Scientific African 25 (2024) e02275

Contents lists available at ScienceDirect

Scientific African

journal homepage: www.elsevier.com/locate/sciaf

Ethnobotanical survey of medicinal plants used in north-central Morocco as natural analgesic and anti-inflammatory agents

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ARTICLE INFO

Editor: DR B Gyampoh

Keywords:
Traditional medicine
Health
Inflammation
Medicinal plants
Fidelity level
Fez-meknes region

ABSTRACT

For centuries, the Moroccan population has relied on herbs as medicine to treat a variety of diseases, especially inflammation and pain-related ones. To the best of our knowledge, no survey had ever been conducted to address this subject in the Fez-Meknes region of Morocco. Thus, a survey was conducted of 544 interviewees, using a semi-structured ethnopharmacological survey designed with "Why-How" questions about plants used, their vernacular names, parts used, mode of preparation, and mode of administration. Fidelity level (FL), relative frequency of citation (RFC), frequency of citation (FC), informant consensus factor (ICF), and family importance value (FIV) were calculated. A total of 104 plant species belonging to 49 families used for inflammatory and pain treatment were documented. Lamiaceae (16 species) was the most used family and *Curcuma longa* L. (RFC=0.069) was the most frequently prescribed by local traditional healers and herbalists. Leaves were the most used part for herbal remedies, appearing in 30.8 % of preparations. Decoctions and infusions were the most popular preparation methods with percentages of 38.3 % and 19.2 %, respectively. Inflammations and pain in the digestive system had the largest widespread affections (IFC= 0.729) in the Fez-Meknes region. The findings of this study uncovered a reliable and original source of ethnomedicinal data pertaining to plants used to treat inflammation and inflammatory pain in the Fez-Meknes region, which could serve as a credible source of knowledge to determine new-based phytomedicines.

Introduction

Medicinal plants represent a natural source of biologically active compounds that are particularly used to prepare drugs to treat numerous diseases [1]. In Africa, aromatic and medicinal plants (AMPs) are commonly employed by most people to treat illnesses [2].

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https://doi.org/10.1016/j.sciaf.2024.e02275
Received 4 December 2023; Received in revised form 30 March 2024; Accepted 4 June 2024
Available online 5 June 2024

Consequently, pharmaceutical industries are becoming more attentive to ethnopharmacological studies of AMPs [3]. In Morocco, traditional medicine plays a significant role in the lives of both urban and rural citizens. This is further reinforced by Morocco's geographical location, climatic, and edaphic conditions, which provide a favourable environment for the growth of various plants. The value of these plants marks a profitable income source for the national economic sector [4]. The country's multifaceted flora has 3913 species and 1298 subspecies, with 426 subspecies representing 155 families and 981 genera. Among them, the endemic plants represent 640 species and 280 subspecies [5,6]. This diverse flora and botanical heritage wealth makes Morocco a large and rich phytotherapy tradition in the Mediterranean countries [7].

Herbal medicine is becoming a more critical inflammation treatment as the number of inflammatory diseases rises [8]. Inflammation or inflammatory reaction is a physiological response of the body's immune system against aggressors of external stressors such as bacteria, allergies, and trauma (e.g., burns), or internal effects like auto-immune diseases [9]. This response includes specific inflammatory cells, including lymphocytes, macrophages, and neutrophils, which release chemical mediators like pro-inflammatory cytokines, eicosanoids, proteins, and histamine [10]. These inflammatory mediators are the key characteristics and symptoms of inflammation by increasing capillary permeability, causing plasma and inflammatory mediators to leak into the extravascular space. This results in redness, edema, and pain triggered by the activation perception of afferent nerve fibres [11]. Inflammatory reactions are the initial phase of the natural immunity system's defence mechanism, and a primordial phase of the defence mechanism of innate immunity. It is characterized by a fast action and short duration that can last for a few minutes to a few days [12]. Generally, acute inflammation can be divided into three principal phases; a vascular phase characterized by the exudation of plasma proteins and fluids with a cellular phase marked by leukocyte migration that will initiate the second phase, which represents the elimination of pathogens and damaged tissues, then, the third phase that will lead to tissue repair [13]. On the other hand, chronic inflammation is manifested by persistent and longer-lasting aggression in tissues exposed to auto-immune reactions where antigenic motifs cannot be eliminated, leads to degenerative diseases such as atherosclerosis, degenerative depression, rheumatoid arthritis, multiple sclerosis, and gout [14]. In the majority of cases, inflammation is accompanied by pain, which is one of the primary reasons why patients seek medical attention [15], and accounts for more than 70 % of consultations [16]. Pathological pain can result from inflammation and or damage to peripheral nerves. The International Association for the Study of Pain has defined pain as a distressing experience associated with actual or potential tissue damage, with sensory, emotional, cognitive, and social components [17]. Currently, pathophysiological studies indicate a strong relationship between inflammation and pain resulting from the close bidirectional interaction of the immune system and the neurosensory system [18]. Drugs usually administered for pain control and treatment of inflammation have undesirable side effects [19], because anti-inflammatory therapy and pain treatment are primarily achieved by synthetic molecules of anti-inflammatory, steroidal (Corticoids), or non-steroidal anti-inflammatory (NSAID) drugs [20] that can cause undesirable effects on different physiological system of the human body, like the digestive system, including gastrointestinal bleeding and haemorrhages, effects on the renal system like decreased renal blood flow with glomerular filtration resulting in renal failure, or the respiratory

