Biodiv. Res. Conserv. 76: 39-49, 2024

BRC
www.brc.amu.edu.pl

DOI 10.14746/biorc.2024.76.1

Submitted 09.05.2024, Accepted 23.12.2024

Therapeutic properties of the Atlas pistachio tree (*Pistacia atlantica* Desf.) in the Naâma region (Algeria)

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Abstract. The Atlas pistachio tree (*Pistacia atlantica*) is a woody deciduous species from the family Anacardiaceae. It thrives in the steppe plains and Saharan Atlas of the Naâma region in south-western Algeria. This tree is well known in traditional Algerian medicine for its active phenolic compounds, particularly those found in its seeds and leaves. To promote its use, an ethnobotanical survey was conducted among herbalists and other knowledgeable individuals in the Naâma region, utilizing 100 questionnaires divided among 25 municipalities. The findings revealed that leaves (42%) and fruits (31%) are the most commonly utilized parts. The predominant preparation methods include decoction and grinding, but also other forms are popular, such as herbal tea or powder mixed with honey, dates, milk, or water. Administration is mainly oral, though external applications are also common, particularly for localized issues. The most frequently treated conditions include oral diseases, stomach ulcers, respiratory infections, Malta fever, and skin rashes, with values of fidelity index ranging from 2% to 14%. Most reported outcomes from these treatments are positive, indicating either cures or improvements. The frequency of use for this plant among the respondents is 100%, underscoring its significant cultural importance. The informant consensus exceeded 0.70, reflecting a robust therapeutic understanding of the plant. The global knowledge index regarding its uses is notably high, highlighting its essential role in the community for medicinal and other applications.

Key words: *Pistacia atlantica*, ethnobotany, traditional medicine, anti-inflammatory, Naâma, medicinal herb, Algeria

1. Introduction

For a long time, the Algerian society, especially rural, has used plant products to meet their needs, especially for food, heating, and healthcare. It has traditional knowledge of collecting and using plants for nutritional and medicinal purposes, which is passed down from one generation to another by the elderly (El Hafian *et al.* 2014; Hamel *et al.* 2018; Boucherit 2018; Meddour *et al.* 2022).

These natural products constitute a source for pharmaceutical development. However, natural plant-based products have been progressively sidelined by the pharmaceutical industry (McChesney *et al.* 2007). Nevertheless, many authors have addressed the value of plants and their potential as sources of medicines (e.g. Kinghorn 1992).

The Atlas pistachio tree is recognized in traditional Algerian medicine for its active phenolic compounds, such as tannins and flavonoids, especially in its fruits and leaves. This species is also used in conventional medicine to treat gastrointestinal and respiratory infections (Giner-Larza *et al.* 2001). Due to its anti-inflammatory, antioxidant, antipyretic, antibacterial, and antiviral properties, numerous medications can be synthesized from this plant. It seems to be a promising source of anticancer drugs (Hashemi *et al.* 2017) and therapeutic antifungals (Oliveira *et al.* 2024).

In the South Oranian region, *Pistacia atlantica* groups constitute a particular natural heritage. They are generally scattered between the steppe plains and the Saharan Atlas. (Benaradj 2017). The tree is commonly called the Atlas pistachio or Betoum. It is one of the most characteristic plant species of the Saharan Atlas, as its

name suggests, but is quite common throughout Algeria in arid and semi-arid areas. Its range extends from the humid Tell Atlas to arid and even Saharan regions, where it is scattered or dense in depressions (dayas) on the high steppe plains, the northern Sahara, at the foothills of the Saharan Atlas in the best-watered parts, and even in the Hoggar in a relict state (Monjauze 1967, 1968, 1980; Ozenda 1983; Benhassaini 2003; Benaradj 2010; Benaradj *et al.* 2021; Ait Bouzid *et al.* 2023). It often grows in clumps of Ziziphus lotus, which thrives in warm regions (Benaradj *et al.* 2015a; Ait Bouzid *et al.* 2023).

