Ethnobotanical statistics of disease groups treated by medicinal plants used in the province of Taza (northern Morocco)

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Research

Abstract

Background: The province of Taza (northern Morocco) constitutes one of the richest and most diversified ecological and floristic zones. Quantitative ethnobotanical indices can enhance the continuous propagation of local phytotherapeutic plants in this area.

Methods: The 91 taxa identified based on an ethnobotanical survey carried out between March and October 2021 in Taza province has been statistically valued. IBM-SPSS-Statistics-25 processed the results. Frequency of Citation (FC), Relative Frequency of Citation (RFC), Use Value (UV), Fidelity Level (FL), Ranking Order Priority (ROP), Informant Consensus Factor (ICF) and Informant Agreement Ratio (IAR) were calculated, and The Principal Component Analysis (PCA) was performed.

Results: These medicinal plants have 61 medicinal uses belonging to 14 disease groups. *Olea europaea* L. subsp. *Europaea* displayed highest values for RFC (0.294) and ROP (74.41), *Salvia officinalis* L. displayed highest UV (0.606) and 15 species displayed highest FL (100%). The classes of diseases where ICF and IAR are high are respectively endocrine, nutritional and metabolic diseases (ICF=IAR=0.92) and Diseases of the digestive system (ICF=IAR=0.88). The PCA revealed that most of the variation was captured by the first component, showing the importance of the using Medicinal plants (79.48%), which grouped (ROP, RFC, IC, UV and T) whose most used species are *Salvia officinalis* L.. While for the second component (16.75%) showing the fidelity of use for a disease, *Cuminum cyminum* L. is the most faithful.

Conclusions: These statistical results reflect the importance of medicinal plants in treating of diseases.

Keywords: Ethnobotanical survey; Medicinal plants; Medicinal uses; Disease group; Ethnobotanical indices; Taza (Morocco).

Background

In African countries, access to drugs remains difficult for a large part of the population, encouraging medicinal plant use. A continuous diffusion of less expensive traditional therapies is observed worldwide (Létard *et al.* 2015). In Morocco, the richness and diversification of the flora offer the local population a fertile ground for practising herbal medicine. Thus,

quantitative ethnobotanical studies in this area are needed to further this field. Ethnobotany targets the healing of disease and injury, as well as protection, food and shelter (Rahman *et al.* 2019). The pharmaceutical industries are more interested in the ethnobotanical study of plants (Didier *et al.* 2011). Ethnopharmacology targets the traditional use of bioactive molecules (Süntar 2020), and the validation of their therapeutic activities remains essential to produce drug-based medicinal plants, most of which treat various infectious diseases (Verma & Singh 2008).

Morocco, a Mediterranean country in North Africa, has great ecological and floristic wealth. Economically, 500 medicinal plants are economically important (Ennabili *et al.* 2000). In more than 4000 identified Moroccan species belonging to almost all botanical families, 600 to 800 are classified as aromatic or medicinal, and 800 are endemic (Hmamouchi 1999, Ismaili *et al.* 2021). A quantitative and qualitative analysis was presented on the vascular flora of Morocco based on a recent inventory, reporting 155 families, 981 genera, 3913 species, 872 additional subspecies and 426 typical subspecies (autonyms) (Fennane & Ibn Tattou 2012). Indeed, several ethnobotanical surveys in Morocco have reported the importance of the use of Medicinal plants through quantitative studies (Barkaoui *et al.* 2017, Bouyahya *et al.* 2017, Eddouks *et al.* 2017, Chaachouay *et al.* 2019a, Chaachouay *et al.* 2019b, Mrabti *et al.* 2019, Skalli *et al.* 2019, Mechchate *et al.* 2020, Chaachouay *et al.* 2022, El Khomsi *et al.* 2022, Ghanimi *et al*. 2022).

Principal component analysis (PCA) belongs to the group of multivariate descriptive methods called factorial methods. PCA looks for differentiated groups across units by looking at which units are similar and different from others (Duby & Robin 2006). The objective of the analysis consists, on the one hand of studying the global dispersion of the objects and on the other hand knowing how the position (the dispersion) of each object evolves when the values of the starting variables observed vary in their respective intervals (Cazes *et al.* 1997). For the variables, we look for those that are strongly correlated with each of them and those that are not correlated between them (Duby & Robin 2006).

Ethnobotanical indices play a crucial role in quantifying and analyzing the knowledge and practices associated with the use of plants by different cultures. They provide a solid framework for measuring the importance and significance of plants in a particular ethnobotanical context. Given the biodiversity and plant wealth characterizing the province of Taza, and to highlight and share its local plant heritage, it was essential to carry out an ethnobotanical survey contributing to the valorization of medicinal plants via a quantitative statistical approach. Thus, the objective of our study is to determine the different medicinal uses among the Tazi populations, to distribute these uses according to the different disease groups, and then to evaluate and characterize quantitatively the importance of the use of medicinal plants in the province of Taza, by calculating ethnobotanical indices and carrying out statistical analyses.

Materials and Methods

Study area

The province of Taza has a strategic geographical position bounded to the south by the province of Sefrou, to the north by the provinces of Driouch and Al Hoceima, to the east by the province of Guercif, and to the west by the province of Taounate. The climate is Mediterranean, winter is cold-humid, and summer is semi-arid (Hakkour *et al.* 2016). It is part of the Fez Meknes Region. It is located in the northeast of Morocco. The administrative organization of the province of Taza after the last administrative division presents four urban communes and 34 rural communes (DRF-M 2016).

This survey is a descriptive and cross-sectional exploratory ethnobotanical study carried out in 28 communities in the province of TAZA (Figure 1), including four urban (Aknoul, Oued Amlil, Taza and Tahla) and 24 rural (Ajdir, Bab Boudir, Bab Marzouka, Bni Frassen, Bni Ftah, Bni Lent, Bouchfaa, Bouhlou, Galdamane, El Gouzate, Ghiata Al Garbia, Gzenaya Al Janoubia, Jbarna, Kaf El Ghar, Maghrawa, Matmata, Meknassa Acharqia, Meknassa Al Gharbia, Msila, Taifa, Tainaste, Tizi Ouasli, Taifa and Traiba) through the use of a questionnaire (face to face) and note taking, between March and October 2021. The survey was carried out among herbalists and the ordinary citizens of the province of Taza.

Questionnaire

The semi-structured interview guide is a set of instructions for interviewers and can provide clear, relevant, reliable and comparable qualitative data (De Albuquerque *et al.* 2007). This ethnobotanical study is carried out using a semi-structured questionnaire used face-to-face.

Sources of information

Plant family names were presented in alphabetical order according to the APGIII system (Haston *et al.* 2009). The identification of the Taxons and the updating of the scientific names were made by the botanist Pr. KHABBACH Abdelmajid

(Laboratory of Biotechnology, Conservation and Valorization of Natural Resources, Faculty of Sciences Dhar El Mahraz, University Sidi Mohamed Ben Abdellah, Fez, Morocco). Name families were presented alphabetically according to the Angiosperm Phylogeny Group III system (Haston *et al.* 2009).

Data processing

The data from the survey sheets were entered and processed on the IBM SPSS Statistics 25 software and were analyzed in the context of quantitative statistics with simple methods by determining the indices. These indices will be at the origin of a principal component analysis (PCA) within the framework of multivariate statistics. The map of the study area was created using ArcGIS software.

