



EXPLORING HERBAL ALTERNATIVES FOR THE MANAGEMENT OF GASTRO-DUODENAL ULCER IN THE CENTRAL ALGERIAN STEPPE

EXPLORANDO ALTERNATIVAS HERBALES PARA EL MANEJO DE LA ÚLCERA GASTRODUODENAL EN LA ESTEPA ARGELINA CENTRAL

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SUMMARY

Introduction and aims: Gastro-duodenal ulcers associated with *Helicobacter pylori* infection remain a significant health concern in the semi-arid regions of Algeria, where traditional herbal medicine continues to play a central role in primary healthcare. This study aimed to explore plant-based therapeutic alternatives for managing *H. pylori*-related gastric disorders in the central Algerian steppe.

M&M: An ethnopharmacological survey was conducted in 22 municipalities of the central Algerian steppe. One hundred phytotherapy practitioners were interviewed using questionnaires. Data included socio-demographic characteristics, plant species, plant parts, preparation methods, and perceived therapeutic effectiveness.

Results: The socio-demographic profile showed a strong male predominance (79 %), with most practitioners aged 40-60 years (48 %), possessing secondary or university education (55 %), and 10-20 years of professional experience (40 %). A total of 61 medicinal plant species were recorded. The most family importance values were observed for Asphodelaceae (0.68), Amaryllidaceae (0.66), and Cupressaceae (0.63). Leaves and aerial parts were the most frequently used plant organs, primarily prepared as infusion (51 %) or decoction (27 %). The results also highlight a strong correlation between perceived effectiveness and citation frequency.

Conclusions: Traditional knowledge from the central Algerian steppe highlights the potential of certain plants for treating gastro-duodenal ulcers linked to *H. pylori* but requires scientific validation to ensure efficacy and safety.

KEY WORDS

Algeria, ethnobotany, gastric disorders, *Helicobacter pylori*, medicinal plants.

RESUMEN

Introducción y objetivos: Las úlceras gastroduodenales asociadas a la infección por *Helicobacter pylori* siguen siendo un problema de salud importante en las regiones semiáridas de Argelia, donde la medicina herbal tradicional continúa desempeñando un papel central en la atención primaria. Este estudio tuvo como objetivo explorar alternativas terapéuticas basadas en plantas para el manejo de trastornos gástricos relacionados con *H. pylori* en la estepa argelina central.

M&M: Se llevó a cabo una encuesta etnofarmacológica en 22 municipios de la estepa argelina central. Cien practicantes de fitoterapia fueron entrevistados mediante cuestionarios. Los datos recopilados incluyeron características sociodemográficas, especies vegetales, partes de las plantas, métodos de preparación y eficacia terapéutica percibida.

Resultados: El perfil sociodemográfico mostró un fuerte predominio masculino (79 %), con la mayoría de practicantes entre 40 y 60 años (48 %), con educación secundaria o universitaria (55 %) y 10-20 años de experiencia profesional (40 %). Se registraron 61 especies de plantas medicinales. Los mayores valores de importancia familiar se observaron para Asphodelaceae (0,68), Amaryllidaceae (0,66) y Cupressaceae (0,63). Las hojas y partes aéreas fueron los órganos más utilizados, preparados principalmente en infusión (51 %) o decocción (27 %). Los resultados también destacan una fuerte correlación entre efectividad percibida y frecuencia de citación.

Conclusiones: El conocimiento tradicional de la estepa argelina central destaca plantas potenciales contra úlceras gastroduodenales asociadas a *H. pylori*, pero requiere validación científica para garantizar eficacia y seguridad.

PALABRAS CLAVE

Argelia, desórdenes gástricos, etnobotánica, *Helicobacter pylori*, plantas medicinales.

INTRODUCTION

Gastro-duodenal ulcers remain major global health problems, affecting millions of people annually (Hooi *et al.*, 2023; WHO, 2023). The infection by *Helicobacter pylori* is recognized as the principal etiological factor responsible for chronic gastritis, peptic ulcer disease, and even gastric cancer (Savoldi *et al.*, 2024; Pal *et al.*, 2025). The increasing resistance of *H. pylori* to conventional antibiotics, coupled with adverse effects and recurrence rates after standard triple therapy, has led to an increased interest in herbal treatments derived from medicinal plants (Hasanuzzaman *et al.*, 2024; Li *et al.*, 2024). These plants are known to contain a wide range of bioactive molecules such as flavonoids, tannins, terpenoids, alkaloids, and phenolic acids, which have demonstrated antimicrobial, antioxidant, and anti-ulcer properties in various experimental studies (Tran *et al.*, 2023).

Traditional herbal medicine continues to play a crucial role in primary healthcare systems, particularly in developing countries, where it represents both a cultural heritage and a practical therapeutic option (Dinat *et al.*, 2023; Belmouhoub *et al.*, 2024; S'hih *et al.*, 2025). In Algeria, especially in the central steppe regions, the use of medicinal plants for digestive disorders is deeply rooted in popular practice and transmitted through generations (Khaled Khodja *et al.*, 2025). These regions, characterized by a semi-arid climate and rich floristic diversity, harbor numerous plant species with potential pharmacological properties that remain scientifically underexplored (Ilhame *et al.*, 2025).

Ethnobotanical surveys are essential tools for documenting this traditional knowledge, identifying the most frequently used species, and guiding pharmacological and phytochemical investigations (Belmouhoub *et al.*, 2022; Yadav *et al.*, 2024; Mikou, 2025). They provide insight into local perceptions of efficacy, preparation methods, and patterns of use, thereby bridging the gap between empirical practice and scientific validation.

This study was undertaken to document and analyze the herbal remedies traditionally used for the treatment of gastro-duodenal ulcers associated with *H. pylori* infection in the central Algerian steppe. The specific objectives were to identify the main plant species employed by local phytotherapy

practitioners; to assess their relative frequency of citation and perceived efficacy; and to highlight the most promising species that may serve as potential sources of natural anti-*H. pylori* agents.

MATERIALS AND METHODS

Study area

This study was conducted in the central Algerian steppe. This region represents an ecological transition zone between the Tell Atlas in the north and the high Saharan plains in the south. It covers an area of approximately 32,280 km² and is characterized by diverse topography, alternating between mountainous areas and semi-arid plateaus. Elevation ranges from over 1,600 m in the east to approximately 150 m in the southern plains. The study area includes 22 municipalities selected to ensure representative coverage of the region's ecological and socio-cultural diversity (Fig. 1).

Climate

The study area has a semi-arid steppe climate, with hot, dry summers, cold winters, low and irregular rainfall, and strong spring winds, all of which strongly influence the distribution and dynamics of local herbal medicinal plants, including medicinal plants (Khaled Khodja *et al.*, 2025). These climatic conditions directly affect the local flora, particularly the availability and distribution of medicinal plants.

