Deep ethnobotanical survey of Anise (*Pimpinella anisum* L.) in Morocco: variation of therapeutic uses, sources of information, and efficacy.

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Research

Abstract

Background: An extensive ethnomedicinal analysis of anise (*Pimpinella anisum* L.) in Morocco was conducted as part of this study. We aimed to compile information on its medicinal uses and the amounts consumed by locals.

Methods: Interviews were conducted in seven Moroccan sites during 2019 and 2020. To examine the gathered data, descriptive and multivariate statistics were employed. We sought participant agreement on the specified therapies for each disorder group.

Results: 85 herbalist males and 600 participants ranging from 20 to 60 years old were interviewed in the study zone that uses or sells it for therapeutic purposes. The plant was primarily utilized by herbalists for food (18.93%), digestive disorders (18.93%), and laxatives (18.93%), while users use it for Dysmenorrhea (34.85%), anti-constipation (33.02%), antitussive (21.31%), and to promote Milk flow (10.82%). Other users used anise as an antitussive (12.47%) and a treatment for Dysmenorrhea (15.81%), while 14.92% of participants used it to encourage milk flow. Participants used the plant in dried form alone, and the usage form was like a Tisane or infusion in all investigated sites. However, all studied parameters varied among the tested sites.

Conclusions: The new study could be of great use in expanding knowledge of the medicinal flora and conserving ancestors' knowledge in Morocco's Middle Atlas and the Saiss Plain.

Background

Anise, *Pimpinella anisum* is a medicinal plant that is being employed in the modern pharmaceutical sector as well as in cuisine, traditional medicine, and folk remedies (Abouzid and Mohamed 2011; Ibrahim *et al.* 2017; Das *et al.* 2021). This plant has been used for thousands of years for both culinary and medicinal purposes, with clear advantages for maintaining human health and boosting quality of life (Sun *et al.* 2019). Anise is mentioned in several ancient literature as a remedy for epilepsy, depression, nightmares, and seizures (Mirheydar 2001; Andallu and Rajeshwari 2011; Abdollahi Fard and Shojaii 2013; Sun et al. 2019; Sarheed and Jaffat 2022). Due to its biochemical richness in bioactive compounds such as *trans*-

anethole, naringin, palmitic, and petroselinic acids (Shobha et al. 2013; Rebey et al. 2019), anise is typically a major spice and traditional medicinal plant used for both food and medicine (Sun *et al.* 2019).
Anise is an annual herb that is native to the Mediterranean region and is widely farmed in the Middle East and Asia (Faravani *et al.* 2013; Shahrajabian *et al.* 2019; Darzi *et al.* 2022). According to Giordano *et al.* 2022) the *Pimpinella anisum* is a member of the Pimpinella Genus and Apiaceae or Umbelliferae Family. According to reports, it is also grown for food, with the edible parts being the seeds and fruits, as well as for the extraction of bioactive substances for use in medicine and other industrial applications (Das *et al.* 2022). The perfume and flavour of anise are attributed to its well-known essential oil. Despite trans-anethole making up between 75 and 90 percent of anise oil, there are other components including coumarins (umbelliprenine, umbelliferone, bergapten, and scopoletin), flavonoids (flavonol, glycosides, isoorientin, flavone, rutin, and isovitexin), lipids (betaarmyrin, stigmasterol, fatty acids, and its salts), carbohydrates, and proteins (Picon *et al.* 2010; Sun *et al.* 2019; Soussi *et al.* 2023). These compounds are behind the therapeutic and food benefits of anise.

Anise seeds are used in traditional medicine as a diuretic, carminative, antiseptic, and migraine analgesic (Amin 2005). Anise is also recommended as a treatment for epilepsy and seizures, as well as for sadness, nightmares, and other conditions (Mirheydar 2001). Rajeshwari *et al.* 2011) observed that aniseed has a wide range of uses and exploitations in the food and pharmaceutical industries since it is a powerful antiperoxidative and antidiabetic agent. In another study, (Ibrahim *et al.* 2017) found that waste residues of anise and star anise are prospective new sources of phenolic antibacterial chemicals, providing the pharmaceutical industry with new business opportunities. They claim that mixing some medicines with anise waste extracts provides a novel option for treating infectious disorders and that waste extracts may change the activity of antibiotics.

In Morocco, many studies have addressed the chemical composition and biological activities of anise seed. The phytochemical components and the antibacterial activity of *Pimpinella anisum* fruits obtained from various cultural zones in Morocco have been discussed by Ajebli *et al.* 2017). Al Maofari *et al.* 2013) evaluated the chemical makeup and antibacterial effects of *Pimpinella anisum* L. essential oils produced in Yemen and Morocco and found notable differences in the biocompounds present in the tested kinds. Despite the importance of results recorded in laboratory investigations, only one study has addressed the ethnobotany of *Pimpinella anisum* in Morocco. However, this study was limited in space and objectives. It targeted only one city (El Hajeb) and only fruits of cultivated varieties.

In the Middle Atlas, the Saiss plain, and the Northern areas, a number of ethnomedicinal surveys were carried out to determine the culinary and medicinal uses of anise seed in Morocco. The main goals of this paper were to: i) identify the medicinal and culinary use of anise seed in Morocco; ii) characterize the uses methods and used parts; iii) understand the selection criteria for this plant; iv) understand how therapeutic uses vary depending on sampling site; and v) assess anise seed toxicity cases.

Material and Methods

Sampled sites

The Middle Atlas, the Saiss Plain, and the North of Morocco were the three areas of Morocco where this study was conducted (Fig. 1). The selected areas have various contexts. The Middle Atlas is a mountainous region with a semi-arid climate. The winter is bitterly cold and snowy with an average annual rainfall of 250 mm. The Saiss plain occupies an area of 40.075 km2, or 5.7% of the entire nation. Summers are hot and dry, and winters are chilly and damp, which are characteristics of the continental climate that dominates in the northern regions. The average annual rainfall is about 500 mm. In Northern regions, the continental climate, is typified by dry and hot summers, while winters are chilly and humid. Over 700 mm of rain falls on average each year, and the downpours are often accompanied by hail and flooding.

Six different locations served as the basis for the data gathering, including Azrou, Ifrane, Immouzar, and Sefrou in the Middle Atlas; Fez and Meknes on the Saiss plain; and Taounate and Taza in the north of Morocco. These sites were selected to present a representative sample of various populations in Morocco.

