects. To ensure that respondents correctly referred to *Opuntia ficus-indica*, the questionnaire included photos of the plant, showing the hole plant, cladodes, flowers, and fruits.

The survey was disseminated via digital platforms, including Google Forms and Facebook, to maximize both geographic and demographic reach. (Banisetti & Kosuri 2023, De Meyer & Ceuterick 2022)

Descriptive statistics were used to summarize the main patterns of use and socio-demographic distribution. Associations between variables were assessed using Chi-square (χ^2) tests to evaluate relationships such as gender and form of use, education level and frequency of use, and source of supply and type of preparation. The statistical strength of associations was interpreted using both p-values and Cramer's V, to ensure that statistically significant results also held practical relevance. To visualize significance patterns, p-values were transformed into $-\log_{10}(p)$, and plotted as heatmaps, highlighting the most notable associations.

To explore the multidimensional interconnections among variables, we conducted a network analysis using R (v4.2.2) in RStudio (R Core Team 2022, RStudio Team 2022), employing the igraph package (Csardi & Nepusz 2006), as well as ggraph (Pedersen 2023a) and tidygraph (Pedersen 2023b).

Networks were constructed such that edges represented co-reporting of variables by individual respondents (e.g., linking a preparation method to a form of knowledge or a user demographic). We calculated key centrality metrics, including degree (to indicate the most connected forms or practices) and betweenness (to identify bridging variables between subgroups), to characterize the structure of usage and knowledge flows. Similar network-based approaches have been applied in ethnobotanical and socio-anthropological studies (Haselmair *et al.* 2014, Lee *et al.* 2021, Marsandi *et al.* 2025) supporting their relevance for analyzing complex decision-making patterns.

Finally, thematic cartographic visualizations were developed to illustrate the geographic distribution of respondents and vernacular names for *Opuntia ficus-indica* across Algerian regions. These maps highlight regional differences in naming practices and usage behaviors, providing a spatial layer to the ethnobotanical diversity observed.

Results and Discussion

Geographic and vernacular distribution

The geographic distribution of respondents (Figure 1) showed a higher concentration in northern Algerian provinces, particularly in urban centers. Out of 525 respondents, 78% were in the northern regions. reflects disparities in access, infrastructure, and healthcare alternatives It also highlights the importance of regional economic development and population density in shaping accessibility to plant-based knowledge and products (Soemarwoto & Iskandar 2021)

Figure 1 revealed 6 distinct vernacular names for *Opuntia ficus-indica*, with "El Hendi" and "Akarmouss" being the most cited. These linguistic variations encode local knowledge and cultural perception of the plant, supporting ethnolinguistic diversity documented in Algerian flora (Patti *et al.* 2025). Differences in naming can reflect not only geographic dialects but also distinctions in fruit color, spination, or medicinal effects (Geertsma *et al.* 2021, Rimlinger *et al.* 2021). Such variations are critical for preserving oral traditions and local taxonomies (Engel 2022).

Figure 2 showed that 68.5% of respondents were female (n = 359), and 61.9% were aged between 18-35 years. Furthermore, 62% had university-level education. This demographic profile suggests that women and young adults are key guardians of ethnobotanical knowledge *(*Belhacini *et al.* 2024*,* Gherib *et al.* 2024*)*. Finally, the marital status of respondents reveals a predominance of single individuals over married ones, highlighting a strong representation of unmarried participants in the studied sample.

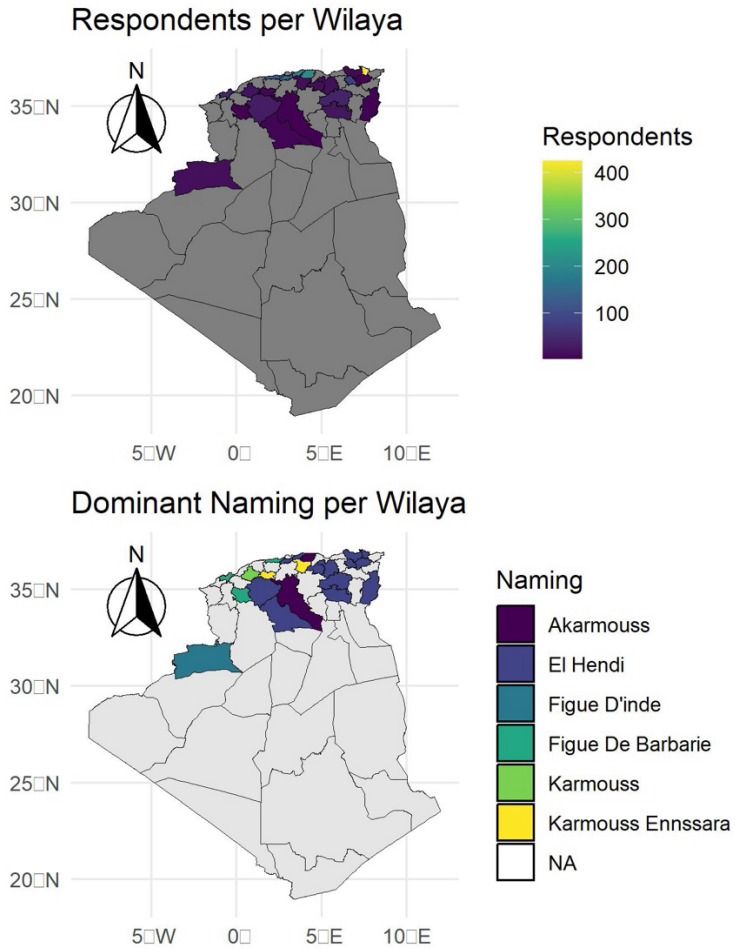

Figure 1. Geographic distribution of respondents and vernacular names of *Opuntia ficus-indica* in Algeria

Sociodemographic determinants of plant use

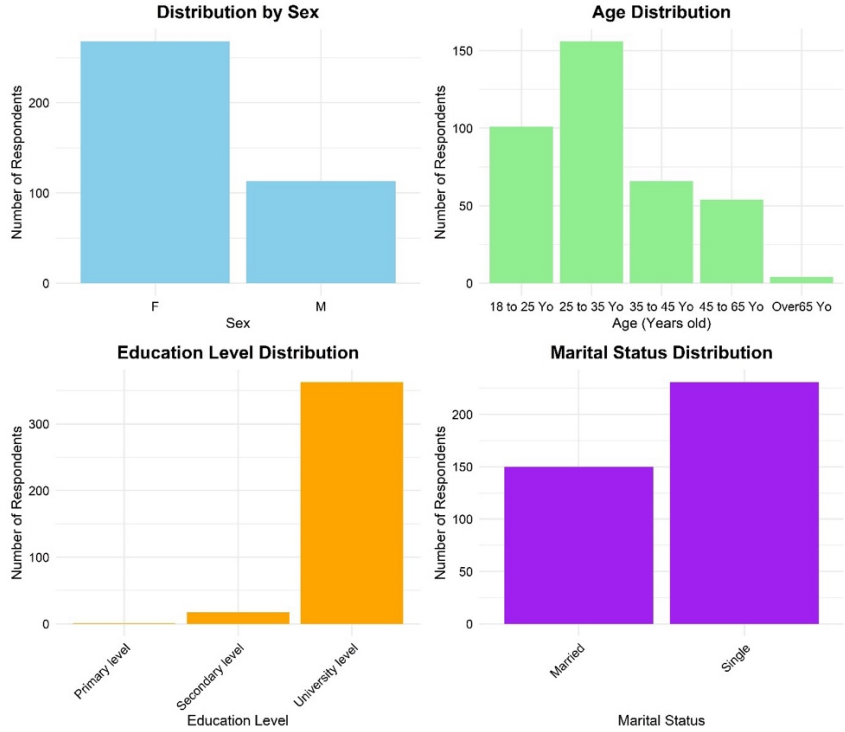

Figure 2. Sociodemographic distribution of respondents by sex, age, education level, and marital status.