Data collection

To document herbal medicinal plants used in the treatment of gastro-duodenal ulcers, an ethnobotanical survey was conducted using a semi-structured questionnaire. The survey took place in April 2025 and targeted a representative sample of 100 randomly selected herbalists. The questionnaire was organized into two main sections. The first aimed to collect socio-demographic information from participants, including sex, age, educational level, and years of professional experience. The second focused on ethnobotanical knowledge, specifically the plant species used, including vernacular names, plant parts employed, preparation methods, and practitioners' perceptions of the remedies' efficacy. This dual approach allowed for the integration of data on both the herbalists' profiles and their phytotherapeutic knowledge.

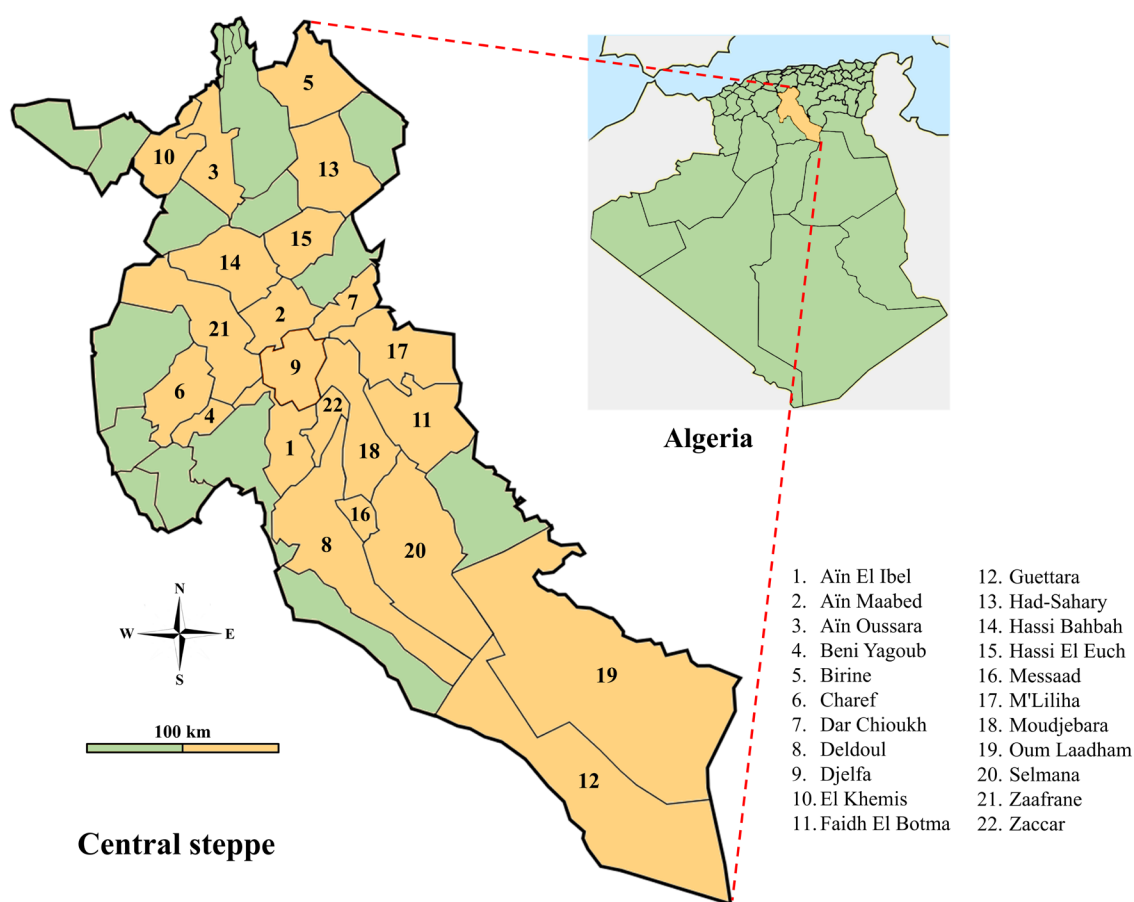


Fig. 1. Geographical representation of the study area. The study sites are marked with a number corresponding to their geographic location.

Botanical identification of the reported species was based on several reference works on the medicinal flora of Algeria and North Africa, including *La Nouvelle Flore de l'Algérie* (Quezel & Santa 1962-1963), *La Flore de l'Afrique du Nord* (Maire, 1953), and *La Flore du Sahara* (Ozenda, 2004). Scientific names were subsequently verified using international botanical databases such as The Plant List (<https://www.theplantlist.org/>) and the Encyclopedia of Life (<https://eol.org/>).

Data analysis

The collected data were entered and processed using Microsoft Excel 2016. Descriptive statistical analyses were performed to determine the usage frequency of each herbal species. The Relative

Frequency of Citation (RFC) was calculated using the formula $RFC(\%) = (FC/N) \times 100$, allowing quantification of the importance of each species in the treatment of gastroduodenal ulcers. This method is widely employed in ethnobotanical studies to assess the relevance of species cited by informants (Tardío & Pardo-de-Santayana, 2008).

The Family Importance Value (FIV) was used to evaluate the relative significance of botanical families by dividing the RFC of a given family by the total number of species recorded within that family (Ns). All data were analyzed using basic descriptive statistics in Microsoft Excel 2016. Comparisons between categorical variables were performed using the chi-square (χ^2) test for independence based on the original frequency data (counts), and statistical significance was set at $p <$

0.05, followed by post hoc pairwise comparisons for multiple comparisons. The results were expressed as percentages for presentation purposes. Graphical representations were generated using OriginPro 2024 SR1 (OriginLab, 2024).

RESULTS AND DISCUSSION

Socio-demography of phytotherapy practitioners

The study was conducted among 100 phytotherapy practitioners, categorized according to four main socio-demographic variables: sex, age, educational level, and professional experience. These criteria, based on the methodology proposed by Umair *et al.* (2017), are recognized for their significant influence on the transmission of knowledge regarding the therapeutic use of medicinal plants (Idm'hand *et al.*, 2019).

The number of traditional medicine practitioners interviewed varied among municipalities and was generally proportional to the population size of each locality. The municipality of *Aïn Oussara* recorded the highest number of herbalists (19 practitioners), followed by *Djelfa* (15) and *Messaad* (11). This distribution may influence the diversity of ethnobotanical knowledge recorded, since areas with a higher number of knowledgeable informants often preserve a broader understanding of medicinal plant use. Traditional healers and herbal practitioners are recognized as key holders of indigenous knowledge related to plant-based therapies, and their knowledge plays an important role in documenting medicinal plants used for healthcare in local communities (Banerjee, 2024; Tamene *et al.*, 2023).

The data reveal a strong male predominance among the practitioners surveyed, with 79 % men and 21 % women (Fig. 2). This imbalance reflects a trend reported in several previous studies (Sarri *et al.*, 2014; Redouan *et al.*, 2020; Rehman *et al.*, 2024). Cultural and traditional factors likely play a major role in this gender disparity in the practice of phytotherapy. With respect to age, 48 % of practitioners belong to the 40-60-year age group, 41 % are between 20 and 40 years old, 8 % are aged 60 years and above, while only 3 % are under 20 years old (Fig. 2). These results indicate that middle-aged individuals constitute the main core of practitioners, thereby supporting the findings of

other ethnobotanical studies conducted in various regions of the world (Alaoui & Laaribya, 2017; Idm'hand *et al.*, 2019; Belhaj & Zidane, 2021).

