Ethnobotanical study on the valorization of a rare forest, fruit and medicinal plant (*Prunus avium*) in north-western Tunisia

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Research

Abstract

Background: This ethnobotanical study aimed to promote the rare medicinal plant *Prunus avium* from Jendouba region in northwestern Tunisia and to collect general information regarding its therapeutic applications.

Methods: Ethnobotanical surveys were conducted among rural populations and herbalists in the three areas (Tabarka, Ain Draham, and Ghardimaou) using a questionnaire on *Prunus avium*. Following the conclusion of the fieldwork, the collected information was processed. It was then sorted and structured into a matrix using XLSTAT software, which enabled the creation of graphs and tables.

Results: The data collected shows that *Prunus avium*, also known as wild cherry, is widely used in the region. In fact, the research conducted in these three areas showed that it was mainly recommended for its anti-inflammatory (23%), diuretic (20.9%), sleep-promoting (16.1%), relief from osteoarthritis (15%), and cholesterol-lowering properties (15%). Respondents also indicated that the leaves and fruits were the most commonly used parts, with 68% and 32%, respectively. Also, decoction (25.55%), fruit juice (23.53%), infusion (21.87%), and compress (20.65%) were generally mentioned.

Conclusion: This work serves as a valuable source of information for pharmacological research, providing a foundation for evaluating the therapeutic efficacy of *Prunus avium*. It emphasizes the effective transmission of knowledge regarding the applications and beneficial effects of wild cherries from one generation to the next.

Keywords: *Prunus avium*, ethnobotanical survey, method of preparation, therapeutic uses, northwestern Tunisia.

Background

The Mediterranean basin is a global hub for plant species biodiversity. The region with approximately 25,000 phanerogams, represents nearly 10% of the world's flora. The high rate of endemics (60%) is a defining feature of the flora of this region (Cuttelod *et al.* 2009). The conservation of plant biodiversity has been a key concern of international bodies for several years, forming part of a sustainable development policy that must guarantee the sustainability of plant genetic resources for future generations. Tunisia, with its diverse soils and climate, is home to a rich and varied wild flora with estimated 2,162 species

(Nabli 1989). The wild cherry has a relatively high rate of growth. However, it is very sensitive to periods of drought. Minimum winter temperatures below 9°C limit its growth (Houghton *et al* 2023). It has the capacity to adapt to varied climatic conditions, but ensuring quality wood production remains a challenge (Jdaidi & Hasnaoui 2018). *Prunus avium* is an edible medicinal plant with proven benefits to many diseases such as cardiovascular health, Alzheimer's disease, inflammatory conditions, and a range of chronic diseases. The fruit is distinguished by its high polyphenol content, while the seeds are notable for their high fatty acid content, particularly polyunsaturated fatty acids. In most countries, and even in Tunisia, wild cherries have a long history of use as food and medicine. The fruits, stems, and seeds are used in traditional medicine to treat a range of conditions, including skin diseases, colds, rheumatism, gout, constipation, stomach aches, and gingivitis. As for the fruits of *Prunus avium*, which characterized by a distinctive sour taste and a deep red coloration, many studies indicate that it may offer protection against diabetes and effective anti-inflammatory benefits (Wallace & Sharkey 2011, Saleh *et al.* 2017).

These fruits are composed of essential nutrients that possess functional properties, which prevent the development of various diseases, including diabetes, obesity, heart disease, inflammatory disorders, and neurological diseases (Kirakosyan *et al.* 2009, Ferretti *et al.* 2010).

The mainly concern of this project was to promote the species of *Prunus avium* by emphasizing its beneficial properties and the diverse traditional applications associated with it. These applications are multifaceted, encompassing domains such as culinary, therapeutic, and cosmetic practices.

The project, which will be carried out through questionnaires and interviews with local communities and herbalists in the northwestern region of Tunisia, will provide further insight into this ancient wisdom, for which there is currently no written evidence. Data on regional medicinal plants is fragmented and scattered, and the knowledge is currently held by only a few people. This study aims to add more knowledge and to shed light on the current situation of this historical practice.

Materials and Methods

Study area

Jendouba Governorate is located in northwest Tunisia; it is on the Tunisian-Algerian border. It encompasses about 3,102 km², or 2% of the country's total surface area. The population exceeded 401,477 as of the 2014 census (INS, 2014). The region is well-known for its rich environment and landscape, and it is home to one of the most prestigious protected areas in the Mediterranean. The Governorate of Jendouba is divided into nine delegations based on its administrative division. The governorate is divided into five natural microregions (Fig. 1).