Methodology and resource person interviews

This ethnomedical study was carried out between the academic years 2019 and 2020. A questionnaire form was designed and distributed across the area to accomplish the study's objectives. Aiming to learn as much as possible about anise seed's culinary and medicinal applications, as well as its methods of preparation, was expected at each research location. The questionnaire was broken down into two sections: one for the respondent's biographical information (surname, first name, age, sex...) and one for the plant (therapeutic uses, source of knowledge, the part used, pathologies treated...). According to

Daget and Godron (1982), the ethnomedical surveys were carried out using a random and stratified sampling strategy, which allowed for the use of a representative sample and is a good technique for obtaining the most thorough inventory possible (Lahsissene *et al.* 2009).

Figure 1. Geographical location of sampled sites in Morocco

In order to determine the groupings of therapeutic uses of anise, Microsoft Word, Excel, and STATGRAPHICS applications were used to collect, process, and statistically analyze the data. All species' scientific names were reviewed and updated using the Plant List website (Rivera *et al.* 2014). Equally, the WHO's global illness classification was used (Staub *et al.* 2015). The questionaire was distributed among herbalists (herbalists that sell anise and users (populations that use anise).

Statistics

We verified that all analyzed parameters were normal before beginning the statistical analysis. We also estimated the percentages of all the factors, such as gender distribution (men and women), ages ([20-30], [31-40], [41-50], [51-60], and > 60), educational attainment (primary, college, high school, university, and illiterate), family circumstances, therapeutic purposes, and style of use. All parameters were compared between herbalists and users to understand the traditional uses of Anise in the studied areas. The independent T-test was used to compare the use of traditional medicine between women

and men, between traditional and modern medicine users, between the form of plant usage, and the preparation modes. Further, we used an ANOVA one-way test to compare the ages of participants, education level, family situation, health problems, diseases treated with Anise, and sources of information about the therapeutic benefits of Anise. Study locations (n = 7) were regarded as independent variables, whereas age categories (n = 5) were regarded as dependent variables, and then factor Analysis (FA) was used to elucidate the difference in responses. The distribution of age, education level (n = 5), therapeutic applications (n = 6), and study sites (n = 7) was clarified using a similar methodology. Therefore, only axes with eight values more significant than one were considered. The use of primary and multivariate statistics aimed to clarify the variation in response between questioned participants and among studied sites.

Results and Discussions

Participants' demographic details

In the study zone, 85 herbalists and 600 informants were questioned; the findings are shown in Table 1. The participants in the study ranged in age from 20 to 60. Among herbalists, the age category [41-50] was the most dominant, with 38.82%, followed by [51-60] with 24.70%, and [31-40] with 22.35% (f = 9.505, df = 4, P = 0.000). In contrast, the categories of ages >60 and [20-30] were the least investigated herbalists, with 2.35% and 11.76%, respectively. Further, age categories were variable among sample sites (Fig. 2). In Immouzer, the ages 20 to 30 were the most dominant among the investigated participants. In Sefrou and Meknes, age >60 was the most dominant, while in Ifrane, 51-60 was the most dominant among participants. In Fez, the participants were dominated by those aged 31-40. In Taounate and Taza, the age category 41-50 was the most dominant among participants (Fig. 3). Further, the totality (100%) of the investigated participants were male, while females were absent. Regarding the family situation, the married participants were dominant with 69.41%, followed by single participants with 21.18% (f = 35.918, df = 2, P 0.001). In contrast, divorced participants presented only 9.41%. Interviewed people were dominated by participants with college levels (75.29%), followed by participants with High school education (16.27%), and participants with Primary education levels (8.24%) (f = 75.626, df = 2, P = 0.000). On the other hand, participants with a university education level and Illiterates were absent among the interviewed people.

Among the 600 participants (users of anise), the age also ranged from 20 to up to 60, while the dominant ages were between 51 and 60 with 26%. The age sections 41-50 and 31-40 presented 22.67% and 22.33%, respectively. The ages > 60 and 20-30 were the least represented among the informants (f = 5.151, df = 4, P = 0.003). The gender ratio was 57.33% for men and 42.67% for women. Further, 32.25% of participants were single, 67.67% were married, and only 10.83% were divorced (f = 66.455, df = 2, P< 0.001). The education of participants was 35.33% illiterate, 23.5% primary, 29.33% college, and 12.33% high school degrees (f = 10.179, df = 4, P<0.003). The distribution of age sections was variable among the investigated sites. In Immouzer, 41-50 was the most dominant; in Sefrou, Taounate, and Ifrane, sections 31-40 and 51-60 were the most recorded, while in Meknes, Taza, and Fez, 20-30 and >60 were the most observed. Equally, the education level of participants varied among the investigated participants. Illiterates and participants with secondary levels were the most recorded in Immouzer, Ifrane, Sefrou, and Taounate; the university level was in Taza; and the Primary level was not dependent on any site.

Table 1. Participants' demographic details (age, gender, education, occupation, and therapeutic techniques)

		Herborists		Users	
	Categories	**Total of participants**	**Percentage %**	**Total of participants**	**Percentage%**
Age	[20-30]	2	2.35	78	13
	[31-40]	19	22.35	134	22.33
	[41-50]	33	38.82	136	22.67
	[51-60]	21	24.70	156	26
	> 60	10	11.76	96	16
Gender	M	85	100	344	57.33
	F	0	0	256	42.67
Familial situation	Single	18	21.18	129	32.25
	Married	59	69.41	406	67.67
	Divorced	8	9.41	65	10.83
Education	Illiterate	0	0	212	35.33
	Primary	7	8.24	141	23.5
	College	64	75.29	176	29.33
	High school	14	16.27	74	12.33
	University	0	0	0	0

Despite the large number of ethnobotanical studies conducted in Morocco (Jouad *et al.* 2001; El Hassani 2020; Fakchich and Elachouri 2021), this is the first study to analyze the therapeutic uses of anise seed among local populations in central Morocco. This study targeted populations in central Morocco with ages varying from young citizens 20 to up to 60 years old. Similar results were cited in other surveys on medicinal plants in Morocco. In a Large-scale inventory on the therapeutic applications of medicinal plants used by the local population in the plain of Saiss and the middle atlas of Morocco, Yaagoubi *et al.* 2023) investigated populations with ages ranging from 35 to 74 years old, with a dominance of 25-34 and 35-44 categories and males compared to females. In another study, (Idm'hand *et al.* 2020) conducted an Ethnobotanical investigation to assess the biodiversity of medicinal plants used in the Tarfaya Province, located in the south of Morocco. The research targeted 600 citizens dominated by the age range [51-60] and up to 60 years (25% each). As a result, 64% of the interviewed men use medicinal plants, compared to 73% of the surveyed women. In our case, the interviewed populations were dominated by males (100%) and the age categories [41-50], [51-60], and [31-40], while the ages >60 and [20-30] were the least recorded. However, the age of the investigated participants varied depending on sampling sites, which is in agreement with the results recorded currently by El Yaagoubi *et al.* 2023). These authors revealed the dominance of 55-64 ages in Ifrane, 65-74 in Meknes, and 25-54 in Immouzer, compared to 20-30 in Immouzer, >60 in Meknes and Sefrou, and 41-50 in Taounate and Taza in our study.