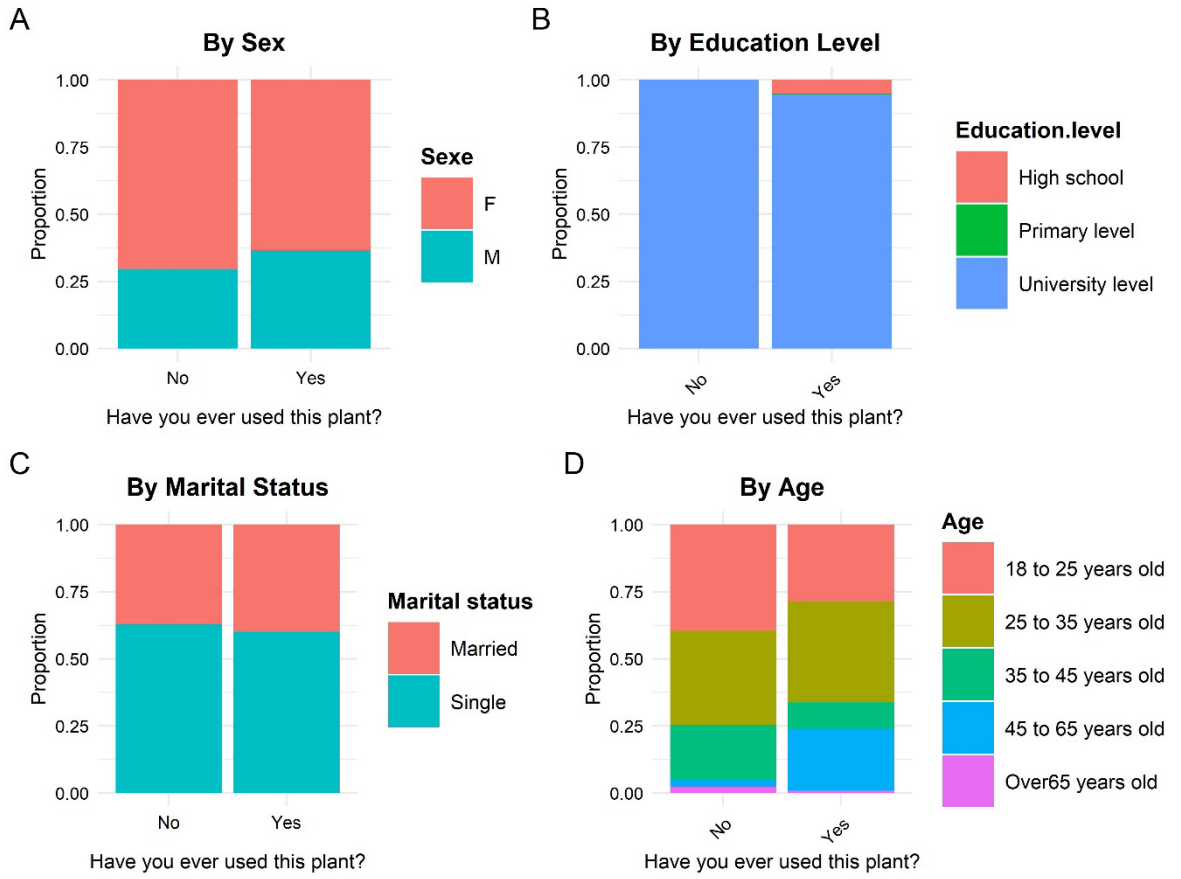

Figure 3. Proportion of *Opuntia ficus-indica* users and non-users across sociodemographic groups.

Figure 3 highlights distinct patterns in *Opuntia ficus-indica* use across sociodemographic groups, with a statistically significant association between education level and plant usage ($\chi^2 = 17.3$, $p < 0.001$). University-educated individuals reported the highest usage rates, underscoring the influence of formal education on ethnobotanical engagement. This aligns with previous findings in Algeria, where higher education has been shown to enhance both awareness and valuation of medicinal flora *(*Belhacini *et al. 2024,* Gherib *et al. 2024).*

Gender distribution also revealed a consistent predominance of women among both users and non-users, while usage remained most frequent among young adults aged 18-35. Marital status analysis indicated that single individuals were slightly more represented among users. These results collectively position young, educated women as key agents in the ongoing transmission and practice of *O. ficus-indica* use in contemporary settings.

Usage forms and preparation practices of prickly pear

Figure 5 presents the various usage forms of *Opuntia ficus-indica* across sociodemographic groups. A significant proportion of women (84%) reported using the plant for cosmetic purposes, while 78% of men cited food and herbal teas as their main forms of use. These gender-based differences were statistically significant ($\chi^2 = 13.6$, $p = 0.002$). Younger individuals aged 18 to 35 were dominant in cosmetic and dietary supplement uses (69%), likely influenced by social media trends and online marketing platforms (Kaesti *et al.* 2023). In contrast, respondents over the age of 45 favored herbal teas and essential oils (56%), consistent with practices associated with the management of chronic conditions and traditional health knowledge (Gardiner *et al.*, 2007). Across all usage forms, university-educated participants represented the overwhelming majority, suggesting a strong link between educational attainment and engagement with diverse plant-based applications.