Stands of *Pistacia atlantica* are found in vast expanses of the Saharan Atlas and the high steppe plains of Algeria, so they constitute an important off-forest heritage of south-western Algeria. It is a species of the future for Algeria, as its resistance to all environmental hazards gives it a special status, compared to the species of southern Algeria. This forest, fruit, and fodder tree, endemic to North Africa, plays an important ecological and socio-economic role for the population (Benaradj *et al.* 2015a, 2023; Benaradj 2017; Mekhloufi *et al.* 2019). The fruits are drupes, locally called *Godhim*, and the bark produces mastic resin (Fig. 1). Its wood is used in crafts, for heating, and carbonization (Monjauze 1980; Benaradj *et al.* 2015b, 2015c). The seeds contain a high proportion of oils (26-64%), so they belong to the oilseed category. Fibres are also significant components, making up 12-32%. Additionally, they contain moderate levels of proteins (8-14%) and polysaccharides (5-9%) (Labdelli *et al.* 2021).

Our ethnobotanical study aimed to contribute to the identification and promotion of the different therapeutic uses of *P. atlantica* among the local population in the Naâma region in Algeria.

2. Material and methods

2.1. Plant material

The study focuses specifically on groups of *Pistacia atlantica* in the wild in the Naâma region (south-western Algeria). It is a large tree, up to 10 m high and often more than 100 cm in diameter. Its crown is voluminous and rounded. It is more abundant in the Saharan region, at altitudes of 700-1400 m (Benaradj *et al.* 2023). Monjauze (1968) describes it as a species par excellence of the high central plains of the Maghreb and the dayas of the southern foothills of the Saharan Atlas. It was abundant in the past but today very scattered; it only regenerates in the tufts of jujube trees (*Ziziphus lotus*). It has a broad ecological plasticity, as it adapts to various soils in the Mediterranean context, tolerates strong winds and long periods of drought (Boudy 1950; Benaradj *et al.* 2012). The bioclimatic areas range from humid to arid, so the pistachio trees are essential species of the scrubland of the Mediterranean zone.

2.2. Study area

The Naâma region (wilaya) is located in south-western Algeria. It covers an area of 29514 km^2 (ca. 1% of the Algerian territory), located between 32°51'N

Fig. 1. Morphology of *Pistacia atlantica*

Explanations: a – tree, b – foliage, c – male flowers, d – female flowers, e – unripe fruits, f – ripe fruits, g – harvested fruits

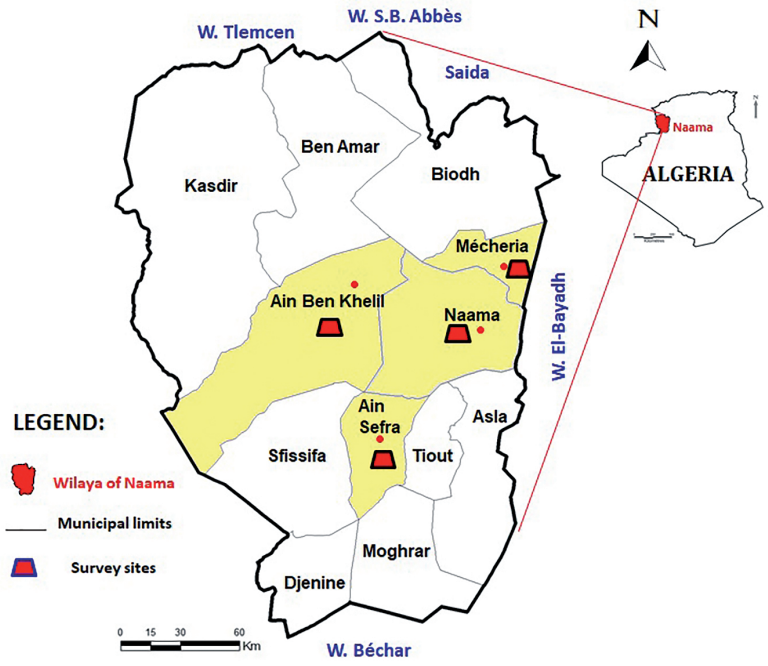

Fig. 2. Distribution of survey sites in the Naâma region (Boucherit 2018)

and 33°33'N and between 00°01'E and 00°02'E (Fig. 2). It is subdivided into a steppe zone in the north and a pre-Saharan zone in the south.