Concerning the education of participants, college level was the most dominant, followed by high school education, while university education level and illiterate people were absent. In another ethnobotanical study conducted in Tarfaya Province (South of Morocco), illiterate people dominated participants with 50%, followed by primary education level with a rate of 42% (Idm'hand *et al.* 2020), which partially agrees with our results. In another study on medicinal plants of the Agadir Ida Ou Tanane (southwest Morocco), (Ouhaddou *et al.* 2014) revealed the dominance of illiterates (52%) and the primary level of education (35%) compared to secondary and university (9%) and 4 %, respectively. These results confirm the variation in educational levels among users of medicinal plants. Equally, in our case, the educational level of participants varied from site to site; the Illiterate were absent in all sampled areas, University level in Taza and Taounate, Primary in Immouzer, Secondary in Meknes, Ifrane, and Sefrou. This variation in terms of participants' age, education level, and family situation is related to the demographic and educational structure of the interviewed populations. Equally, the sampling sites could interfere with the structure of the investigated participants.

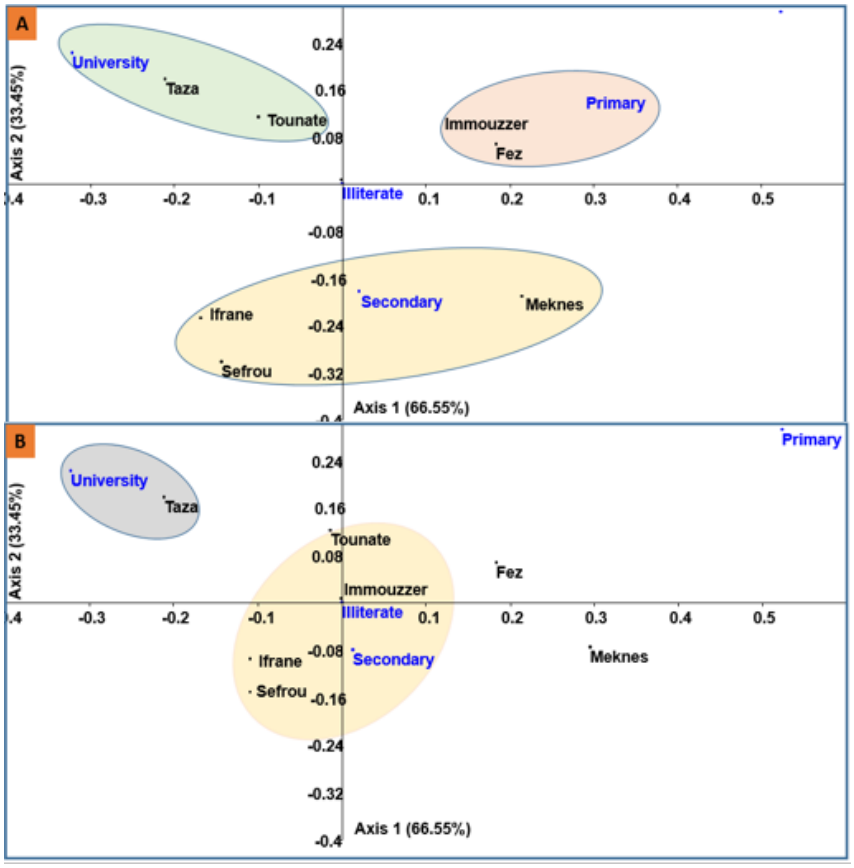

Figure 2. Geographical distribution of educational level among sampled cities in central Morocco (A: Herbalists; B: Users)

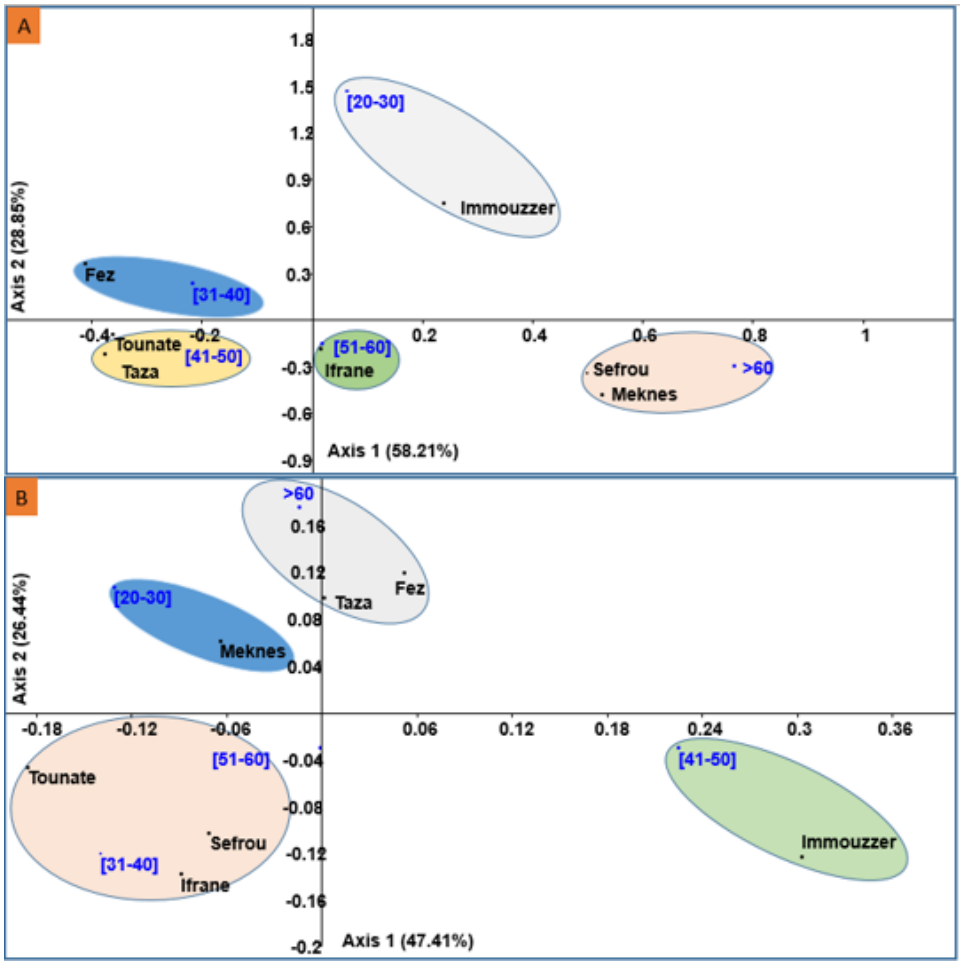

Figure 3. FCA plot showing the geographical distribution of age categories among interviewed herbalists (A) and participants (B) in central Morocco