Analysis of academic qualifications revealed considerable diversity among practitioners: 4 % were illiterate, 12 % had completed primary education, 29 % had a middle school level, 39 % had secondary education, and 16 % held a university degree (Fig. 2). This distribution indicates that interest in traditional medicine spans all educational levels. However, these findings contrast with several studies suggesting that ethnophytotherapeutic knowledge is primarily transmitted among less-educated populations (Ahmad *et al.*, 2018).

The distribution of practitioners according to professional experience is presented in Fig. 2. The majority (40 %) had 10-20 years of experience, reflecting relative stability in the practice. In contrast, 38 % had less than 10 years of experience, which may indicate a renewed interest in phytotherapy in recent years. These observations are consistent with those of Dey *et al.* (2014), who reported that most practitioners had 10-20 years of experience. In contrast, only 15 % of practitioners had 20-30 years of experience, which may indicate temporary disengagement or a professional shift. Practitioners with more than 30 years of experience accounted for just 7 %, possibly reflecting the challenges associated with long-term careers in this field.

Diversity of herbal medicinal plant species

The inventory of herbal medicinal plants traditionally used for managing *H. pylori* associated infections in the central Algerian steppe revealed a high diversity of species across multiple botanical families (Table 1). Traditional treatment of *H. pylori* infection relies on 61 species belonging to 34 botanical families, including Lythraceae, Lamiaceae, Pinaceae, and Cupressaceae. The most frequently cited species include *Punica granatum*, *Teucrium polium*, *Pinus sylvestris*, and *Juniperus phoenicea*, reflecting a strong local preference for plants recognized for their carminative and anti-inflammatory properties (Bais *et al.*, 2014).

The number of recorded medicinal plant species used for the treatment of *H. pylori* varied among the surveyed municipalities. *Aïn Oussara* showed the highest species richness, with a total of 53

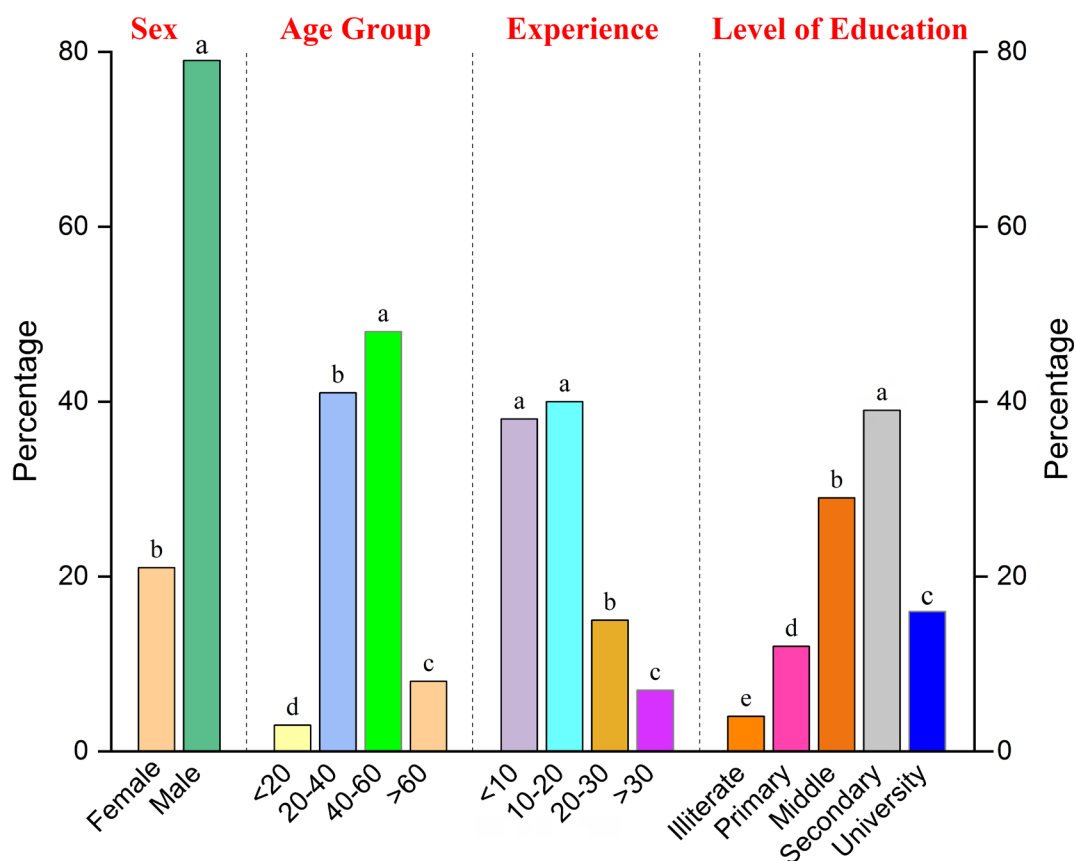


Fig. 2. Socio-demographic characteristics of practitioners of traditional herbal medicine interviewed in the central Algerian steppe. Values are expressed as percentages; however, statistical significance was determined based on the original frequency data. Different letters for each categorical variable indicate significant differences (Chi-square test followed by post hoc pairwise comparisons, $p < 0.05$, $a > b > c > d > e > f > g > h$).

recorded species. This result may be related to the ecological characteristics of the area. Indeed, the vegetation of *Ain Oussara* corresponds to a semi-arid steppe ecosystem, mainly dominated by *Stipa tenacissima* and *Artemisia herba-alba*, which are characteristic species of the Algerian steppe formations. These steppe ecosystems are known for their important floristic diversity and their traditional use in local ethnomedicine (Habib *et al.*, 2020).

The Lamiaceae family, represented notably by *T. polium*, is widely used in traditional medicine for its anti-inflammatory and antimicrobial effects. Studies have shown that *T. polium* extracts contain bioactive compounds such as flavonoids and terpenes, which exhibit significant antibacterial

activity against various pathogens, including *H. pylori* (Soussa *et al.*, 2024). Cupressaceae species, such as *Juniperus phoenicea*, are known for their antiseptic and anti-inflammatory properties. The essential oil of *J. phoenicea* has demonstrated notable gastroprotective activity in experimental models of gastric ulcers, attributed to its antioxidant effects and modulation of defense enzymes such as superoxide dismutase and catalase (Bais *et al.*, 2014).