The region has a Mediterranean climate with a decreasing bioclimatic gradient from north to south, ranging from semi-arid to lower arid and pre-Saharan. Precipitation is low and irregular, 190-250 mm/year, with a fairly long dry period of 6-7 months, characterized by low temperatures generally falling below -4°C. Temperature data show cold winters (-0.3°C < mean daily minimum < 2°C), and very hot summers (32°C < mean daily maximum < 39°C). This coincides with the meso- and thermo-Mediterranean vegetation belts and explains its belonging to the arid bioclimatic zone (Boucherit 2018; Benaradj *et al.* 2021).

Based on the French soil classification (CPCS 1967), the soils of the Naâma wilaya are generally shallow and can be classified as raw mineral soils, less evolved soils (including groves and dayas), calcimagnesic soils, and halomorphic soils (Pouget 1980; Halitim 1988; Haddouche 1998; Bensaid 2006; Benaradj 2009; Boucherit 2018; Boucherit *et al.* 2024).

The wilaya has a vast area rich in vegetation: the steppe rangelands, forests, and scrublands. It is characterized mainly by steppe formations in the herbaceous stratum in particular (*Stipa tenacissima*, *Lygeum spartum*, *Stipagrostis pungens*, *Hammada scoparia*), while forest formations are mostly dominated by *Pinus halepensis*, *Quercus ilex*, *Pistacia atlantica*, and *Juniperus phoenicea* (Benaradj 2017; Boucherit 2018; Boucherit *et al.* 2024).

2.3. Methodological approach of the ethnobotanical survey

The ethnobotanical survey was conducted in 4 survey sites: Naâma (the capital of the wilaya, Mecheria (in the north of the wilaya), Ain Sefra (in the south), and Ain Ben Khelil (in the south-west), which is the municipality most endowed with the natural heritage of *Pistacia atlantica.*

2.3.1. Data collection

The survey was conducted from March to June 2023 in Arabic and local languages. Simple random sampling was adopted. Information on the use of the Atlas pistachio tree was obtained through interviews with people from the local population and herbalists. Using 100 questionnaire sheets (25 per municipality) we asked about gender, age, and academic level of the respondent, the disease treated, the plant parts used, the methods of preparation, use and administration as well as the related side effects.

2.3.2. Classification and data analysis

The collected data were sorted, organized, and processed to describe the demographic status of the users of the plant and to determine its most used parts, the most common method of preparation, and the diseases treated.

2.3.3. Exploration of ethnobotanical indices

We calculated ethnobotanical indices, which allow knowing and understanding the traditional and cultural

knowledge related to the plant and its importance for the society. Indeed, these indices are defined by many authors for research on several species simultaneously and adapted for the study of a single species.

The frequency of use (FU) was calculated to assess the importance of P. atlantica for the populations surveyed (Assogbadjo et al. 2011) according to the formula:

$$FU = \frac{Rv + Rh + Raf}{Ne},$$

where Rv = number of elderly people (>60 years), Rh = number of middle-aged adults (40–60 years), and Raf = number of young people (< 40 years) using the species; and Ne = total number of people interviewed.

The plant part use value (PPV) is the ratio of the sum of uses of a plant part to the total number of uses for the plant. This index, determining the most used organ/part in the species, is calculated according to Lykke (2004):

$$PPV = \frac{RU \text{ plant part}}{RU},$$

where RU = total number of reported uses for the plant.

PPV is practically the same as the use value (UV) of the plant defined by Gomez-Beloz (2002), Avocèvou *et al*. (2009), and Atakpama et al. (2012) to assess knowledge of the species. It is calculated according to the formula:

$$UV = \frac{\sum RU \text{ plant part}}{RU},$$

where RU = total number of reported uses for the plant.

The cultural importance index (CII) is used to determine the cultural importance of the plant and of its parts (Houehanou *et al.* 2011) for a given category of use (Tardío & Pardo-DeSantayana 2008). It is calculated by the following formula:

$$CII = \sum_{U\text{-}U1}^{UNc} \sum \frac{URi}{N},$$

where UR = number of informants using a given species for a specific use category; U = Use Specific of the plant; Nc = total number of use categories; and N = total number of informants.