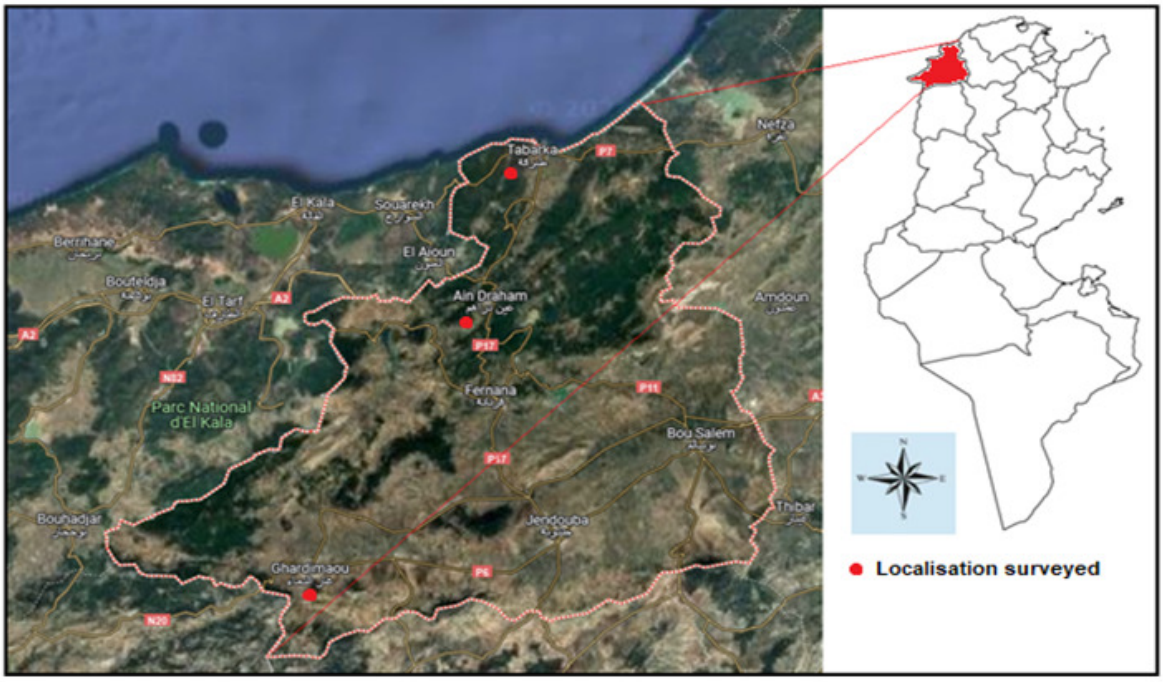

Figure 1. Location of the surveyed areas in Jendouba Governorate

The governorate is divided into delegations: Tabarka, Aïn Draham, Fernana, Ghardimaou, Oued Meliz, Bou Salem, Balta Bou Aouane, and Jendouba Nord. The region has the wettest climate in the country, with annual rainfall averages approximately 1,050 mm in Tabarka and exceeds 1,500 mm in Ain Draham. In winter, the average temperature is between 5 and 10°C, while in summer it is between 25 and 30°C.

Three areas were selected for this ethnobotanical study on *Prunus avium*: Ain Draham, Tabarka and Ghardimaou (Fig. 2). These forest areas are composed of three distinct plant strata. The first is a monospecific tree stratum, which includes *Quercus suber* L. (Fagaceae), *Quercus coccifera* (Fagaceae), and *Quercus canariensis* L. The second is a dense shrub layer, which is defined by the presence of *Phlyrea angustifolia* L. (Oleaceae) and *Phlyrea media* L. (Oleaceae). The third is a mixed shrub layer, which includes a variety of species. The following species are present: *Pistacia lentiscus* (Anacardiaceae), *Rubus fruticosus* L. (Rosaceae), *PrunusVavium* L. (Rosaceae), *Erica arborea* L. (Ericaceae), and *Arbutus unedo* L. (Ericaceae). Additionally, the region is home to *Myrtus communis* (Myrtaceae) and certain grasses. Additionally, the region is home to a rich variety of medicinal and aromatic plants, fodder, and honey.