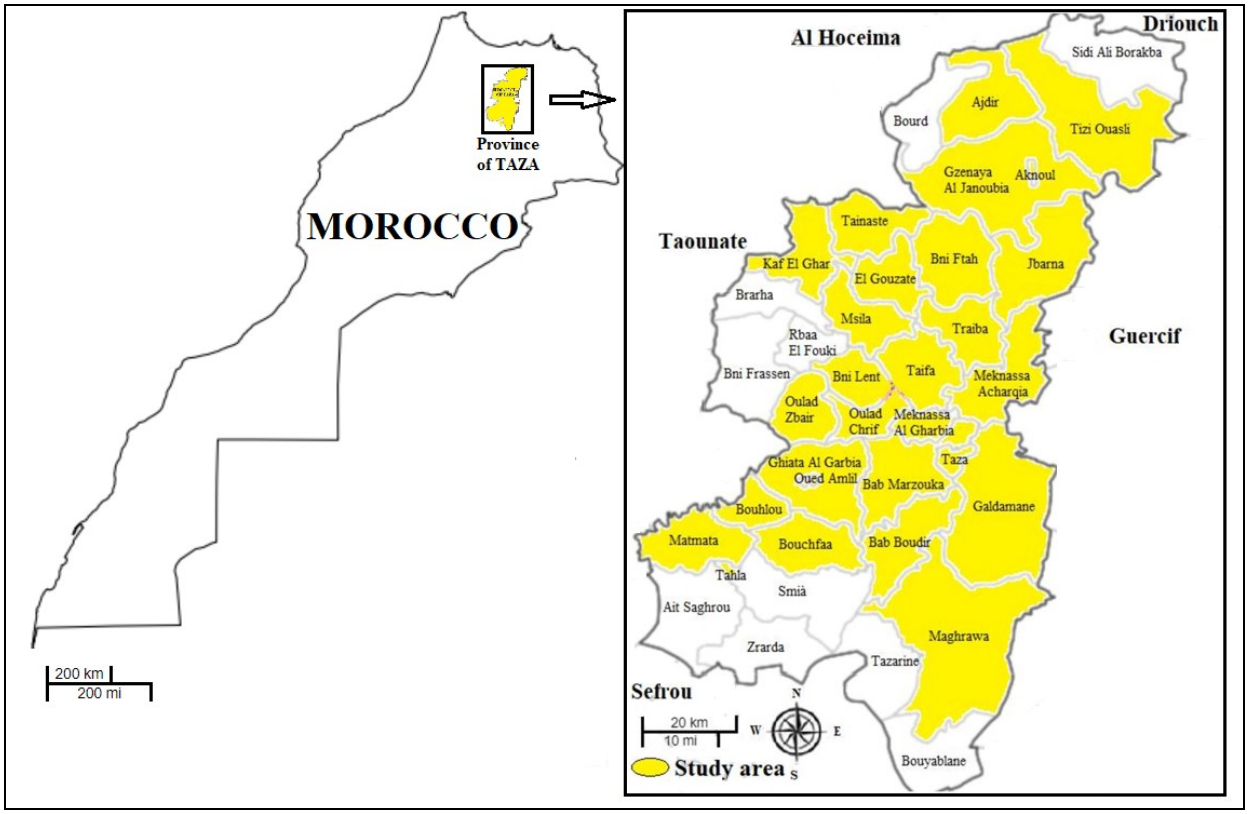

Figure 1. Map showing the study area in the Province of Taza (Source: DRF-M 2016; Created via ArcGIS software)

Quantitative Data Analysis

The International Classification of Diseases (WHO, 2019) was used to classify the different medicinal uses cited by the study population.

Quantitative ethnobotany measured the importance of plants for people, this quantitative approach uses indices defined as common tools to quantify otherwise qualitative data in the biological and social sciences (Hoffman & Gallaher 2007). In quantitative ethnobotanical studies, five ethnobotanical indices are the most used: The Informant Consensus Factor (ICF), Fidelity Level (FL), the Relative Index of Importance (RI), the Use Value (UV), the Cultural Importance Index (CI) (Houéhanou *et al.* 2016).

Relative Frequency of Citation (RFC)

Relative Frequency of Citation (**RFC**), the Local importance of each plant species was calculated based (Tardio & Pardo-De Santayana 2008).

$$FC = \mathrm{Fc}/\mathrm{N}$$

Where Fc is the number of informants who mentioned the use of the species, and N is the total number of informants (N).

Fidelity Level (FL)

Fidelity Level (**FL**) used for medicinal use, quantifies the importance of a species for a given purpose (Friedman *et al*. 1986).

$$FL = \mathrm{Np/N}$$

Where Np is the number of informants mentioning a species for a certain use p, and N is the number of information mentioning the species for any use.

Use Value (UV)

Use Value (**UV**) of (Phillips and Gentry 1993) modified, evaluates the importance of a plant for a given community (Rossato *et al.* 1999).

$$UV = \sum_{I=1}^{In} Ui/_{n}$$

Where Ui is the number of uses mentioned by an informant I, and n present the total number of informants interviewed.

Rank order priority (ROP)

Rank order priority (**ROP**) explain the celebrity of the species distribution compared to the richness of all the cited resources (Friedman *et al*. 1986).

$$ROP = \mathrm{FL\ x\ RP}$$

With FL (Fidelity Level) and RP (Relative Popularity) traduced the number of informants who cite a species/ the number of informants who cite the most frequently cited species.

Informant Consensus Factor (ICF)

Informant Consensus Factor (**ICF**) used for medicinal use and more apt to indicate the homogeneity of ethnomedicinal information (Heinrich *et al.* 1998).

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

Where Nur is the number of times that a particular category p of affection was mentioned, and Nt is the number of a plant(s) mentioned for the treatment of this particular affection P.

Informant Agreement Ratio (IAR)

Informant Agreement Ratio (**IAR**) indicates the agreement that exists between users of medicinal plants in the treatment of diseases (Ernst *et al.* 2015).

$$IAR_{disease} = 1 - (N_t/N_u)$$

Where N_t is the number of a plant(s) mentioned for the treatment of a particular disease category, and N_u is the total number of uses.

Principal component analysis (PCA)

A Principal component analysis of the variables, ethnobotanical indices and species was made using the IBM SPSS Statistics 25 software, to study the relationships between these variables.

Principal component analysis is one of the factorial methods (multivariate descriptive methods). The PCA of the variables, ethnobotanical indices and species, was made using the IBM SPSS Statistics 25 software to study the relationships between these two variables by seeking to distinguish groups in the study set. Thus, the overall dispersion of the variables is evaluated based on the positions to find those that are strongly correlated with each other from those that are not.

Results and Discussion

Collection of ethnobotanical data

At the ethnobotanical level, a total of 91 species of plants belonging to 48 families are used by the population of the province of Taza for various purposes (Ghabbour et al. 2023 Submitted). Concerning the taxa of *Capparis* spp., *Lavandula* spp. and *Thymus* spp. Referring to five previous works carried out, which covered half of our communities (14 communities of the 28 constituting our study area). We report the possibility of finding two species of *Capparis* spp. (Capparaceae): *Capparis spinosa* subsp. *spinosa* and *Capparis orientalis* L. (Libiad *et al.* 2021), three species of *Lavandula* spp. (Lamiaceae): *Lavandula stoechas* L. (Kabbach *et al.* 2012, Boulfiaa *et al.* 2018, Haouari *et al.* 2018, El Brahimi *et al.* 2022), *Lavandula multifida* L. (Kabbach *et al.* 2012, El Brahimi *et al.* 2022) and *Lavandula officinalis* L. (El Brahimi *et al.* 2022), and three species of *Thymus* spp. (Lamiaceae): *Thymus zygis* L. (Kabbach *et al.* 2012, Boulfiaa *et al.* 2018, El Brahimi *et al.* 2022) *Thymus vulgaris* L. (Haouari *et al.* 2018) and *Thymus manbyanus* ssp. *ciliatus* Bois & Rent. (Boulfiaa *et al.* 2018).

Plants were exhibited with their scientific names and families as well as their uses. Additionally, previous literature was reviewed to compare and extract similarities, dissimilarities, and highlight the novelty of these research findings (Table 1).

Medicinal use

The results obtained in Table 1 showed that the species listed have various medicinal uses (Digestive system, diabetes, hypertension, renal system, cardiac, etc.). Sixty-one medicinal uses were cited according to the studied population. Thus, digestive system (62 species), diabetes (61 species), respiratory system (23 species), cardiac (22 species), hypertension (21 species), stomach pain (21 species) and cold (21 species) displayed highest number of medicinal species used. However, the species showing the highest medicinal uses are *Rosmarinus officinalis* L. (24 medicinal uses), *Artemisia herba-alba* Asso., *Mentha pulegium* L., *Origanum compactum* Benth., *Origanum vulgare* L. and *Salvia officinalis* L. (14 medicinal uses), *Trigonellafoenum-graecum* L., and *Calamintha nepeta subsp. spruneri (Boiss.) Nyman (Clinopodium nepeta* ssp. *glandulosum* (Req.) Govaerts) (13 medicinal uses) (Table 1). The diversity of medicinal uses attributed to plant species shows the cultural importance of these plants within the province of Taza.

The high number of uses is consistent with (El Hilaly *et al.* 2003, El Khomsi *et al.* 2022). The digestive system, which is the most treated according to the number of species, was also represented the most treated according to the work of (Daoudi *et al.* 2016, Boulfia *et al.* 2018, Haouari *et al.* 2018, Fatiha *et al.* 2019, Hayat *et al.* 2020, El Khomsi *et al.* 2022). The number of species (62) obtained in this study, treating diseases of the digestive system is almost equal to that (63 species) reported by (Daoudi *et al.* 2016), but higher than that (34 species) found in (El Khomsi *et al.* 2022). The number of species (61) revealed in this study of treating diabetes is consistent with the number (63 species) found in (Tahraoui *et al.* 2007) but higher than the number (37 species) found in (Eddouks *et al.* 2002).

Many medicinal uses are revealed in the present survey, and which are found most relevant in other works: Digestive system (63 species), respiratory system (20 species), urogenital (23 species) rheumatological (23 species), dermatological (24 species), cardiovascular (15 species) neurological, microbial, ear, nose and throat (ENT) diseases and typhoid (42 species) (Daoudi *et al.* 2016). Infections (Beniaich *et al.* 2022). Diabetes (37 species) hypertension and cardiac diseases (73 species) (Eddouks *et al.* 2002). Digestive (34 species), skin (30 species), urogenital (six species), rheumatic (seven species), respiratory (eight species) metabolic (12 species), and nervous system (12 species) (El Khomsi *et al.* 2022). Digestive, respiratory, and dermatological disorders (Fatiha *et al.* 2019). Diabetes (54 species), cardiac diseases (11 species), hypertension (19 species) and renal diseases (33 species) (Jouad *et al.* 2001). Gastrointestinal disorders (33 species), joint system disorders, ENT (ear, nose and throat) diseases and headaches (24 species), and skin problems (11 species) (Khabbach *et al.* 2012). Gastrointestinal (16) (Souilah *et al.* 2021). Diabetes (63 species) and hypertension (54 species) (Tahraoui *et al.* 2007). These results quantify knowledge about plant species used by traditional communities by systematically analyzing associated cultural uses and practices and assessing the depth and breadth of traditional knowledge.