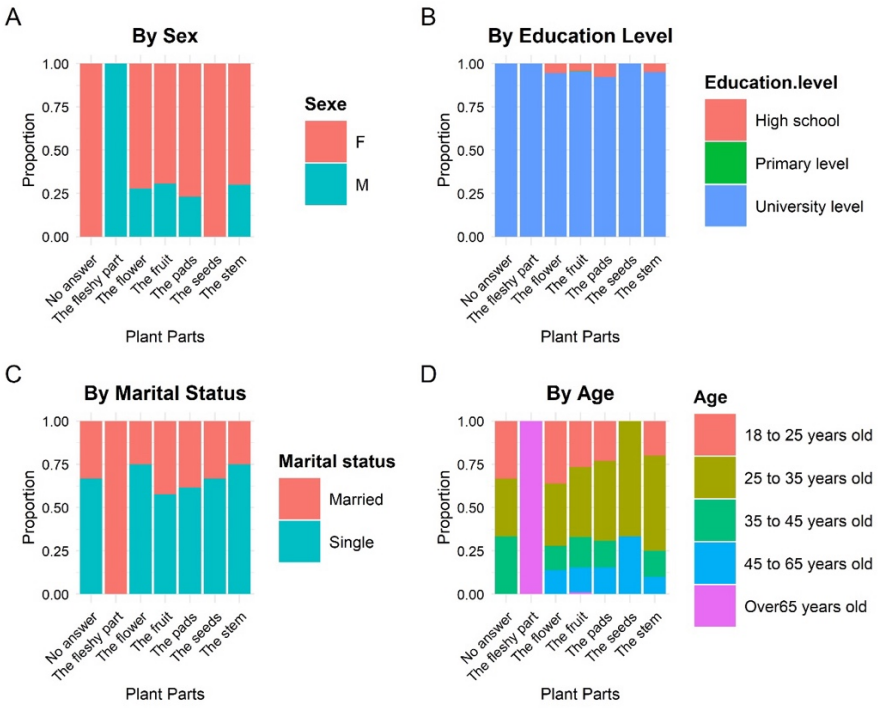

Figure 4. Reported use of different *Opuntia ficus-indica* plant parts across sociodemographic groups

Figure 4 presents the use of different parts of *Opuntia ficus-indica* across sociodemographic groups. The fruit was by far the most commonly used part (92%), followed by the seeds (64%) and the cladodes or pads (49%). Women were significantly more likely to use all parts of the plant compared to men ($\chi^2 = 14.8$, $p = 0.003$), with female respondents consistently representing over two-thirds of users across all categories. Single individuals reported higher usage of key parts, particularly the fruit, seeds, and pads, compared to their married counterparts. University-educated participants showed the highest usage rates in every category and reported engagement with a wider range of plant parts, including flowers and stems. This pattern likely reflects greater phytotherapeutic literacy and enhanced access to information through formal education and media networks (Gardiner *et al.*, 2007). Additionally, the 18-35 age group accounted for the majority of reported usage, emphasizing its central role in the contemporary transmission and application of knowledge related to *O. ficus-indica*.

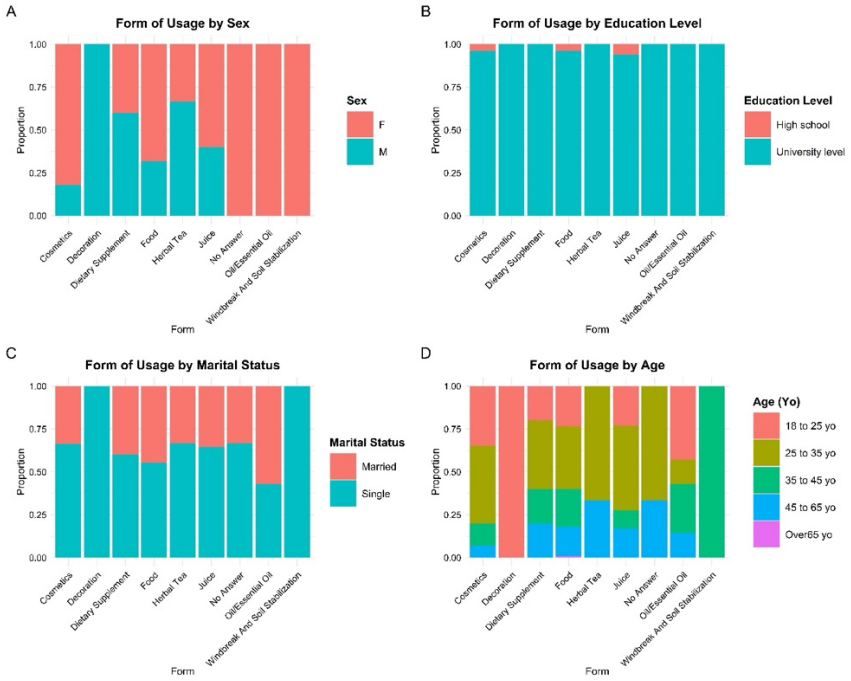

Figure 5. Distribution of cosmetic, dietary, and medicinal uses of *Opuntia ficus-indica* by sociodemographic factors.

The delivery of these diverse applications depends on the form in which the plant is used. According to the data, 72% of respondents used prickly pear in its natural state, while 28% preferred ready-to-use products. Women constituted 75% of users in both categories. Education level was significantly associated with the usage form ($\chi^2 = 10.9$, $p = 0.001$), with university graduates showing a stronger preference for commercial formats such as oils, capsules, and creams (Figure 6). This trend may be linked to perceptions of standardization, convenience, and safety, which increasingly shape consumer behavior in urban herbal health markets. (Suryaningrum *et al.* 2024).

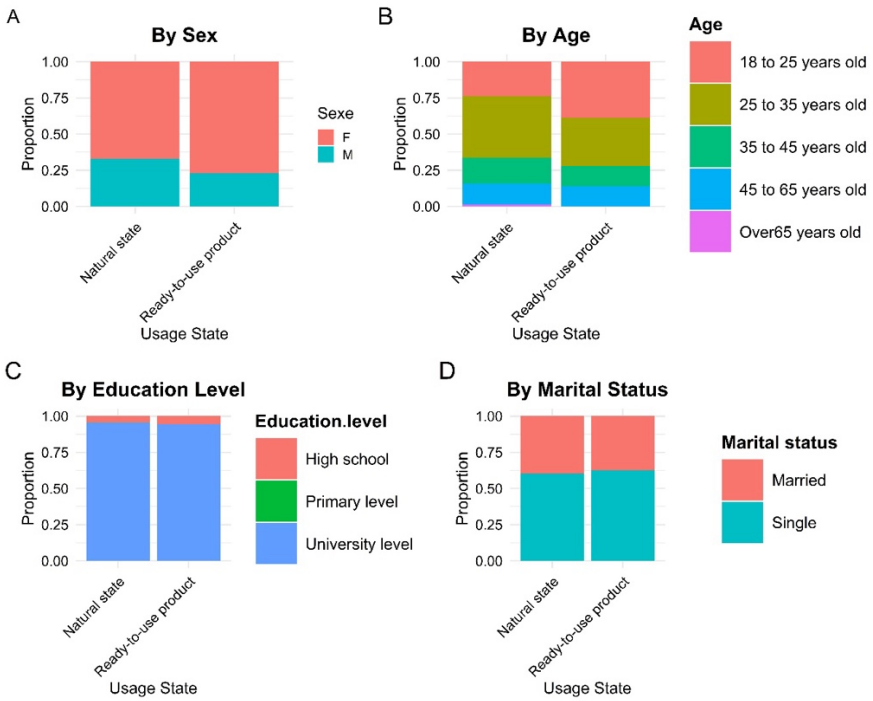

Figure 6. Distribution of natural vs. processed forms of *opuntia ficus-indica* use by sociodemographic factors.