The informant consensus factor (ICF) evaluates the level of consensus of populations on the uses of woody species (Heinrich et al. 1998). According to many authors (Trotter & Logan 1986; Molares & Ladi 2009; Musa et al. 2011), this factor is calculated by the formula:

$$ICF = \frac{Nur - Nt}{Nur - 1},$$

where Nur = number of citations for each category; Nt = number of species for the same category. Its value varies between 0 and 1. FCI close to 0 indicates that the informants do not agree on the plant used to treat a given disease. A value close to 1 suggests that the consensus between users is high.

The index of fidelity of use (IFU) or fidelity level reflects the relationship between the plant and its role in the treatment of a given disease category. According to Giday et al. (2009) and Ugulu (2012), it is calculated with the formula:

$$IFU = Np/N,$$

where Np = number of informants using the plant for a specific disease; and N = total number of informants using the plant for any disease. We therefore obtain a value for each disease treated.

The global knowledge index (GKI) is used to assess the knowledge of the species by populations with the aim of its conservation and promotion. The index estimates the average number of preparation methods and diseases treated per user. It is calculated according to the formula (Assogbadjo et al. 2011; Lougbegnon 2013):

$$GKI = \frac{Vm}{N},$$

where Vm = average number of the preparation methods used and diseases treated; and N = number of users.

3. Results and discussion

3.1. Analysis of sociodemographic data of respondents

3.1.1. Sex of respondents

At the 4 study sites, in total 100 people were surveyed (women and men). We found that most of them (69%) were female. Indeed, women have more knowledge about the medicinal use of the plant. As home managers, they are interested in the health of their families as well as in aesthetic care (Kouakou *et al.* 2020). However, men often harvest the plant material (Ganka *et al.* 2022).

3.1.2. Age of respondents

The people surveyed, aged from 20 to over 60, were divided into 3 groups: under 40, between 40 and 60, and over 60. The results obtained suggest that the traditional therapeutic use of the Atlas pistachio is common mainly among people over 60 years old (58%). They are the most knowledgeable and traditional practitioners of medicinal plants, followed by those aged 40 to 60 (31%), represented mainly by herbalists. Those aged 20 to 40 represented a small share of the study group (11%) and they returned to traditional medicine only when their doctor's medications did not give good results. Some

of them say they cannot stand the taste and toxic effects of the plant. These results confirm other ethnobotanical works on medicinal plants, which have approved that older people have more knowledge about the therapeutic use of the plant (Mehdioui & Kahouadji 2007). Indeed, the acquisition of knowledge of herbal medicine is done by inheritance in long years of experience (Kouakou *et al.* 2020; Camara *et al.* 2024). This knowledge is transmitted from one generation to another orally (Blama *et al.* 2024) but currently this knowledge is likely to disappear given the difficulties of its transmission by the elderly (Ganka *et al.* 2022) or their death (Tedjani 2024).

3.1.3. Academic level of respondents

Illiterate people accounted for the highest percentage of the study group (38%), followed by those with a primary level of education (33%), whose therapeutic information is transmitted by their older family members: grandparents and parents. People with a middle, secondary or university level (11%, 10%, and 8%, respectively) were represented mainly by herbalists. In these categories, information was acquired and transmitted by their families as well as by reading (books and the Internet). This confirms the results obtained by Blama *et al.* (2024) but Mehdioui and Kahouadji (2007) stated that the high rate of illiterate medicinal herb users constitutes an obstacle against local development and leads to the degradation of plant heritage in the region.

3.2. Use of *P. atlantica* by the respondents

3.2.1. Plant parts used

According to the survey, 6 parts of *P. atlantica* are used in traditional therapeutic treatment in the Naâma region. The most used parts are the leaves and fruits (42% and 31% of answers, respectively), followed by bark (12%), while usage values of flowers and resin are moderate (8% and 6% respectively). These results are in agreement with earlier reports (Daoudi *et al.* 2013; Benaradj *et al.* 2015b) on the therapeutic use of the same species and of other medicinal plants (Benaradj & Boucherit 2022; Boucherit & Benaradj 2023; Koukoura *et al.* 2022; Blama *et al.* 2024). The high use of these parts is explained by the fact that they are sites of biosynthesis, so they constitute reserves of phenolic compounds and other secondary metabolites. In addition, the frequency of their use is also due to the ease and speed of their harvest (Gnagne *et al.* 2017; Beldi *et al.* 2021). In contrast, roots are used rarely (less than 1%) because their harvest is difficult and it damages the tree.