Punica granatum, from the Lythraceae family, is traditionally used for its astringent and antioxidant properties. Research has confirmed its efficacy against *H. pylori*, with pomegranate peel extracts significantly inhibiting bacterial growth and reducing gastric lesions in animal

Table 1. Inventory of herbal remedies traditionally used for the treatment of gastro-duodenal ulcer in the central Algerian steppe. Abbreviation= RFC: Relative Frequency of Citation

Family	Scientific Name	Plant origin	Part used	Method of use	RFC
Lythraceae	<i>Punica granatum</i> L.	Cultivated	Bark	Decoction	0.93
Lamiaceae	<i>Teucrium polium</i> L.	Wild	Aerial parts	Infusion	0.81
Pinaceae	<i>Pinus sylvestris</i> L.	Introduced	Bark	Infusion	0.77
Cupressaceae	<i>Juniperus phoenicea</i> L.	Wild	Berries	Decoction	0.72
Asphodelaceae	<i>Aloe vera</i> (L.) Burm.f.	Introduced	Leaves	Fresh gel	0.68
Amaryllidaceae	<i>Allium sativum</i> L.	Cultivated	Bulbs	Maceration	0.66
Lamiaceae	<i>Thymus vulgaris</i> L.	Wild and cultivated	Leaves	Infusion	0.64
Lauraceae	<i>Cinnamomum verum</i> J. Presl	Imported	Bark	Decoction and infusion	0.62
Lamiaceae	<i>Salvia rosmarinus</i> Spenn.	Wild	Leaves	Infusion	0.61
Lamiaceae	<i>Plectranthus amboinicus</i> (Lour.) Spreng.	Introduced	Leaves	Maceration	0.59
Rosaceae	<i>Rosa × damascena</i> Mill.	Cultivated	Flowers	Infusion	0.59
Theaceae	<i>Camellia sinensis</i> (L.) Kuntze	Imported	Leaves	Infusion	0.57
Brassicaceae	<i>Brassica oleracea</i> L.	Cultivated	Leaves	Infusion	0.54
Asteraceae	<i>Achillea millefolium</i> L.	Wild	Flowers	Infusion	0.54
Cupressaceae	<i>Juniperus oxycedrus</i> L.	Wild	Berries	Decoction	0.53
Myrtaceae	<i>Myrtus communis</i> L.	Wild	Leaves	Infusion	0.53
Lamiaceae	<i>Origanum majorana</i> L.	Cultivated	Leaves	Infusion	0.53
Lamiaceae	<i>Ocimum basilicum</i> L.	Cultivated	Leaves	Infusion	0.5
Combretaceae	<i>Terminalia chebula</i> Retz.	Imported	Fruits	Powder	0.48
Lamiaceae	<i>Ziziphora hispanica</i> L.	Wild	Aerial parts	Decoction and infusion	0.47
Meliaceae	<i>Azadirachta indica</i> A. Juss.	Introduced	Leaves	Decoction	0.44
Myrtaceae	<i>Eucalyptus globulus</i> Labill.	Introduced	Leaves	Decoction and infusion	0.43
Pinaceae	<i>Pinus pinaster</i> Aiton	Introduced	Bark	Infusion	0.41
Piperaceae	<i>Piper nigrum</i> L.	Imported	Seeds	Powder	0.39
Asparagaceae	<i>Asparagus officinalis</i> L.	Cultivated	Roots	Infusion	0.38
Myrtaceae	<i>Syzygium cumini</i> (L.) Skeels	Introduced	Fruits	Decoction and infusion	0.36
Myrtaceae	<i>Psidium guajava</i> L.	Introduced	Leaves	Infusion	0.33
Violaceae	<i>Viola abyssinica</i> Steud. ex Oliv.	Wild	Aerial parts	Decoction and infusion	0.32
Bromeliaceae	<i>Ananas comosus</i> (L.) Merr.	Imported	Stem	Stem extract	0.32
Moringaceae	<i>Moringa oleifera</i> Lam.	Introduced	Leaves	Powder	0.3
Caricaceae	<i>Carica papaya</i> L.	Imported	Latex	Powder	0.3
Anacardiaceae	<i>Schinus molle</i> L.	Introduced	Fruits	Infusion	0.29
Fabaceae	<i>Tetrapleura tetraptera</i> (Schumach. & Thonn.) Taub.	Imported	Fruits	Powder	0.29
Ginkgoaceae	<i>Ginkgo biloba</i> L.	Introduced	Leaves	Infusion and maceration	0.26
Asteraceae	<i>Artemisia campestris</i> L.	Wild	Aerial parts	Decoction and infusion	0.26
Solanaceae	<i>Hyoscyamus albus</i> L.	Wild	Leaves	Decoction and infusion	0.24

Family	Scientific Name	Plant origin	Part used	Method of use	RFC
Apiaceae	<i>Foeniculum vulgare</i> Mill.	Cultivated	Seeds	Decoction and infusion	0.24
Asteraceae	<i>Artemisia herba-alba</i> Asso	Wild	Aerial parts	Decoction and infusion	0.22
Ranunculaceae	<i>Nigella sativa</i> L.	Cultivated	Seeds	Maceration	0.19
Cucurbitaceae	<i>Citrullus colocynthis</i> (L.) Schrad.	Wild	Fruit	Decoction	0.19
Lamiaceae	<i>Mentha pulegium</i> L.	Cultivated	Leaves	Infusion	0.19
Fabaceae	<i>Glycyrrhiza glabra</i> L.	Imported	Root	Decoction and infusion	0.16
Zingiberaceae	<i>Zingiber officinale</i> Roscoe	Imported	Rhizome	Decoction	0.16
Burseraceae	<i>Boswellia sacra</i> Flueck.	Wild	Resin	Chewing	0.16
Asteraceae	<i>Matricaria chamomilla</i> L.	Wild	Flowers	Decoction and infusion	0.14
Lamiaceae	<i>Lavandula stoechas</i> L.	Cultivated	Flowers	Infusion	0.14
Apiaceae	<i>Cuminum cyminum</i> L.	Cultivated	Seeds	Infusion	0.11
Moraceae	<i>Ficus carica</i> L.	Cultivated	Latex	Infusion	0.11
Oleaceae	<i>Olea europaea</i> L.	Cultivated	Leaves	Infusion	0.11
Lamiaceae	<i>Mentha spicata</i> L.	Imported	Leaves	Infusion	0.09
Myrtaceae	<i>Syzygium aromaticum</i> (L.) Merr. & L.M. Perry	Cultivated	Flower buds	Infusion	0.09
Poaceae	<i>Triticum durum</i> Desf.	Cultivated	Seeds	Decoction and infusion	0.08
Apiaceae	<i>Petroselinum crispum</i> (Mill.) Fuss	Imported	Leaves	Decoction and infusion	0.08
Lythraceae	<i>Lawsonia inermis</i> L.	Wild	Leaves	Powder	0.08
Zingiberaceae	<i>Curcuma longa</i> L.	Cultivated	Rhizome	Decoction and infusion	0.05
Rosaceae	<i>Prunus spinosa</i> L.	Imported	Fruits	Decoction	0.05
Anacardiaceae	<i>Pistacia lentiscus</i> L.	Cultivated	Resin	Chewing	0.05
Asteraceae	<i>Saussurea costus</i> (Falc.) Lipsch.	Imported	Root	Decoction	0.05
Fabaceae	<i>Trigonella foenum-graecum</i> L.	Imported	Seeds	Infusion	0.02
Myristicaceae	<i>Myristica fragrans</i> Houtt.	Imported	Seeds	Decoction and infusion	0.02
Rhamnaceae	<i>Hovenia dulcis</i> Thunb.	Imported	Fruits	Decoction and infusion	0.02

models (Mayyas *et al.*, 2021; Muhialdin *et al.*, 2023). Although less documented, the Pinaceae family, including *Pinus sylvestris*, is employed in traditional medicine for its antiseptic and anti-inflammatory properties. Studies suggest that phenolic compounds in *P. sylvestris* extracts may help inhibit *H. pylori* growth (Bais *et al.*, 2014).

