Exploring ethnobotanical knowledge and traditional uses of *Ceratonia siliqua* L. in the Taounate Region, Morocco

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Research

Abstract

Background: Documenting traditional knowledge about plant species is important for their conservation. *Ceratonia siliqua* L., a Mediterranean plant in the *Ceratonia* genus and *Fabaceae* family, is widely grown in the Taounate region for its medicinal properties. The choice of this study area is particularly important, as Taounate has a rich tradition of carob use, making it an ideal place to explore local knowledge. This study aims to assess and document ethnomedical knowledge related to *C. siliqua*, as transmitted by the indigenous population, in order to promote its use.

Methods: A total of 115 indigenous informants were interviewed using semi-structured questionnaires. The data collected were analysed and compared using descriptive indicators such as relative citation frequency, Fidelity level, Jaccard index, chi-square test and multiple correspondence analysis.

Results: The results of the study reveal that digestive disorders is the disease category for which the relative frequency of citations reaches its maximum (0.644) and the level of fidelity reaches 100%. Four categories of use of *Ceratonia siliqua* L. were identified by the different groups of informants, with food (89.56%) and medicinal uses (64.44%) predominating. The most common form of preparation was powder. In addition, we documented traditional recipes used by the population to treat various illnesses. In particular, this study identified new uses, notably for the treatment of pneumonia and eye diseases in cattle, which is a first in the ethnobotanical literature concerning this species. In addition, significant relationships were established between the sources of knowledge and the socio-demographic characteristics of the informants, such as gender, socio-economic level and level of education, underlining the importance of these factors in the transmission of traditional knowledge.

Conclusions: Our results enrich the documentation of local knowledge, support the development of conservation strategies and promote the sustainable use of *Ceratonia siliqua* L., while encouraging further pharmacological research.

Keywords: Ethnobotanical study, socio-economic, traditional uses, traditional medicine, *Ceratonia siliqua* L., Taounate, Morocco

Background

Traditional medicine in Africa is an ancient and varied system, recognised as one of the best known in the world (Mahomoodally. 2013). African countries use different forms of traditional medicine (Ozioma and Chinwe. 2019). Morocco, located in the north of the continent, is bordered by two seas: the Mediterranean to the north and the Atlantic Ocean to the west. Thanks to its Mediterranean climate, the country is home to a rich and diverse flora, with over 42,000 plant species divided into 150 families and 940 genera (Bellakhdar 1997). In Morocco, traditional medicinal knowledge is passed down orally from generation to generation (Aboukhalaf *et al.* 2022). It is important to carry out ethnobotanical studies to document this traditional knowledge before it fades. Moreover, this knowledge makes it possible to identify, preserve, perpetuate and exchange ancestral knowledge about local medicinal plants.

One of the best-known species in Morocco is *Ceratonia siliqua* L. (*C. siliqua*) which belongs to the *Ceratonia* genus and the *Fabaceae* family (Azab. 2017). The word carob comes from kharrub or el kharroube, tasliroua or tikida in barber (Tahri *et al.* 2012), it is located in the plains and middle mountains of the Rif, the Middle Atlas and the Anti-Atlas, in humid, sub-humid, semi-arid and coastal arid bioclimates with warm and temperate variants. It is generally sheltered from the wind and cold (Benmahioul and Kaid-Harche. 2011; Mzabri *et al.* 2023).

The carob is a subtropical species of the legume family. It is an evergreen tree with a very spreading crown that can reach heights of 8 to 17 m, 85 cm in diameter and live up to 200 years. The fruit is an oblong pod, 10-30 x 1.5-3 cm, shiny brown and indehiscent, containing tough, viscous, tasty pulp (Sbay. 2008).

The *C. siliqua* species is often mentioned in various ethnobotanical studies for its applications in traditional medicine. Each part of the plant has specific medicinal uses. For example, in Algeria, carob fruits are used to relieve stomach aches and treat diarrhea (Senouci *et al.* 2019). The leaves, fruit and roots are also used in Morocco as an antidiarrheal and for their stomachic effects, as well as to treat intestinal and gastric disorders (Abouri *et al.* 2012). In Spain, carob fruits are used to create a chocolate or coffee substitute, and can be eaten raw or in flour. The leaves are also used to preserve olives (Tardío *et al.* 2006). In Turkey, the flowering shoots, leaves, bark, fruit and roots of carob are used to treat urinary problems, anemia and sexual disorders (Uzun and Koca. 2020).

Little laboratory research has been carried out on the *C. siliqua* plant in Morocco, particularly on its various parts, with the majority of studies focusing on the pods. In addition, there are no specific ethnobotanical studies on this plant, which results in a lack of reliable information, thus constituting a major obstacle to its conservation and sustainability. Although this survey is limited geographically, it will help to fill the gaps in local knowledge and support the implementation of a management and conservation strategy for this resource.

The study was carried out in the province of Taounate, located in northern Morocco, in the communes of Ain Mediouna, Bouadel, Bni Ouelid, Ghafssai and Tafrante. Due to their climatic conditions and geographical position, these communes are characterised by an abundance of the *Ceratonia siliqua* (L.) plant. In this respect, the aim of this research is to document local knowledge of *C. siliqua*, to assess traditional knowledge according to socio-demographic factors such as gender, age, socio-economic level and level of education, to characterize the methods of use as well as the parts of the plant employed, and to identify the different uses according to the sampling sites.