3.2.2. Preparation methods

The survey highlighted that the dominant method of preparation is decoction (47% of answers), followed by grinding (34%), infusion (12%), and poultice (7%). Decoction and grinding are used mostly for leaves and fruits. These methods make it possible to collect the most active ingredients and reduce or eliminate the toxicity in various recipes (Gnagne *et al.* 2017; Amrouche *et al.* 2019). Similar results were obtained in earlier research (Daoudi *et al.* 2013; Benaradj *et al.* 2015b, 2017; Guenane 2017; Boucherit *et al.* 2018; Benaradj & Boucherit 2022; Souilah *et al.* 2023) on the medicinal use of *P. atlantica* and other medicinal plants.

3.2.3. Use and administration

The prepared medicines are mainly used as herbal tea (54% of answers), with a dose of one glass, or in powder (32%) as a spoonful, a pinch or a handful mixed with other plants in milk, or in olive oil or paste (14%) with honey or dates. The administration is mainly oral (54%), but the liquid can be also used for rinsing (24%). The mixed powder is applied by brushing (16%) or massage (6%) on the affected part of the body. The duration of treatment varies depending on the result and the effectiveness of the treatment. It usually lasts 3-40 days and sometimes until improvement or recovery. The dominance of oral administration can be explained by the fact that it is simple, fast, and allows good absorption of the bioactive ingredients of the medicinal plant (Camara *et al.* 2024).

3.2.4. Diseases treated

The survey results show that this plant is widely used: for the treatment of oral and dental inflammations in 14% of answers, gastric diseases (stomach ulcer, abdominal pain) in 13%, respiratory diseases (rate, asthma, throat infections, seasonal allergy) in 11%, Malta fever in 11%, internal diseases (diabetes, elevated cholesterol) in 10%, neurodegenerative diseases (stress, anxiety crisis, insomnia) in 9%, skin conditions (eczema, leishmaniasis, burns) in 8%, headaches (migraine, cephalalgia) in 7%, urogenital diseases (urinary tract infections, kidney stones) in 6%, and liver diseases in 4%. The Atlas pistachio was also reported to be good for bones (fractures, back pain) in 3%, and hair (against hair loss and greying) in 2%, and is used for skin cleansing in 2%. These results are consistent with those of Daoudi *et al.* (2013) on the same plant in the Meknes region of Morocco and Benaradj *et al.* (2015b) among the population of Béchar in south-western Algeria, who additionally noted that the resin of *P. atlantica* is used as a masticatory for teeth whitening, while galls as an anti-diarrhoeal remedy.

Studies carried out on extracts of the leaves and fruits of *P. atlantica* have revealed that it has good antioxidant, anti-cholinesterase and anti-proliferative activities (Achili *et al.* 2020). Its antioxidant power reaches its maximum in August, so this is the optimal period for

harvesting leaves and fruits (Benguechoua *et al.* 2021). The plant has anti-diabetic and anti-hyperlipidemic properties (Mahjoub *et al.* 2018). Phytochemical studies of *P. atlantica* have shown its richness in volatile compounds, flavonoids, phenolic compounds, fatty acids, tocopherols, and phytosterols, which provide it with pharmacological properties, such as antimicrobial, antifungal, anti-inflammatory, analgesic, anti-nociceptive, wound healing, anticancer, cytotoxic, anticholinesterase, anti-diabetic, hepatoprotective, urease-inhibiting, antihypertensive, nipple fissure healing, anti-leishmanial, and antiplasmodial activities (Amri *et al.* 2018; Ahmed *et al.* 2021). It is an excellent anticancer remedy that can eliminate the proliferation of gastric and cervical carcinoma (Hashemi *et al.* 2017). It may also contribute to the stability of curcumin in the digestive system (Naji-Tabasi *et al.* 2024).