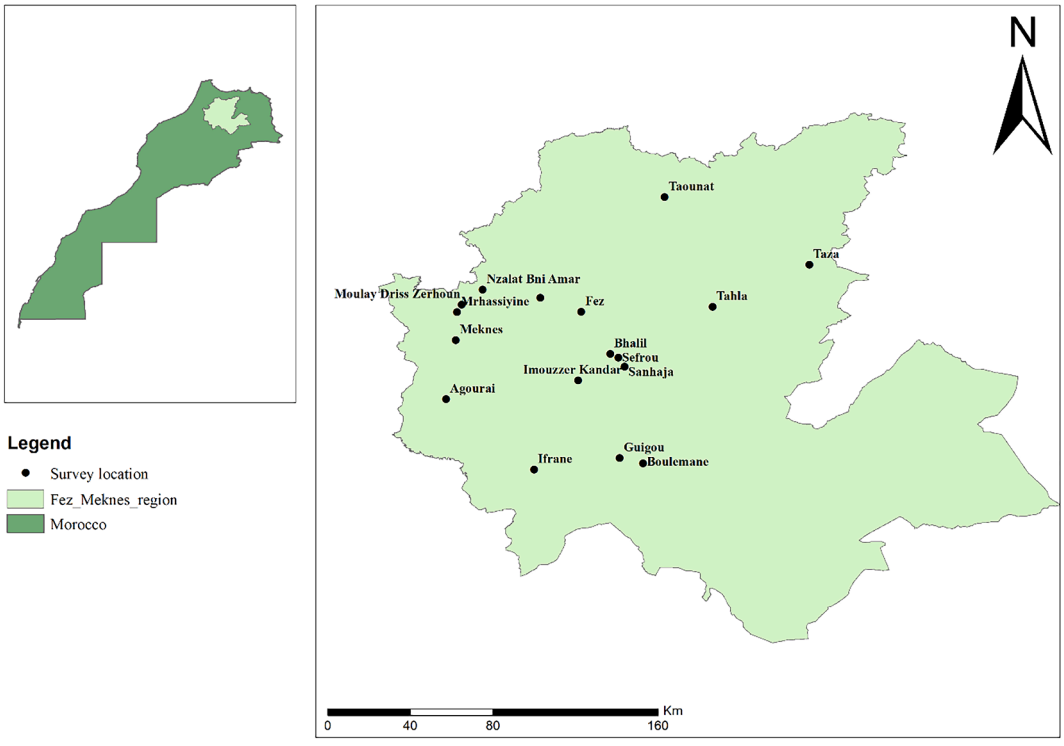


Fig. 1. Distribution of the survey sites in the study area.

system, such as asthma attacks, and cardiovascular system like increased blood pressure [21]. Currently, scientists and pharmaceutical industries are interested in validating medicinal plants as reliable analgesics and anti-inflammatories assets [22]. Uses of medicinal plants by the indigenous population of the Fez-Meknes region for treating inflammation and inflammatory pain has yet to be investigated. Therefore, this ethnopharmacological study aimed to determine and explore new medicinal and aromatic plant species adopted by the population of the Fez-Meknes region to treat inflammation and inflammatory pain.

Material and methods

Description of the study area

To meet the objective of identifying the most effective plants, recommended by informers to treat inflammation and inflammatory pain, a survey was conducted in the Fez-Meknes region, from February 2, 2021 to January 31, 2022. The region is situated in the north central of Morocco and covers an area of 40,075 km^2, representing 5.7 % of the national territory. In particular, the areas of Fez, Meknes, Taza, Taounat, Boulemane, Ifran and Sefrou were surveyed. Geographically, it is bounded to the west by Rabat-Sale-Kenitra, to the east by the region of Oriental, to the south by the region of Draa-Tafilalet and to the north by the region of Tangier-Tetouan-Al Hoceima, where it incorporates the mountain ranges of the Rif, partly the plain of Saïss and bordering the Middle Atlas Mountains. According to the general census of population and housing in 2014, the region of Fez-Meknes has 4236,892 inhabitants, compared to 3873,207 in 2004. The population of Fez-Mernes is 60.52 % are urban.

The climate varies from Mediterranean to continental, having cold winters and hot summers and a precipitation rate ranging from 300 mm to 800 mm per year, which results in a great diversity of natural species [23]. Fez-Meknes has a diverse flora, which is dominated by species such as *Abies marocana* Trab, *Pinus halepensis* Mill, *Cannabis sativa* L., *Cedrus atlantica* Endl., *Quercus suber* L., *Quercus ilex* L., and *Quercus canariensis* Willd. The region of Fez-Meknes (Fig.1) is one of the areas where the use of traditional medicine to combat various illnesses is most widespread.

Ethnopharmacological survey

This ethnopharmacological survey was conducted to collect information about medicinal plants used to treat inflammation and inflammatory pain types in the Fez-Meknes region. The survey, was performed according to a stratified random sampling that consisted of 17 strata, including rural areas (Villages, Douars, Souks) and urban areas (Cities). What distinguished one stratum from another was climatic and edaphic factors, vegetal diversity, and the distribution of the population. During this survey, information was based on semi-structured interviews [24], with the help of a survey in the form of questions (544 forms), used to interview herbalists, traditional practitioners, healers, and therapists. The individuals in each case were asked to participate in a verbal discussion that consisted of two parts. In the first section, details regarding the person, like education, sex, therapy practices, and family life, were obtained. The second part was focused on the plants utilized to treat inflammation and pain, including the way they were administered, the part used, and the length of treatment. Samples of each stratum are allocated in six urban communities: Fez, Meknes, Taounat, Taza, Ifrane and Sefrou with fifty participants in each, and eleven rural communities, including Guigo, Imouzzar-kander, Bhalil, Boulemane, Sanhaja, Tahla, Moulay Driss, Nzalat Bni Amar, Moulay yakoub, Mrhassiyine, Agourai. Numbers of participants varied between 22 and 24 in these rural aeras.

Determination and identification of plant species

Specimens of plants were identified in the field, with the assistance of local herbalists and healers. Identifications were then finalized at the Laboratory of Biotechnology Environment Agrofood and health (LBEAS), Faculty of Sciences Dhar El Mahraz, Fez. Samples collected, including whole plants, leaves, aerial parts and flowers (Fig. 5) were compared to reference specimens held in the herbarium, as well as the botanical name given in ''La Flore pratique du Maroc'' (The Practical Flora of Morocco) [25] and the scientific name from the 2019 Annual Checklist (https://www.catalogueoflife.org/col/).

Statistical analyses

The survey's ethnopharmacological information was assessed to corroborate our study. The data was tabulated and studied using Microsoft Excel 2010 and IBM-SPSS Statistics Base 21. Furthermore, the processed data was assessed using quantitative metrics such as Relative Frequency of Citation (RFC), Family Importance Value (FIV), Fidelity Level (FL), and Informant Consensus Factor (ICF).

Fidelity level (FL)

The level of fidelity (FL) is a valuable indicator to determine the rate of plant species widely used by informants for the treatment of particular pathologies [26] (Eq. (1)).

$$FL\ (\%) = \frac{NP}{N} x100 \tag{1}$$

where Np: Number of informants who claimed the usage of plant species to treat a specific disease, and N: Total number of informants

who used medicinal plants as a remedy for any disease.

Relative frequency of citation (RFC)

The relative frequency of citation (RFC) is a parameter frequently used for the evaluation of the relative importance of locally mentioned plant species in traditional medicine for treating inflammatory affections [27] (Eq. (2)).

$$RFC = \left(\frac{FC}{N}\right)x100 \tag{2}$$

where FC: Number of respondents who use plant species to fight a type of inflammation, and N: Total number of informants who used medicinal plants as a remedy for any disease.