Figure 2. Photos of the three areas studied. (a) Tabarka; (b) Ain Draham; (c) Ghardimaou (Jdaidi 2023)

Ehnobotanical survey

The ethnobotanical field surveys were conducted over a two-year period, from May to September of 2023 and 2024. A variety of individuals were consulted on an anonymous basis (Fig. 3).The ethnobotanical study was conducted using a series of pre-established questionnaires. These included specific questions about the informant (age, gender, educational level), the part used, the methods of preparation, and the therapeutic and traditional use against diseases.

In addition, respondents were queried about potential toxicity or adverse effects associated with *Prunus avium*. Concurrently with the investigations in the three rural regions under consideration, we conducted surveys among herbalists in the Jendouba governorate to obtain supplementary data on the medicinal utilization of this species.

To ensure a more representative sample of the region, we employed a proportional stratified random sampling methodology. Our survey yielded a total of 292 responses, providing insights into the main characteristics of the Jendouba population.

Figure 3. Wild cherry (*Prunus avium* L.) plant. (a) Fruit; (b) Leaf; (c) Tree (Jdaidi 2023)

Data Processing

Statistical analysis of the knowledge scores was determined by using XLSTAT 2022 software to test the influence of gender, education level and age on ethnobotanical knowledge. The Mann-Whitney U test was used to determine the differences of gender in medicinal plant knowledge. However, the Kruskal-Wallis test was performed to evaluate the relationship between the socio-demographic data of the informants and their ethnobotanical knowledge. Principal Correspondence Analysis (PCA) was used to illustrate the relationship between socio-demographic and ethnobotanical data of *Prunus avium*.

Citation Frequency

The citation frequency of each taxon is calculated according to the formula used by Tardío and Pardo-de-Santayana (2008):

$$\mathbf{FC} = \frac{\mathbf{n}}{\mathbf{N}} \times \mathbf{100}$$

n: Number of individuals who cited the species.

N: Total number of individuals interviewed.

Relative frequency of citation (RFC) was calculated as a numerical representation. The latter was calculated in the ethnobotanical survey to demonstrate the importance of traditional knowledge (Tardío and Pardo-de-Santayana 2008). This index is calculated by dividing the frequency of citation (CF) by the total number of respondents (N), as represented the following formula:

$$\mathbf{RFC} = \frac{\mathbf{FC}}{\mathbf{N}}$$

Results and Discussion

The study population consists of 292 informants residing in the surveyed areas in this study: Tabarka, Ain Draham, and Ghardimaou. The questionnaires were distributed to individuals from diverse socio-cultural profiles within the governorate of Jendouba. The data collected during the ethnobotanical survey is stored in a database, processed and analyzed, and then interpreted.

Frequency of Use of Medicinal Plants

According to the Type of Medicine

During ourethnobotanical survey, 292 participants were asked to indicate the type of medicine they use to relieve infections. They could choose between modern medicine or traditional medicine (herbal medicine) or both at the same time. The results showed that 35% of participants mentioned preferred modern medicine, compared to 65% who used traditional medicine (Fig. 4). Our findings are consistent with those of previous studies, several of which have found that the frequency of medicinal plant use is quite high. This rate was 67.5% for Ziyyat *et al.* (1997), 76% for Jouad *et al.* (2001), 80% for Eddouks *et al.* (2002), and 77.47% for Mouheb (2019). According to the responses obtained from the 292 users of medicinal plants, about 43.3% of them attest the effectiveness of the plants used, about 51.6% acquire them, 3% select them because of their cost-effectiveness, and about 2.1% believe that the drugs are no longer effective. This high rate of medicinal plant use in the northwest of Tunisia indicates that traditional medicine continues to play a significant role in primary health care, alongside modern medicine.

The economic challenges, including drug costs and the post-revolution economic crisis, may be the primary factors contributing to the resurgence of herbal medicine.

The natural regeneration of *Prunus avium* by seeding or suckering is strongly influenced by climate change which makes a direct impact on its ecological habitat and distribution area in Tunisia. The climatic variability in the recent years has had a negative impact on the ethnobotanical availability of these species. Similar result was found by Jdaidi et al. (2023) and showed that the availability of species such as *Olea europea*, *Myrtus communis*, *Arbutus unedo* and *Laurus nobilis* was very influenced by climate change.