Materials and Methods

Study area

Before starting our survey in the Taounate region, we first consulted the resource persons at the Provincial Direction of National Agency for Water and Forests (DPNAEF) and the Provincial Direction of Agriculture: In the province of Taounate, carob is of major socio-economic interest, which explains the constant commitment of the National Agency for Water and Forests to supervising local players and developing this resource over the years. Storage depots for carob pods have developed considerably, with around twenty being set up to date, the first being established in 2017 (Fig. 1). These depots, located in Bni Ouelid, Ain Mediouna, Bouhouda, Tissa, Galaz, Zrizar, Tafrante and Ghafsai, illustrate the wealth of carob trees in these communes (DPANEF-Taounate 2024).

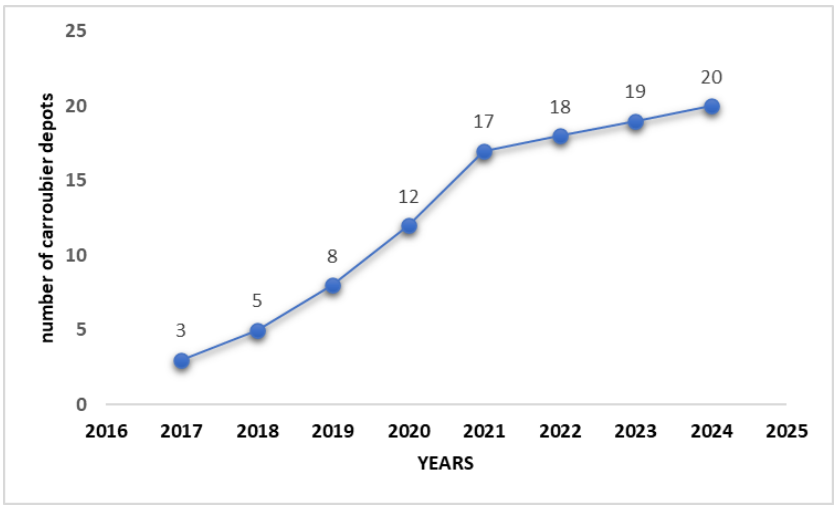

Figure 1. Number of carob depots in the Taounate region (DPANEF-Taounate 2024)

The data collected enabled us to identify a study area where the plant of interest, carob, is particularly abundant. Consequently, the survey was carried out in the five rural communes of Ain Mediouna, Bni Ouelid, Bouhouda, Ghafsai and Tafrante (Fig. 2), which concentrate almost 80% of carob deposits (DPANEF-Taounate 2024). This high concentration underlines the economic and ecological importance of carob cultivation in this region, justifying our choice to explore these communes to document in depth the uses of this plant by the local population. Indeed, these communities are actively involved in the cultivation and exploitation of the carob tree, offering a valuable opportunity to examine traditional practices, cultivation techniques and the various uses to which this plant is put on a daily basis. The survey was carried out between June and September 2024.

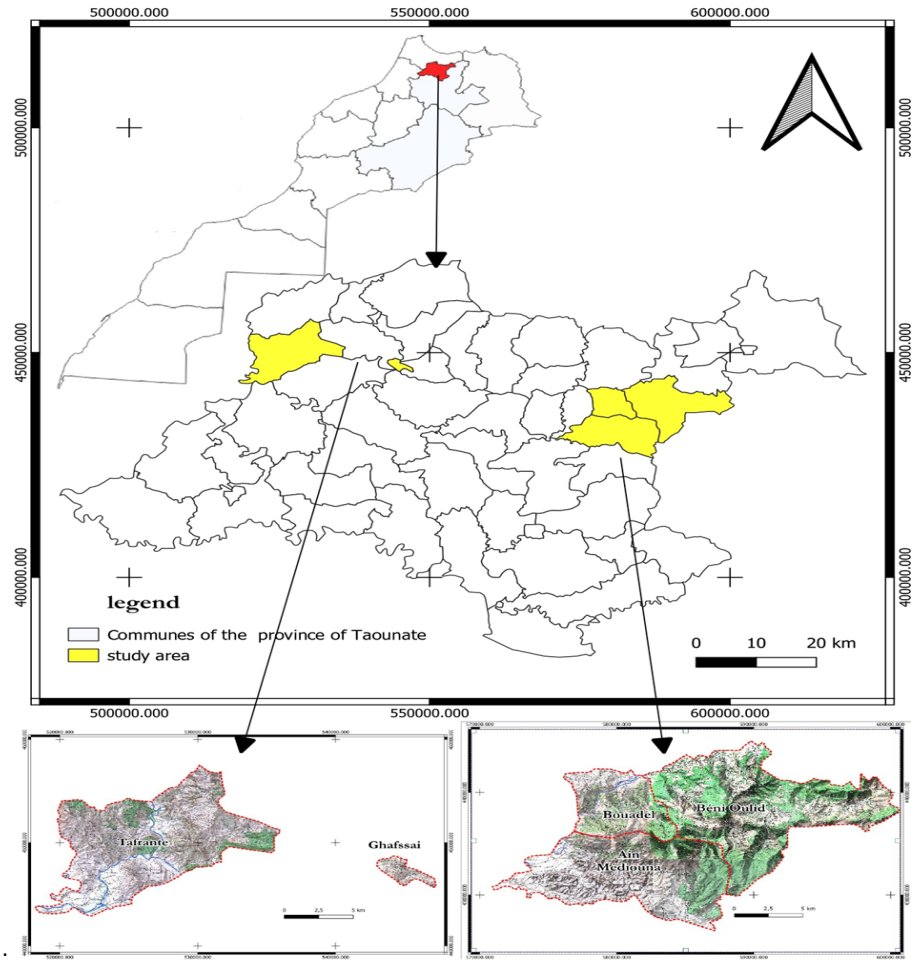

Figure 2. Location map of the study area in the Taounate region- Generated with Version 3.26.3 of QGIS Software