Family importance value (FIV)

Family Importance Value (FIV) is an indicator demonstrating the importance of the therapeutic care applied in the ethnobotanical survey for the valuation of the families and the assessment of the cited plant species [28] (Eq. (3)).

$$FIV = \frac{FCfamily}{NS} \tag{3}$$

FC family: The number of informants who reported the plant family and NS = the total number of plant species in each family type.

Informant consensus factor (ICF)

The Informant Consensus Factor (ICF) was developed to link informants with the different remedies for each disease category, informant consensus factor settings are ranged from 0 to 1 [29] (Eq. (4)).

$$IFC = \frac{Nur - Nt}{Nur - 1} \tag{4}$$

Nur: The number of reported utilizations in each category of illness and Nt: The number of species employed.

Table 1
Demographic and socio-economic profile of the informants interviewed.

		Number of citations	Percentage%
Sex	Men	343	63.1
	Women	201	36.9
Level of instruction	Elementary School	116	21.3
	Illiterate	374	68.8
	High school	38	7
	University	16	2.9
Family situation	Married	398	73.2
	Single	22	4
	Widowed	92	16.9
	Divorced	32	5.9
Profession	Other	65	11.9
	Healers	175	32.2
	Herbalists	304	55.9
Age range	< 20 years	16	2.9
	21–40 years	93	16.7
	41–60 years	292	52.5
	>60 years	143	25.7
Information source	Internet	16	2.9
	Books	13	2.4
	Personal experience	69	12.7
	Family member	446	82.0
Preferences	Both	11	2
	Medical therapy	22	4
	Phototherapeutic care	511	93.9
Reason for preference	Lesser cost	396	72.8
	More effective	129	23.7
	Absence of secondary effects	19	3.5
Consultation	Healer	168	30.9
	Medical / Professional	376	69.1

Table 2
Plants used to treat inflammation and pain in the studied area.

Scientific Name	Family	Vernacular Name	FC	FL %	RFC	FIV	Distribution
Agave Americana L. *BPRN100*	Agavaceae	Assabar Al ameriqui	2	66	0.003	0.003	Spontaneous
Carpobrotus edulis L. *BPRN101*	Aizoaceae	Asabiae Zaynabe	1	100	0.001	0.001	Spontaneous
Aloe vera (L.) Burm.f *BPRN99*	Aloaceae	Sabar	6	60	0.011	0.01	Cultivated
Pistacia lentiscus L. *BPRN81*	Anacardiaceae	Drou	5	100	0.009	0.009	Spontaneous
Ammodaucus leucotrichus Coss. *BPRN70*	Apiaceae	Kamoun soufi	9	75	0.016	0.009	Spontaneous
Ammi visnaga L. *BPRN20*	Apiaceae	Bachnikha	3	100	0.005	0.009	Spontaneous
Apium graveolens L. *BPRN25*	Apiaceae	KraaFez	2	66	0.003	0.009	Cultivated
Apium nodiflorum (L.) Lag *BPRN97*	Apiaceae	Ziyata	2	100	0.003	0.009	Spontaneous
Carum carvi L. *BPRN15*	Apiaceae	Karwiya	11	78	0.020	0.009	Cultivated
Carum ammoïdes Benth& Hook *BPRN89*	Apiaceae	Nanoukha	1	66	0.001	0.009	Spontaneous
Coriandrum sativum L. *BPRN28*	Apiaceae	Kassbour	5	100	0.009	0.009	Cultivated
Cuminum cyminum L. *BPRN72*	Apiaceae	Kamoun	6	85	0.011	0.009	Cultivated
Ferula communis L. *BPRN98*	Apiaceae	Boubal	1	100	0.001	0.009	Spontaneous
Foeniculum vulgare subsp. *vulgare* Miller *BPRN111*	Apiaceae	Bessbass	1	100	0.001	0.009	Spontaneous
Pimpinella anisum L. *BPRN18*	Apiaceae	Habbat Halâwa	4	57	0.007	0.009	Cultivated
Petroselinum crispum Mill. Fuss *BPRN30*	Apiaceae	Maâdnouss	5	62	0.009	0.009	Cultivated
Foeniculum vulgare Mill *BPRN73*	Apiaceae	Nafaâ	16	94	0.029	0.009	Cultivated /
Caralluma europaea Guss *BPRN64*	Apocynaceae	Daghmous	3	60	0.005	0.007	Spontaneous
Nerium oleander L. *BPRN97*	Apocynaceae	Defela	5	50	0.009	0.007	Spontaneous
Aristolochia longa L. *BPRN85*	Aristelochiaceae	Berraztam	2	100	0.003	0.003	Spontaneous
Asphodelus microcarpus Viv *BPRN95*	Asphodelaceae	Berwag	1	100	0.001	0.001	Spontaneous
Anacyclus pyrethrum L. *BPRN93*	Asteraceae	Tigentest, Oud El Atass	3	75	0.005	0.001	Spontaneous
Saussurea alpina L. *BPRN112*	Asteraceae	Aghrisse	1	50	0.001	0.007	Imported