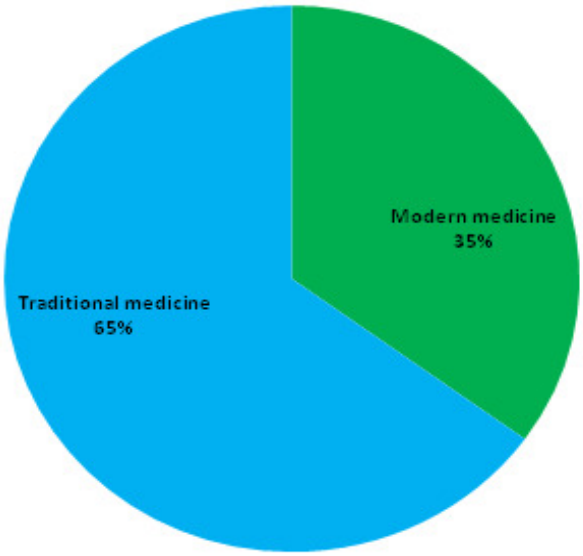

Figure 4. Distribution of the participants according to the type of medicine

Sociodemographic study on the medicinal use of *Prunus avium*

According to age

Table 1 show the age distribution of the sample under study. The majority of respondents were between 40 and 60 years old of about 40.1%, followed by those over 60 with 31.6% and those between 20 and 40 years old was about 20.5%. However, Informants under the age of 20 was the last with about 7.8% according to the Kruskal-Wallis test ($x^2 = 82.72$, $P < .001$). The results show that the older informants (40-60 and >60) have more knowledge about medicinal plants than other age groups. This explained that the young age informants group is not taking interested in the tradition knowledge of medicinal plant and its preservation. As we know, experience gained with age is the main source of information about the use of plants in traditional medicine.

At present, the traditional medical knowledge transmitted from generation to generation is appearing to be in danger because transmission between older and younger generations is not always assured. These values confirm the results obtained in national and global studies by Anyinam (1995), Mehdioui & Kahouadji (2007), Benkhnigue *et al.* (2011), and Jdaidi & Hasnoui (2016). Previous research indicates that the older adults are more likely to use medicinal herbs, but younger adults are less interested in using it. The use of medicinal plants is generally learned through years of experience. It is passed down from one generation to the next (Beldi *et al.* 2021). Older people are often considered the most confident ethnobotanists due to their extensive knowledge of medicinal plant applications (Miara *et al.* 2018, Lazli *et al.* 2019, Senouci *et al.* 2019, Bouafia *et al.* 2021, Gherib *et al.* 2024).

According to gender

The majority of informants involved in this study are female (54.11%), compared to male informants (45.89%), resulting in a sex ratio of 1.17. Descriptive and inferential statistics showed that women (n = 158) had a higher knowledge of medicinal plants than men (n = 134), although the Mann-Whitney U test (U = 272.35, P = 0.255) did not show a significant difference between male and female informants regarding the use of the recorded medicinal species (Table 1). These results confirm many other ethnobotanical studies carried out at the nationally and internationally scale. As the primary caregivers for household and child health, women make use of medicinal plants more frequently than men. This finding aligns with numerous studies conducted in Tunisia, Algeria, and Morocco, which have demonstrated that women tend to provide more

detailed information about the medicinal plants they utilize. This phenomenon can be attributed to the fact that women exhibit a stronger commitment to the preservation and transmission of traditional knowledge across generations (Rhattas *et al.* 2016, Jdaidi & Hasnaoui 2016, Alaoui & Laarbya 2017, Katiri *et al.* 2017, Miara *et al.* 2018, Lazli *et al.* 2019, Senouci *et al.* 2019, Beldi *et al.* 2021, Hedidi *et al.* 2024, Gherib *et al.* 2024).

According to academic level

Regarding the level of education, 45.9% of the participants were illiterate, followed by the categories of primary and secondary education with percentages of 25% and 19.8%, respectively. People with a university education were the least likely to use medicinal plants, with a percentage of 9.2% (Table 1). The difference between education level and indigenous knowledge was therefore significant (Kruskal-Wallis: $x^2 = 84.55$, $P< 0.001$).

We can observe that the use of medicinal plants decreases as the level of education increases. However, our results are similar to those reported in the studies of Benkhnigue et al. (2011) and Jdaidi & Hasnaoui (2016).These previous studies show that 60% of illiterate people prefer herbal medicine, while this percentage is less than 6% among academics. However, our study indicates that the majority of respondents (35%) obtained their knowledge through oral transmission of ancestral knowledge, while 30% acquired their information through reading, 20% consulted healers, as for the remaining 15%, they contacted herbalists. This observation aligns with the findings of Klotoé *et al.* (2013) and Benlamdini *et al.* (2014). According to Chaachouay et al (2020), the majority of informants are illiterate or at the primary level. The low level of education is not a constraint on the knowledge of plants and their uses or the transmission of ethnobotanical information from one generation to the next orally.