Province presentation

The province of Taounate is predominantly rural, with scattered settlements in over 1,600 villages. It covers an area of 5,585 km² and has a population of 662,246 (Table 1). Its climate is Mediterranean, characterized by cold, wet winters, with rainfall varying from north (1800 mm/year) to south (500 mm/year). (Direction Nationale Taza-Al Hoceima-Taounate. 2013).

Table 1. Demographic characteristics and administrative distribution of the Taounate Region

Administrative organization	Number of Communes	Total	49
		Urban	5
		Rural	44
	Number of cercles	4	
Population distribution	Total	662 246	
	Urban	86 222	
	Rural	576 024	
Population density	Surface area in km²	5 585	
	Population in 2014	662 246	
	Density in inhab./km²	119	
Distribution of total regional population by gender	Female	Effective	329 729
		Percentage	49.9%
	Male	Effective	331 007
		Percentage	50.1%

Data collection

Ethnobotanical data were obtained by means of semi-structured questionnaires with the local population of the study area, with their consent after they had been informed of the purpose of this study. A total of 115 indigenous respondents were randomly selected on the basis of their knowledge of *C. Siliqua*. The questionnaire consisted of two sections: the first included personal information about the informants (gender, age, education level, socio-economic status). The second section contained ethnobotanical data (vernacular name, harvesting period, use of the plant, medicinal uses, mode of use, parts used, mode of administration, side effects, etc.).

Data analysis

The data collected during the survey were carefully digitally processed and statistically analyzed using Microsoft Excel 2019 and SPSS version 26 software. The main objective of this analysis was to compare informants' local knowledge of the *C. siliqua* species, a subject of interest for ethnobotanical studies..To this end, several statistical tests and indices were employed:

A multiple correspondence analysis (MCA) was carried out to examine the relationship between socio-demographic characteristics and sources of documented knowledge. In addition, a Pearson Chi-square test was carried out to assess the strength of the correlation between socio-demographic variables and the source of knowledge concerning the *C. siliqua* plant.

The relative citation frequency (RFC) index was used to evaluate the citation frequency (FC) of informants who mentioned the use of a species, by dividing it by the total number of informants who participated in the study (N) (Butt *et al.* 2015). The formula is as follows

$$\mathbf{RFC} = \left(\frac{FC}{N}\right) \times \mathbf{100.}$$

For the purposes of this research, this index was calculated for each category of disease-related use. In addition, a chi-square test was performed to analyze the relationship between relative citation frequency and socio-demographic characteristics such as gender, age, education and socio-economic level.

In parallel, the Fidelity level (FL) was used to assess the consistency of informants' knowledge of the use of the *C. siliqua* plant in the survey. This index determines the percentage of respondents who mentioned this plant for each specific use (Friedmanetal.1986). The formula is as follows

$$\mathbf{FL\ (\%) = \frac{Np}{N} \times 100}$$

where (Np) represents the number of mentions of use of the plant for a given application, and (N) is the total number of informants who cited this plant. Thus, FL offers a clear perspective on the importance and recognition of this species in local practices.

Finally, Jaccard's index has been incorporated as an essential statistical tool for measuring similarity between two sets in our study. Named after the Swiss botanist Paul Jaccard, this index evaluates similarity by taking the ratio between the size of the intersection and that of the union of the sets concerned (Kidane *et al.* 2018). The JI is calculated using the following formula:

$$\mathbf{JI=\frac{|A \cap B|}{|A \cup B|}.}$$

We used Jaccard's index to compare two sets: the first (A), representing the categories of *C. siliqua* use identified in our research, and the second (B), corresponding to the categories observed in subsequent studies. This approach enabled us to compare our results with those of other studies carried out in various regions of Morocco, as well as in other randomly selected countries. Using this index, we were able to highlight significant similarities and differences, offering valuable insights into the understanding and use of this plant within different cultural and geographical contexts.

Results and Discussion

Socio-demographic data

The survey was conducted among local residents of the study area, with a total sample of 115 participants (Table 2). With regard to the profile of respondents, the majority belonged to the age group [30-50 years] (47.83%), followed by the age group [50-60 years] (28.70%), while those in the age group [18-30 years] represented only 13.91% of respondents, with respondents over 60 years of age being the least represented (9.57%). The gender breakdown shows a majority of men (58.26%) versus 41.74% of women. In terms of level of education, most of the participants were illiterate (39.13%), followed by those with primary and secondary schooling with an equivalent percentage (25.22%), with those with a university degree being the least numerous with a percentage of 10.43%. Finally, with regard to socio-economic level, a large proportion of participants had a low socio-economic level (54.78%), against 45.22% with an average level.