Table 1. The medicinal uses of the species and their number

Family	Scientific name	VC	Medicinal use	Nu
Agavaceae	*Agave sisalana* Perrine	**1**	Digestive system	1
Alliaceae	*Allium cepa* L.	**2**	Diabetes Hypertension Digestive system	3
	Allium sativum L.	**3**	Diabetes Hypertension Digestive system Microbial infection (Covid 19) Immune deficiency Stomach pain Ear diseases	7
Aloaceae	*Aloe vera* (L.) Burm. f.	**4**	Digestive system Respiratory system Dizziness	3
Amaranthaceae	*Atriplex halimus* L.	**5**	Hypertension Digestive system Immune deficiency, Osteoporosis, Anemia	5
	Dysphania ambrosioides (L.) Mosyakin & Clemants	**6**	Hypertension Digestive system Fever Respiratory system Stomach pain Intoxication Ear diseases Infection Urinary diseases	9
Anacardiaceae	*Pistacia lentiscus* L.	**7**	Digestive system Stomach pain Mouth sores	3
Apiaceae	*Ammodaucus leucotrichus* Coss. & Durieu	**8**	Digestive system Stomach pain Diuretic	3
	Visnaga daucoides Gaertn.	**9**	Diabetes Digestive system Respiratory system Stomach pain Tooth hygiene Tooth infection	6
	Apium graveolens L.	**10**	Diabetes Hypertension Digestive system Renal system Stomach pain	5
	Carum carvi L.	**11**	Digestive system	1
	Coriandrum sativum L.	**12**	Diabetes Digestive system	2
	Cuminum cyminum L.	**13**	Digestive system Diarrhea	2
	Anethum foeniculum L.	**14**	Diabetes Hypertension Digestive system Renal system Tiredness Dizziness	6
	Pimpinella anisum L.	**15**	Diabetes Digestive system	2
	Petroselinum crispum (Mill.) Fuss	**16**	Diabetes Hypertension Digestive system Respiratory system Renal system	5
Apocynaceae	*Nerium oleander* L.	**17**	Diabetes Digestive system Microbial infection (Covid 19) Immune deficiency Renal system Intoxication	6
Arecaceae	*Chamaerops humilis* L.	**18**	Diabetes Cardiac	2
Aristolochiaceae	*Aristolochia fontanesii* Boiss. & Eut.	**19**	Saignement Mouth sores Infection Goitre Sores	5
Asteraceae	*Artemisia absinthium* L.	**20**	Diabetes Headaches Digestive system Cold Cough Fever Depression Stomach pain Tiredness Sexual diseases	10
	Artemisia herba-alba Asso.	**21**	Diabetes Digestive system Intestinal pain Cold Cough Microbial infection (Covid 19) Fever Immune deficiency Depression Stomach pain Tiredness Dizziness Nervousness Flu	14
	Dittrichia viscosa (L.) Greuter	**22**	Diabetes Digestive system Circulatory diseases Burn Sores	5
	Matricaria chamomilla L.	**23**	Diabetes Hypertension Digestive system Cold Acne Diarrhea Dry hair Nervous system	8
	Scolymus hispanicus L.	**24**	Cardiac LDL	2
Berberidaceae	*Berberis hispanica* Boiss. & Reut.	**25**	Diabetes Cough Renal system Liver Traces of wounds Cholesterol	6

Brassicaceae	*Brassica oleracea subsp. capitata* (L.) Duchesne	**26**	Diabetes Immune deficiency Cancer LDL	4
	Lepidium sativum L.	**27**	Diabetes Hypertension Digestive system Respiratory system Acne Bone diseases Thyroid	7
Cactaceae	*Opuntia ficus-indica* (L.) Mill	**28**	Diabetes Digestive system Osteoporosis Cardiac Renal system Tiredness Diarrhea	7
Caesalpiniaceae	*Ceratonia siliqua* L.	**29**	Diabetes Digestive system Diarrhea	3
Capparaceae	*Capparis* spp.	**30**	Diabetes Digestive system Cold	3
Caryophyllaceae	*Corrigiola telephiifolia* Pour.	**31**	Diabetes Digestive system Microbial infection (Covid 19) Traces of wounds Acne Dizziness	6
Cucurbitaceae	*Citrullus colocynthis* (L.) Sch	**32**	Diabetes Cold Cancer LDL	4
Cupressaceae	*Tetraclinis articulata* (Vahl) Mast.	**33**	Diabetes Digestive system Intestinal pain Cold Respiratory system Stomach pain Intoxication	7
Euphorbiaceae	*Croton tiglium* L.	**34**	Renal system	1
	Euphorbia resinifera O. Berg	**35**	Diabetes Digestive system Microbial infection (Covid 19) Asthma Fever Stomach pain Goitre Cyst	8
Fabaceae	*Cicer arietinum* L.	**36**	Sexual diseases	1
	Glycine max (L.) Merr.	**37**	Osteoporosis Cardiac	2
	Glycyrrhiza glabra L.	**38**	Hypertension Digestive system Cold Respiratory system Tooth hygiene Tooth infection	6
	Lupinus albus L.	**39**	Diabetes Digestive system	2
	Trigonella foenum-graecum L.	**40**	Diabetes Digestive system Cold Cardiac Respiratory system Renal system LDL Stomach pain Tiredness Dizziness Sexual impotence Circulatory diseases Cardiac	13
Fagaceae	*Quercus ilex* L.	**41**	Diabetes Digestive system Cardiac	3
Gentianaceae	*Centaurium erythraea* Rafn	**42**	Diabetes Cough Fever Anemia Tiredness	5
Globulariaceae	*Globularia alypum L.*	**43**	Diabetes Hypertension Fever	3
Illecebraceae	*Herniaria hirsuta* L.	**44**	Hypertension Digestive system Osteoporosis Renal system	4
Juglandaceae	*Juglans regia* L.	**45**	Diabetes Tiredness Tooth hygiene	3
Lamiaceae	*Ajuga iva (L.) Schreb.*	**46**	Diabetes Digestive system Respiratory system	3
	Calamintha nepeta subsp*. spruneri* (Boiss.) Nyman *(Clinopodium nepeta* subsp*. glandulosum* (Req.) Govaerts)		Diabetes Digestive system Cold Cough Fever Respiratory system Renal system Stomach pain Diarrhea Flu Sexual diseases Mouth diseases Stomach ulcer	13
	Lavandula spp.	**47**	Diabetes Digestive system Cold Cough Fever Dry hair Flu Respiratory system Renal system Sexual diseases Urinary diseases	11
	Lavandula stoechas L.	**49**	Diabetes Digestive system Respiratory system	3
	Marrubium vulgare L.	**50**	Diabetes Intestinal pain Cold Stomach pain Tooth hygiene Mouth sores	7
	Mentha pulegium L.	**51**	Diabetes Headaches Digestive system Cold Cough Fever Respiratory system Stomach pain Tiredness Diarrhea Flu Throat inflammation Yellowing Cardiac	14
	Mentha rotundifolia Muds.	**52**	Depression Tiredness	2
	Mentha spicata L.	**53**	Headaches Depression Tiredness	3

	Micromeria graeca (L.) Benth. ex Rchb.	**54**	Headaches Depression	2
	Ocimum basilicum L.	**55**	Hypertension	1
	Origanum compactum Benth.	**56**	Diabetes Digestive system Cold Cough Microbial infection (Covid 19) Fever Respiratory system Cancer Stomach pain Tiredness Nervousness Flu Mouth diseases Cardiac	14
	Origanum majorana L.	**57**	Hypertension Headaches Digestive system Cough Immune deficiency Depression Respiratory system Cardiac	8
	Origanum vulgare L.	**58**	Diabetes Digestive system Cold Cough Microbial infection (Covid 19) Fever Respiratory system Cancer Stomach pain Tiredness Nervousness Flu Mouth diseases Cardiac	14
	Rosmarinus officinalis L.	**59**	Diabetes Headaches Digestive system Intestinal pain Cold Cough Fever Respiratory system Renal system Dental pain Stomach pain Tiredness Diarrhea Intestin Dizziness Sexual impotence Nervous system Nervousness Flu Sexual diseases Mouth diseases Circulatory diseases Cardiac Stomach ulcer	24
	Salvia officinalis L.	**60**	Diabetes Hypotension Digestive system Cough Immune deficiency Respiratory system Renal system Stomach pain Tiredness Dizziness Sexual impotence Sexual diseases Circulatory diseases Cardiac	14
	Thymus spp.	**61**	Diabetes Headaches Digestive system Respiratory system Intestinal pain Cold Flu Intoxication Infection	9
Lauraceae	*Cinnamomum cassia* Lour.	**62**	Diabetes Digestive system Intestinal pain Microbial infection (Covid 19) Cardiac LDL Stomach pain Blood circulation Sexual diseases Mouth diseases Cardiac	11
Linaceae	*Linum usitatissimum* L.	**63**	Diabetes Digestive system	2
Malvaceae	*Hibiscus sabdariffa* L.	**64**	Diabetes Hypertension Hypotension	3
	Malva pusilla Sm.	**65**	Digestive system Stomach pain	2
Moraceae	*Ficus carica* L.	**66**	Diabetes Digestive system	2
Moringaceae	*Moringa oleifera* Lam.	**67**	Hypertension Cardiac	2
Myrtaceae	*Eucalyptus globulus* Labill.	**68**	Diabetes Hypertension Digestive system Asthma Fever Immune deficiency Lung inflammation Respiratory system Flu Yellowing Cardiac	11
	Eugenia caryophyllata Thunb.	**69**	Diabetes Digestive system Immune deficiency Respiratory system Dental pain Mouth sores Mouth diseases	7
	Myrtus communis L.	**70**	Diabetes Hypertension Digestive system Cold Cough Microbial infection (Covid 19) Asthma Lung inflammation Nervous system Mouth diseases Intoxication	11
Oleaceae	*Olea europaea* L. subsp. *europaea*	**71**	Diabetes Hypertension Infection Headaches Digestive system Respiratory system Tiredness Dizziness Mouth diseases	9
Pedaliaceae	*Sesamum indicum* L.	**72**	Digestive system	1
Poaceae	*Cenchrus americanus* (L.) Morrone / *Cenchrus spicatus* (L.) Cav.	**73**	Cold Sexual diseases	2
	Triticum turgidum L.	**74**	Diabetes Liver Intestin	3