Artemisia herba-alba Asso *BPRN16*	Asteraceae	Chih	6	75	0.011	0.007	Spontaneous
Atractylisgummifera L. *BPRN96*	Asteraceae	Addâd	1	100	0.001	0.007	Spontaneous
Artemisia absinthium L. *BPRN46*	Asteraceae	Chiba	3	100	0.005	0.007	Cultivated
Calendula arvensis L. *BPRN94*	Asteraceae	Jemra	2	50	0.003	0.007	Spontaneous
Chamaemelum nobile L. *BPRN35*	Asteraceae	Babounj	12	70	0.022	0.007	Cultivated
Cynara humilis L. *BPRN92*	Asteraceae	Taymet	2	100	0.003	0.007	Spontaneous
Dittrichia viscosa L. *Greuter BPRN75*	Asteraceae	Trehela,	9	69	0.016	0.007	Spontaneous
Borrago officinalis L. *BPRN115*	Boraginaceae	Lessane tour	2	66	0.003	0.003	Imported
Lepidium sativum L. *BPRN42*	Brassicaceae	Hebrchad	5	62	0.009	0.005	Cultivated/ Spontaneous
Sinapis alba L. *BPRN91*	Brassicaceae	kherdel	1	50	0.001	0.005	Cultivated
Opuntia ficus-indica L. *Mill BPRN24*	Cactaceae	Handia	1	50	0.001	0.001	Cultivated
Capparis spinosa L. *BPRN31*	Capparaceae	kebbar	4	100	0.007	0.007	Spontaneous
Herniaria cinera DC. *BPRN32*	Caryophyllaceae	Herraslehjir	5	100	0.009	0.005	Spontaneous
Corrigiola telephiifolia Pourret BPRN75	Caryophyllaceae	Serghina	1	100	0.001	0.005	Spontaneous
Chenopodium ambrosioides L. *BPRN27*	Chenopodiaceae	Mekhinza	7	70	0.012	0.010	Spontaneous
Cucurbita maxima L.*BPRN34*	Cucurbitaceae	Gueraaselawiya	5	62	0.009	0.009	Cultivated
Tetraclinis articulata (Vahl)Masters BPRN33	Cupressaceae	Aârar	2	66	0.003	0.003	Spontaneous
Euphorbia falcata L. *BPRN38*	Euphorbiaceae	Hayyatennufus	1	50	0.001	0.001	Spontaneous
Ricinus communis (L.) *BPRN29*	Euphorbiaceae	Kherouaâ	1	50	0.001	0.001	Cultivated
Glycyrrhiza glabra L. *BPRN78*	Fabaceae	ÂrqSûs	27	87	0.049	0.024	Spontaneous
Trigonellafoenum-graecum L. *BPRN45*	Fabaceae	Helba	12	75	0.022	0.024	Cultivated
Ceratonia siliqua L. *LBPRN61*	Fabaceae	Alkharoub	1	50	0.001	0.024	Cultivated
Centaurium erythraea Rafn BPRN26	Gentianaceae	Gosset ʟ-hayya	2	100	0.003	0.003	Spontaneous
Geranium graveolens (L'Hér.) Thunb BPRN114	Geraniaceae	Âetercha	1	50	0.001	0.001	Cultivated
Illicium verum Hook. *F BPRN80*	Illiaceae	lebadiane	2	100	0.003	0.003	Imported
Crocus sativus L. *BPRN22*	Iridacea	ZafranHor	1	100	0.001	0.001	Cultivated
Juglans regia L. *BPRN21*	Juglandacceae	Swak, guergaâ	5	83	0.009	0.009	Cultivated
Ajuga iva L.*Schreber BPRN69*	Lamiaceae	Chandgoura	3	75	0.005	0.014	Spontaneous
Marrubium vulgare L. *BPRN55*	Lamiaceae	Meriwta	20	80	0.036	0.014	Spontaneous
Ocimum basilicum L. *BPRN84*	Lamiaceae	L'hbak	16	72	0.029	0.014	Cultivated
Mentha pulegium L. *BPRN49*	Lamiaceae	Flio	12	85	0.022	0.014	Spontaneous
Mentha piperita L. *BPRN39*	Lamiaceae	Na'nae labdi	6	66	0.011	0.014	Cultivated
Mentha rotundifolia L.*Hudson BPRN38*	Lamiaceae	Merssita	3	50	0.005	0.014	Spontaneous
Rosmarinus officinalis L. *BPRN37*	Lamiaceae	Azir	12	75	0.022	0.014	Cultivated/ Spontaneous
Origanum compactum Benth BPRN11	Lamiaceae	Zaâtar	17	74	0.031	0.014	Spontaneous
Calamintha officinalis Moench *BPRN14*	Lamiaceae	Manta	5	100	0.009	0.014	Spontaneous
Lavandula multifida L. *BPRN83*	Lamiaceae	Kohila	1	50	0.001	0.014	Spontaneous
Lavandula Stoechas L. *BPRN56*	Lamiaceae	Helhale	4	100	0.007	0.014	Spontaneous
Lavandula angustifolia (P.) Mill *BPRN82*	Lamiaceae	khezama	7	53	0.012	0.014	Cultivated
Salvia officinalis L. *BPRN58*	Lamiaceae	Salmia	11	78	0.020	0.014	Cultivated/ Spontaneous
Salvia verbenaca (L.) Briq *BPRN36*	Lamiaceae	Khiyata	3	100	0.005	0.014	Spontaneous
Origanum majorana L. *BPRN74*	Lamiaceae	Merdeddouch	4	66	0.007	0.014	Cultivated/ Spontaneous
Thymus vulgaris L. *BPRN19*	Lamiaceae	Zâitra	6	85	0.011	0.014	Spontaneous
Laurus nobilis L. *BPRN34*	Lauraceae	Ourakmoussa	18	78	0.033	0.022	Spontaneous