Table 2. Socio-demographic characteristics of informants

Socio-demographic characteristics	Informant	Effective	Percentage
Gender	Female	48	41.74%
	Male	67	58.26%
Age	[18-30]	16	13.91%
	[30-50]	55	47.83%
	[50-60]	33	28.70%
	> 60	11	9.57%
Education level	Illiterate	45	39.13%
	University	12	10.43%
	Secondary	29	25.22%
	Primary	29	25.22%
Socioeconomic level	Low	63	54.78%
	Middle	52	45.22%
	High	0	0.00%

Knowledge of *Ceratonia siliqua* L. and its uses

Vernacular name

The species *Ceratonia siliqua* is called '*kharroub*' in the study area, which is consistent with previous ethnobotanical studies in Morocco (Ajjoun *et al.* 2021; Benkhnigue *et al.* 2023; El Yaagoubi *et al.* 2023), and Algeria (Boudjelal *et al.* 2013).

Knowledge of *C. siliqua*

The *C. siliqua* plant is extremely well known to the inhabitants of the study area. Indeed, all the people interviewed were familiar with the plant, indicating a high level of awareness of it within the local community. This may reflect the cultural, economic or ecological importance of *C. siliqua* in the area. Ethnobotanical studies carried out in the Taounate region concur with our findings. Indeed, most of the surveys carried out in this region mention the *C. siliqua* plant (El-Assri *et al.* 2021; El-Hilaly *et al.* 2003).

Source of knowledge

The main sources of knowledge about the use of the *Ceratonia siliqua* L. plant vary considerably. A majority of respondents, 73%, rely on knowledge passed down from generation to generation, highlighting the importance of cultural heritage in preserving traditional practices. In contrast, 19% of respondents rely on the recommendations of herbalists, reflecting a more modern, professional approach to medicinal plant expertise. A smaller proportion (8%) indicated that information is gathered by consulting specialist literature, as well as television, radio and other awareness-raising channels as additional sources of information about plants

Analysis of the data using the chi-square test revealed that there was no significant correlation between participants' age and source of knowledge of the *C. siliqua* plant, suggesting that age does not influence how individuals acquire their knowledge of this plant. On the other hand, significant relationships were observed between the source of knowledge and other socio-demographic variables, including gender, education and socio-economic level, with a p-value of less than 0.05 and with a strong correlation (Table 3). These results indicate that gender, education and socio-economic level may play a determining role in sources of knowledge.

In fact, men mainly declare that their source of knowledge is generational transmission (85.07%), while 31.25% of women often refer to herbalists as a source of knowledge on the use and knowledge of *C. siliqua*. In addition, people from low socio-economic backgrounds 76.19% rely on the inheritance of knowledge from one generation to the next, while 50% of those with a university education point to the media, books and newspapers as a source of knowledge.

Table 3. Results of statistical treatment: Chi-square test

Socio-demographic characteristics	**Source of knowledge**		
	Chi-square	P-value	Phi/ v Cramer
Gender	10.449	0.005	0.301
Age	4.856	0.562	---
Socioeconomic level	6,568	0.037	0.239
Education level	42.431	0.000	0.607

Analysis of socio-demographic characteristics and various sources of knowledge using Multiple Correspondence Analysis (MCA).

The graphical representation resulting from the Multiple Correspondence Analysis (MCA) highlights the links between socio-demographic variables and sources of knowledge about the plant. A significant connection was observed between key informants and sources of inherited knowledge. Furthermore, informants with a university education acquired their knowledge through awareness channels such as books, media and newspapers, underlining the importance of documentation and awareness, particularly for this category. Furthermore, knowledge of *C. siliqua* among adult women is linked to recommendations from herbalists, reflecting the trust this category places in these practitioners, as illustrated in Fig. 3.

Plant use

All respondents (100%) indicated that they use the plant on a regular basis. This frequency of use suggests that the plant plays an important role in their daily lives or in their usual practices.

Categories of use

The responses gathered revealed four main categories of use for the *Ceratonia siliqua* plant: food, medicinal use, as well as other areas such as trade and ecology (fig. 4). Among these categories, food use stands out as the most predominant, accounting for 89.56% of cases mentioned. This is followed by traditional medicine, with 64.44% of respondents indicating its therapeutic importance. Commercial applications come third, accounting for 35.65% of responses. On the other hand, ecological use is the least mentioned category, with only 14.78% of respondents citing it.