	Zea mays L.	**75**	Diabetes Digestive system Cardiac Renal system	4
Polygonaceae	*Emex spinosa* (L.) Campd	**76**	Liver	1
Punicaceae	*Punica granatum* L.	**77**	Diabetes Digestive system	2
Ranunculaceae	*Nigella sativa* L.	**78**	Diabetes Digestive system Cold Cardiac Respiratory system Circulatory diseases	6
Rhamnaceae	*Rhamnus alaternus* L.	**79**	Anemia	1
	Ziziphus lotus (L.) Lam.	**80**	Diabetes Digestive system Stomach pain Intestin Cardiac	5
Rosaceae	*Crataegus monogyna* Jacq.	**81**	Diabetes	1
	Fragaria vesca L.	**82**	Diabetes	1
	Prunus dulcis (Mill.) D.A. Webb	**83**	Diabetes Digestive system Fever Immune deficiency Hair loss Dried skin	6
Rubiaceae	*Coffea arabica* L.	**84**	Diabetes Hypertension Headaches	3
Salicaceae	*Populus alba* L.	**85**	Intestin	1
Sapotaceae	*Argania spinosa* (L.) Skeels	**86**	Diabetes	1
Solanaceae	*Capsicum annuum* L.	**87**	Diabetes Cold Cough	3
Urticaceae	*Urtica dioica* L.	**88**	Digestive system Cold Renal system Circulatory diseases Cardiac	5
Verbenaceae	*Aloysia citriodora* Palau.	**89**	Hypertension Digestive system Intestinal pain Fever Immune deficiency Depression Tachycardia Nervous system	8
Zingiberaceae	*Zingiber officinale* Roscoe	**90**	Diabetes Digestive system Fever Cardiac Sexual impotence	5
Zygophyllaceae	*Peganum harmala* L.	**91**	Digestive system	1

VC=Voucher codes. Nu=Number of uses.

Classes of diseases treated by medicinal plants

The International Classification of Diseases (WHO, 2019) allowed us to construct Table 2. The 61 medicinal uses cited by the population of the province of Taza are distributed over the groups of diseases. Fourteen groups of diseases were treated by the medicinal plants used. Thus, the number of species and the percentage of medicinal plants used in the treatment of each group of diseases are as follows: I (A00-B99): Certain infectious and parasitic diseases (37 species) (9.57%). II (C00-D48): Neoplasms (four species) (0.26%). III (D50-D89): Diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism (14 species) (1.71%). IV (E00-E90): Endocrine, nutritional and metabolic diseases (63 species) (33.89%). V (F00-F99): Mental and behavioral disorders (eight species) (1.36%). VI (G00-G99): Diseases of the nervous system (24 species) (5.53%). VIII (H60-H95): Diseases of the ear and mastoid process (two species) (0.09%). IX (I00-I99): Diseases of the circulatory system (39 species) (10.14%). X (J00-J99): Diseases of the respiratory system (30 species) (6.15%). XI (K00-K93): Diseases of the digestive system (67 species) (23.66). XII (L00-L99): Diseases of the skin and subcutaneous tissue (six species) (0.66%). XIII (M00-M99): Diseases of the musculoskeletal system and connective tissue (seven species) (0.44%). XIV (N00-N99): Diseases of the genitourinary system (22 species) (4.74%). XIX (S00-T98): Injury, poisoning and certain other consequences of external causes (10 species) (1.8%).

Based on the medicinal uses constituting the groups of diseases. We found that these groups are implicitly reported in other works. I (A00-B99): Certain infectious and parasitic diseases (Daoudi *et al.* 2016, Beniaich *et al.* 2022). II (C00-D48): Neoplasms (Mlilo & Sibanda 2022). III (D50-D89): Diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism (Kharchoufa *et al.* 2021). IV (E00-E90): Endocrine, nutritional and metabolic diseases (Jouad *et al.* 2001, Eddouks *et al.* 2002, Tahraoui *et al.* 2007, Boulfia *et al.* 2018, El Khomsi *et al.* 2022). VI (G00-G99): Diseases of the nervous system (Daoudi *et al.* 2016, El Khomsi *et al.* 2022). VIII (H60-H95): Diseases of the ear and mastoid process (Kharchoufa *et al.* 2021): Diseases of the circulatory system (Jouad *et al.* 2001, Eddouks *et al.* 2002, Tahraoui *et al.* 2007, Daoudi *et al.* 2016). X (J00-J99): Diseases of the respiratory system (Daoudi *et al.* 2016, Boulfia *et al.* 2018, Fatiha *et al.* 2019, Kharchoufa *et al.* 2021, El Khomsi *et al.* 2022). XI (K00-K93): Diseases of the digestive system (Khabbach *et al.* 2012, Daoudi *et al.* 2016, Boulfia *et al.* 2018, Fatiha *et al.* 2019, Kharchoufa *et al.* 2021, Souilah *et al.* 2021, El Khomsi *et al.* 2022). XII (L00-L99): Diseases of the skin and subcutaneous tissue (Khabbach *et al.* 2012, Daoudi *et al.* 2016, Fatiha *et al.* 2019, El Khomsi *et al.* 2022). XIII (M00-M99): Diseases of the musculoskeletal system and connective tissue (Khabbach *et al.* 2012, Daoudi *et al.* 2016, El Khomsi *et al.* 2022). XIV (N00-N99): Diseases of the genitourinary system (Daoudi *et al.* 2016, El Khomsi *et al.* 2022). XIX (S00-T98): Injury, poisoning and certain other consequences of external causes (El Khomsi *et al.* 2022).

Quantitative Data Analysis

Frequency of Citation (FC) and Total Citation Frequency T(FC)

Table 2 shows the citation frequencies determined for each species in each group of diseases. The results obtained showed that the highest Citation Frequency was recorded for *Olea europaea* L. subsp. *europaea* (FC=100) for endocrine, nutritional and metabolic diseases. So, if we take the highest citation frequency of the species recorded in each group of diseases we found: *Mentha pulegium* L. (FC=30) for Certain infectious and parasitic diseases. *Euphorbia resinifera* O. Berg (FC=3) for Neoplasms. *Allium sativum* L. (FC=8) for Diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism. *Artemisia herba-alba* Asso. (FC=14) for Mental and behavioral disorders. *Aloysia citriodora* Palau. (FC=21) for Diseases of the nervous system. *Allium sativum* L. and *Dysphania ambrosioides* (L.) Mosyakin & Clemants (FC=1) for Diseases of the ear and mastoid process. *Salvia officinalis* L. (FC=63) for Diseases of the circulatory system. *Mentha pulegium* L. (FC=23) for Diseases of the respiratory system. *Origanum compactum* Benth. (FC=45) for Diseases of the digestive system. *Corrigiola telephiifolia* For. (FC=7) for Diseases of the skin and subcutaneous tissue. *Lepidium sativum* L. (FC=5) for Diseases of the musculoskeletal system and connective tissue. *Herniaria hirsuta* L. (FC=26) for Diseases of the genitourinary system. *Dittrichia viscosa* (L.) Greuter (FC=13) for injury, poisoning and certain other consequences of external causes.

The highest total citation frequency in disease treatment was recorded by *Salvia officinalis* L. (TFC=206). The scientific name (Salvia: "cure") of the latter clearly explains its therapeutic importance (Chevallier 2001). *Salvia officinalis* L. *Trigonella foenum-graecum* L. and *Rosmarinus officinalis* L. showed the highest TFCs and are very common (Jouad *et al.* 2001, Tahraoui *et al.* 2007, El Amrani *et al.* 2010, Ghourri *et al.* 2013).

These results implicitly show specifically identified plants' cultural, social and economic value.