(*continued on next page*)

Table 2 (*continued*)

Scientific Name	Family	Vernacular Name	FC	FL %	RFC	FIV	Distribution
Cinnamomum zeylanicum Nees *BPRN32*	Lauraceae	El Qarfa	7	77	0.012	0.022	Imported
Allium sativum L. *BPRN52*	Liliaceae	Touma	7	58	0.012	0.009	Cultivated
Allium cepa L. *BPRN43*	Liliaceae	Bessela	3	75	0.005	0.009	Cultivated
Lawsonia inermis L. *BPRN31*	Linaceae	Henna	2	50	0.003	0.003	Cultivated
Linumu sitatissimum L. *BPRN57*	Linaceae	Zeriate lKetan	2	66	0.003	0.003	Cultivated
Punica granatum L. *BPRN65*	Lythraceae	Remane	6	75	0.011	0.010	Cultivated
Hibiscus sabdariffa L. *BPRN17*	Malvaceae	karkadil	1	100	0.001	0.001	Cultivated
Myrtus communis L. *BPRN60*	Myrtaceae	Rayhane	7	70	0.012	0.014	Cultivated
Eugenia caryophyllata Thunb *BPRN02*	Myrtaceae	Qoronfel, oud nouwar	14	82	0.025	0.014	Imported
Eucalyptus globulus Labill *BPRN23*	Myrtaceae	Kaliptus	3	50	0.005	0.014	Spontaneous
Olea europaea L. *BPRN12*	Oleaceae	Zitoune	3	60	0.005	0.005	Spontaneous
Sesamum indicum L. *BPRN66*	Pedaliaceae	ZenjlAne	1	50	0.001	0.001	Cultivated
Pinus pinaster Aiton *BPRN05*	Pinaceae	Tayda	3	100	0.005	0.003	Spontaneous
Quercus suber L. *BPRN13*	Pinaceae	Debagh	1	100	0.001	0.003	Spontaneous
Plantago major L. *BPRN06*	Plantaginaceae	Messassa	1	100	0.001	0.001	Spontaneous
Pennisetum typhoides Burm.Stapf. & Hubb *BPRN10*	Poaceae	Illân	3	60	0.005	0.003	Cultivated
Avena sativa L. *BPRN08*	Poaceae	kherrtal	1	50	0.001	0.003	Imported
Polygonum aviculaire L. *BPRN07*	Polygonaceae	Wadmou	1	100	0.001	0.001	Spontaneous
Nigella sativa L. *BPRN53*	Ranunculaceae	Sanuj	9	75	0.016	0.009	Cultivated
Ranunculus bullatus L. *BPRN04*	Ranunculaceae	Wedninhalouf	1	50	0.001	0.009	Spontaneous
Zyziphus lotus L. *BPRN09*	Rhamnaceae	Sedera, Nbeg	4	66	0.007	0.004	Spontaneous
Rhamnus alaternus L. *BPRN03*	Rhamnaceae	Mliles	1	50	0.001	0.004	Spontaneous
Rosa damascena Mill *BPRN87*	Rosaceae	lwared	2	50	0.003	0.003	Cultivated
Rubia tinctorum L. *BPRN111*	Rubiaceae	Fowa	1	50	0.001	0.001	Spontaneous
Populus alba L. *BPRN44*	Salicaceae	Sefssaf	3	75	0.005	0.005	Spontaneous
Argania spinosa L. *BPRN116*	Sapotaceae	Argane	2	66	0.003	0.003	Cultivated
*Tamarix aphyllaL.*H.karst *BPRN41*	Tamaricaceae	Takawet	1	50	0.001	0.004	Spontaneous
Rutachalepensis L. *BPRN47*	Tamaricaceae	L'fijel	4	60	0.007	0.004	Spontaneous
Daphne gnidium L. *BPRN40*	Thymelaeaceae	Lazaze	2	50	0.003	0.003	Spontaneous
Urtica pilulifera L. *BPRN59*	Urticaceae	Harrigua	7	53	0.012	0.010	Spontaneous
Lippia triphylla (L'Her.) Britt *BPRN77*	Verbenaceae	Louwiza	5	55	0.009	0.009	Cultivated
Vitex agnus castus BPRN113	Verbenaceae	Kafemeryem	1	100	0.001	0.009	imported
Curcuma longa L. *BPRN67*	Zingiberaceae	Kharqum	38	82	0.069	0.062	imported
Zingiber officinale Roscoe BPRN62	Zingiberaceae	Skenjbir	30	87	0.055	0.062	imported
Alpinia officinarum Hance *BPRN63*	Zingiberaceae	khodnjale	3	60	0.005	0.062	Spontaneous
Elettaria cardamomum L. *BPRN71*	Zingiberaceae	Qaâqolla	2	100	0.003	0.062	Emported
Zygophyllum gaetulum Emb. & Maire *BPRN15*	Zygophyllaceae	Àakaya	1	100	0.001	0.001	Spontaneous

Results and discussion

Socio-demographic profile of the informants interviewed

Sociodemographic information included gender, age, education level, profession, and perspective towards medical and herbal treatment of each participant in this study (Table 1).

A total of 544 individuals were interviewed, of which 63.1 % were male in both urban and rural regions. This predominance of men was due to the fact that most herbalists are men, and the profession is rarely practiced by women, who are occupied with other duties in households. Most traditional healers and herbalists have inherited the position and knowledge of herbal therapy from their parents, which is passed on verbally from one generation to the next. Identical results have been obtained in the region of "Oulad Daoud Zkhanine" in Northeastern Morocco [30]. Among the participants, 73.2% were married, 16.9% were widowed, 5.9% were divorced, and 4% were single. Married and widowed individuals typically choose more efficient and affordable alternatives to address the various pathologies to lower their costs, and the traditional herbal medicine is being the best alternative for most participants who believe that herbal medicines have no side effects compared to conventional drugs in the treatment of inflammation and inflammatory pain.

Ages between 41 and 60 made up the largest proportion (52.5 %), followed by those over 61 years old (25.7%), while 16.7% were between 21 and 40 years old, and only 2.9 % were under 20 years old. Therefore, traditional medicine is used to manage inflammation more frequently with age. Our results are in accordance with other studies [31], showing significant percentages of people over 40 and 60 years old who are interested in phytotherapy. Most respondents were functionally illiterate, with a percentage of 68.8% [32]. Nearly 21.3% attended elementary school, 7% in high school, and only 2.9% continued their university education. The prevalence of illiteracy could be explained by the ancestral oral transmission of the population using traditional medicine.

Source of information and preference for a phytotherapeutic method

The most significant source of information for 82 % of herbalists and healers interviewed was knowledge handed down from one

generation to the next [33], followed by research and personal experience with a percentage of 12.7 %, while books and the Internet represented only 2.4 % and 2.9 %, respectively. Arabic and Amazigh legacies concerning medicinal plants, which is influenced favorably by the Islamic culture, has a long and rich history of using medicinal plants [34]. 93.9 % of the investigators prefer phytotherapy since it is a natural remedy, affordable, and effective with few side effects, while 4 % prefer medical care and 2% use both due to the complementarity between synthetic drugs and complementary medicine. Due to the lack of trained medical professionals in rural areas, 68.9 % of people visit a doctor for an accurate prognosis, while 30.7 % of people representing the majority of rural populations, resort to traditional healers.

Diversity of medicinal plants used by the population

The present study was conducted in two distinct areas of the Fez-Meknes region, some rural: Moulay driss, Guigo, Imouzzer Kandar, Boulemane, Sanhaja, Tahla, Nzalat Bni Amar, Moulay yakoub, Agourai, Mrhassiyine, Bhalile and some urban: Meknes, Fez, Taza, Ifrane, Sefrou, Taounat. In this region, 104 plant species belonging to 49 families were mentioned to have effects against inflammation and inflammatory pain. The ethnobotanical data related to uses of these plants, including vernacular names, scientific names, families that have been classified in alphabetical order, as well as quantitative and qualitative indices such as FL, RFC, FIV and ICF, have been collated (Table 2). Among the botanical families mentioned for the treatment of different types of inflammation, Lamiaceae had the largest number of species (16), followed by Apiaceae (13) and Asteraceae (9) (Fig. 2). The dominance of Lamiaceae and Apiaceae can reflect the wide diversity of bioactive molecules in the plants belonging to these families, as well as their distribution and abundance in the studied area. Indeed, the interviewees in the region have a deep knowledge regarding the plant species of these families, which presents a major economic interest due to their chemical composition, especially essential oils [35]. According to the inventory performed by Lemhadri et al., [36] for the state of conservation of AMPs in Morocco, Lamiaceae and Apiaceae represented 210 and 160 taxa respectively [37,38].