3.2.5. Treatment results

In total, 67% of the people surveyed reported an improvement and 33% claimed to have been healed. Admittedly, some declarations of herbalists about improvement or cure of people could be of mainly commercial interest but our results are similar to those obtained by (Daoudi *et al.* 2013) on the use of the same plant in the Meknes region of Morocco.

3.2.6. Toxicity and side effects

Most of the respondents (81%) did not record any toxic effects but some patients allergic to the fruits of the Atlas pistachio reported oral and gastric problems (19%). A study conducted by Benmahieddine (2024) confirms the absence of toxic effects in the leaf buds of *P. atlantica*. Furthermore, the chemical analysis of this species carried out by Ait Kaki (2016) showed that its extracts are non-toxic. However, phenolic compounds may exhibit some toxicity due to the presence of monoterpenic ketones (Bouanane & Boussehel 2005), particularly in cases of uncontrolled use. This valuable species has multiple uses (fodder, nutritional, and medicinal), due to the various interests. For instance, the leaves have provided a food appetizer for sheep and goats (Benaradj 2017). Their phenolic and lipid extracts have a good non-toxic antioxidant power (Zouzou 2016) but according to Daoudi *et al.* (2013) the ingestion of the resin in its raw state can cause some toxicity. Indeed, the prepared treatments must be taken with caution because of the potential side effects.

3.3. Ethnobotanical evaluation by indices

3.3.1. Frequency of use (FU)

The frequency of use of *P. atlantica* in the study group reached 100%. This suggests that local populations commonly use this plant for the traditional therapies and indicates effectiveness of the treatment. Moreover, the frequent use of the species can be caused by its availability for free, accessibility, and simplicity of harvest (Shalukoma *et al.* 2015). Our results confirm other works carried out on medicinal plants (e.g. Mehdioui & Kahouadji 2007; Shalukoma *et al.* 2015).

3.3.2. Use value (UV)

The use values of leaves and fruits reach 0.42 and 0.31, respectively. The high frequency can be attributed to the presence of phenolic compounds and other secondary metabolites, such as flavonoids and tannins, which are recognized for their antioxidant, anti-inflammatory and antimicrobial properties. Their availability and simplicity make them a good choice for harvesting. These results confirm the biochemistry works carried out on the organs of *P. atlantica* (e.g. Hashemi *et al.* 2017; Toul *et al.* 2017; Amri *et al.* 2018; Naji-Tabasi *et al.* 2024). The use value of bark is 0.12, as because of its richness in tannins (Benguechoua *et al.* 2021) it is generally applied to treat skin conditions, but its harvest can be more complex, as compared to leaves and fruits. In contrast, the values of flowers, resin, and roots are lower: 0.08, 0.06, and 0.01, respectively. Resin can be used for its healing and antiseptic properties (Benabdallah *et al.* 2017), but its lower availability and difficulty of extraction restricts its application. Likewise, flowers and roots, in spite of their specific properties, are difficult to harvest. In addition, the use value of leaves and fruits dominates due to their richness in bioactive substances and their availability, while resin, bark, and especially roots are rarely exploited because they protect the tree.

3.3.3. Cultural importance index (CII)

The high CII value (100%) reflects the good knowledge of the informants on the therapeutic application of the plant. Its different parts are used to treat various health problems, thanks to its multiple therapeutic properties. According to El Zerey-Belaskri & Benhassaini (2017), it is a paleo-pharmaceutical species. However, the knowledge of the informants on traditional medicinal treatments by this plant could be low because the transfer of therapeutic information is limited: transmitted from one generation to another mostly orally, with absolute family confidentiality. Thus the knowledge of respondents can be general, as also reported by Ouôba *et al.* (2006). In addition, according to Dossou (2010), the importance of a plant depends on whether it meets the needs of society and not on its availability. This study shows that *P. atlantica* is a species of great socio-cultural importance in the life of the local population in several areas, given its medicinal and fodder potential.