The results of this study are consistent with other research conducted in similar regions. For example, an ethnobotanical survey in Tunisia identified species from the Lamiaceae and Cupressaceae families as frequently used for treating gastric disorders, highlighting similarities in the traditional use of herbal medicinal plants across the Mediterranean basin (Bais *et al.*, 2014).

Importance of herbal families

The distribution of Family Importance Values (FIV) highlights a remarkable diversity of herbal families used in the traditional treatment of gastric ulcers associated with *H. pylori* infection in the central Algerian steppe region (Fig. 3). Families with the highest FIVs, such as Asphodelaceae (0.68), Amaryllidaceae (0.66), and Cupressaceae (0.63), play a major role in traditional medicinal practices. Conversely, families such as Zingiberaceae (0.11) and Oleaceae (0.11) exhibit the lowest FIVs, suggesting a more marginal use or lower cultural prominence in local phytotherapeutic traditions. Families like Meliaceae and Combretaceae show moderate importance, indicating that while some

families dominate medicinal use, others contribute to a broader spectrum of traditional remedies, particularly in the management of *H. pylori* infections.

The diversity of botanical families employed in the traditional treatment of *H. pylori* infections varies considerably across the studied region, reflecting local ecological, cultural, and socio-economic specificities. In the central Algerian steppe region, this diversity is strongly influenced by factors such as plant availability, arid climatic conditions, and the intergenerational transmission of traditional knowledge. The analysis of FIVs provides valuable insights into the cultural and therapeutic significance of these families within traditional practices. This distribution demonstrates that although certain families predominate in therapeutic applications, others contribute to the enrichment of ethnobotanical knowledge, especially in the context of *H. pylori*-related gastric disorders.

The predominance of particular plant families in central Algerian steppe's traditional medicine can be attributed to several factors. The region's semi-arid climate favors the growth of xerophytic plants, mainly belonging to the families Lamiaceae, Asteraceae, and Cupressaceae. Moreover, the high content of bioactive compounds such as flavonoids, essential oils, and tannins within these families confers desirable therapeutic properties for the treatment of gastric ailments.

In comparison, other regions of Algeria exhibit notable differences in the botanical families used to manage *H. pylori* infections. For instance, a study conducted in the Naâma region revealed a significant reliance on the Lamiaceae and Asteraceae families, with species such as *Rosmarinus officinalis* and *Artemisia herba-alba* being frequently cited for their antimicrobial and anti-inflammatory activities (Bouafia *et al.*, 2021).

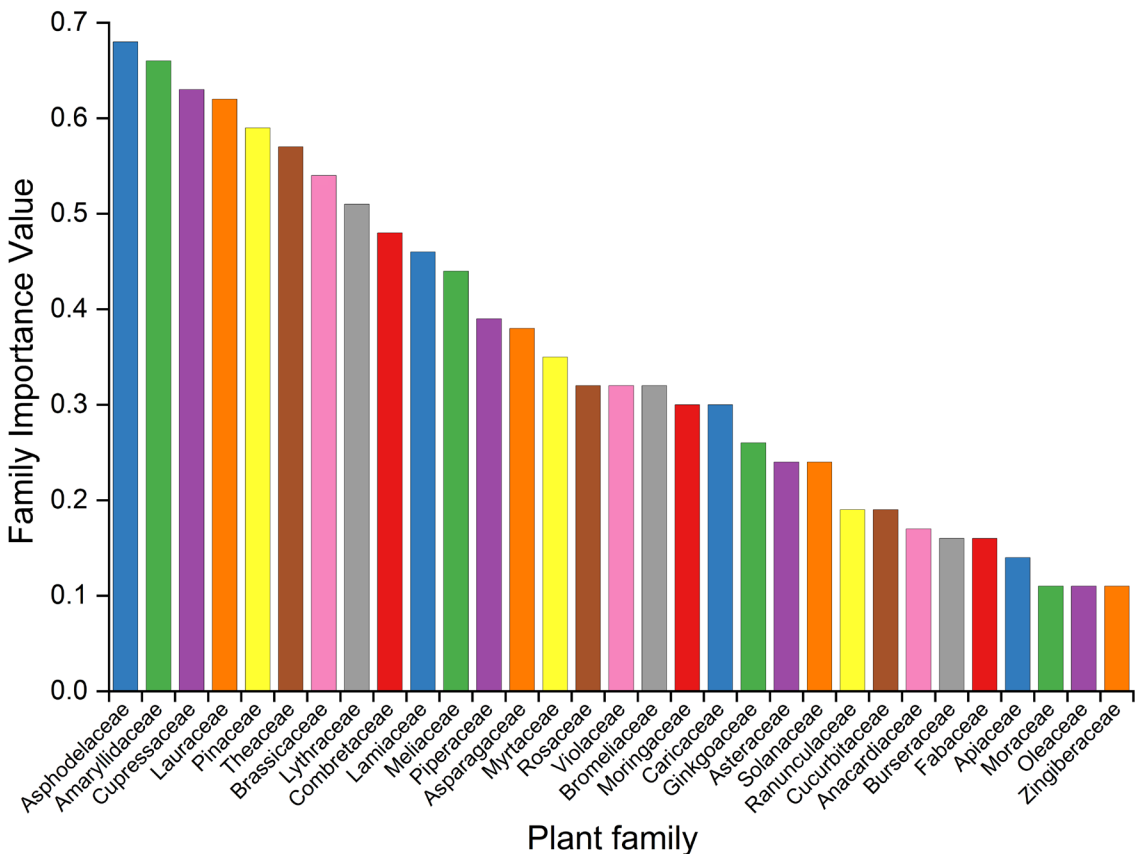


Fig. 3. Importance of Herbal Families Used in Treating Gastro-Duodenal Ulcer in the Central Algerian Steppe

Frequency of use of herbal remedies

The analysis of the frequency of use of medicinal plants employed in the treatment of *H. pylori* infections in the central Algerian steppe region highlights the particular prominence of certain species according to local herbalists (Fig. 4). *Punica granatum* (RFC = 0.93) clearly dominates, reflecting its central role in the local traditional pharmacopeia for managing *H. pylori* infections. The tannin-rich exocarps of this species inhibit *H. pylori* growth and reduce the expression of virulence genes, confirming empirical traditional knowledge (Abo-Saif *et al.*, 2024).