The Fidelity level is a parameter used to establish the main plant species used in treatment of inflammation. The values of FL in this study ranged from 50 to 100 %, with greatest values observed for the following species: *Pistacia lentiscus* L. (100 %), *Pimpinella anisum* L. (94 %), *Zingiber officinale* Roscoe. (90 %), *Glycyrrhiza glabra* L. (87 %), for the treatment of different types of inflammation and associated pain in the region Fez-Meknes. These results are consistent with the literature, which indicated that these species are recommended for the management of inflammatory ailments [39,33]. Alternatively, medicinal plants with an important FL, which are not mentioned in recent publications could be recommended for further studies related to clinical practice [40]. The family use value FIV is a parameter that expresses the relationship between families and the total number of plant species reported in these families. Herbalists and healers mentioned 49 families for the traditional treatment of inflammatory diseases. The greatest values of FIV were observed in the following families: Zingiberaceae (FIV=0.062), Fabaceae (FIV=0.024), Lamiaceae (FIV=0.014), while Geraniaceae, Euphorbiaceae, and Verbenaceae showed the lowest values with a FIV of 0.001 % for each family.

Table 3 outlines various types of inflammatory illnesses and associated pains reported in the region of Fez-Meknes, along with corresponding pathologies. Furthermore, the results are presented based on the medicinal plants' usage ways. Consequently, a wide range of methods for the preparation and administration of herbal remedies was observed and discussed. For example, some plants were mainly used topically, in the shape of poultices, ointments or compresses, while others were prepared in the form of infusions, decoctions or extracts for oral consumption. Additionally, it was noted that certain plants were used in versatile ways, both locally and

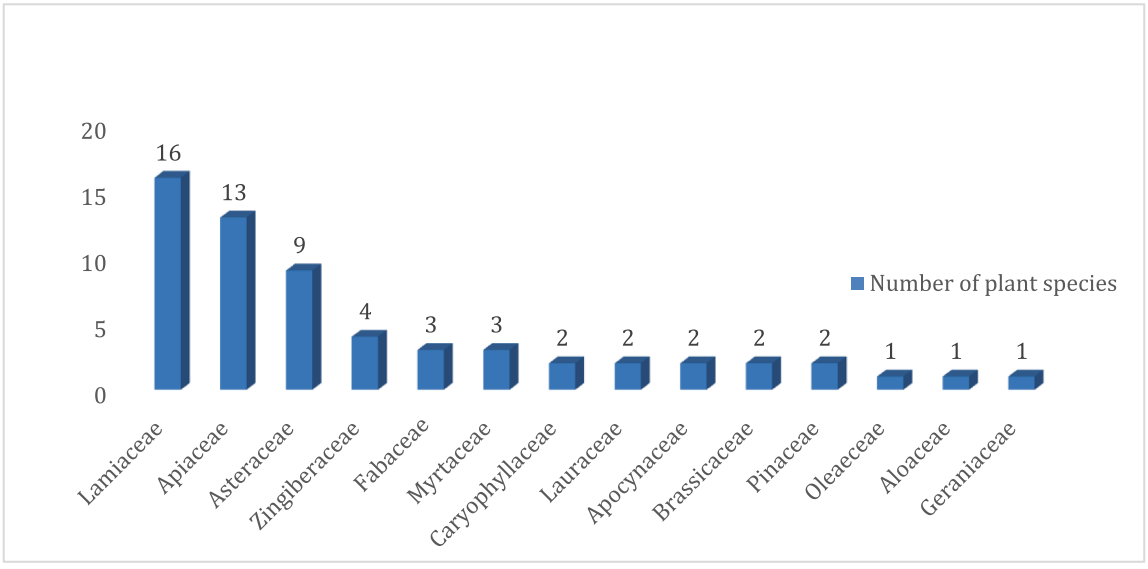


Fig. 2. Number of plant species per botanical family.

Table 3
Plant species used in the treatment of inflammatory and painful ailments in the region of Fez- Meknes.

Scientific name	Family	Vernacular name	Part used	Mode of Preparation	Exipient/ Dissolvent	Administration mode	Pathologies treated
Carpobrotus edulis L.	Aizoaceae	Asabiae zaynabe	AP	Cataplasm	–	External	Eczema
Aloe vera (L.) Burm.f.	Aloaceae	Sabar	Lt	Infusion	Water	External/ Oral	Skin Inflammation, Inflammation And Stomach Pain
Pistacia lentiscus L.	Anacardiaceae	Drou	L	Decoction/ Powder	Water	Oral	Stomach Pain
Ammodaucus leucotrichus Coss.	Apiaceae	Kamoun Soufi	S	Decoction Infusion	Water	Oral	Intestinal Inflammation, Irritable Bowel Pain
Ammi visnaga L.	Apiaceae	Bachnikha	Fr	Fumigation/ Decoction	Water	Oral/External	Headache, Dental pain
Apium graveolens L.	Apiaceae	Kraafes	S	Decoction	Water	Oral	Inflammation And Stomach Pain
Apium nodiflorum Lag.	Apiaceae	Ziyata	WP	Decoction	Water	Oral	Stomach Bloating Pain
Carum ammoïdes Benth& Hook.	Apiaceae	Nanoukha	WP	Decoction	Water	Oral	Joint Pains
Carum carvi L.	Apiaceae	Karwiya	S	Decoction	Water	Oral	Intestinal Pain
Coriandrum sativum L.	Apiaceae	Kassbour	S	Decoction	Water	Oral	Inflammation And Stomach Pain
Cuminum cyminum L.	Apiaceae	Kamoun	S	Decoction	Water	Oral	Stomach Pain
Ferula communis	Apiaceae	Boubal	AP	Baked	–	Oral	Joint Pains
Foeniculum vulgare subsp. *vulgare* Miller.	Apiaceae	Bessbass	R	Decoction	Water	Oral	Inflammation And Stomach Pain, Gum Inflammation
Petroselinum crispum Mill. Fuss		Maâdnouss	AP	Decoction	Water	Oral	Urinary inflammation and pain, Bronchitis Inflammation
Pimpinella Anisum L.	Apiaceae	Habbat halâwa	S	Powder	Water	Oral	Joint Pain And Rheumatism, Inflammation And Stomach Pain
Caralluma europaea Guss	Apocynaceae	daghmous	AP	Infusion	Water	Oral	Vaginal pain
Nerium oleander L.	Apocynaceae	Defela	L/R	Fumigation	–	Oral	Joint Pains, Epileptic Pain
Asphodelus microcarpus Viv.	Asphodelaceae	Berwag	R	Powder	Honey	External	Skin Inflammation
Anacyclus pyrethrum L.	Asteraceae	Tigentest, Oud El Atass	R	Rinsing	Water	External	Buccal Pain
Artemisia herba-alba Asso.	Asteraceae	Chih	AP	Decoction	Water	Oral	Vaginal inflammation
Atractylis gummifera L.	Asteraceae	Addâd	R	Powder	Water	External	Inflammation and burns
Calendula arvensis L.	Asteraceae	Jemra	FL	Decoction	Water	Oral	Menstrual pain
Chamaemelum nobile L.		Babounj	FL	Powder	Essential oil	External	Vaginal inflammation, Buring pain
Cynara humilis L.	Asteraceae	Taymet	R	Decoction	Water	External	Skin Inflammation
Dittrichia viscosa L. *Greuter*	Asteraceae	Terhla, Magraman	L	Decoction	Water	External	Inflammation and scarring
Saussurea alpina L.	Asteraceae	Aghrisse	ST	Powder	–	Oral	Lung Inflammation
Borrago officinalis L.	Boraginaceae	Lessane Tour	L	Decoction	Water	Oral	Ulcers And Stomach Inflammation
Lepidium sativum L.	Brassicaceae	Hebrchad	S	Infusion	Water	Oral	Epileptic Pain
Sinapis alba L.	Brassicaceae	Kherdel	S	Cataplasm	Vegetable Oil	External	Joint Pain And Rheumatism
Opuntia ficus-indica (L.) Mill.	Cactaceae	Handia	Fr	Fresh	–	Oral	Inflammation And Stomach Pain
Capparis spinosa L.	Capparaceae	Kebbar	Fr	Powder	Vegetable Oil	External	Joint Inflammation
Corrigiola italica L.	Caryophyllaceae	Serghina	Wp	Decoction	Water	Oral	Abdominal Pain
Herniaria cinera DC.	Caryophyllaceae	Herras Lehjir	L	Infusion	Water	Oral	Renal Pain
Chenopodium ambrosioides L.	Chenopodiaceae	Mekhinza	L	Cataplasm	Water	External	Headache/Migraine
Cucurbita maxima L.	Cucurbitaceae	Gueraa selawiya	B	Inhalation	Water	Oral	Headache/Migraine
Tetraclinis articulata (Vahl) Masters	Cupressaceae	Aârar	L	Decoction	Water	Oral	Shortness of Breath
Euphorbia falcata L.	Euphorbiaceae	Hayyatennufus	Wp	Decoction	Water	Oral	Vaginal inflammation
Ricinus communis L.	Euphorbiaceae	Kherouaâ	L	Vegetable Oil	–	External	Sciatica Pain