Health and use of medicinal plants

Health and diseases among interviewed participants are presented in the Fig. 4. As a result, 34.64% of participants were unaffected by any diseases in the study sites, compared to 55.46% with various diseases. Diabetes was the most recorded disease, with 26.14%, followed by High blood pressure at 16.99% and digestive troubles at 14.38% (f=75.626, df=4, P=0.009). In contrast, only 7.84% of participants were affected by cardiovascular diseases. However, the geographical distribution of recorded diseases varied among sampled sites (Fig. 5). The absence of diseases was primarily recorded in Ifrane and Meknes. In Taounate, participants were affected by cardiovascular and High blood pressure diseases. In Fez and Sefrou, participants were mainly affected by diabetes, while in Immouzer and Taza, participants were mostly affected by digestive disorders.

Of the participants, 29.66% were unaffected by any disease compared to 69.44% of unhealthy people. High blood pressure was the most recorded disease, with 21.83%, followed by Diabetes at 20.17% and digestive disorders at 19.5% (f=2.737, df=3, P=0.066). In contrast, cardiovascular problems were less recorded among tested populations. The recorded diseases showed dissimilar distribution among investigated sites. In Taza, digestive disorders were the most recorded, while in Immouzer, High blood pressure was the most observed among participants. Diabetes and cardiovascular diseases were recorded most in Taounate, Ifrane, and Meknes. In contrast, the healthy people were not related to a specific site since these people were dominant in all sites.

Many studies have investigated the diseases among the users of medicinal plants. This study demonstrated that diabetes was the most recorded disease among participants. In comparison, Idm'hand *et al.* 52020) recorded the dominance of gastrointestinal diseases (31.96%) and genito-urinary disorders (12.19%) among 600 participants (users of medicinal plants) in the Tarfaya Province, which is different from our results. Briguiche and Zidane 52016) have reported that most used plants in traditional medicine in Jadida City (Northwest Morocco) were mentioned to treat gastrointestinal disorders. In another

study, (El-Hilaly *et al.* 2003) have found that medicinal plants recorded in Taounate region (North Morocco) are used principally in the treatment of digestive problems. However, the laboratory investigations showed that the anise seed has significant anti-diabetic effects thanks to its bioactive compounds. Aniseed (*Pimpinella anisum* L.) fractions obtained from the progressive fractionation of methanolic extract by benzene, hexane, n-butanol ethyl, acetate, and water were investigated for their antidiabetic properties (in vitro) by Shobha & Andallu, (2018). As a result, ethyl acetate fraction of aniseeds showed the strongest anti-diabetic activity in terms of -glucosidase and -amylase (0.15mg/ml and IC50 0.12mg/ml, respectively). Methanolic extract and all investigated fractions of aniseeds also showed anti-diabetic activities. Equally, Shobha & Andallu, (2018) proved the Anti-Diabetic Effects of Aniseeds (*Pimpinella anisum* L.) in in vitro and in in vivo tests. All cited papers indicate the beneficial roles of anise seeds against diabetes and could help the interviewed participants to fight against this disease considered as chronic and was listed in 2016 as the seventh leading cause of death (Meerza *et al.* 2013; WHO).

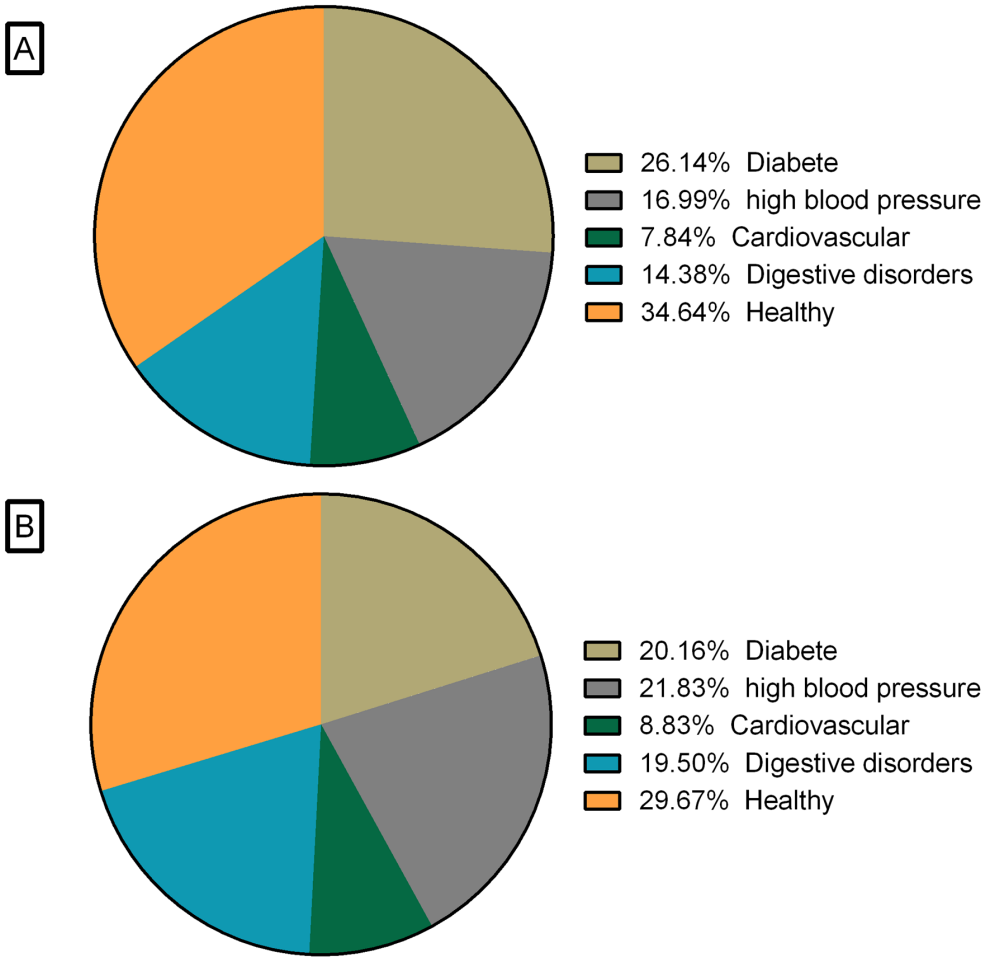

Figure 4. Health and diseases among interviewed herbalists (A) and participants (B)