At the level of preparation, women dominated decoctions and maceration-based methods ($\chi^2 = 11.1$, $p = 0.005$), often associated with traditional medicinal practices passed through generations (Belhouala & Benarba 2021). University-educated respondents preferred modern delivery systems such as encapsulated oils and cosmetic emulsions (Figure 7). The statistical significance of education level ($p < 0.01$) reinforces the view that formal knowledge complements traditional know-how in determining technique selection (Rani *et al.* 2023)

As shown in Figure 8, 60% of respondents sourced products from pharmacies or parapharmacies, with 52% of university-educated users preferring regulated vendors. This reflects a broader transition toward the formalization of herbal medicine, where trust in safety and standardization is increasingly shaping consumer behavior (Suryaningrum *et al.* 2024)

Chi-square analysis confirmed strong associations between education and sourcing method ($\chi^2 = 18.7$, $p < 0.001$, Cramer's V = 0.36). In contrast, men and older adults were more likely to rely on traditional sources such as nature, family gardens, or informal vendors ($\chi^2 = 12.2$, $p = 0.004$).

Figures 9 further detailed these procurement strategies. Pharmacies accounted for 41% of purchases, local markets 29%, and online platforms 15%. Younger and single respondents were more inclined toward modern outlets ($p = 0.007$), likely due to convenience, marketing exposure, and limited access to land or gardens (Kaesti *et al.* 2024, Kunwar *et al.* 2016)

Married respondents prioritized local markets and personal or familial plantations, reflecting greater integration with domestic provisioning and long-term familiarity with the plant through household networks. These patterns suggest that sourcing behaviors are not only shaped by market trends but also by life stage, household structure, and resource access, which together define how individuals interact with both traditional and formal supply chains (Brahmi *et al.* 2023)

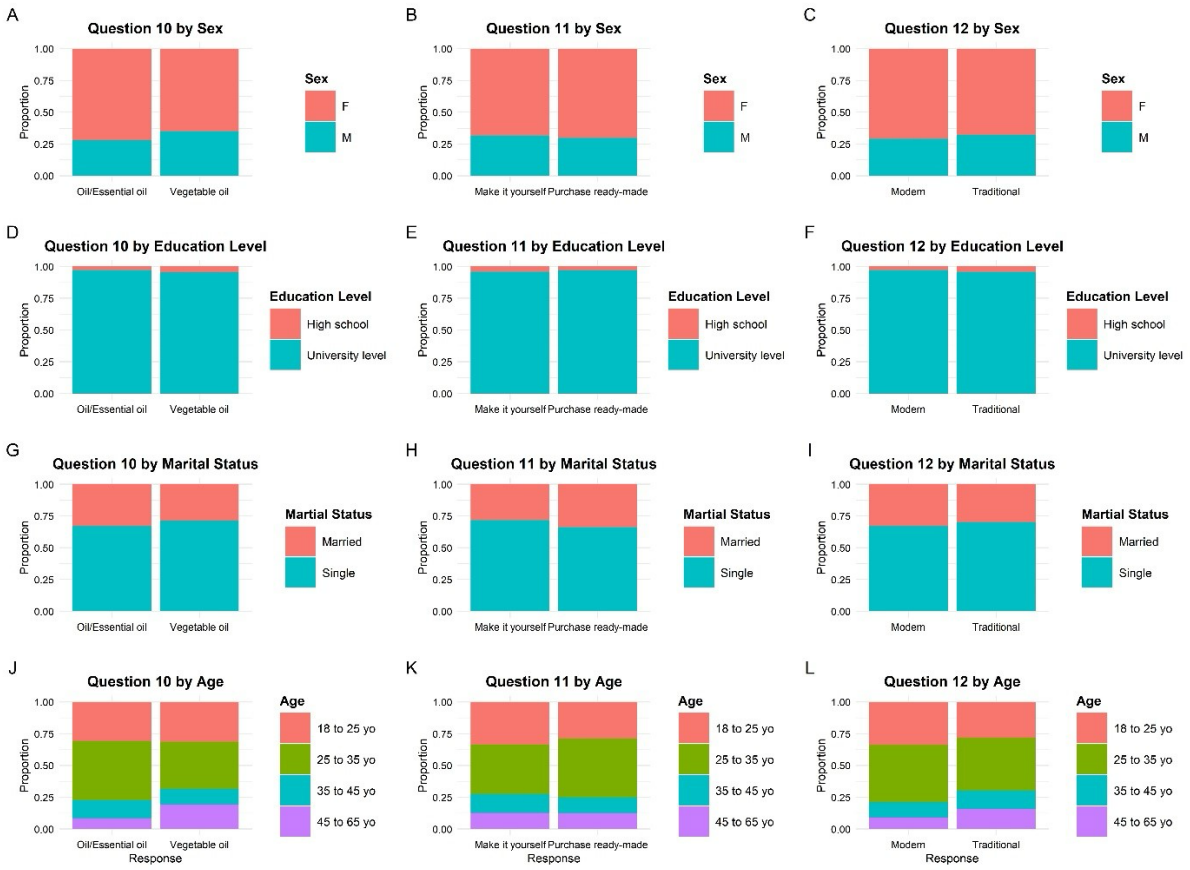

Figure 7. Preparation methods of *Opuntia ficus-indica* (e.g., decoction, encapsulation) by sociodemographic group.

Figure 8. Sources of plants and products across sociodemographic factors.

Perceived benefits and risks

According to Figure 10, 72% of women reported awareness of anti-inflammatory properties, compared to 58% of men. University graduates cited antidiabetic effects in 67% of responses. These findings reflect both empirical experience and exposure to health information channels (Kelutur *et al.* 2025). Notably, 15% of all respondents reported side effects, primarily digestive (e.g., bloating, diarrhea, abdominal discomfort). Risk perception was significantly influenced by age and education ($p < 0.01$), with younger and less-educated individuals showing greater caution in adopting the *Opuntia* products (Kashif *et al.* 2022). This trend may reflect differing levels of phytotherapeutic literacy and differential exposure to risk communication about natural products.

The intersection between perceived benefit and perceived risk underscores the complex cognitive framing surrounding traditional plant use, particularly as it transitions into formalized health contexts. These findings point to the importance of integrating both efficacy claims and safety literacy in herbal medicine promotion strategies, especially for commercially distributed forms.