It demonstrates that the benefits of plants are indispensable and continuously adapted and this traditional knowledge passed down from generation to the next.

Table 1. Demographic characteristic of participants

Variable	Category	Number of informants (N=292)	%	Test	P
Sex	Female	134	45.89	U=272.35	0.255
	Male	158	54.11		
Age	<20	23	7.8	X^2=82.72	<0.001
	20-40	60	20.5		
	40-60	117	40.1		
	>60	92	31.6		
Education level	Primary School	73	25	X^2=84.55	<0.001
	Secondary School	58	19.9		
	University	27	9.2		
	Analphabetic	134	45.9		

Ethnobotanical analysis of the plant *Prunus avium*

According to the parts of the plant used

The graph below illustrates the distribution of the sample studied according to the parts of the plants most frequently used in the treatment of diseases. The fruits of *Prunus avium* are the least frequently used in the treatment of diseases, with 32% of the responses. The majority use of the leaves (68%) is explained by their richness in active compounds (Fig. 5). The exclusive use of the aerial part can be attributed to the established efficacy of this part in herbal medicine or to the management and protection of the plant.

Our findings coordinate with previous studies (Benarba *et al.*(2015), Kadri *et al.* (2018), Beldi *et al.*(2021), Guechi (2022), Hedidi *et al.* (2024), and Gherib *et al.* (2024)). The high level use of leaves and fruits can be explained by the ease and speed with which these parts of the plant can be harvested. In addition, leaves are the main parts of plants where photosynthesis happens and where secondary metabolites are stored. These secondary metabolites are responsible for the pharmacological properties of the plant (Garrido et al 2023). Since leaves are the engine of photochemical reactions, rich in active compounds, and they are easy to harvest, this outlines our findings. Furthermore, the use of leaves does not pose any threat to plant regeneration and assists in maintaining the biodiversity of the flora.

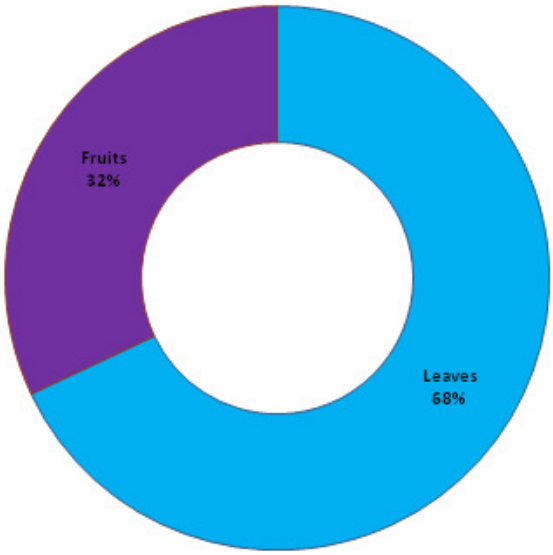

Figure 5. Distribution of the used parts of the *Prunus avium* species

According to the method of preparation

To be precise, investigators lack efficacy knowledge of the weight and dimensions of the plants when they manufacture and distribute herbal medicines. Thus, the responses obtained do not address the precise quantity of each component of the plant to use, nor do they address the appropriate cooking time for the different parts of the plant to prepare the medicine. Additionally, they are unable to determine the correct dosage for each patient. The most prevalent preparation methods include decoction (25.55%), fruit juice (23.53%), infusion (21.87%), and poultice (20.65%) (Fig. 6). The local population favors decoction and fruit juice given their perceived efficacy in warming and disinfecting the body (Tahri et al. 2012). As proven, decoction has been shown to extract the most active substancein the plant and to reduce or cancel the toxic effect of some recipes (Salhi *et al.* 2010, Benarba *et al.* 2015, Bendif *et al.* 2020).