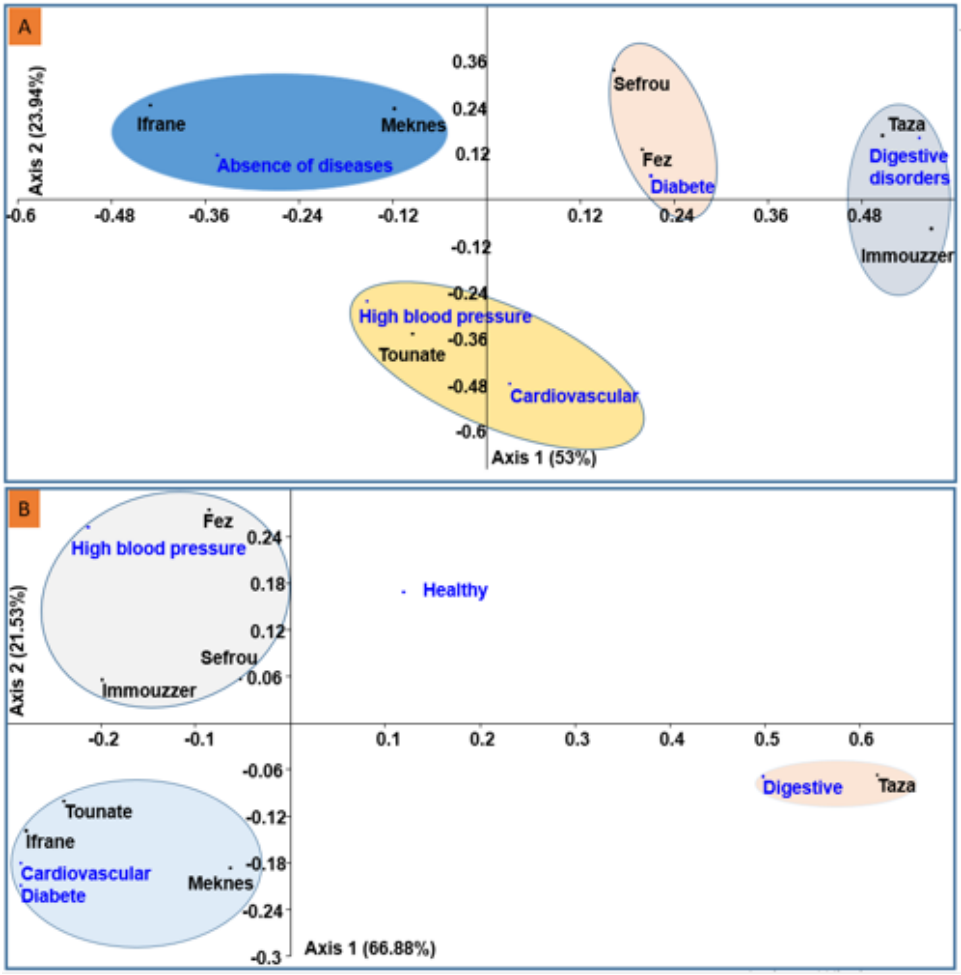

Figure 5. Distribution of recorded diseases among sampled sites analyzed with FCA (A: Herbalists; B: Users)

Use of traditional medicine

The use of traditional medicine depending on gender of participants is presented in Fig. 6. In result, 87% of females use the traditional medicine compared to 13% of males in the study sites (t=2.089, df=12, P= 0.059). In terms of the selection of traditional medicine based on medicinal plants, 77.65% of participants (herbalists) mentioned the effectiveness and the low cost as reasons to select this approach. On the other side, 22.35% of participants cited the easy acquisition of medicinal plants and their derivatives as the main reason for the selection of traditional medicine.

Among tested participants (users), 84.33% use traditional medicine, while only 15.77% use only modern medicine. Females used traditional medicine more than men (t=2.089, df=12, P= 0.059).These users buy medicinal plant Anise from various sources counting herbalists (57.33%), local markets named Souk (38.66%), and Supermarkets (4.00%). The source of medicinal plant was variable among tested sites. In Immouzar, the principal source of Anise is the local market Souk. On the contrary, in Sefrou, Meknes, Ifrane and Taounate the principal source was the herbalists, while the supermarket was the principal source of medicinal in Fez and Taza. On the other hand, 83.33% of users mentioned the low price and efficacy as the principal reasons behind the use of traditional medicine compared to easy acquisition cited by 16.67% of the population.

Many ethnobotanical studies in Morocco and other North African countries revealed the use of traditional medicine based on medicinal plants to treat various health diseases (Abouri *et al.* 2012; Idm'hand *et al.* 2020; Karous *et al.* 2021; Bencheikh *et al.* 2021; Souilah *et al.* 2022). For instance, Idm'hand *et al.* 2020) found that in the Tarfaya Province, 73% of the women surveyed used medicinal plants, compared to 64% of the men interviewed. This finding is consistent with our research. Similar conclusions were reported in Mechraâ Bel Ksiri (Northwest Morocco) and High Atlas (Central Morocco), respectively, by (Benkhnigue *et al.* 2010; Benlamdini *et al.* 2014). On the other hand, the selection of medicinal medicine was controlled by effectiveness and the low cost of this approach, which is like the reasons cited by Idm'hand *et al.* 2020) in the South of Morocco.