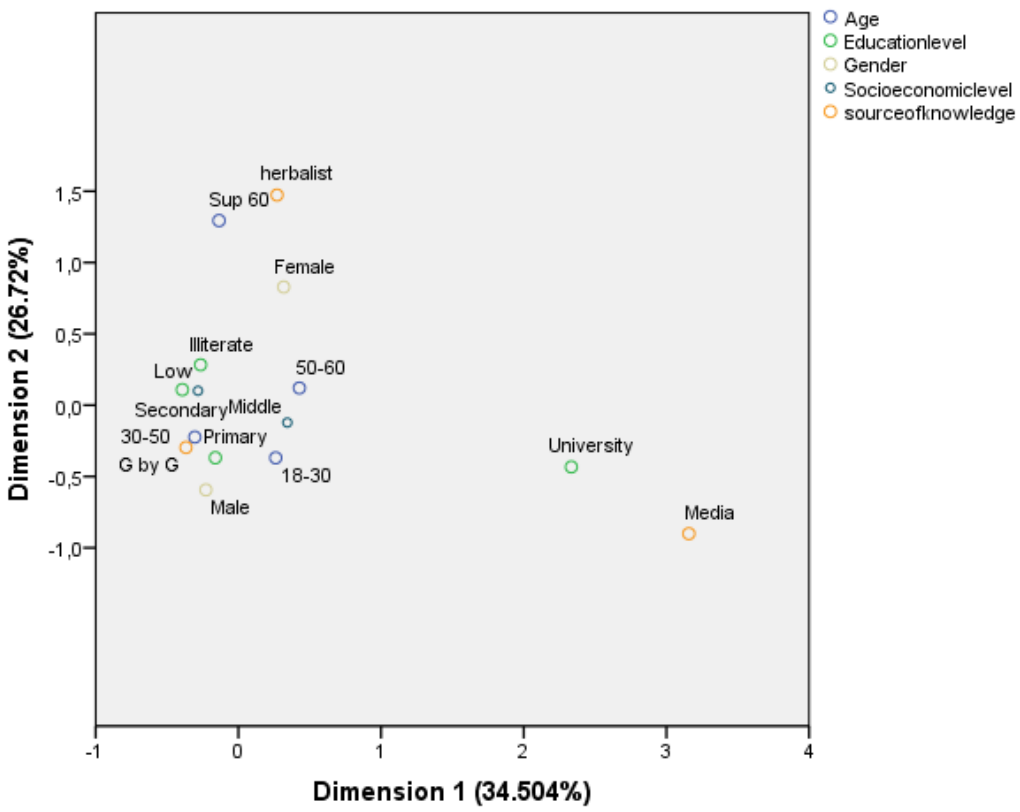

Figure 3. Graphic representation of the multiple correspondence analysis (MCA)

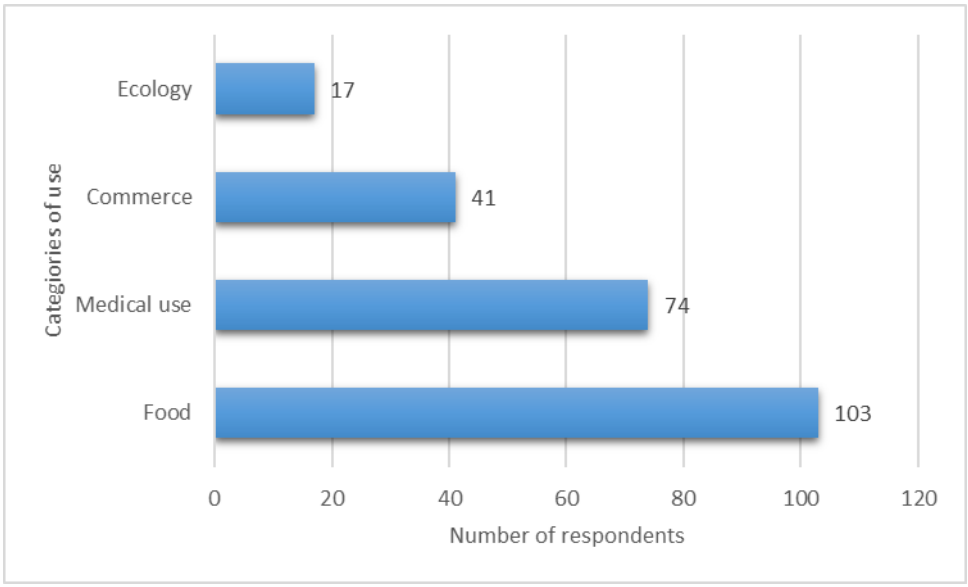

Figure 4. Categories of *C. siliqua* use in the study area.

Food

Our ethnobotanical survey revealed that *C. siliqua* is widely used for food in a variety of ways. Firstly, chewing the plant's pods, prized for their unique taste and nutritional benefits, is a common practice in local culture. Similarly, the pods are often made into jams, the traditional recipes for which vary, adding a sweet, homemade touch to local gastronomy. Finally, the powder from the plant is incorporated into various recipes, offering added value in terms of both taste and nutrition. These uses testify to the culinary richness associated with the plant.

These uses are corroborated by other ethnobotanical studies carried out in different regions. For example, research carried out among the local population of Messiwa, Morocco, showed that *C. siliqua* fruits are eaten as snacks (Ghanimi *et al.* 2022). Similarly, an ethnobotanical survey in Barcelona revealed that carob fruits are used to prepare a thick syrup called “arrop” (Marín *et al.* 2023). In Turkey, *C. siliqua* fruits are used to make a traditional molasses known as “Pekmez” (Sargin *et al.* 2015).

Commerce

The results of the survey revealed that 35.65% of participants use *C. siliqua* to market its pods. This activity takes place both on a small scale, within local souks, and on a larger scale, for the benefit of industry. This situation underlines the plant's socio-economic importance in the region studied.

Ecology

From an ecological perspective, 15.78% of survey participants mentioned the use of pod bark as cattle feed. This practice offers a number of advantages worth highlighting.

Firstly, the use of bark contributes to the sustainable management of natural resources. By integrating this part of the plant into animal feed, livestock farmers can valorize a by-product that would otherwise be lost, thus reducing waste. What's more, this feeding method can have positive effects on livestock health. Bark may contain essential nutrients, and its inclusion in animal feed could boost immunity and improve growth. It could also reduce feeding costs, offering an economic advantage to livestock farmers.