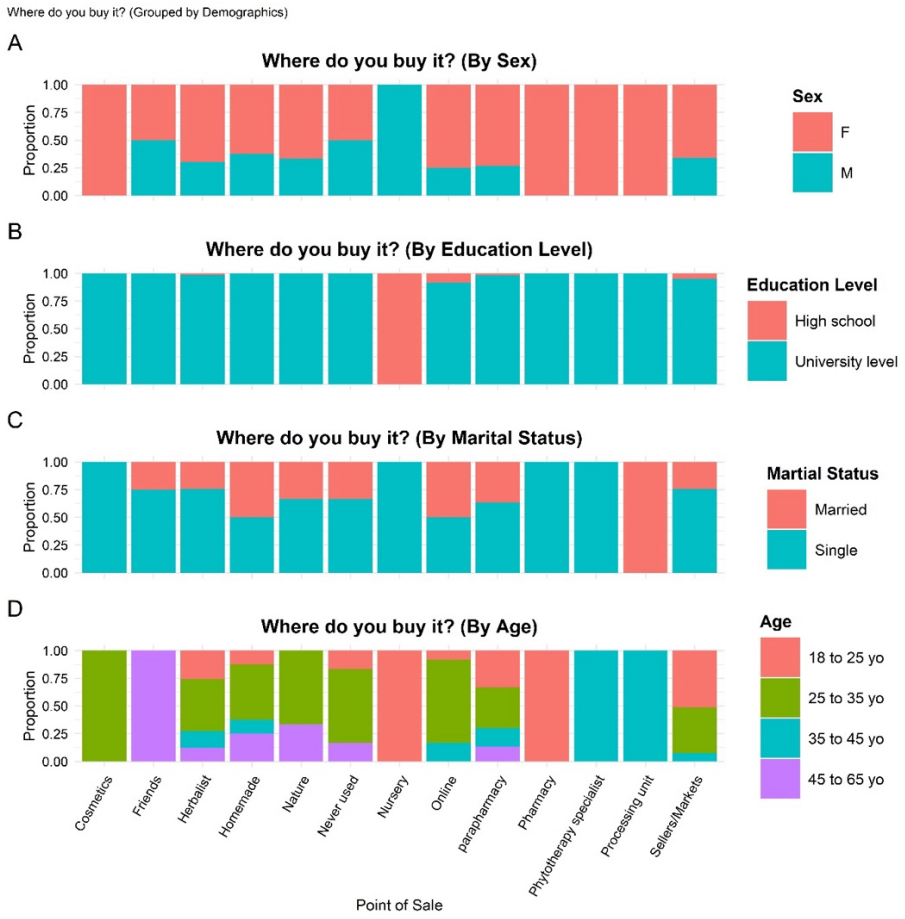

Figure 9. Preferred Purchase Locations for *Opuntia ficus-indica* by Demographic Group

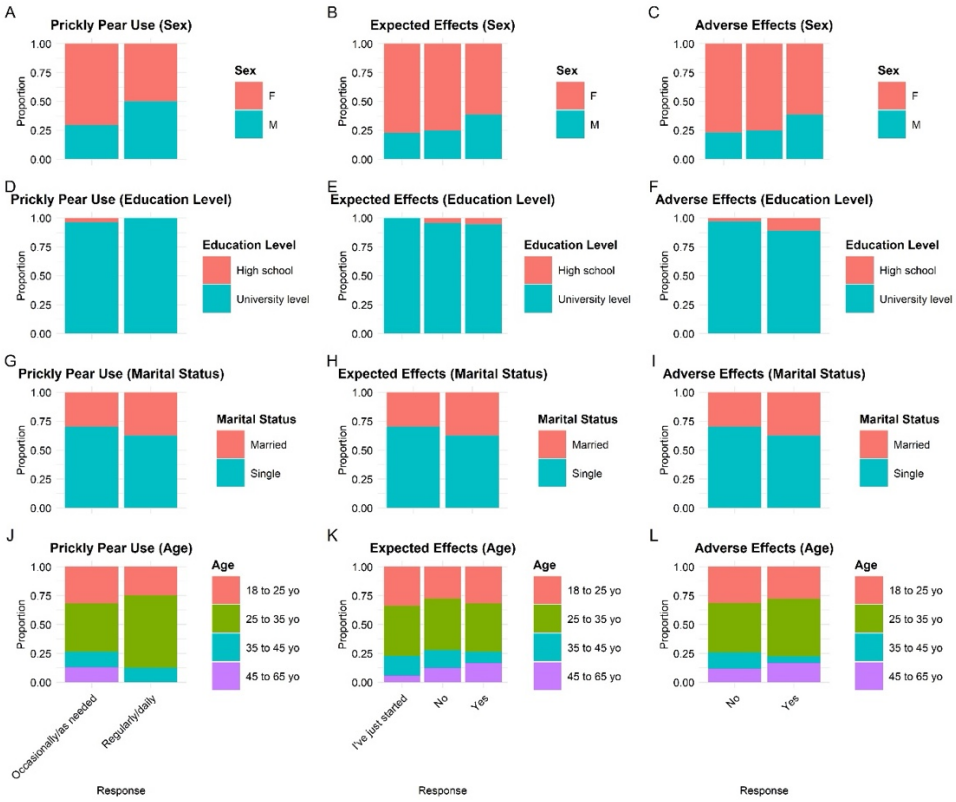

Figure 10. Perceived benefits and side effects of *Opuntia ficus-indica* use by sociodemographic group.

Profession and consumption behaviors

Figure 11 displays profession-based distributions among respondents: biologists (n = 31), students (n = 22), and teachers (n = 19) were the most represented, indicating strong participation from scientific and educational sectors. These groups demonstrated both high usage rates and a broad range of applications, including medicinal, dietary, and cosmetic forms ([Reference on (Nolan 2001).Farmers, while fewer in number (n = 12), contributed key qualitative insights into traditional cultivation cycles, particularly highlighting practices aligned with dry-season fruiting and intercropping in arid zones (Patti *et al.*, 2025).