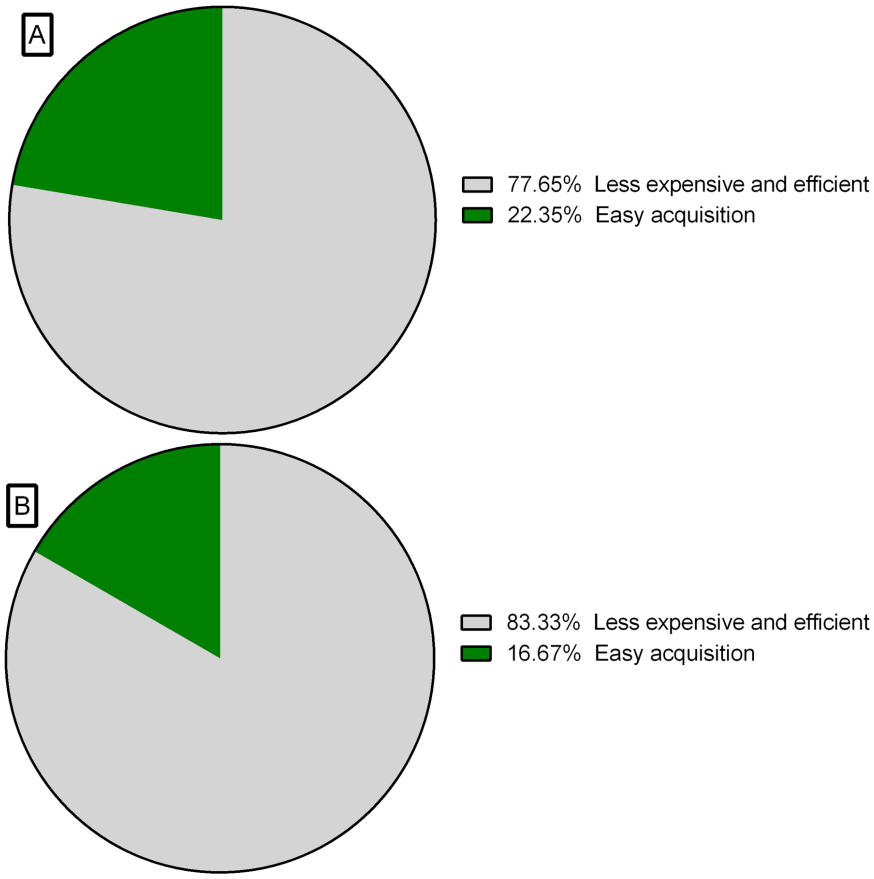

Figure 6. Reasons for the selection of traditional medicine (use of medicinal plants)

Therapeutic uses of anise seed

The therapeutic uses of Anise seed are presented in Fig. 7. Based on herbalists, the plant is used to treat five diseases in all sampled sites, counting laxative, dysmenorrhea, promote milk flow, antitussive, digestive disorders, and food. Investigated participants used the plant mostly against laxative (18.93%), digestive disorders (18.93%), and for food purposes (18.93%). Other participants used the Anise seed to treat dysmenorrhea (15.81%) and as antitussive (12.47%) (f=2.906, df=3, P=0.055). Moreover, 14.92% of participants used the plant to promote milk flow. However, the uses of the Anise seed differed depending on sampling sites (Fig. 8). In Fez, most participants used seeds of Anise to promote milk flow, while in Ifrane and Sefrou the plant was used as antitussive. In Meknes and Immouzer, the plant was used for tree purposes, including treatment of laxative and digestive disorders, and for food purposes. In Taza and Taounate, participants used the plant only to treat Dysmenorrhea.

Based on responses of user participants, the anise is used to treat three diseases counting dysmenorrhea (34.85%), anti-constipation (33.02%), and as antitussive (21.31%), as well as a promoter of milk flow (10.82%) (f=26.213, df=3, P=0.000). The therapeutic uses of anise varied also among tested sites. In Meknes, dysmenorrhea is the principal therapeutic use, while in Taza anise is mostly used to as promoter of milk flow. In Ifrane and Immouzer, the anise was mostly used as anti-constipation, while in Taounate and Sefrou the plant is used as antitussive.

Anise (*Pimpinella anisum* L.) is a traditional medicinal herb and a dominant spice for medicinal and nutrition purposes. Recent research has demonstrated that anise seeds have antiviral, antifungal, antibacterial, anti-inflammatory, anticonvulsant, analgesic, and anti-diabetic properties (Sun *et al.* 2019; Ghosh *et al.* 2019; El-Rokiek *et al.* 2020). These activities are offered by the diversity and quantity of chemical compounds recorded in this plant's essential oils and extracts (Sun *et al.* 2019; Soussi *et al.* 2022, 2023). For example, Anise is rich in anethole, used in the food, pharmaceutical, flavoring, and perfumery industry (Özcan and Chalchat 2006; Tuncturk and Yildirim 2011). In our case, Anise is also used for food and therapeutic purposes, principally against laxatives, dysmenorrhea, antitussive, and digestive disorders. Other studies revealed the use of anise seeds are an analgesic in migraine and an anti-diuretic in traditional medicine (Amin 2005).

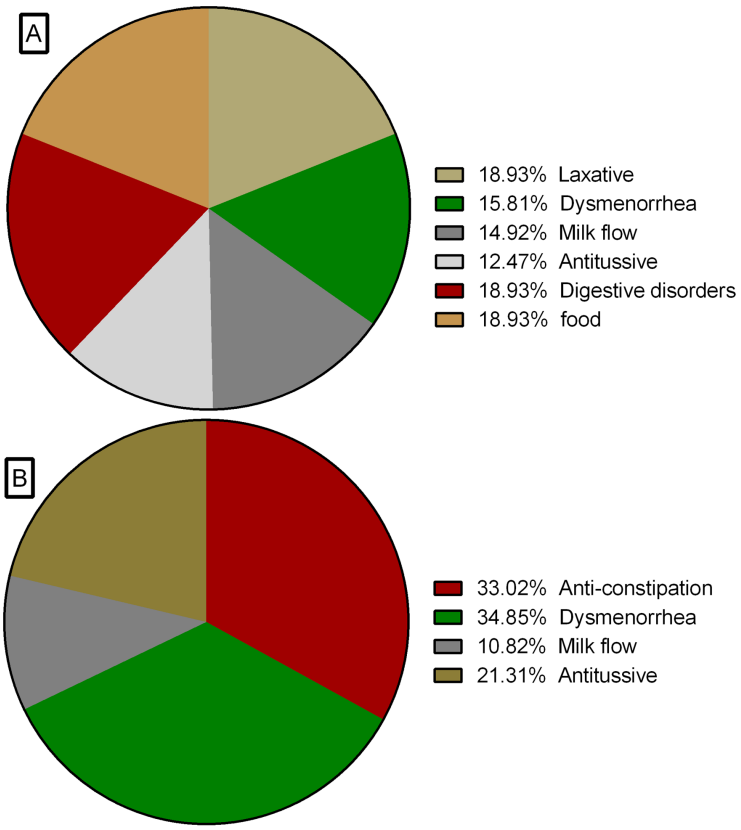

Figure 7. Therapeutic uses of Anise seed among herbalists (A) and participants (B)