This predominance may be attributed to its richness in bioactive compounds, including tannins, flavonoids, and phenolic acids, which exhibit antimicrobial and anti-inflammatory activities, thereby protecting the gastric mucosa. Its frequent use reflects not only the intergenerational transmission of therapeutic knowledge but also a perceived efficacy that justifies its status as a first-line traditional remedy in the central Algerian steppe region. *Teucrium polium* (RFC = 0.81) ranks as the second most cited species, underscoring its importance in local tradition. It is known for its flavonoid content, which promotes gastric ulcer healing. Its popularity stems from the presence of phenolic diterpenes with anti-ulcer and antibacterial activities. However, its hepatotoxic potential at high doses requires cautious use (Mansour *et al.*, 2025).

Pinus sylvestris (RFC = 0.77) and *Juniperus phoenicea* (RFC = 0.72) illustrate the prominent role of conifers in local traditional medicine. Their essential oils, rich in monoterpenes such as α -pinene and cedrol, exhibit bactericidal and urease-inhibitory properties, an enzyme essential for *H. pylori* survival (Korona-Glowniak *et al.* 2020; Jeong *et al.*, 2022; Chelouati *et al.*, 2023). *Pinus sylvestris* contains labdane-type diterpenes, such as manoyl oxide acid, which reduce gastric inflammation and inhibit bacterial proliferation. *Juniperus phoenicea* is valued for its anti-ulcer and antioxidant properties due to its essential oil's richness in bioactive constituents.

Aloe vera, *Allium sativum*, and *Thymus vulgaris* (RFC = 0.68-0.64) combine direct antibacterial action with gastroprotective effects. Recent *in vitro* studies confirm their ability to reduce bacterial loads and gastric inflammation (Balick & Cox, 1996). *Cinnamomum verum* (RFC = 0.62) provides

cinnamaldehyde, a compound effective against *H. pylori* and less prone to resistance development. *Rosmarinus officinalis* and *Plectranthus amboinicus* (RFC $\approx$ 0.60) further emphasize the importance of the Lamiaceae family, as their phenolic compounds (rosmarinic acid, carvacrol) act synergistically to inhibit bacterial adhesion. *Camellia sinensis* (RFC = 0.57), probably acting by inhibiting bacterial ATPase synthesis and modulating the inflammatory response.

The results regarding the origin of medicinal plants used in the treatment of *H. pylori* infections indicate considerable diversity in sources of supply. Data show that 31.03 % of medicinal species are derived from local cultivation, highlighting the importance of domestication and sustainable management of plant resources to meet therapeutic needs (Adli *et al.*, 2021). This high proportion underscores the efforts of practitioners to cultivate certain medicinal species despite the semi-arid climatic constraints of the region.

Wild species accounted for 27.59 % of the recorded plants, reflecting the richness of the steppe flora and the accessibility of local plants for traditional populations. This natural availability facilitates the collection of raw materials and supports the transmission of ethnobotanical knowledge related to the use of native species. Finally, 22.41 % of species were imported, indicating a degree of dependence on external trade and supply chains to fulfill the needs of traditional medicine. This significant proportion also reflects the adaptation of practitioners to local ecological and economic constraints, particularly the scarcity of certain species in the central Algerian steppe.

Among the 61 medicinal plant species recorded in this study, a considerable proportion had already been previously reported in the literature for their anti-ulcer or anti-*Helicobacter pylori* activities. Several highly cited species such as *Punica granatum* have been demonstrated to inhibit *H. pylori* growth and reduce gastric lesions (Mayyas *et al.*, 2021). Similarly, *Teucrium polium* has been reported to possess antimicrobial and antioxidant properties relevant to gastric ulcer treatment (Mansour *et al.*, 2025). Conifer species such as *Juniperus phoenicea* and *Pinus sylvestris* are also known for their antibacterial and gastroprotective effects through essential oils and phenolic compounds (Korona-Glowniak *et al.* 2020; Jeong

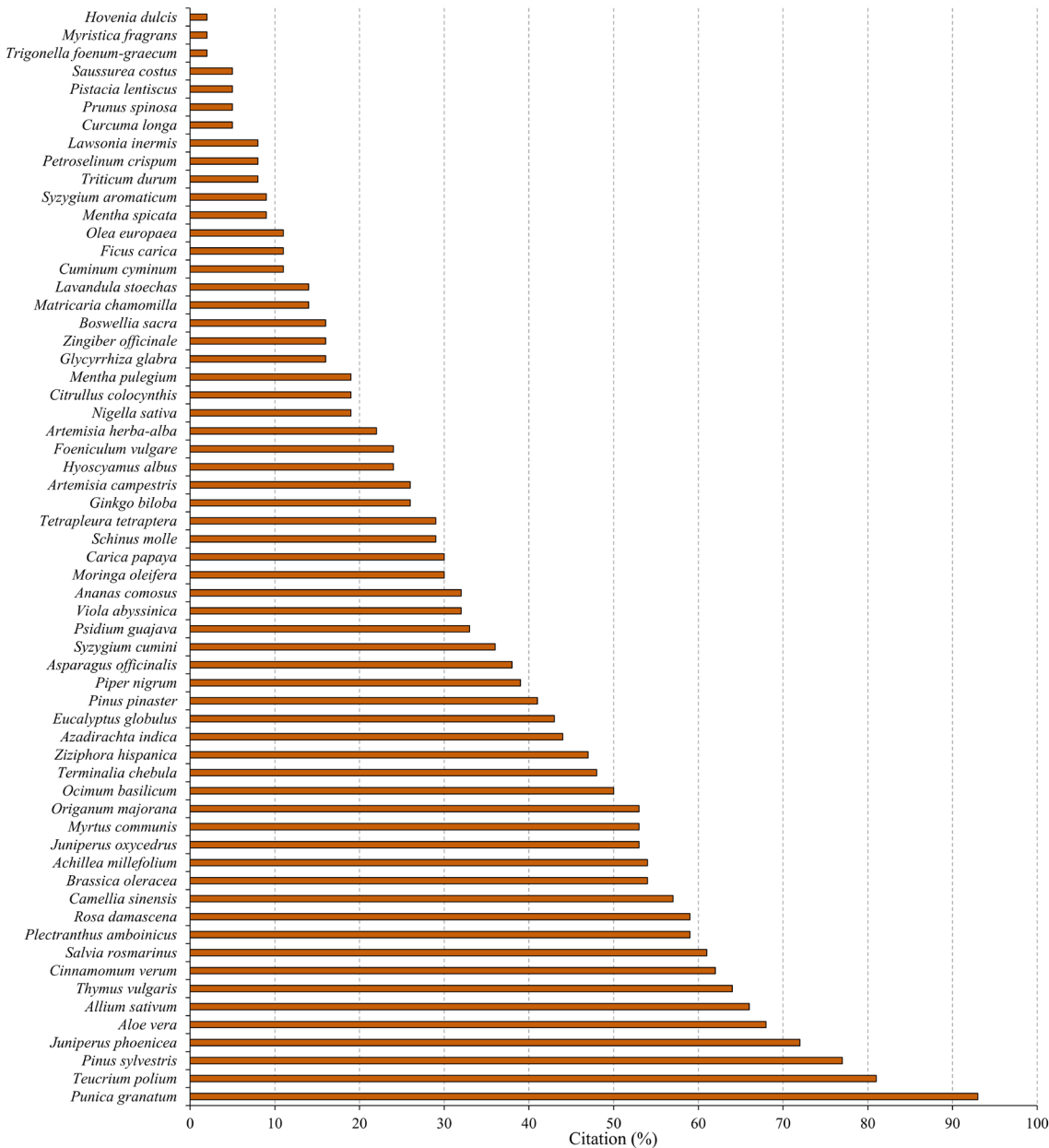


Fig. 4. Frequency of use of medicinal plants for the treatment of gastro-duodenal ulcer in the central Algerian steppe.

et al., 2022). In addition, *Cinnamomum verum* has been reported to inhibit *H. pylori* through the activity of cinnamaldehyde (Li *et al.*, 2024).