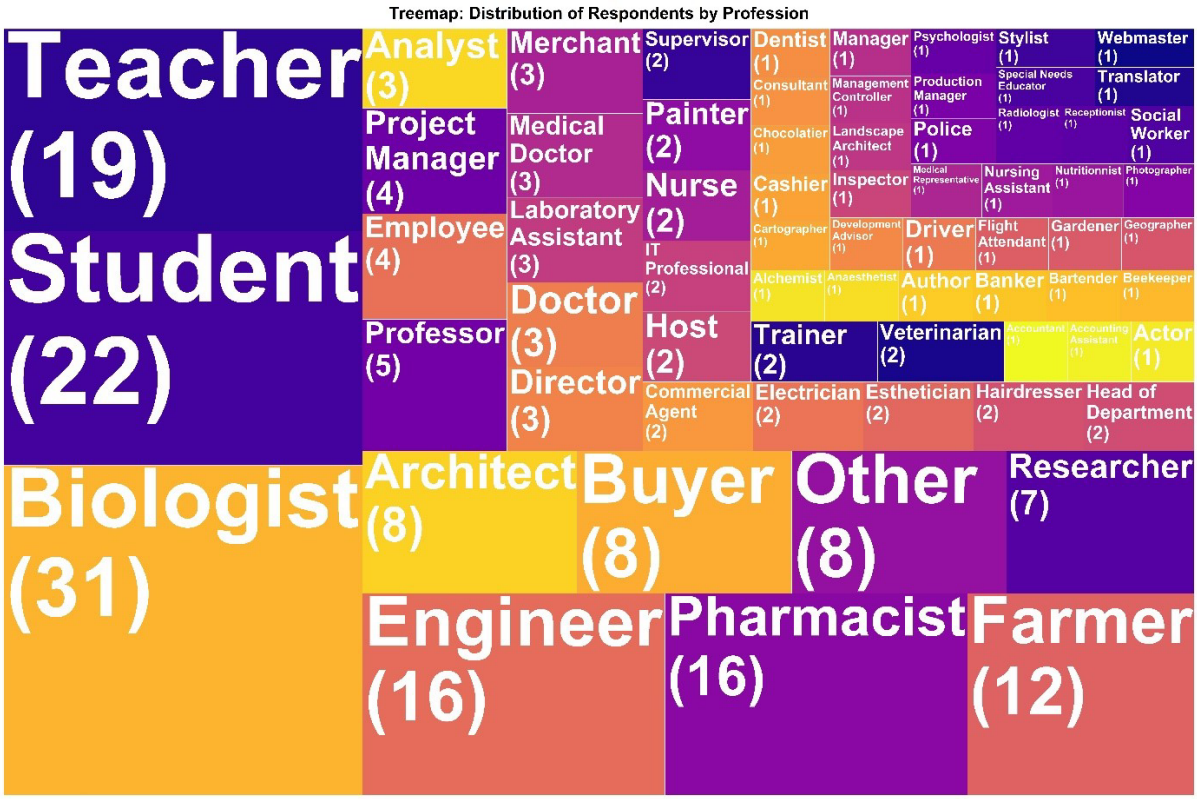

Figure 11. Distribution of *Opuntia ficus-indica* usage across professions.

Figure 12 illustrates profession-specific preferences for form of use. Teachers, analysts, and students showed strong connections to the use of prickly pear in its natural state, reflecting traditional engagement and ecological familiarity (Angmo *et al.* 2024). In contrast, ready-to-use products were more commonly favored by engineers, employees, and researchers (62%), suggesting time-constrained lifestyles and higher access to commercial health outlets. Notably, analysts and multidisciplinary researchers emerged as bridging profiles, combining traditional and modern practices — a role aligned with knowledge integration and public health dissemination in evolving phytotherapeutic systems (Davis & Choisy 2024).

To visually trace the influence of demographic variables on plant use preferences, a Sankey diagram was employed. The Sankey diagram in Figure 13 provides a comprehensive visualization of how these factors interact to shape the overall pathways leading to the use of *Opuntia ficus-indica* in either natural or ready-to-use form. The Sankey diagram presents a comprehensive overview of the demographic distribution and product preferences of the surveyed population. It reveals a significant dominance of females over males in the sample, with most individuals having a university-level education. Only a small minority, particularly males, had attained only a high school education. The largest age group represented is 18 to 25 years, followed by 25 to 35 years, both predominantly single and highly educated. These two younger groups primarily prefer products in their natural state, suggesting a trend among youth toward traditional, unprocessed alternatives that are prepared or used at home without industrial processing. As age increases, particularly among the 35 to 45 and 45 to 65 age groups, there is a noticeable shift toward married status and a corresponding preference for ready-to-use products, reflecting changes in lifestyle and time availability. The transition from natural to processed product use appears linked not only to age and marital status but also to the reduction in university-level education observed in older groups, possibly indicating generational differences in educational attainment and consumer behavior, (Fondevila-Gascón *et al.* 2022, Saulais *et al.* 2023). Moreover, the strong representation of single university-educated young females aligning with natural product

use may also reflect emerging trends influenced by health consciousness, environmental concerns, or social norms (Madureira *et al.* 2025, Melekoglu 2023). Altogether, the diagram demonstrates how demographic factors such as gender, education, age, and marital status interact to shape consumer preferences in a multidimensional and visually intuitive manner.