Relative Frequency of Citation (RFC)

The Relative Frequency of Citation (RFC) of the species was calculated only for the group of diseases with the highest citation frequency. For example, *Salvia officinalis* L.'s highest citation frequency was recorded in the Endocrine, nutritional and

metabolic diseases group (FC=79). Thus, the Relative Frequency of Citation (RFC) (Table 2) was significant for *Olea europaea* L. subsp. *Europaea* (RFC=0.294), *Trigonella foenum-graecum* L. (RFC=0.235), *Salvia officinalis* L. (RFC=0.232), *Origanum compactum* Benth (RFC=0.132) and *Rosmarinus officinalis* L. (RFC=0.126). These results clearly showed the relative importance of each species mentioned by many informants in the treatment of a well-defined disease group. However, the RFC of some of these species have been reported in other Moroccan works: *Olea europea* L. *var. sativa* (RFC=0.12), *Trigonella foenum-graecum* L. (RFC=0.17), *Salvia officinalis* L. (RFC=0.15), *Rosmarinus officinalis* L (RFC =0.03) (Skalli *et al.* 2019). *Olea europaea* L. subsp. *europaea*, (RFC=0.243), *Salvia officinalis* L. (RFC=0.230), *Trigonella foenum graecum* L. (RFC=0.205) (Mrabti *et al.* 2019). *Rosmarinus oficinalis* L. (RFC=0.189), *Trigonella foenum-graecum* L. (RFC=0.054) and *Olea europea* L. (RFC=0.051) (Chaachouay *et al.* 2022). *Rosmarinus oficinalis* L. (RFC=0.33) (Ghanimi *et al.* 2022). And in Algeria: *Trigonella foenum graecum* L. (RFC=0.25), *Rosmarinus officinalis* L. (RFC =0.21), *Salvia officinalis* L. (RFC =0.06) and *Olea europea* L. var. *sativa* (RFC=0.25) (Telli *et al.* 2016).

In Moroccan, the highest RFC value recorded in our study (RFC=0.294) remains higher than those reported by other studies (Chaachouay *et al.* 2022) (RFC=0.189), (Mrabti *et al.* 2019) (RFC=0.243) and (Chaachouay *et al.* 2019a) (RFC= 0.28). While it is lower than that of (Ghanimi *et al.* 2022) (RFC=0.53), (Barkaoui *et al.* 2017, El Brahimi *et al.* 2022) (RFC=0.64) and (Idm'hand *et al.* 2020) (RFC=0.32). The difference found between our results and those of (El Brahimi *et al.* 2022) can be explained by the fact that we worked on 28 municipalities in the province of Taza, while (El Brahimi *et al.* 2022) only worked on one municipality called Bouchfaa, and which included in our study area. Far from Morocco, the highest RFC value observed in the present study remains higher than that found in (Mlilo & Sibanda 2022) (RFC=0.16). While it is much lower than that of (Ahmad *et al.* 2014) (RFC =0.95) and (Srinivasan *et al.* 2022) (RFC=1). A high RFC of a medicinal plant species treating a disease requires ethnopharmacological evaluation to produce drugs.

Fidelity Level (FL)

The Fidelity Level (FL) index is based on an agreement between interviewees to know the fidelity of a plant for the treatment of a disease. To determine the most frequent plant species in the traditional treatment of certain groups of diseases, the FL of a species (mostly represented) for a disease group category was calculated. The results obtained (Table 2) showed that 17 species present the highest FL (FL=100%) and are: *Rhamnus alaternus* L., *Crataegus monogyna* Jacq, *Fragaria vesca* L., *Populus alba* L., *Argania spinosa* (L.) Skeels, *Peganum harmala* L., *Agave sisalana* Perrine, *Mentha rotundifolia Muds.*, *Cuminum cyminum* L., *Carum carvi* L, *Croton tiglium* L., *Cicer arietinum* L., *Ocimum basilicum* L., *Moringa oleifera* Lam, *Malva pusilla* Sm., *Sesamum indicum* L. and *Emex spinosa* (L.) Campd. This number (17) is higher than that (12) found in (Chaachouay *et al.* 2019a) and lower than that (18) found in (Srinivasan *et al.* 2022), (38) (Idm'hand *et al.* 2020) and (37) (El Brahimi *et al.* 2022). Thus, in (Bouyahya *et al.* 2017) the highest value of FL was recorded for *Origanum compactum* Benth. (100%) and *Myrtus communis* L. (93.50%). While, in the present work, the value of FL for *Origanum compactum* Benth. and *Myrtus communis* L. were respectively (54.88% and 31.03%).

The FL value assesses particularly the effectiveness of a species for the treatment of a disease compared to others. It suggests a specific relationship "Plant X - Disease Y" based on a better healing potential. In our study, the FL of the species varied between 28.48% and 100% while they varied from 3.33 to 78.95% (Barkaoui *et al.* 2017). The lowest FL value recorded by *Rosmarinus officinalis* L. is explained by the fact that the latter is used in the treatment of 8 disease group categories. While the FL of *Rosmarinus officinalis* L. remains lower than that (FL=100%) reported by (Chaachouay *et al.* 2019b, Chaachouay *et al.* 2022). FL of *Olea europaea* L. subsp. *Europaea* (FL=83.33%), *Trigonella foenum-graecum* L. (FL=51.95%) and *Marrubium vulgare* L. (FL=47.83%) are higher, while *Salvia officinalis* L. (FL=38.35%), *Artemisia herba-alba* Asso. (FL=34.29%) and *Nigella sativa* L. (FL=33.33%) are respectively lower than those (FL=62%) (FL=41.13%) (FL=37%) (FL=45 %) (FL=42%) (FL=57%) from (Eddouks *et al.* 2017).

Table 2. Classes of diseases treated by medicinal plants, Frequency of Citation (FC), Total Citation Frequency T(FC), Relative Frequency of Citation (RFC), Fidelity Level (FL), Use Value (UV), Relative Popularity (RP), Rank Order Priority (ROP), Informant Consensus Factor (ICF), Informant Agreement Ratio (IAR).

Species	FC														T (FC)	UV	RFC	FL %	I C	RP	ROP
	I : A00-B99	II : C00-D48	III : (D5-D89)	IV : E00-E90	V : F00-F99	VI : G00-99	VIII : H60-95	IX : I00-I99	X : J00-J99	XI : K00-93	XII : L00-L99	XIII : M00-99	XIV : N00-99	XIX : S00-T98							
Agave sisalana Perrine										1					1	0.003	0.003	100	1	0.009	0.90
Allium cepa L.				5				5		2					12	0.035	0.015	41.67	7	0.062	2.58
Allium sativum L.	1		8	12			1	31		5					58	0.171	0.091	53.45	34	0.304	16.25
Aloe vera (L.) Burm. f.						1			1	1					3	0.009	0.003	33.33	1	0.009	0.30
Atriplex halimus L.			2					1		1		1			5	0.015	0.006	40	2	0.018	0.72
Dysphania ambrosioides (L.) Mosyakin & Clemants	28						1	1	3	2			1	1	37	0.109	0.082	75.68	31	0.277	20.96
Pistacia lentiscus L.										3				1	4	0.012	0.009	75	4	0.036	2.70
Ammodaucus leucotrichus Coss. & Durieu										7			2		9	0.026	0.021	77.78	7	0.062	4.82
Anethum foeniculum L.				11		2		5		13			2		33	0.097	0.038	39.39	22	0.196	7.72
Apium graveolens L.				6				4		2			2		14	0.041	0.018	42.86	7	0.062	2.66
Carum carvi L.										2					2	0.006	0.006	100	2	0.018	1.80
Coriandrum sativum L.				10						11					21	0.032	0.029	52.38	15	0.134	7.02
Cuminum cyminum L.										9					9	0.026	0.026	100	9	0.080	8
Petroselinum crispum (Mill.) Fuss				7				9	1	10			8		35	0.103	0.029	28.57	16	0.143	4.08
Pimpinella anisum L.				1						4					5	0.015	0.012	80	4	0.036	2.88
Visnaga daucoides Gaertn.	6			20					1	5					32	0.094	0.059	62.5	21	0.187	11.69
Nerium oleander L.	2		6	6						2			1	1	18	0.053	0.018	33.33	9	0.080	2.66
Chamaerops humilis L.				2				2							4	0.012	0.006	50	3	0.027	1.35
Aristolochia fontanesii Boiss. & Reut.	1		2	2										4	9	0.026	0.012	44.44	6	0.054	2.40
Artemisia absinthium L.	3			19	6	8			1	13			1		51	0.150	0.059	37.25	27	0.241	8.98
Artemisia herba-alba Asso.	19		1	36	14	10			7	18					105	0.309	0.106	34.29	55	0.491	16.83
Dittrichia viscosa (L.) Greuter				1				1		6				13	21	0.062	0.038	61.90	13	0.116	7.18
Matricaria chamomilla L.	1			2		12		2		2	2				21	0.062	0.035	57.14	14	0.125	7.14