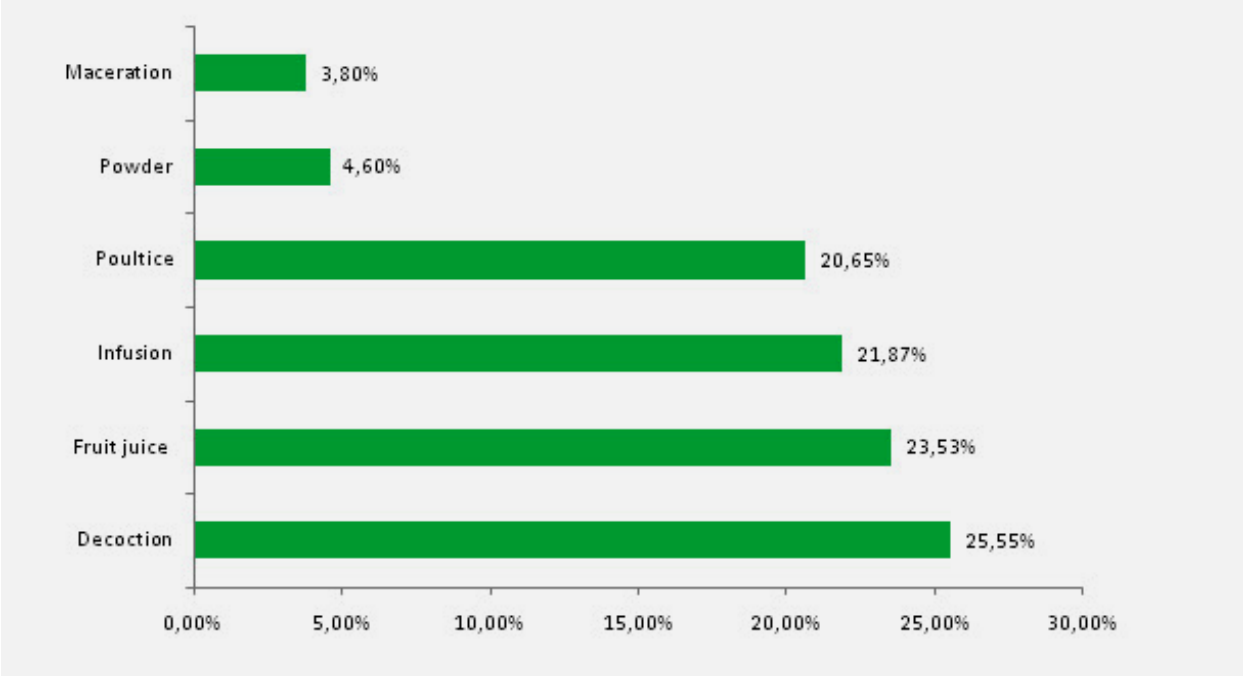

Figure 6. The proportions of the preparation methods

According to the diseases treated and relative frequency of citation (RFC)

A daily consumption of cherry juice for a period of four weeks has been demonstrated to significantly promote health by reducing signs of inflammation (23%) and diuretic effects (20.9%) associated with chronic diseases and also lower the levels of systolic blood pressure (BP). Other significant benefits of regular cherry consumption include good sleep (16.1%), reduced bad cholesterol (15%), relief from osteoarthritis (15%), and improved gut health (10%) (Fig. 7). For each disease category, the RFC values ranged from 0 to 1. Anti-inflammatory indications accounted for the most usage reports, followed by relief from osteoarthritis (0.15), diarrhea (0.209), sleep improvement (0.161), and low-density lipoprotein (0.15). The high values of RFC can be explained by the fact that this plant is the best known and has long been used by the majority of informants, representing a source of reliability.

In Tunisia, this species has a high RFC, which should be subjected to pharmacological, phytochemical, and biological studies to evaluate and substantiate its authenticity.

These results clearly showed the relative importance of this species, mentioned by many informants in the treatment of a well-defined group of diseases. The RFC of our species is very close to that of other species obtained in Morocco: *Olea europea* L. subsp. sativa (RFC = 0.12), *Trigonella foenum-graecum* L. (RFC = 0.17), *Salvia officinalis* L. (RFC = 0.15) (Skalli et al. 2019). *Olea europaea* L. subsp. *europaea* (RFC = 0.243), *Salvia officinalis* L. (RFC = 0.230), *Trigonella foenum-graecum* L. (RFC = 0.205) (Mrabti et al. 2019). *Olea europaea* L. subsp. *europaea* (RFC = 0.243), *Salvia officinalis* L. (RFC = 0.230), *Trigonella foenum-graecum* L. (RFC = 0.205) (Mrabti et al. 2019). *Rosmarinus officinalis* L. (RFC = 0.189) (Chaachouay et al. 2022). *Rosmarinus officinalis* L. (RFC = 0.33) (Ghanim et al. 2022). And in Algeria: *Trigonella foenum graecum* L. (RFC = 0.25), *Rosmarinus officinalis* L. (RFC = 0.21), *Salvia officinalis* L. (RFC = 0.06) and *Olea europaea* L. subsp. *europaea* (RFC = 0.25) (Tellier et al. 2016). Conversely, our species presents a higher RFC than *Trigonella foenum-graecum* L. (RFC = 0.054) and *Olea europaea* L. subsp. *europaea* (RFC = 0.051) (Chaachouay et al. 2022). This can be explained by the fact that these plants are the most well-known and have been used for a long time by most informants, which represent a source of reliability. However, Species with higher RFC values should be prioritized for phytochemical and pharmaceutical analysis to identify their active compounds for potential drug development (Kayani et al. 2015, Mukherjee et al. 2012, Vitalini et al. 2013).