However, some plants cited by the interviewed herbalists remain poorly investigated or rarely reported for this specific therapeutic use. Species such as *Ziziphora hispanica*, *Viola abyssinica*,

Tetrapleura tetraptera, and *Hovenia dulcis* are scarcely documented in the literature in relation to the treatment of *H. pylori*-associated gastric disorders. Their citation by local practitioners highlights the originality of ethnobotanical knowledge preserved in the central Algerian steppe and suggests that these plants may represent

promising candidates for future phytochemical and pharmacological investigations (Dinat *et al.*, 2023; Yadav *et al.*, 2024).

Relationship between herbal parts used and preparation methods

The results concerning the traditional use of different plant parts in relation to the preparation methods such as infusion, decoction, and maceration used in the treatment of *H. pylori* infections are presented in Fig. 5. The most frequently employed method is infusion, accounting for more than 51 % of the reported preparations. This predominance can be attributed to its efficiency in extracting active compounds, particularly from tender parts such as leaves. Aerial parts and leaves are commonly used in infusions, as observed for *Teucrium polium* and *Thymus vulgaris*. Infusion facilitates the extraction of flavonoids and essential oils with anti-inflammatory and wound-healing properties, thereby supporting gastric mucosa regeneration.

Decoction ranks second in frequency and is typically applied to harder plant parts, including bark, roots, and seeds. This method, which involves prolonged boiling, is traditionally considered more effective for extracting certain active principles that are poorly soluble at room temperature. Decoction efficiently extracts tannins and phenolic compounds known for their antimicrobial and astringent properties, providing mucosal protection and inhibiting *H. pylori* growth.

Less common techniques such as maceration, powdering, and chewing are also reported, albeit to a lesser extent. Their use often depends on the nature of the plant, or specific local traditions. In terms of plant parts, leaves are the most frequently used, followed by seeds, roots, fruits, and latex, reflecting the wide diversity of plant materials utilized. *Juniperus phoenicea* galbules are typically prepared by decoction to release essential oils and terpenoids responsible for *H. pylori* inhibition and gastric mucosal protection. Some species,

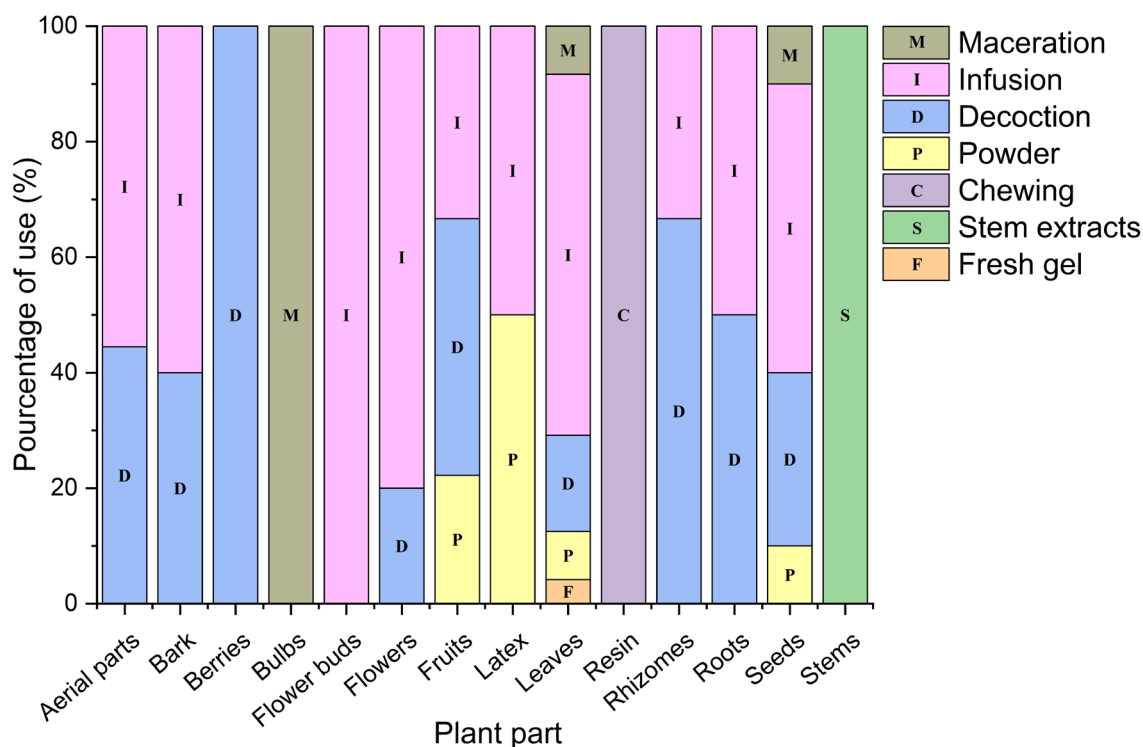


Fig. 5. Relationship between plant parts used of the most cited medicinal plants and preparation methods for treating gastro-duodenal ulcer in the central Algerian steppe. The global citation percentages are placed in parentheses.

such as *Allium sativum* and *Rosa × damascena*, require maceration to preserve heat-sensitive active compounds such as sulfur- and phenolic-based constituents that underpin their antibacterial activity (Cellini *et al.*, 1996).

The use of fresh *Aloe vera* gel enables the direct application of polysaccharides with healing and mucosal-protective properties, thereby enhancing local defenses against *H. pylori*. Although latex is less commonly employed in other medicinal contexts due to its potential irritant effects, its selective use here highlights a refined and contextualized understanding of its therapeutic application. The specific association between plant parts and preparation methods reflects an empirical optimization of available vegetal resources, revealing a deep traditional knowledge of the medicinal properties and active principles of plants among the herbalists of central Algerian steppe.

Efficacy of highly cited herbal species

The distribution of efficacy levels reveals clear differences in the perceived therapeutic performance of the studied medicinal plants. Overall, good and excellent evaluations predominate, although their relative proportions vary markedly among species, reflecting heterogeneous user experiences and traditional practices (Fig. 6).