Scolymus hispanicus L.				1			4							5	0.015	0.012	80	4	0.036	2.88
Berberis hispanica Boiss. & Reut.				17				3	3	1		3		27	0.079	0.050	62.96	17	0.152	9.57
Brassica oleracea subsp. *capitata* (L.) Duchesne		1	1	2										4	0.012	0.006	50	2	0.018	0.90
Lepidium sativum L.				20			4	2	9	2	5			42	0.124	0.059	47.62	30	0.268	12.76
Opuntia ficus-indica (L.) Mill				15		1	1		16		2	7		42	0.124	0.047	38.10	17	0.152	5.79
Ceratonia siliqua L.				1					6					7	0.021	0.018	85.71	6	0.054	4.63
Capparis spinosa L.	4			1					1					6	0.018	0.012	66.66	5	0.045	3
Corrigiola telephiifolia Pour.	3			11		1			2	7				24	0.070	0.032	45.83	14	0.125	5.73
Citrullus colocynthis (L.) Sch	2	1		8										11	0.032	0.024	72.73	8	0.071	5.16
Tetraclinis articulata (Vahl) Mast.	1			11				2	7				12	33	0.097	0.035	36.36	27	0.241	8.76
Croton tiglium L.												1		1	0.003	0.003	100	1	0.009	0.9
Euphorbia resinifera O. Berg	5	3		20				6	3					37	0.109	0.059	54.05	22	0.196	10.59
Cicer arietinum L.												1		1	0.003	0.003	100	1	0.009	0.90
Glycine max (L.) Merr.							1				1			2	0.006	0.003	50	1	0.009	0.45
Glycyrrhiza glabra L.	3						1	2	1					7	0.021	0.009	42.86	4	0.036	1.54
Lupinus albus L.				18					5					23	0.068	0.053	78.26	18	0.161	12.60
Trigonella foenum-graecum L.	5			80		12	19	1	33			4		154	0.453	0.235	51.95	91	0.812	42.18
Quercus ilex L.				1			1		1					3	0.009	0.003	33.33	1	0.009	0.30
Centaurium erythraea Rafn	2		4	4		2		1						13	0.038	0.012	30.77	5	0.045	1.38
Globularia alypum L.	7			7			1							15	0.044	0.021	46.67	9	0.080	3.73
Herniaria hirsuta L.							1		2		1	26		30	0.088	0.076	86.66	26	0.232	20.10
Juglans regia L.	4			13		1								18	0.053	0.038	72.22	15	0.134	9.68
Ajuga iva (L.) Schreb.				11				3	4					18	0.053	0.032	61.11	16	0.143	8.73
Calamintha nepeta subsp. spruneri (Boiss.) Nyman (Clinopodium nepeta subsp. glandulosum (Req.) Govaerts)	18			5				10	15			4		52	0.153	0.053	34.62	26	0.232	8.03
Lavandula stoechas L.				3				1	3					7	0.021	0.009	42.86	5	0.045	1.93
Lavandula sp.	6			13				6	16	1		9		51	0.150	0.047	31.37	40	0.357	11.20
Marrubium vulgare L.	6			4					11				2	23	0.068	0.032	47.83	11	0.098	4.69
Mentha pulegium L.	30			9		2	2	23	24					90	0.265	0.088	33.33	58	0.518	17.26
Mentha rotundifolia Muds.						3								3	0.009	0.009	100	2	0.018	1.80
Mentha spicata L.					1	3								4	0.012	0.009	75	3	0.027	2.03

Micromeria graeca (L.) Benth. ex Rchb					1	1							2	0.006	0.003	50	2	0.018	0.90
Ocimum basilicum L.							1						1	0.003	0.003	100	1	0.009	0.90
Origanum compactum Benth.	7	1		16	1	4	2	6	45				82	0.241	0.132	54.88	51	0.455	24.97
Origanum majorana L.			1		1	1	2	5	2				12	0.035	0.015	41.66	9	0.080	3.33
Origanum vulgare L.	5			6		2	1	2	11				27	0.079	0.032	40.74	18	0.161	6.56
Rosmarinus officinalis L.	15			40	5	10	13	14	43		11		151	0.444	0.126	28.48	85	0.759	21.61
Salvia officinalis L.			4	79		7	63	3	34		16		206	0.606	0.232	38.35	112	1	38.35
Thymus vulgaris L.	8			4		3		2	16			1	34	0.100	0.047	47.06	16	0.143	6.73
Cinnamomum cassia Lour.	2			23			5		19		1		50	0.147	0.068	46	37	0.330	15.18
Linum usitatissimum L.				3					1				4	0.012	0.009	75	4	0.036	2.7
Hibiscus sabdariffa L.				5			8						13	0.038	0.024	61.54	5	0.045	2.77
Malva pusilla Sm.									2				2	0.006	0.006	100	2	0.018	1.8
Ficus carica L.				1					1				2	0.006	0.003	50	1	0.009	0.45
Moringa oleifera Lam.							2						2	0.006	0.006	100	2	0.018	1.8
Eucalyptus globulus Labill.	7		1	5			7	15	2				37	0.109	0.044	40.54	29	0.259	10.50
Eugenia caryophyllata Thunb.			4	4				4	10			5	27	0.079	0.029	37.04	14	0.125	4.63
Myrtus communis L.	4			1		9	3	7	4			1	29	0.085	0.026	31.03	19	0.170	5.27
Olea europaea L. subsp. *europaea*	1			100		9	4	1	5				120	0.353	0.294	83.33	100	0.893	74.41
Sesamum indicum L.									1				1	0.003	0.003	100	1	0.009	0.90
Cenchrus americanus (L.) Morrone / *Cenchrus spicatus* (L.) Cav.	1										1		2	0.006	0.003	50	1	0.009	0.45
Triticum turgidum L.				1					2				3	0.009	0.006	66.66	2	0.018	1.20
Zea mays L.				2			4		3		4		13	0.038	0.012	30.77	5	0.045	1.38
Emex spinosa (L.) Campd									1				1	0.003	0.003	100	1	0.009	0.90
Punica granatum L.				7					32				39	0.115	0.094	82.05	33	0.295	24.20
Nigella sativa L.	1			4			7	5	4				21	0.062	0.021	33.33	13	0.116	3.87
Rhamnus alaternus L.			1										1	0.003	0.003	100	1	0.009	0.90
Ziziphus lotus (L.) Lam.				3			1		4				8	0.023	0.012	50	4	0.036	1.80
Crataegus monogyna Jacq.				3									3	0.009	0.009	100	3	0.027	2.7
Fragaria vesca L.				1									1	0.003	0.003	100	1	0.009	0.90
Prunus dulcis (Mill.) D.A. Webb	2		2	42					4	2			52	0.153	0.124	80.77	42	0.375	30.29
Coffea arabica L.				1		1	2						4	0.012	0.006	50	2	0.018	0.90
Populus alba L.									2				2	0.006	0.006	100	2	0.018	1.80

Argania spinosa (L.) Skeels				1											1	0.003	0.003	100	1	0.009	0.90
Capsicum annuum L.	1			1					2						4	0.012	0.003	50	2	0.018	1.8
Urtica dioica L.	1							3		2			2		8	0.023	0.009	37.5	4	0.036	1.35
Aloysia citriodora Palau.	4		2		2	21		5		2					36	0.106	0.062	58.33	29	0.259	15.10
Zingiber officinale Roscoe	2			4				2		5			1		14	0.041	0.015	35.71	7	0.062	2.21
Peganum harmala L.										1					1	0.003	0.003	100	1	0.009	0.90
Total	218	6	39	772	31	126	2	231	140	539	15	10	108	41	2278						
Pourcentage (%)	9.57	0.26	1.71	33.89	1.36	5.53	0.09	10.14	6.15	23.66	0.66	0.44	4.74	1.8	100						
Nombre d'espèces	37	4	14	63	8	24	2	39	30	67	6	5	22	10	91						
IAR	0.83	0.34	0.64	0.92	0.77	0.81	0	0.83	0.78	0.88	0.6	0.5	0.8	0.76	0.96						
ICF	0.83	0.4	0.66	0.92	0.77	0.82	0	0.83	0.79	0.88	0.64	0.55	0.8	0.77	0.96						

Use value (UV)

To show the relative importance of the use of medicinal plants in the studied area, the use value was calculated (Table 1). The results obtained showed that the highest usage values were for *Salvia officinalis* L. (UV=0.606), *Trigonella foenum-graecum* L. (UV=0.453) and *Rosmarinus officinalis* L. (UV=0.444). While the highest UV values for *Origanum compactum* Benth. (UV=0.62) and *Myrtus communis* L. (UV=0.52) were reported by (Bouyahya *et al.* 2017). And *Anchusa italica* Retz (UV=0.196) was the most for (El Khomsi *et al.* 2022).

The UV of *Rosmarinus officinalis* L. in our study is higher than those (UV=0.24 and UV=0.325) found respectively in the literature (Eddouks *et al.* 2017, Chaachouay *et al.* 2019b) despite that the UV of *Rosmarinus officinalis* L. was the highest in these two studies, while the UV of *Salvia officinalis* L. (UV=0.606) in our study was much higher than that (UV=0.205) found by (Chaachouay *et al.* 2019b). However, the low UV values (UV=0.003), recorded for *Agave sisalana* Perrine, *Croton tiglium* L., *Cicer arietinum* L., *Ocimum basilicum* L., *Sesamum indicum* L., *Emex spinosa* (L.) Campd, *Rhamnus alaternus* L., *Fragaria vesca* L., *Argania spinosa* (L.) Skeels and *Peganum harmala* L., can be attributed to the fact that these species are less involved in the traditional medicine of the local population of Taza Province.

Our UV ranged from 0.003 to 0.606 while they ranged from 0.010 to 0.340 in (Idm'hand *et al.* 2020) and from 1 to 1.83 in (Barkaoui *et al.* 2017). According to these results, the found UVs clearly show the important place of the species mentioned in the popular culture and the heritage knowledge of the population of the province of Taza.