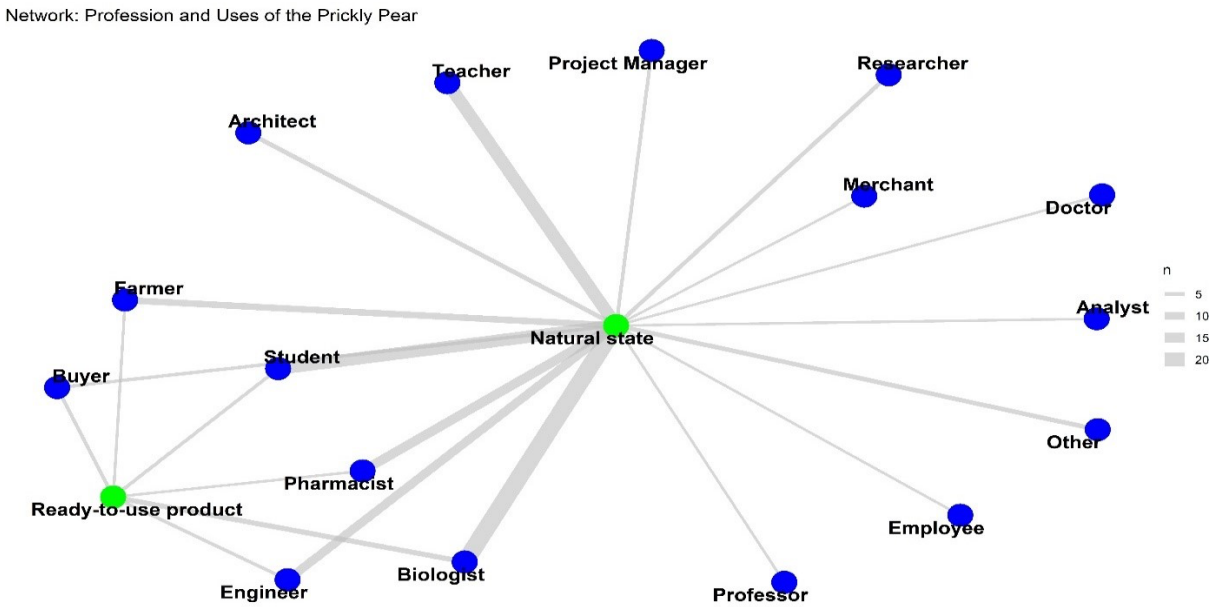

Figure 12. Relationship between profession and mode of consumption

Network-based insights into perception and usage

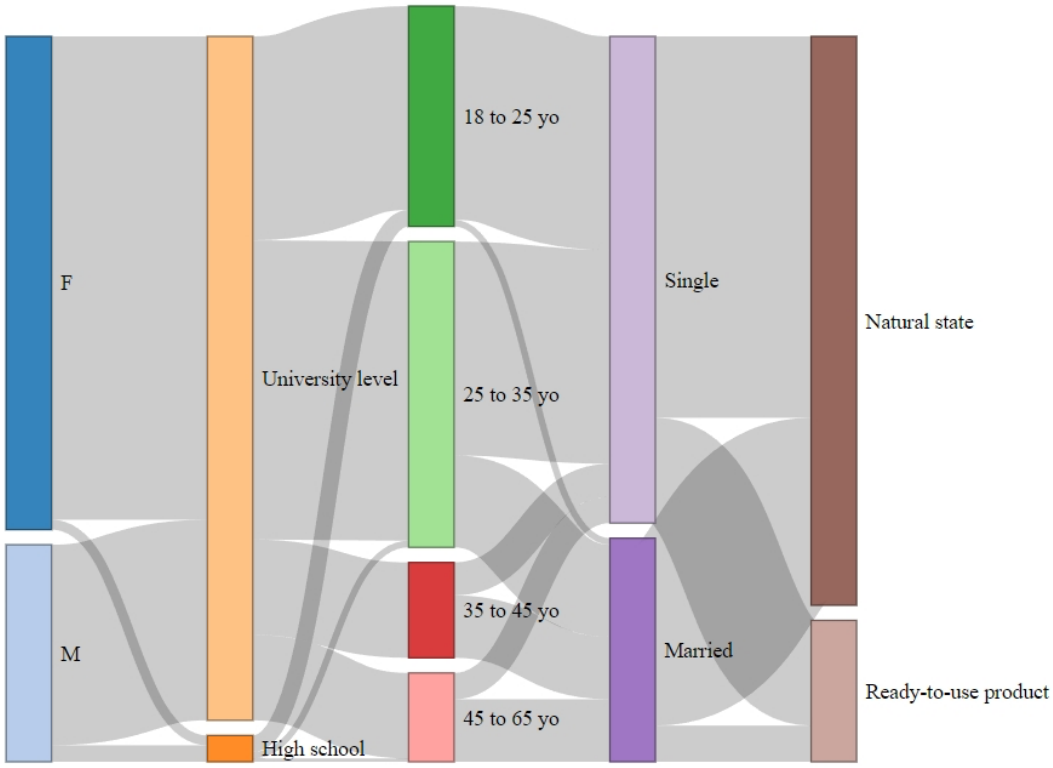

Figure 13. Sankey diagram showing demographic flows shaping preferences for natural versus ready-to-use *Opuntia ficus-indica* products.

To uncover the structural relationships among usage patterns and demographic factors, a network graph was generated based on significant statistical associations. Figure 14 highlighted question Q6 (form of use) as a central node (degree = 7) (Tie *et al.* 2024) connecting to Q4 (parts used), Q15 (frequency), and Q16 (expected effects) (Costa *et al.* 2021). These links suggest an interwoven understanding of form, function, and expected outcomes in user behavior, indicating that the form in which *Opuntia ficus-indica* is used plays a mediating role in how it is perceived and applied. This reflects how network centrality can expose demographic clustering and shared decision logics. Age and education emerged as major network hubs, reinforcing their structural influence on plant-related decisions and preference patterns. The observed associations (Q6-Q16: $p < 0.001$; Q4-Q17: $p = 0.003$) validate that plant knowledge and application practices are shaped by interrelated demographic drivers, rather than isolated individual choices (Tamene *et al.* 2024).

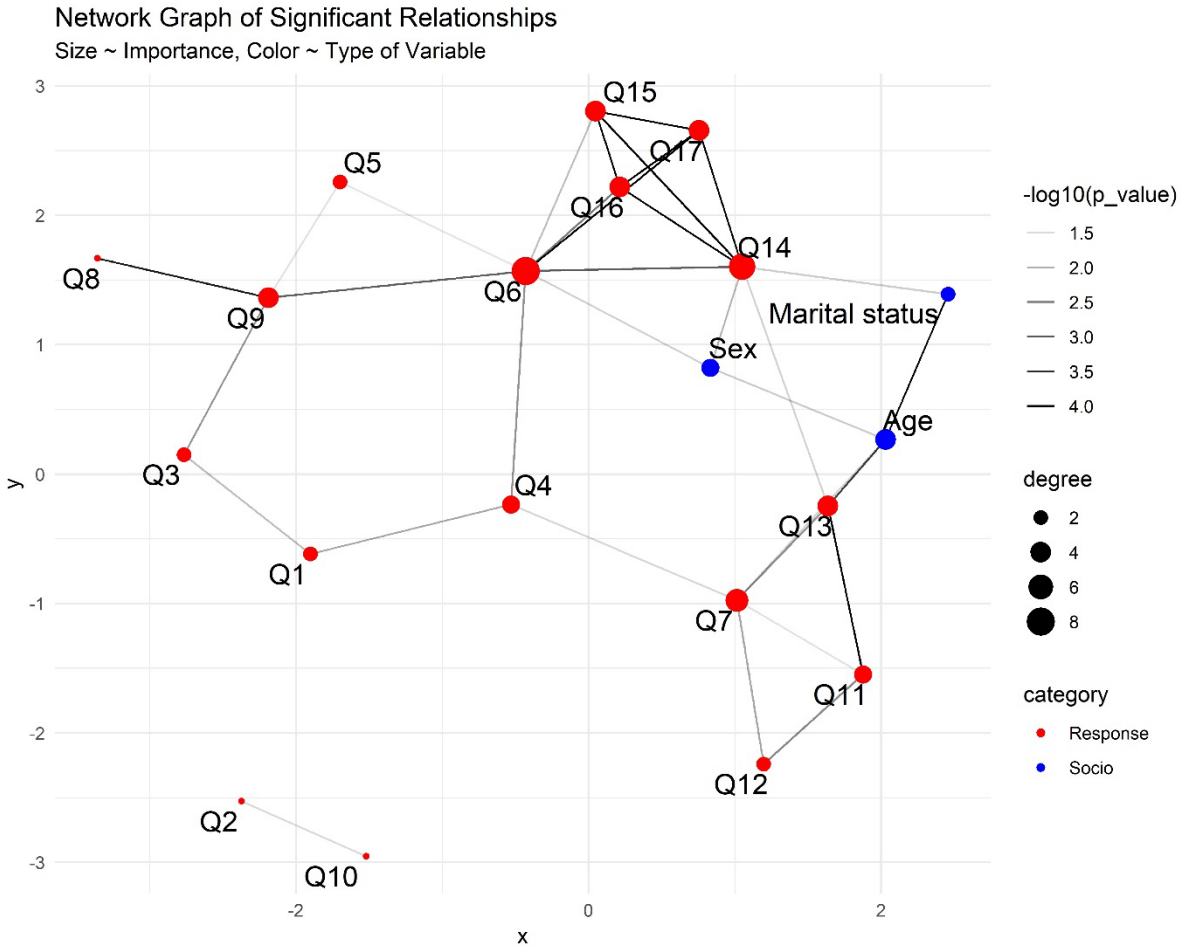

Figure 14. Network graph of significant demographic and usage variable interactions in *Opuntia ficus-indica* use

Statistical associations and global trends

Figure 15 summarized the significant statistical relationships between demographic variables and usage behaviors. Age vs. frequency of use ($\chi^2 = 23.4$, $p < 0.001$), marital status vs. purpose of use ($\chi^2 = 18.1$, $p < 0.001$), and education vs. sourcing behavior ($\chi^2 = 20.1$, $p < 0.001$) were among the strongest associations. These results support the conclusion that plant-based knowledge and practices are not uniformly distributed but are patterned along lines of education, age, and to a lesser extent, marital status (Tamene *et al.* 2024). Gender showed weaker associations across most categories ($p > 0.10$), but usage frequency among women was still high, indicating more equitable access to knowledge and usage practices.