Alba et al 2019 illustrated that *Prunus avium* has been used as a preventive agent against cardiovascular damage, Alzheimer's disease, inflammatory diseases and chronic diseases characterized by high oxidative stress, such as cancer and diabetes. However, Kelley et al 2018 showed that cherry improves appetite, reduces blood pressure and inflammation, secure against oxidative stress, reduces pain and muscle damage caused by exercise, and also make normal blood sugar levels.

These beneficial effects of tart cherries are explained by the high content of antioxidant compounds in the species, which play an important role in promoting human health in different ways.

More importantly*, Prunus avium* fruits are considered the noblest fruits because of these many health benefits. They have a low content of simple sugars (8 g/100 g and also rich in vitamin A and total phenolics (254.1 g/100 g) and anthocyanins (54.5 g/100 g) (Carbonero, 2017).

In addition*, Prunus avium* has very high antioxidant activity (Sokół-Łętowska et al., 2020), as does cherry extract, which has the ability to prevent and treat diabetic eye disease (Saleh et al., 2017; Xiao & Xiao, 2019). They are known for their polyphenol content (in the form of anthocyanins and isoflavonoids). Moreover, many studies have focused on the defensive role of sour cherries in inflammation (Brio et al., 2019; Raafat et al., 2020).

Analysis of sociodemographic variables and different uses of investigators by Principal Correspondence Analysis (PCA)

To improve our understanding of the interaction between sociodemographic and ethnobotanical data regarding *Prunus avium*, we grouped and sorted the responses from the spreadsheet into a matrix. We performed a principal component analysis (PCA) using seven variables (Fig. 8). The two axes collectively account for 85.39% of the total variance, with axis 2 accounting for 17.41% and being positively defined by age, education level, and the category of diseases treated. The other parameters of which part of the plant used contribute marginally to the variation. Axis 1 accounts for 67.99% of the total inertia, and its positive definition includes methods of preparation and gender. In addition, a negative correlation exists for the preparation methods on the same axis.