These results contribute to the conservation and sustainable management of plant resources. These plants showing their cultural significance provide insight into the potential impact of plant use on local biodiversity and ecosystem dynamics. to guide conservation efforts and support the development of sustainable practices that maintain a balance between human needs and ecological preservation.

Rank Order Priority (ROP)

In the present study, the ROP was calculated for each plant species encountered (Table 2) to explain the celebrity of the species distribution compared to the richness of all the cited resources. the highest ROPs of *Olea europaea* L. subsp. *europaea*, *Trigonella foenum-graecum* L. and *Salvia officinalis* L. were respectively (74.41%, 42.18% and 38.35%), while the lowest ROP (0.30%) were found for *Aloe vera* (L.) Burm. f. and *Quercus ilex* L. Comparing our ROP values to those of (Eddouks *et al.* 2017), the highest ROP (74.41%) was observed in our *Olea europaea* L. subsp. *europaea*, remains higher than the highest one obtained for *Origanium vulgare* L. (53%). Thus, we report that some of our species (*Olea europaea* L. subsp. *europaea*, *Trigonella foenum-graecum* L., *Citrullus colocynthis* L. Schrad. and *Marrubium vulgare* L. present respectively higher ROP values (74.41%, 42.18%, 5.16% and 4.69%) comparing to the respective ones (17%, 20%, 4% and 4%) recorded by Eddouks *et al.* (2017). The high ROPs revealed in the present study indicate clearly that these species are the most famous among the population studied in the study area (Taza province). However, *Rosmarinus officinalis* L., *Artemisia herba-alba* Asso. and *Nigella sativa* L. showed respectively the lower ROP values (21.61%, 16.83%, 3.87%) than those (31%, 30%, and 14%) reported by Eddouks *et al.* (2017). These findings may be attributed not only to the different study areas nor their richness of medicinal plants but also to the local knowledge of traditional uses of plants practiced by the local population of each area.

Informant Consensus Factor (ICF) and Informant Agreement Ratio (IAR)

The ICF and IAR were calculated for each disease group to know if a disease category is commonly treated with Medicinal plants (Table 2). These two indices assess the agreement that exists between Medicinal plant users against the groups of diseases to be treated in the studied area. The results obtained showed that the two indices are almost equal or equal for several classes of diseases. This allows us to conclude that these two indices present almost the same information. The results obtained (Table 2) showed that disease classes with the highest IAR and ICF are, respectively, E00-E90: Endocrine, nutritional and metabolic diseases (IAR=ICF=0.92), K00-K93: Diseases of the digestive system (IAR=ICF =0.88), A00-B99: Certain infectious and parasitic diseases & I00-I99: Diseases of the circulatory system (IAR=ICF=0.83).

Knowing that 'Diabetes' and 'digestive system' are two medicinal uses cited by the studied population (Table 1), and belong respectively to the classes of 'E00-E90: Endocrine, nutritional and metabolic diseases' and 'K00-K93: Diseases of the digestive system' (Table 2), the results obtained for E00-E90: Endocrine, nutritional and metabolic diseases (IAR=ICF=0.92) and K00-K93: Diseases of the digestive system (IAR=ICF=0.88) are respectively due to the increased medicinal use of anti-diabetic plants (61 species) and plants for the digestive system (62 species) (Table 1). Thus, looking for IARs of diabetes (0.92) and digestive system (0.88), we found that the IAR of these two medicinal uses is equal to those of their classes (Table 2). These results demonstrate a significant degree of agreement within the studied population. The obtained Diabetes IAR (0.92) is

near to that (0.98) found by (Chaachouay *et al.* 2019b). The IAR (0.88) for the digestive system was in accordance with that (0.9) reported by (El Khomsi *et al.* 2022).

Regarding the ICF (Table 2), the high values indicate a great homogeneity of knowledge and a perfect agreement in the population on medicinal uses. The agreement decreased at the same time with the diminution in ICF. Except VIII (H60-H95): Diseases of the ear and mastoid process (ICF=0), our other results obtained of ICF are higher than the highest ones (Diseases of the respiratory system & digestive system disorders (ICF=0.29), (Respiratory system diseases & digestive system disorders (ICF=0.29), urogenital and gynecological diseases & nervous disorders (ICF=0.22) of (Eddouks *et al.* 2017). Our highest result of ICF remains slightly lower than that found (ICF=0.97) in (Idm'hand *et al.* 2020). Thus, our ICF results for diseases of the nervous system (0.82), diseases of the respiratory system (0.79) and diseases of the digestive system (0.88) are higher than the highest mentioned values for the respiratory system (0.69), for the digestive system problems (0.63) and nervous system disorders (0.69) reported by (Bouyahya *et al.* 2017).

These ICF results show clearly that each class of disease is generally treated with specific Medicinal plants according to local popular agreement. However, the class of VIII (H60-H95): Diseases of the ear and mastoid process (IAR=ICF=0) reflects the phytotherapeutic difficulty found for the treatment of this class of disease and also reflects the low level of local knowledge and ignorance on this subject. Things that require the validation of these ethnobotanical results by ethnopharmacological tests.
These results facilitate comparing and contrasting the relative importance of plants and their uses in different cultural contexts, leading to a better understanding of human-plant interactions.

Principal component analysis (PCA)
The results of PCA (Figure 2) revealed that the first two axes are sufficient to interpret the results (percentage of cumulative variance on axis 1 and axis 2 (95.62%). Most of the variation was presented by the first component (PC1) showing the importance of Medicinal plant uses (79.48% of the total variance), which grouped (ROP, RFC, IC, UV and T). While for the second component (PC2) (16.75%) indicates a contribution to the fidelity of use (FL) towards a disease.

The results obtained (Figure 2) showed that ROP, RFC, IC, UV and T contribute strongly to building axis 1. While FL contributes highly to building axis 2. In addition, PC1 was correlated positively and significantly with ROP, RFC, IC, UV and T, but it is correlated negatively with FL. PC2 was positively correlated with ROP and positively and significantly correlated with FL, while it was negatively correlated with RFC, IC, UV and T.

Based on the correlation coefficient (r=-0.949) (Figure 2) which shows an almost perfect negative linear correlation. And taking (I=Importance) with (I=∑ ROP, RFC, IC, UV and T) and (FL). The increase of the variable I leads to a decrease in the value of the variable FL and vice versa. Changes in any of these variables (ROP, RFC, IC, UV and T) of I will influence both I and FL. ROP, RFC, IC, UV and T which are all very close to 1 of PC2, therefore show an almost perfect correlation and tend to increase or decrease together. FL shows a perfect correlation on PC1.

Indeed, regarding the results of a regression analysis (Figure 2). X and Y are connected by the fitted regression line on the graph with the equation: Y=0.87-1.04X. Based on the slope of -1.04, each increase of 1 in X decreases Y by 1.04. The coefficient of determination (R^2=0.900) is close to 1, which shows that the adjustment is of good quality. The resulting equation can be used for prediction. For example, in a random population of the Province of Taza, each increase of 1 of the indices showing the importance of use (I) of Medicinal plants will decrease the Fidelity of use (FL) by 1.04.

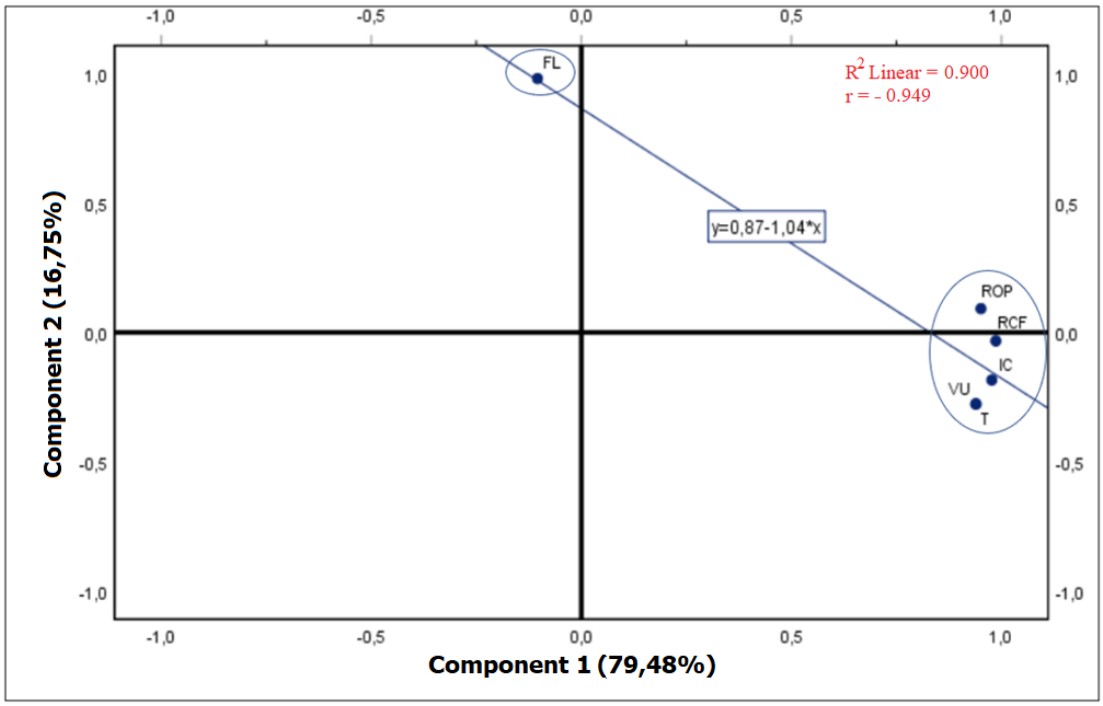

Figure 2. Factorial map of the Principal Component Analysis (PCA) of the variables: Ethnobotanical indices of plant species.