(*continued on next page*)

Table 3 (*continued*)

Scientific name	Family	Vernacular name	Part used	Mode of Preparation	Exipient/ Dissolvent	Administration mode	Pathologies treated
Glycyrrhiza glabra L.	Fabaceae	Ârqsûs	R	Decoction	Milk	External Oral	Inflammation and burns Ulcers And Stomach Inflammation
Trigonella foenum-graecum L.	Fabaceae	Helba	S	Maceration	Water	Oral	Inflammation And Stomach Pain
Ceratonia siliqua L.	Fabaceae	Alkharoub	S	Infusion	Water	Oral	Stomach Pain
Centaurium erythraea Rafn	Gentianaceae	Gosset ʟ-Hayya	Fl	Decoction	Olive Oil	Oral	Bronchitis Inflammation
Geranium graveolens (L'Hér.) Thunb	Geraniaceae	Äetercha	L	Infusion	Water	Oral	Headache
Crocus sativus L.	Iridacea	Zafranhor	St	Infusion	Milk	Oral	Neuron Inflammation
Juglans regia L.	Juglandacceae	Swak	Fr/B	Maceration	Water	External	Dental Pain
Ajuga iva (L.) Schreber.	Lamiaceae	Chandgoura	Wp	Decoction	Water	Oral	Inflammation And Stomach Pain
Calamintha officinalis Moench	Lamiaceae	Manta	L	Infusion	Water	Oral	Irritable Bowel Pain
Lavandula angustifolia P. Mill	Lamiaceae	Khezama	Fl	Essential Oil	–	External	Buring pain
Lavandula multifida L.	Lamiaceae	Kohila	L	Decoction	Water	Oral	Chest Pain
Lavandula Stoechas L.	Lamiaceae	Helhale	Wp	Decoction	Water	Oral	Urinary inflammation and pain
Marrubium vulgare L.	Lamiaceae	Meriwta	Wp	Instillation/ decoction	Water/olive oil	Oral	Lung Inflammation, ear Inflammation, Inflammation And Stomach Pain
Mentha piperita L.	Lamiaceae	Na'Naelabldi	L	Decoction	Water	Oral	Bronchitis Inflammation
Mentha pulegium L.	Lamiaceae	Flio	Ap	Decoction	Water	Oral	Chest Pain, Throat Inflammation
Mentha rotundifolia (L.) Hudson	Lamiaceae	Merssita	L	Infusion	Lemon juice	Oral	Inflammation And Stomach Pain
Ocimum basilicum L.	Lamiaceae	L'Hbak	L	Infusion	Water	Oral	Stomach Inflammation
Origanum compactum Benth	Lamiaceae	Zaâtar	L	Decoction	Water	Oral	Larynx Inflammation
Rosmarinus officinalis L.	Lamiaceae	Azir	Ap	Decoction	Water	Oral	Menstrual pain
Salvia officinalis L.	Lamiaceae	Salmia	L	Decoction	Water	Oral	Menstrual pain
Salvia verbenaca L. Briq	Lamiaceae	Khiyata	L	Cataplasm	Honey	External	Inflammation and scarring
Thymus vulgaris L.	Lamiaceae	Zâitra	St	Decoction	Water	Oral	Chest Pain, Abdominal Pain
Cinnamomum zeylanicum Nees	Lauraceae	El Qarfa	B	Ointment	–	External	Menstrual pain, Inflammation and itching
Laurus nobilis L.	Lauraceae	Ourakmoussa	L	Essential Oil Infusion	– Water	External Oral	Joint Pain And Rheumatism, Inflammation And Stomach Pain
Allium cepa L.	Liliaceae	Bessela	Bl	Inhalation	Vegetable Oil	Oral	Headache,Fever, Paranasal Sinus Inflammation
Allium sativum L.	Liliaceae	Touma	Rh	Powder	Vegetable Oil	Oral	Inflammation And Oral Pain
Lawsonia inermis L.	Linaceae	Henna	L	Powder	Juice of lemon	External	Buring pain
Linum usitatissimum L.	Linaceae	Zeriatel Ketan	S	Decoction	Water	Oral	Sciatica Pain
Punica granatum L.	Lythraceae	Remane	Fr	Decoction/ Fresh	Water	External/Oral	Mouth Inflammation/ Ulcers And Stomach Inflammation
Hibiscus sabdariffa L.	Malvaceae	Karkadil	L	Decoction	Water	Oral	Shortness of Breath
Eucalyptus globulus Labill	Myrtaceae	Kaliptus	L	Inhalation	Water	Oral	Shortness of Breath
Eugenia caryophyllata Thunb.	Myrtaceae	Qoronfel, Oud Nouwar	Fl	Decoction	Water	External Oral	Dental Pain Stomach Inflammation
Myrtus communis L.	Myrtaceae	Rayhane	L	Decoction	Water	External	Skin Inflammation, Gum Inflammation
Olea europaea L.	Oleaceae	Zitoune	Fr/L	Decoction	Water	External	Inflammation And Oral Ulcer
Sesamum indicum L.	Pedaliaceae	Zenjlnae	S	Powder	–	Oral	Joint Inflammation
Pinus pinaster Aiton	Pinaceae	Tayda	B	Powder	Water	External	Skin Inflammation
Quercus suber L.	Pinaceae	Debagh	Ap	Decoction	Water	Oral	Stomach Pain
Plantago major L.	Plantaginaceae	Messassa	L	Powder	Water	External	Buring pain