New use

In comparison with various ethnobotanical surveys carried out in the countries of the Mediterranean basin, including Morocco, our study has highlighted, for the first time, a hitherto undocumented use: Use of the plant's flowers as a remedy to treat eye ailments in cattle, by local application to the eyes.

Medicinal uses

In our study, we found that medicinal use of the *C. siliqua* plant is very common, with 74 people exploiting its pharmacological properties in particular to treat digestive problems. Indeed, 100% of *C. siliqua* users surveyed claimed that the plant was effective in relieving various disorders such as bloating, stomachache and diarrhea. These results underline the importance of this medicinal plant in the management of digestive disorders. Interestingly, 52.7% of users also exploit the plant's properties to treat lung ailments. This suggests that users recognize the extent of *C. siliqua*'s benefits beyond the digestive system. With regard to diabetes, 29.73% of users claim to use *C. siliqua* as an anti-diabetic. Finally, 21.62% of participants use them for urinary disorders, highlighting the versatility of this plant in the treatment of various ailments (Fig. 5).

These results highlight not only the perceived efficacy of *C. siliqua*, but also users' confidence in natural remedies, often handed down by tradition or recommended within their community. The results obtained are in line with the findings of other ethnobotanical studies carried out in Morocco, which identified the same disease categories as our study (Belhaj and Zidane. 2021; Es-Safi *et al.* 2020; Idm'hand *et al.* 2020; Redouan *et al.* 2022).

Relative Frequency of Citations (RFC) and Fidelity level (FL)

RFC values for each disease category ranged from 0.14 to 0.644. The highest usage ratios were reported for digestive problems, followed by respiratory system diseases (pneumonia) (0.34), metabolic system (diabetes) (0.19) and finally urinary disorders (0.14) (Table 4). The fidelity level calculated in this study evaluates the importance of *C. siliqua* in the treatment of different diseases. Fidelity ranged from 21.62% to 100%. *C. siliqua* is the plant recommended for digestive disorders (100%). A study carried out by (Idm'hand *et al.* 2020) in the Tarfaya province of Morocco obtained similar results, identifying *C. siliqua* as one of the most cited and preferred plants, with an FL value of 69% for its use in the treatment of digestive disorders. Similarly, an ethnobotanical study conducted in the Sidi Slimane region of Morocco on plants used to treat diabetes revealed a low citation of the *Ceratonia siliqua* plant, with an FL value of just 0.5% for its use in this context (Laadim *et al.* 2017).

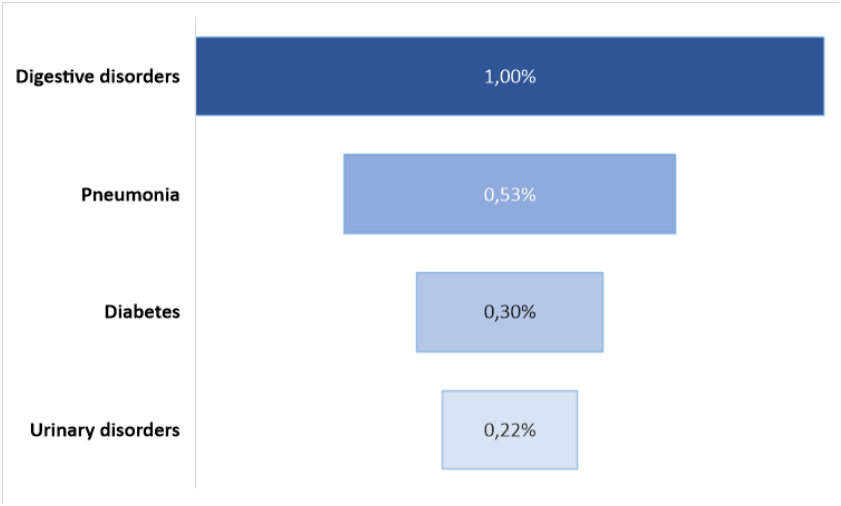

Figure 5. Medicinal uses of *C. siliqua*

Table 4. RFC and FL by disease category

Disease class	Examples of diseases	Number of uses	RFC	FL (%)
Digestive system	Diarrhea, Bloating, Digestive difficulties, Constipation, Gastrointestinal diseases	74	0.644	100
Respiratory system	Pneumonia	39	0.34	52.70
Metabolic system	Diabetes	22	0.19	29.73
Urinary system	Urinary disorders	16	0.14	21.62

Jaccard Index (JI)

Table 5 shows the values of Jaccard's index, used to assess the degree of similarity of the medicinal uses observed in our study compared with other research carried out in various regions of Morocco (South-East, North-East, Western High Atlas and Middle Atlas) as well as in countries such as Algeria, Turkey, Iraq, Croatia and Libya.

The results obtained in Morocco reveal that the Middle Atlas (Ben Akka *et al.* 2019) shows a strong similarity with our study area in the Taounate region (JI=0.6), particularly with regard to uses related to digestive, respiratory and metabolic disorders. Similarly, the Eastern High Atlas (El-Ghazouani *et al.* 2024) shows moderate similarity (JI=0.4), focusing mainly on treatments for digestive and urinary disorders. In contrast, the south-east (Abouri *et al.* 2012) and north-east (Benchikh and Louailèche . 2014) regions show the lowest similarity (JI=0.25), as the studies carried out there only mentioned one medicinal use: that of digestive disorders. Analysis of similarity with other ethnobotanical studies in Morocco highlights the importance of our research in the chosen area. Most previous studies have focused primarily on uses related to digestive disorders. In contrast, our study revealed other categories of use, underlining the know-how of the local population regarding the medicinal applications *of C. siliqua*.