The distribution of plant species used (according to their numbers of codes in Table 1) according to the specific characteristics of their ethnobotanical indices, were presented in Figure 3. The analysis revealed an agglomeration of species at the center of the two factorial axes (PC1 and PC2), which indicates that several species are used similarly by the entire population. However, some species emerge from the group and are clustered differently around the two axes. Thus, the numbers of a few species are superimposed in Figure 3, and therefore it is the most relevant ones that are experienced.

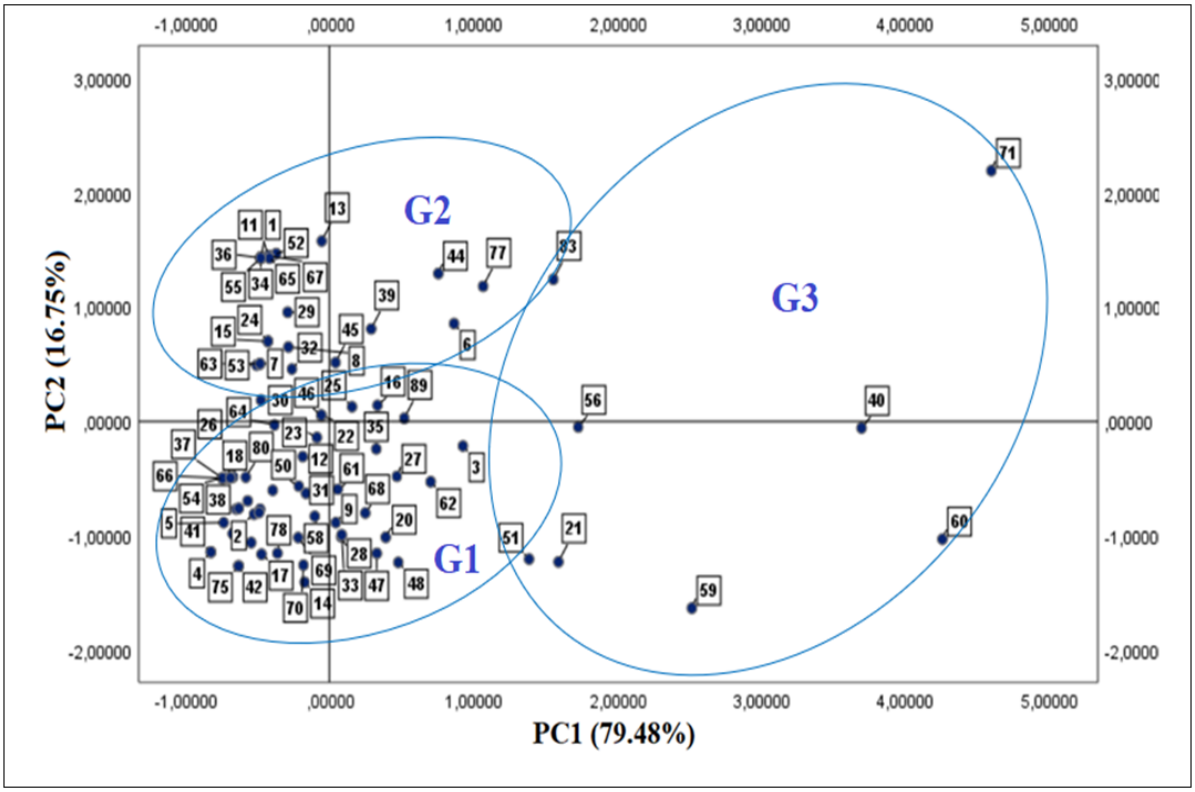

Figure 3. Simple dispersion of plant species (according to their number codes in Table 1) according to the two components representing the importance (PC1) and fidelity (PC2) of use.

If we want to be less diligent in analyzing the content of Figure 3. We can select to distinguish three large groups: G1 of species clustered at the center of the two factorial axes (especially the negative extremity), showing the large part of the plant species which have both an importance and a fidelity of an average uses and are very close to each other. The G2 of species correlated positively with PC2 by getting closer to the center of PC1, these species are getting closer in their fidelity of uses. The G3 is correlated positively with PC1 and constitutes the species considered the most important in terms of use.

G2 is characterized mainly by the presence of plant species that have a small number of medicinal uses (generally one, two to three medicinal uses per species), which makes them faithful species for treating specific diseases, and we mainly find: *Cuminum cyminum* L. **13,** *Ceratonia siliqua* L. **29,** *Citrullus colocynthis* (L.) Sch **32,** *Lupinus albus* L. **39,** *Herniaria hirsuta* L., **44** *Juglans regia* L., **45** *Linum usitatissimum* L., **63** *Punica granatum* L.**77** et *Crataegus monogyna* Jacq. **81.**

The G3 is mainly characterized by the presence of plant species with many medicinal uses (generally 13,14 or 24 medicinal uses per species), making which makes them species with very low fidelity, but very important in their uses. since they can be used to treat a large number of diseases at the same time, and we mainly find: *Artemisia herba-alba* Asso. **21**, *Trigonella foenum-graecum L.* **40**, *Mentha pulegium* L. **51**, *Origanum compactum* Benth. **56**, *Rosmarinus officinalis* L. **59**, *Salvia officinalis* L. **60** et *Olea europaea L. subsp. europaea* **71**.

The G1 containing the largest number of species is characterized by the presence of plant species with an average number of medicinal uses. As a result, these species indicate average fidelity and importance of use. They can be used to treat an average number of diseases at the same time (non-G2 and non-G3 species). These results contribute to the preservation of traditional knowledge systems. By quantifying and analyzing correlated traditional knowledge about these medicinal plant species, these indices provide a valuable archive for future research. This valuable information on practices related to the use of plants must be archived over time.

Conclusion

This quantitative ethnobotanical study on the groups of diseases treated by medicinal plants among the population Tazi reflects the diversity of medicinal uses (61 medicinal uses belonging to 14 disease groups) and the cultural importance of these plants within the province. The present work reflects the popularity of the species distribution in the Taza province, and the considerable agreement within the Tazi population regarding the use of medicinal plants to treat illnesses. Each category of disease is commonly treated with medicinal plants. Thus, some species are too selective in their uses against certain diseases, things which suggest a specific “Plant X – Disease Y” relationship, based on greater healing potential. The significant use values of medicinal plants in the studied area clearly clearly show the important place of the species mentioned in the Tazi population's popular culture and heritage knowledge. Factorial analysis based on importance and Fidelity of use showed a significant overall selective dispersion of medicinal plants used differently depending on the population studied (3 groups are considered). These results constitute a valuable archive for future research. We suggest validation of these ethnobotanical results by ethnopharmacological tests since the phytochemical composition and biological activity are not fully known and may contain important bioactive molecules to produce new medicinal plants. Indeed, this work can promote cultural preservation, biodiversity conservation and sustainable practices in Taza Province.

Declarations

List of abbreviations: VC=Voucher codes. Nu=Number of uses. FC/CF=Frequency of Citation, T(FC)=Total Frequency of Citation, RFC/RCF=Relative Frequency of Citation, UV=Use Value, FL=Fidelity Level, IC=Informant Citations, ICF=Informant Consensus Factor, IAR=Informant Agreement Ratio, RP=Relative Popularity ROP=Rank Order Priority, PCA=Principal component analysis, ENT=(ear, nose, and throat), I (A00-B99)=Certain infectious and parasitic diseases. II (C00-D48)=Neoplasms. III (D50-D89)=Diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism. IV (E00-E90)=Endocrine, nutritional and metabolic diseases. V (F00-F99)=Mental and behavioural disorders. VI (G00-G99)=Diseases of the nervous system. VIII (H60-H95)=Diseases of the ear and mastoid process. IX (I00-I99)=Diseases of the circulatory system. X (J00-J99)=Diseases of the respiratory system. XI (K00-K93)=Diseases of the digestive system. XII (L00-L99)=Diseases of the skin and subcutaneous tissue. XIII (M00-M99)=Diseases of the musculoskeletal system and connective tissue. XIV (N00-N99)=Diseases of the genitourinary system. XIX (S00-T98)=injury, poisoning and certain other consequences of external causes.

Ethics Approval: The authors confirm that the study was reviewed and approved by an Institutional Review Board of the Laboratory of Natural Resources and Environmental; Polydisciplinary Faculty of Taza; University of Sidi Mohammed Ben

Abdellah. The committee further approved that the study will have no direct negative impact on the participants and the biodiversity of the study area. All participants provided oral prior informed consent before the interviews.

Consent for publications: Oral permission. All authors agreed for submission.

Data Availability: Data is available on demand.

Conflict of Interest: Authors have no conflict of interest.

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