Several plants stand out for their high effectiveness, characterized by a strong dominance of “excellent” ratings and very low proportions of “satisfactory” responses. *Punica granatum* shows the most favorable profile (63 % excellent; 4 % satisfactory), indicating strong consensus on its efficacy. Similarly, *Teucrium polium* (59 % excellent) and *Pinus sylvestris* (55 % excellent) display consistently high perceived effectiveness,

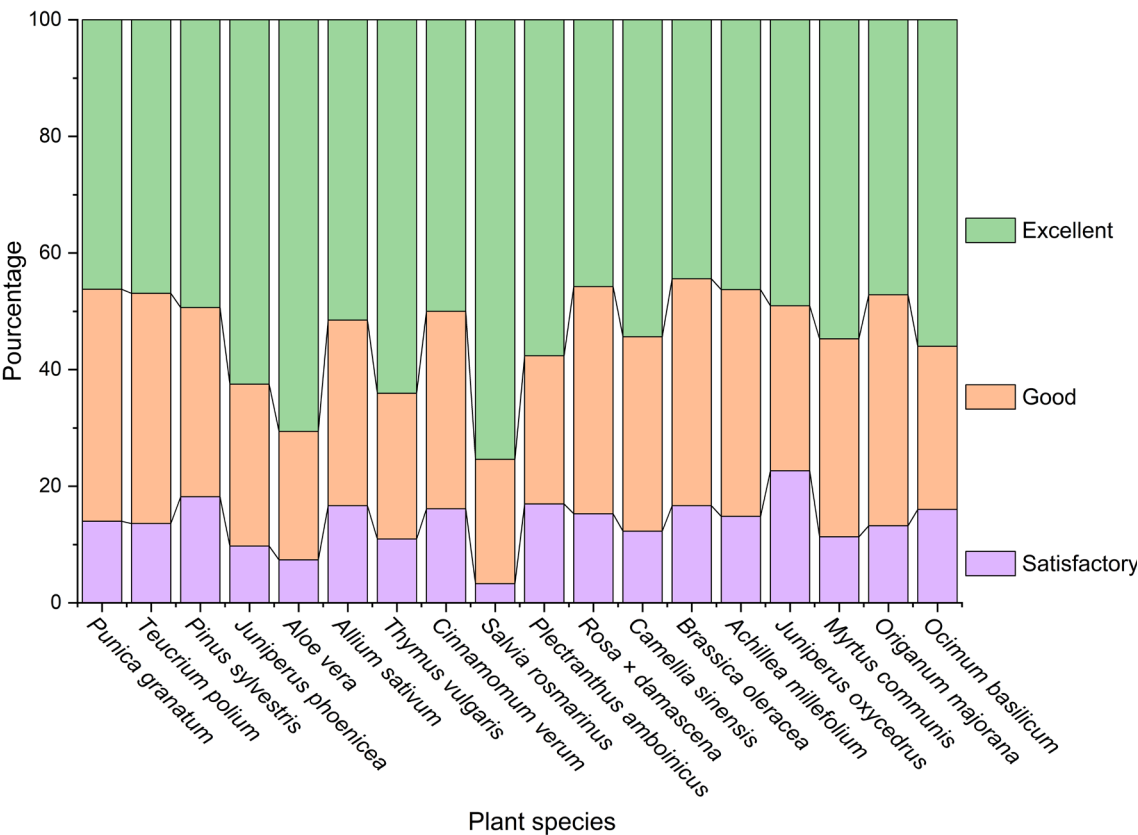


Fig. 6. Stacked bar chart illustrating the efficacy of the most commonly cited medicinal plants (RFC ≥ 0.5) in the treatment of gastro-duodenal ulcer in the central Algerian steppe.

while *Juniperus phoenicea* combines a high “excellent” rate (51 %) with a substantial proportion of “good” responses (43 %), suggesting reliable but slightly more variable outcomes.

A second group of species is mainly associated with high “good” ratings and moderate “excellent” proportions, indicating generally effective but not uniformly optimal outcomes. This pattern is observed for *Aloe vera* (49 % good; 45 % excellent) and *Allium sativum* (43 % good; 48 % excellent). *Thymus vulgaris* shows the highest proportion of “good” responses (61 %) but a lower “excellent” rate (29 %), suggesting widely recognized yet moderate efficacy.

Several plants display more balanced distributions between “good” and “excellent” categories, including *Cinnamomum verum*, *Salvia rosmarinus*, *Plectranthus amboinicus*, and *Rosa × damascena*, reflecting consistent therapeutic value with noticeable interindividual variability.

In contrast, *Camellia sinensis*, *Brassica oleracea*, *Achillea millefolium*, *Juniperus oxycedrus*, *Myrtus communis*, *Origanum majorana*, and *Ocimum basilicum* present higher proportions of “satisfactory” responses and lower “excellent” rates, indicating more heterogeneous or moderate perceived efficacy.

Overall, these findings show that traditional knowledge effectively distinguishes plants with consistently high efficacy from those with more variable outcomes. Species such as *Punica granatum*, *Teucrium polium*, *Pinus sylvestris*, and *Juniperus phoenicea* emerge as the most promising candidates for further phytochemical and pharmacological investigations.

Perceived therapeutic efficacy was strongly associated with citation frequency. Citation exhibited a strong positive correlation with “Excellent” responses ($r = 0.85$), a moderate positive correlation with “Good” ($r = 0.35$), and a strong negative correlation with “Satisfactory” ratings. This pattern indicates that higher perceived efficacy is linked to increased citation frequency, whereas more moderate or heterogeneous effects are associated with lower citation levels.

CONCLUSIONS

Our results reveal the richness of medicinal plant species in the central Algerian steppe for the traditional management of gastro-duodenal ulcers associated with *Helicobacter pylori* infection. This study documented 61 medicinal plant species from 34 botanical families, based on 100 interviews with phytotherapy practitioners. Lamiaceae, Lythraceae, Pinaceae, and Cupressaceae were the most represented families. *Punica granatum*, *Teucrium polium*, *Pinus sylvestris*, and *Juniperus phoenicea* were identified as the most frequently cited species. Leaves and aerial parts accounted for most plant organs used, while infusion and decoction were the dominant preparation methods. The analysis also revealed a strong relationship between perceived effectiveness and citation frequency. These findings allowed the identification of the main plant species used by local phytotherapy practitioners and highlighted those with the highest relative frequency of citation and perceived efficacy. Overall, the high citation frequencies and their rich content in bioactive compounds such as tannins, flavonoids, terpenes, and polysaccharides underscore their therapeutic relevance and highlight several species as promising candidates for further investigation as potential natural anti-*H. pylori* agents, supporting the need for further phytochemical and pharmacological validation for the management of *H. pylori*-associated gastric disorders.

AUTHOR CONTRIBUTION

YKK: Conceptualization, Data curation, Investigation, Methodology, Validation Visualization Writing—original draft. MK: Formal analysis, Supervision, Administración. MSEB: Data curation, Resources, Formal analysis. MB-B: Conceptualization, Methodology, Software, Supervision, Writing—review & editing.

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