3.3.4. Informant consensus factor (ICF)

A high FCI (> 0.70) expresses a good general knowledge on the medicinal use of the plant, exchangeable between users (Heinrich *et al*. 1998; Amiguet *et al.* 2005; Gazzaneo *et al.* 2005). However, traditional medicine is considered secret by some authors (Baerts & Lehmann 1989; Schulz *et al.* 2001; Shalukoma *et al.* 2015). During the survey in this study, herbalists and traditional practitioners did not want to declare the different uses of the plant. They required an individual interview asking the reason for which the study is reported. According to some authors (Collins *et al.* 2006; Soengas 2010; Shalukoma *et al.* 2015), this secret factor leads to the progressive loss of traditional therapeutic knowledge. Thus ethnobotanical surveys constitute a source for the preservation of this knowledge (Senouci *et al.* 2019; Tedjani 2024).

3.3.5. Index of fidelity of use (IFU) or fidelity level

The fidelity rates of use of the plant for the treatment of different categories of diseases are between 2% and 14%. Oral and dental inflammations and gastric diseases were the most often mentioned diseases in this study. According to Shalukoma *et al.* (2015), common and accessible species can reach 100% fidelity. This is confirmed by other studies, e.g. in Senegal (Gueye *et al.* 2012) and Turkey (Ugulu 2012). Moreover, the high fidelity of some forest species can be explained by their abundance in the habitat. Nevertheless, species can be faithful to different disease categories and less frequent or even rare. This results in a decrease in knowledge about these species (Musa *et al.* 2011).

3.3.6. Global knowledge index (GKI)

The high GKI of the Atlas pistachio tree (100%) indicates a good level of knowledge of the Naâma population on traditional herbal medicine. Overall, the local population has a good knowledge of *P. atlantica*, especially since it is a native plant with significant ecological and landscape interest in the arid environment, with various fodder, food, and medicinal uses. Similar results were obtained by Hermann *et al.* (2020) in an ethno-zoological study in Benin. This importance can lead to anthropogenic pressure on the plant and its resultant decline. Natural resource managers are recommended to implement a plan for the exploitation and conservation of the species and its evaluation for pharmacological studies.

The field survey indicates that the traditional medicinal use of *P. atlantica* is transmitted mainly by the elderly. Herbalists become experts by reading or are apprenticed by healers. The analysis of our survey sheets allowed us to show that this species is often used to treat various diseases. The common use of this species in traditional medicine and pharmacology can be attributed to the phenolic content of its different parts (Ben Ahmed *et al.* 2017). The richness of the leaves and fruits in essential oils characterized by bactericidal and antioxidant effects illustrates the important nutritional and medicinal potential of the plant (Bahmani *et al.* 2015; Benabdallah *et al.* 2017; Benguechoua *et al.* 2021). However, the quality and quantities of phenolic compounds in *P. atlantica* fruits vary depending on the degree of maturity. The antioxidant and antibacterial effect of the fruits is optimal before their maturity (Guenane 2017).

4. Conclusions

The ethnobotanical survey allowed us to gather information on the traditional therapeutic uses of the Atlas pistachio tree by the local populations of the Naâma region in Algeria. Our results show that Pistacia atlantica is applied to treat various conditions. The most used organs are the leaves and fruits because they are the richest in essential oils and phenolic compounds. The major methods of preparation are decoction and grinding. The prepared herbal medicines are applied orally or by brushing. The results of the treatments are usually positive. The frequent use of the species and its high cultural importance for the local society indicate that *P. atlantica* remains a valuable source of medicines for the population studied, thanks to its effectiveness in treatment, in the absence or ineffectiveness of certain modern medicines. In addition, it constitutes good fodder for livestock and ensures the maintenance of the arid ecosystem.

This study constitutes part of a project to enhance and conserve the medicinal heritage in the Naâma region. The results can be used in further scientific research to validate experimentally the remedies identified by rigorous scientific protocols and develop the pharmacological research on the Atlas pistachio tree with techniques that allow the heritage to be preserved and its exploitation to be rationalized.

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Data analysis and interpretation: S. Belaid, A. Benaradj
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Critical revision of the article: S. Belaid, T. Nouri, A. Benaradj
Final approval of article: A. Benaradj

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