The heatmap visualization also highlighted co-dependencies between knowledge depth, procurement channels, and reported effects, reinforcing the interconnected nature of ethnobotanical systems (Kunwar *et al.* 2022, Tamene *et al.* 2024)

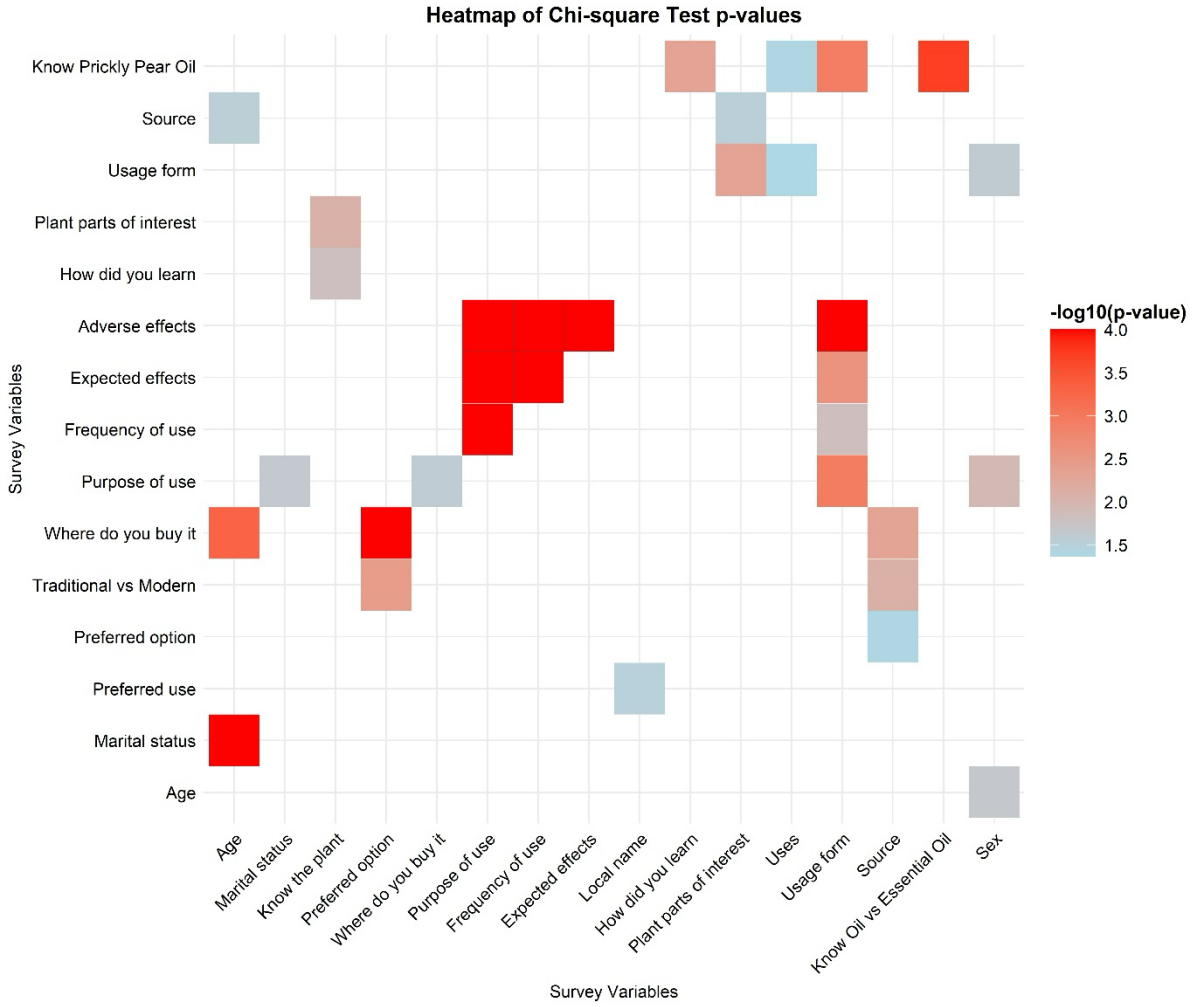

Figure 15. Heatmap of chi-square test results: significant associations between survey variables.

Study limitations

This study was based on a non-probabilistic sampling approach, which limits the generalizability of the findings to the broader Algerian population. The sample predominantly consisted of younger, educated, and urban individuals, likely due to unequal access to digital platforms. Although this demographic includes active users and custodians of traditional knowledge, it may underrepresent older, rural, or less-connected communities. Nevertheless, the statistical patterns observed are robust within the sample and offer valuable insights for guiding future, more targeted investigations.

Conclusion

This study provides a comprehensive ethnobotanical overview of *Opuntia ficus-indica* usage in Algeria, drawing on a robust, statistically validated dataset. The results highlight pronounced sociodemographic patterns, with women, youth, and university-educated individuals emerging as the primary custodians and consumers of the plant's diverse applications. The integration of traditional and modern usage forms, ranging from natural consumption to ready-to-use cosmetic and therapeutic products, reflects the dynamic and evolving relationship between cultural heritage and contemporary lifestyles.

Our findings show strong associations between educational attainment and both the frequency and diversity of use, sourcing behavior, and perceived benefits. Network and statistical analyses confirmed the central role of variables such as age, education, and gender in shaping usage trajectories, while profession-specific data emphasized the importance of knowledge dissemination across academic, agricultural, and health-related domains. Notably, the risk perception and reported adverse effects underscore the need for improved phytotherapeutic education and product regulation.

This research reinforces the growing relevance of *Opuntia ficus-indica* as both a culturally embedded and commercially viable plant resource in North Africa. It also demonstrates the value of integrating quantitative ethnobotany with participatory and

network-based tools to uncover nuanced patterns in traditional knowledge systems. Future studies should deepen this approach by incorporating longitudinal data and biochemical validation of claimed uses, particularly in light of increasing market demand and climate resilience challenges.

Declarations

Ethics approval and consent to participate: This study involved an online ethnobotanical survey administered via Google Forms and distributed through Facebook. Participants were provided with an introductory information statement explaining the purpose of the research, their rights, and data confidentiality. In line with ethical standards for low-risk online research, informed consent was implied through voluntary completion and submission of the questionnaire. No personal interviews or direct contact were involved.

Consent for publication: Not applicable

Availability of data and materials: Data can be accessed by consulting the first author.

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