With regard to neighboring countries, the Tlemcen national park (Zatout *et al.* 2021), the Ouled Ben Abdelkader region (Hedidi *et al.* 2024) and the Bissa region (Senouci *et al.* 2019), all located in Algeria, show a similarity of JI = 0.25, with only one common use linked to digestive disorders.

Studies carried out in various regions, such as Turkey (Mediterranean region, JI = 0.17), Iraq (Kurdistan region, JI = 0.25), northwest Croatia (JI = 0.20) and eastern Libya (JI = 0.40), reveal similarities. In Turkey, *Ceratonia Siliqua* has been used to treat urinary problems, anaemia and sexual disorders (Uzun and Koca. 2020). In Iraq, its use focused on digestive disorders (Ahmed. 2016). In Croatia, it targeted digestive problems and allergies (Krstin *et al.* 2024), while in Libya, it was used for digestive, urinary and infertility disorders (El-Mokasabi. 2022).

Several factors may explain these results. The survey revealed widespread medicinal use, whereas most previous studies have only documented the use of *Ceratonia siliqua* for digestive disorders. Although our study showed 100% use for these disorders, it also identified other applications, such as for diabetes, pneumonia and urinary disorders. This omission in other

research has contributed to a lower Jaccard similarity index, as fewer common uses result in a lower intersection between the data collections.

Table 5. Jaccard index for the Taounate region compared with other regions

Countries	Study area	Use	JI	Reference
Morocco	Southeast (Tata province)	Digestive disorders	0.25	(Abouri *et al.* 2012)
	North-east	Digestive disorders	0.25	(Benchikh and Louailèche. 2014)
	Western High Atlas	Digestive disorders Urinary disorders Nervous disorders	0.4	(El-Ghazouani *et al.* 2024)
	Middle Atlas (Moyen-Oum Rbia)	Traumatology, Digestive disorders, Respiratory disorders, Metabolic disorders	0.6	(Ben Akka *et al.* 2019)
Algeria	Extreme north-west (Tlemcen National Park)	Gastrointestinal (digestive) disorders	0.25	(Zatout *et al.* 2021b)
	Northwest (Ouled Ben Abdelkader region)	Digestive disorders	0.25	(Hedidi *et al.* 2024)
	North-eastern Dahra mountains (Bissa region)	Digestive disorders	0.25	(Senouci *et al.* 2019)
Turkey	Mediterranean region (Kahramanmara)	Urinary disorders, sexual disorders	0.17	(Uzun and Koca . 2020)
Iraq	North (Kurdistan Region)	Digestive disorders	0.25	(Ahmed . 2016)
Croatia	Northwest	Digestive disorders, allergies	0.2	(Krstin *et al.* 2024)
Libya	East	Digestive disorders, Sterility	0.4	(El-Mokasabi. 2022)

Parts used

In general, *C. siliqua* fruit is the most widely used part, accounting for 88.7% of cases, followed by seeds (5.22%), flowers (4.35%) and leaves (1.74%) (Fig. 6). This observation is in line with other ethnobotanical studies showing that *C. siliqua* fruits are widely used in different regions of Morocco. Indeed, a recent review of 82 research publications on available ethnobotanical and pharmacological data concerning plants used to treat gastrointestinal diseases in Morocco revealed that the fruit of *C. siliqua* is the most frequently studied part (Idm'hand *et al.* 2023). The predominant use of the fruit can be explained by the exceptional taste of the carob pod, its pharmacological benefits and the ease of harvesting and preparation.

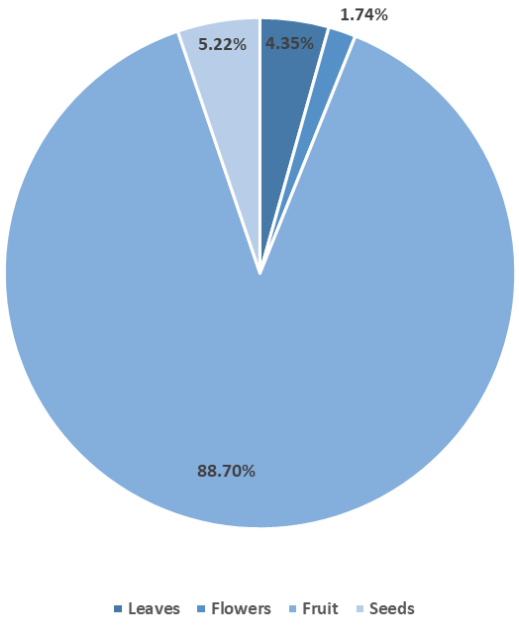

Figure 6. Part of *Ceratonia siliqua* used

Method of preparation and application

Preparation in powder form was the most frequent method, followed by chewing the pod and decoction, often in water, with percentages of 43.48%, 35.65% and 20.87% respectively (Fig. 7). Our study is in line with other research which highlights the use of *C. siliqua* powder and raw fruit as the most commonly employed method of preparation and administration (Belhaj *et al.* 2020; Ghabbour *et al.* 2024).