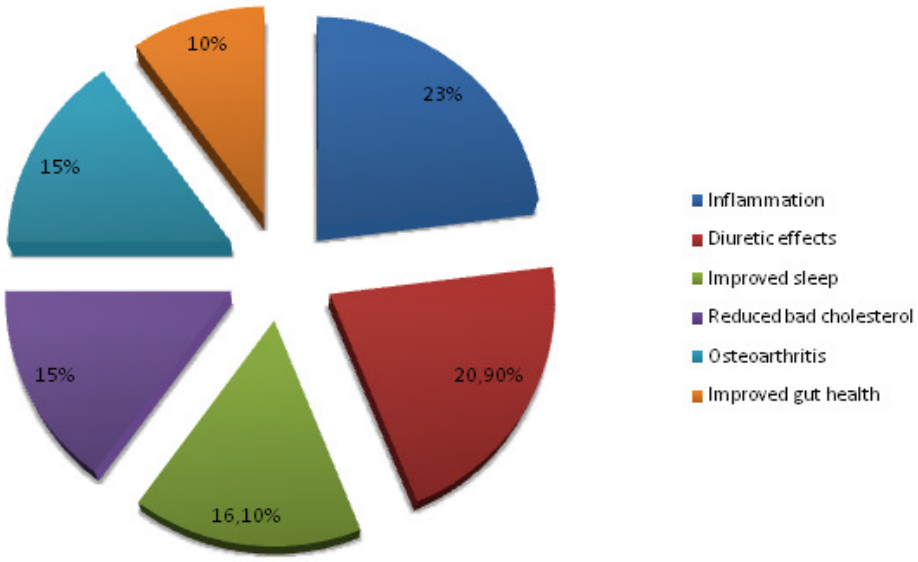

Figure 7. Frequency of therapeutic use of *Prunus avium*

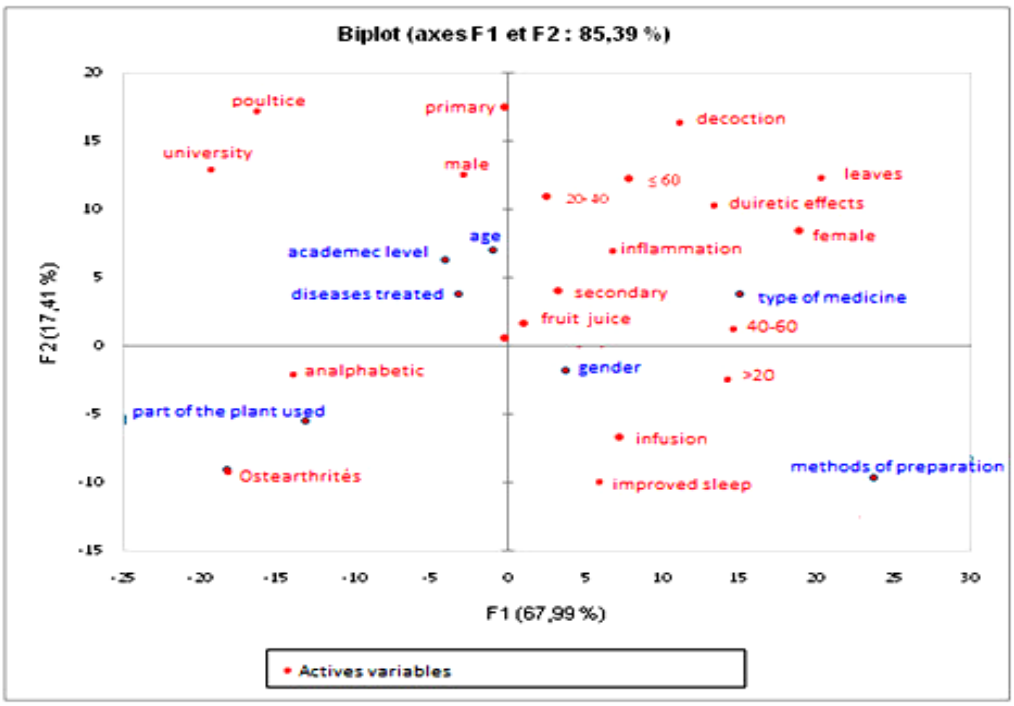

Figure 8. Principal component analysis of sociodemographic and ethnobotanical data on the plan defined by axes 1 and 2.

Conclusion

Herbal medicine is a time-honored therapeutic approach that dates back to ancient times. It represents a significant chapter in the history of humanity, as our ancestors first began to utilize plants for sustenance and to identify remedies for afflictions. A recent ethnobotanical study conducted in the region of Jendouba, situated in the northwestern part of Tunisia, underscores the profound significance of traditional herbal medicine in this locale area. The ethnobotanical study carried out for this purpose highlighted the importance of *Prunus avium* plant in the traditional herbal medicine of the local populations in the three regions considered of northwestern Tunisia.

An analysis of questionnaires and observations of the flora at the site revealed that 65% of the Tunisian rural population uses traditional medicine for the remedy of many diseases. This ethnobotanical research reveals that the use of *Prunus avium*, a tree present in the study area, is common for treating inflammation, digestive disorders, improving sleep quality, relieving osteoarthritis, and cholesterol disorders.

The treatments are primarily made from the leaves, the most used plant organ, and by decoction, the predominant preparation method in traditional herbal medicine.

In conclusion, these results can serve as a valuable source of information for scientific research in phytochemistry and pharmacology of *Prunus avium*.

Declarations

List of abbreviations: RFC: Relative frequency of citation.
Ethical approval and consent to participate: All respondents from the Jendouba region gave their prior consent to participate in the surveys.
Consent for publication: Not applicable
Availability of data and materials: All the figures, tables and appendices in the manuscript are available from the author.
Competing interests: The authors declare that they have no conflicts of interest.
Funding: This research has not received any funding.
Authors' contributions: Jdaidi Nouri: data analysis, figure generation and drafting the work, Selmi Houcine: supervision and revision, Cyrine El Baher Dhafer: drafting the work and Chaabane Abbes: supervision and revision.

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