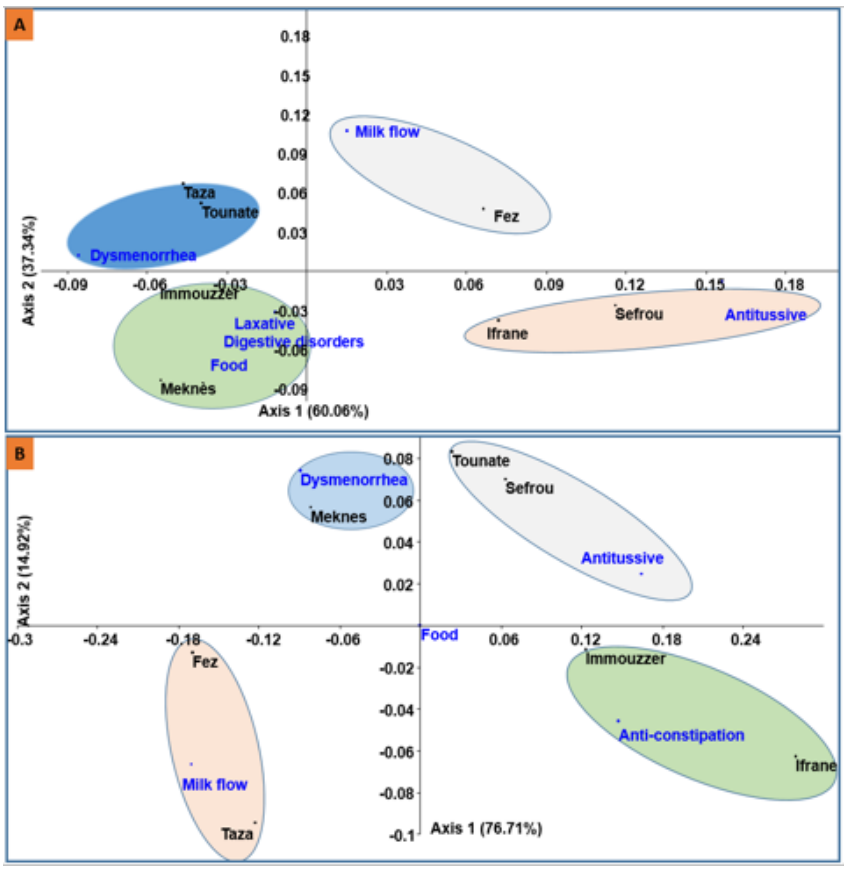

Figure 8. Therapeutic uses of anise seed among herbalists (A) and participants (B) in sampled sites in central Morocco

Sources of information about the therapeutic roles of anise

The sources of the information about anise seed among tested participants is presented in Fig. 9. The principal source of information about the therapeutic benefits of the plant among herbalists were medias (68.24%) counting TV, RADIO, Social medias, followed by educational trainings with 15.29%. Other sources such as families and between friends' discussions, books represented only 16.47% of source about the medicinal uses of anise. On the other hand, these sources differed among visited sites (Fig. 10). In Ifrane and Sefrou the sources of information about the plant were Medias. In Fez and Meknes, the knowledge of medicinal effects of anise were acquired from trainings. In Taounate, Taza, and Immouzer, the information about the medicinal effects of anise were acquired from other sources.

Among the 600 users, the source of information about the therapeutic benefits of anise were trainings, media, herbalists, and other sources. Herbalists were the most important source with 55.5%, followed by other sources (family and the other users) with 30.5%, and media with 14.5% (f=31.117, df=2, P=0.000). The cited sources varied among monitored sites. In Taza, the media were the principal source of information about the therapeutic uses of anise, while the herbalists were the principal sources in Meknes, Taounate, Ifrane, and Immouzer. In Sefrou, the professional training was the principal source compared to other sources in Fez.

Dissimilar results were mentioned in other ethnobotanical studies conducted in Morocco. For example, in Tarfaya, sources of information on the use of medicinal plants was the ancestry experience with a rate of 70.60% (Idm'hand *et al.* 2020). In the case of Tarfaya, the oral image of the traditional know-how transmission from one generation to the next was very important, while in our case, the media take place.

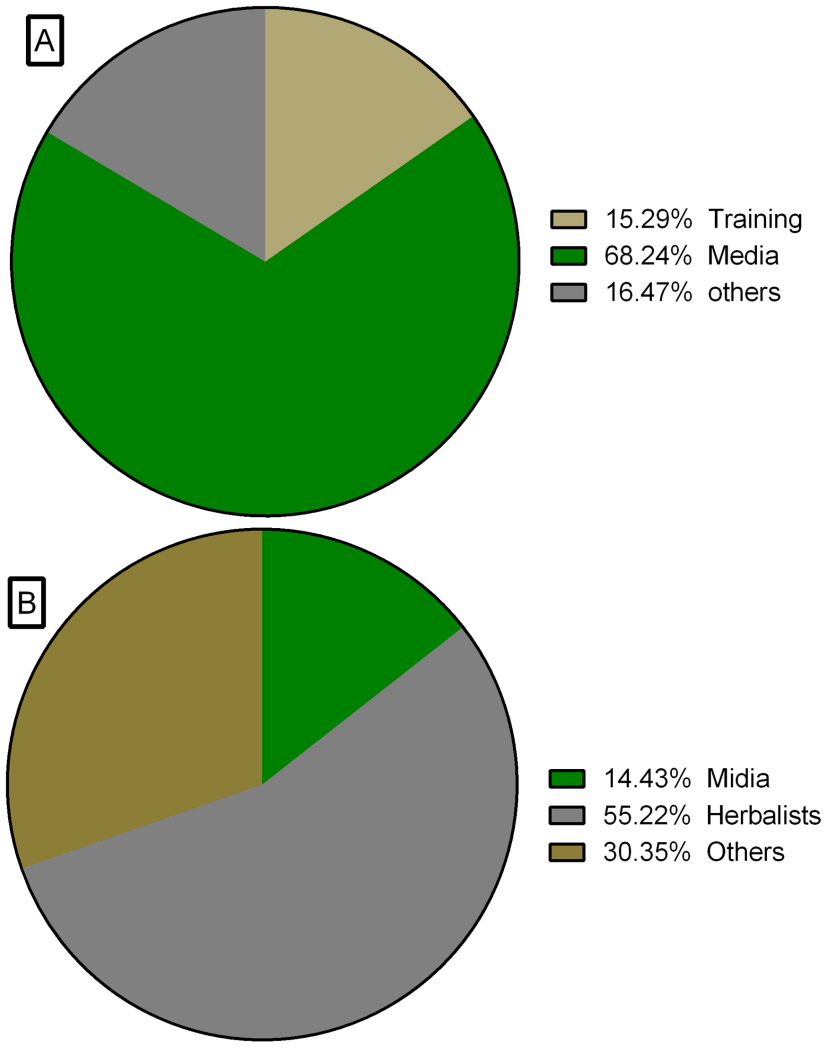

Figure 9. Sources of information about the therapeutic uses of anise among herbalists (A) and participants (B)