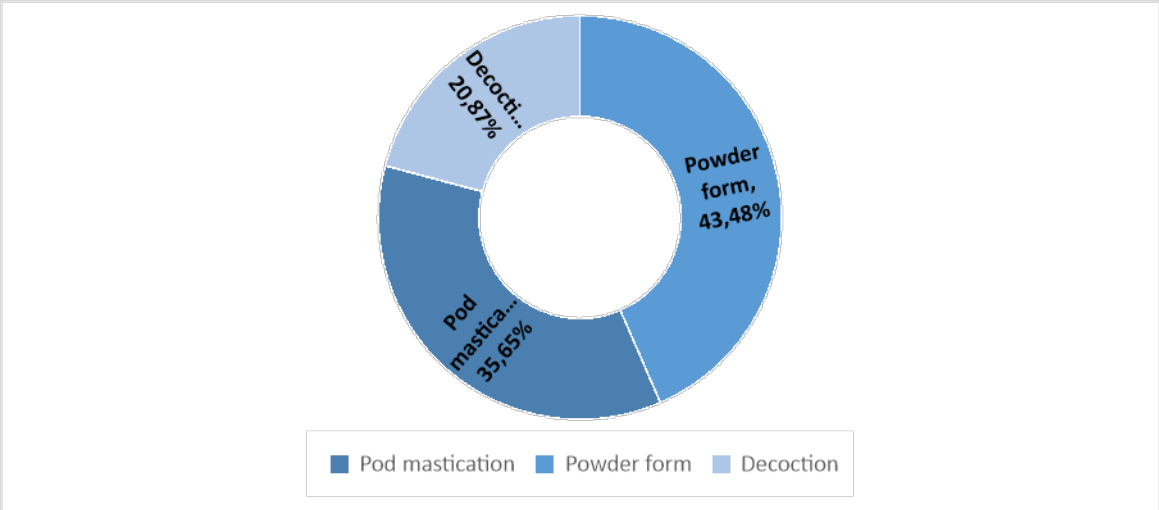

Figure 7..*C. siliqua* preparation methods

According to 59.46% of informants, the *C. siliqua* plant can be combined with other plants, such as oregano (Origanum vulgare), also known as "zaâtar", or the fruit of Rhamnus cathartica, called "Nebaq". In addition, it has been noted that this plant can be prepared with non-plant ingredients such as honey and whey, which are commonly used in the culture of the study area.

Traditional recipes and ancestral knowledge

To relieve digestive disorders such as abdominal pain, diarrhea, vomiting and nausea, our survey revealed a traditional recipe involving the use of *Ceratonia siliqua* pod powder mixed with pure honey. To prepare this remedy, simply dry the pods, then grind them to a fine powder. This powder can then be mixed with a spoonful of pure honey, to be consumed directly. Alternatively, whey can be combined to create a soothing, nutritious drink.

To treat digestive problems and support respiratory health in the event of pneumonia, our survey revealed a traditional recipe. It involves mixing *C. siliqua* pod powder with oregano. To prepare this remedy. Oregano and *C. siliqua* pods are boiled in water for a few minutes to extract the medicinal properties of both species. Another recipe with the same aim is to mix carob pod powder with buckthorn fruit powder, topped with a little olive oil and pure honey.

Finally, a recipe that has gained in popularity among the local population of the communes studied is considered highly effective for stomach problems. Reportedly, this miracle remedy involves mixing carob pod powder with dried pomegranate peel and royal jelly. This nutrient-rich blend is prized for its soothing and digestive virtues, offering natural support for gastrointestinal well-being.

All investigators have indicated that the *C. siliqua* plant has no negative effects on health.

Threat to *Ceratonia siliqua* L.

According to the results of the survey, 63% of respondents felt that the plant was under threat in the region. Several factors were identified as potential causes of this decline, including climate change, diseases affecting the plant, fire hazards, inappropriate harvesting methods and premature harvesting.

Conclusion

This survey was carried out in the province of Taounate to explore knowledge and use of the species Ceratonia siliqua L. (carob). Our results show that this plant is widely recognized and used to treat various ailments, such as digestive disorders,

diabetes and urinary problems. Interestingly, these practices are not limited to Morocco, but are also observed in other countries. The study reveals a strong correlation between knowledge of carob and various socio-economic factors, notably socio-economic level, level of education and gender. Knowledge of this plant is mainly transmitted orally, from generation to generation. The pods are generally used in dried form, whether chewed, powdered or decocted.

All informants reported the absence of side effects associated with the use of this plant. In addition, the survey brought to light two new applications: some people mentioned the use of carob flowers as a remedy for eye diseases in cattle, while pod powder is used to treat pneumonia. It is important to validate these new uses through laboratory analysis and experimental trials. This would not only guarantee the efficacy and safety of traditional remedies, but also provide a sound scientific basis for their use. Such an approach would help strengthen the recognition and integration of traditional knowledge into modern health practices.

Declarations

Ethics approval and consent to participate: The data were collected with confidentiality, anonymity and consent. All respondents were informed of the purpose of the study and provided prior informed consent.
Consent for publication: Not applicable
Availability of data and materials: Data will be made available on request
Competing interests: The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper
Funding: No funding was received.
Authors' contributions: L.B. Study design, ethnobotanical survey, active participation in structuring the methodology, data analysis and interpretation (statistical analysis), drafting of the original manuscript, revision and editing of the manuscript. T.H. manuscript improvement and revision, supervision. B.D: Conceptualization, supervision. M.B. Conceptualization, Methodology, supervision of work, validation.

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