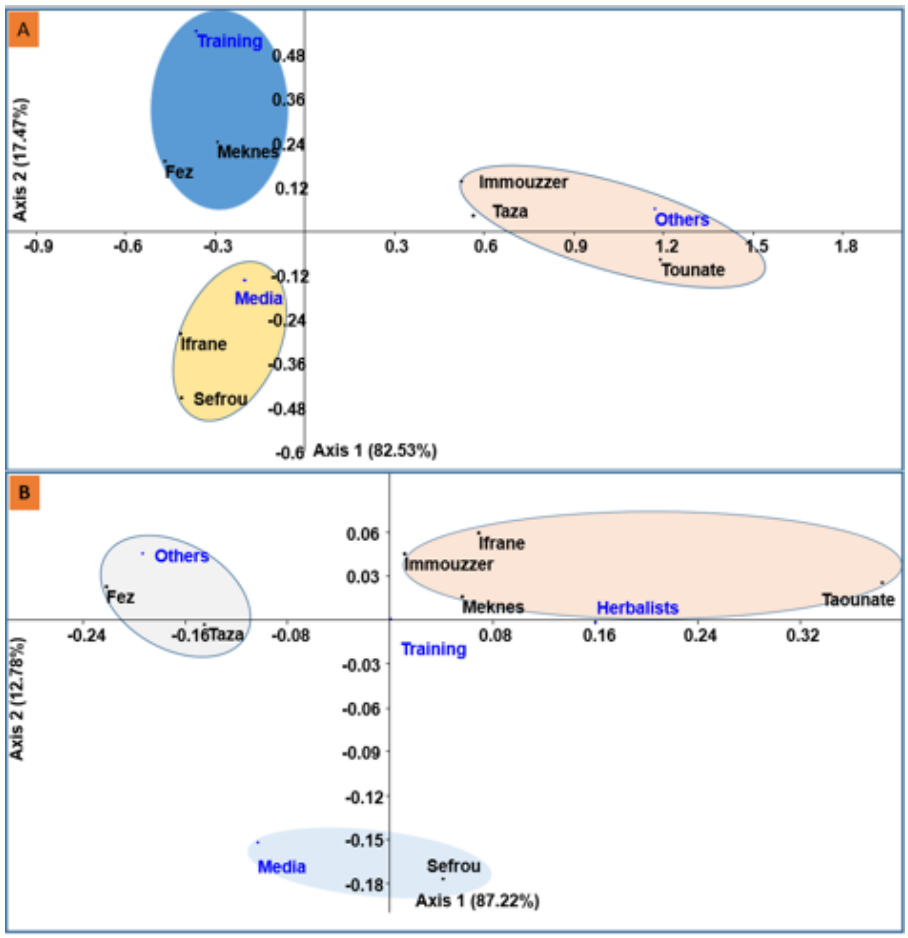

Figure 10. Sources of information about the therapeutic usages of anise seed in sampled sites (A: Herbalists; B: Users)

Usage mode of anise seed

In all investigated sites, herbalists use the plant in dried form. Further, they used it alone, while none has used anise seed in a mixture with other plants or products. The usage form was Tisane in all investigated sites. The preparation mode was 100% Infusion in all investigated cities. The anise seed was used with 100% when needed, and the results were 100% amelioration of treated cases. All investigated participants mentioned the absence of any cases in terms of toxicity and secondary effects. As precautions for use, all herbalists used the plant alone with no mixture with other products to avoid toxicity or secondary effects. Equally, 100% of herbalists have conserved the plant and its infusions away from light and room temperature.

In participants (user population), dried from is the only used (100%). The users used anise plants, principally seeds alone (100%), without mixing with other products. Further, Tisane is the principal form of usage with 77.83% compared to powder with 22.17% (t=6.302, df=12, P= 0.000). The infusion is the only preparation mode, and 89.67% of users use imprecise quantities of anise compared to 10.33% of users that use accurate spoonfuls (t=-10.127, df=12, P< 0.001). As precautions for use, all participants used the plant alone with no mixture with other products to avoid toxicity or secondary effects. Equally, 100% of participants have conserved the plant and its infusions away from light and room temperature. All investigated participants mentioned the absence of any cases in terms of toxicity and secondary effects.

Currently, Yaagoubi *et al.* 2023) conducted an extensive study on medicinal plants used in traditional medicine in the same areas. As a result, anise seed was among the recorded plants and was used with three modes Decoction, brewing, and cataplasm. The most used part was fruit, which is different from our result. Since both studies were realized in the same sites, the variation could be attributed to users' knowledge and source of information about the used parts and preparation mode. On the other hand, all investigated participants mentioned the effectiveness and absence of toxicity cases after using anise; In contrast, Sun *et al.* 2019) mentioned the toxicity of estragole, anethole, and veranisatin (A, B, and C) from anise when used at high doses. The absence of toxicity in our case is attributed to the excellent conservation conditions and the use of adequate quantities of the anise (Table 2).

Table 2. Mode of use, result sand effects of anise seed

	Herbalists	Users
Dosage	100% as needed	100% as needed
Results	100% improvements	100% improvements
Side effects	None	None
Toxicity	In no case	None
Precautions for use	100% no mixture with other plants	100% no mixture with other plants
Storage conditions	100% protected from light and ambient temperature	100% protected from light and ambient temperature

Conclusion

The current study presents the first and deep ethnobotanical investigation of the therapeutic uses of Anise seed in Morocco and Northwest Africa. We investigated the therapeutic and food uses of anise seed among populations of central and North Morocco depending on the age and education level and their variation depending on sampling sites. Equally, we investigated the sources of information on this plant's medicinal uses and assessed its effectiveness in therapeutic uses. The most important conclusion was that populations of ages (20 to 60) use medical medicine, including anise seed, for both food and therapeutic uses. The plant treats diseases, counting laxatives, dysmenorrhea, digestive disorders, and antitussives in food, such as promoting milk flow. Women dominated the users, which were variable depending on the sampling site. The principal source of information about the therapeutic benefits of the anise were media counting TV, RADIO, and social media. In all investigated sites, participants used the plant in dried form and alone. The usage form was Tisane, and the preparation mode was infusion. The anise seed was used when needed, and the results were 100% amelioration of treated cases, and all investigated participants mentioned the absence of toxicity cases. The outcomes showed the importance of anise seed in the traditional medicine of Moroccan populations. However, it is essential to broaden this kind of research to numerous areas of the country to transform intuition into knowledge and verify the cures discovered by precise scientific methods experimentally. This scientific valuation is believed to raise the economic significance of natural resources and, as a result, the incomes of rural and underprivileged populations.

Declarations

Ethics approval and consent to participate: Before conducting interviews, prior informed consent was obtained from all participants. No further ethics approval was required.

Consent for publication: Not applicable

Conflicts of interest: The authors declare that there is no conflict of interests regarding the publication of this paper.

Data Availability Statement: The data used to support the findings of this study are included within the article.

Author Contributions: Conceptualization, M.S and L.E.G methodology, M.S. software, validation, formal analysis, M.S., W.E.Y., M.B.; writing—original draft preparation, M.S. and W.E.Y; writing—review and editing, M.S., M.B and W.E.Y.; visualization, L.E.G and M.F.; supervision, M.B. and L.E.G.

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