(*continued on next page*)

Table 3 (*continued*)

Scientific name	Family	Vernacular name	Part used	Mode of Preparation	Exipient/ Dissolvent	Administration mode	Pathologies treated
Avena sativa L.	Poaceae	Kherrtal	S	Powder	Water	External	Skin Inflammation
Pennisetum typhoides (Burm.) Stapf. & Hubb.	Poaceae	Illân	S	Powder	Milk	Oral	Bone Pain
Polygonum aviculaire L.	Polygonaceae	Wadmou	R	Cataplasm	Water	Oral	Psoriasis
Nigella sativa L.	Ranunculaceae	Sanuj	S	Infusion	Water	Oral	Joint Pain And Rheumatism
Ranunculus bullatus L.	Ranunculaceae	Wednin halouf	L	Powder	Water	External	Buring pain
Rhamnus alaternus L.	Rhamnaceae	Mliles	L	Decoction	Water	Oral	Abdominal Pain
Zyziphus lotus L.	Rhamnaceae	Sedera / Nbeg	L/Fr	Decoction	Water	Oral	Inflammation And Stomach Pain
Rosa damascena Mill.	Rosaceae	Lwared	Fl	Instillation	–	External	Gum Inflammation
Rubia tinctorum L.	Rubiaceae	Fowa	R	Decoction	Water	Oral	Abdominal Pain
Populus alba L.	Salicaceae	Sefssaf	L	Infusion	Water	External	Buring pain
Argania spinosa L. skeels	Sapotaceae	Argane	S	Essential Oil	–	External	Joint Pain And Rheumatism
Ruta chalepensis L.	Tamaricaceae	L'Fijel	L	Infusion	Water	Oral	Bronchitis Inflammation
Tamarix aphylla L. H. karst	Tamaricaceae	Takawet	S	Decoction	Water	Oral	Inflammation And Oral Ulcer
Daphne gnidium L.	Thymelaeaceae	Lazaze	L	Cataplasm	Water	External	Muscle Pain
Urtica pilulifera L.	Urticaceae	Harrigua	S/L	Infusion	Water	Oral	Paranasal Sinus Inflammation
Lippia triphylla (L'Her.) Britt	Verbenaceae	Louwiza	L	Infusion	Water Milk	Oral	Neuron Inflammation
Vitex agnus castus	Verbenaceae	Kafemeryem	Wp	Decoction	Water	Internal	Vaginal pain, Sciatica Pain
Alpinia officinarum Hance	Zingiberaceae	Khodnjale	R	Decoction	Water	Oral	Joint Inflammation And Pain
Curcuma longa L.	Zingiberaceae	Kharqum	Rh	Powder	Water	External Oral	Joint Inflammation And Pain, Mouth Inflammation, stomach Inflammation
Elettaria cardamomum L.	Zingiberaceae	Qaâqolla	S	Decoction	Water	Oral	Headache
Zingiber officinale Roscoe.	Zingiberaceae	Skenjbir	Rh	Decoction	Water	Oral	Stomach Inflammation

Lt: latex; Ap: aerial part; L: leaves; S: Seeds; Fr: Fruit; Wp: whole part; R: Root; Fl: Flower; St: Stem; B: Bark; Bl: bulb; Rh: Rhizome.

through ingestion.

Carpobrotus edulis L., also known as *Asabiae zaynabe*, is reported to treat skin and gastric inflammation, and commonly applied as an external poultice to treat eczema. In another hand, *Aloe vera* (L.) Burm.f., commonly known as Sabar, is prepared as a water infusion and can be administered locally to the affected skin or orally. This plant is traditionally used to alleviate cutaneous inflammation and gastric pain.

Eucalyptus globulus Labill, often used as an inhalant, can help relieve symptoms of breathlessness. Similarly, *Allium cepa* L. shows promise in relieving headaches, fever, and inflammation of the paranasal sinuses when inhaled or taken orally, while *Allium sativum* L. is reputed to be effective against inflammation and mouth pain when taken as a powder with vegetable oil.

Glycyrrhiza glabra L. is used as a decoction to treat mouth inflammation and burns, as well as ulcers and gastric inflammation. *Trigonella foenum-graecum* L., *Ceratonia siliqua* L. and *Ajuga iva* (L.) Schreber., are all mentioned for their ability to relieve inflammation and stomach pain, each prepared differently for oral administration. *Centaurium erythraea Rafn* is used as decoction with olive oil to treat inflammatory bronchitis, while *Crocus sativus* L. is renowned for its infusion in milk, useful in cases of neuronal inflammation. *Juglans regia* L. is used as a maceration to relieve toothache, and *Calamintha officinalis* Moench., is infused to soothe irritable bowel pain, while the essential oil of *Lavandula angustifolia* P. Mill. is employed as to relieve skin pain.

This diversity of medicinal plants and methods of use, as documented in the Fez-Meknes region, reflects the extent of natural

Table 4
ICF values by groups for the care of inflammatory diseases in the Fez- Meknes region.

Informant Consensus Factor (ICF)	Nur	Nt	IFC
Inflammation and oral pain/ORL	65	28	0.58
Inflammation and pain (muscles/joints)	66	33	0.51
Vaginal inflammation and urinary tract pain	37	18	0.53
Inflammation of skin	64	28	0.57
Digestive inflammation and pain	230	63	0.73
Inflammation and respiratory illness	41	23	0.45
Inflammation and pain of the nervous system	39	22	0.45

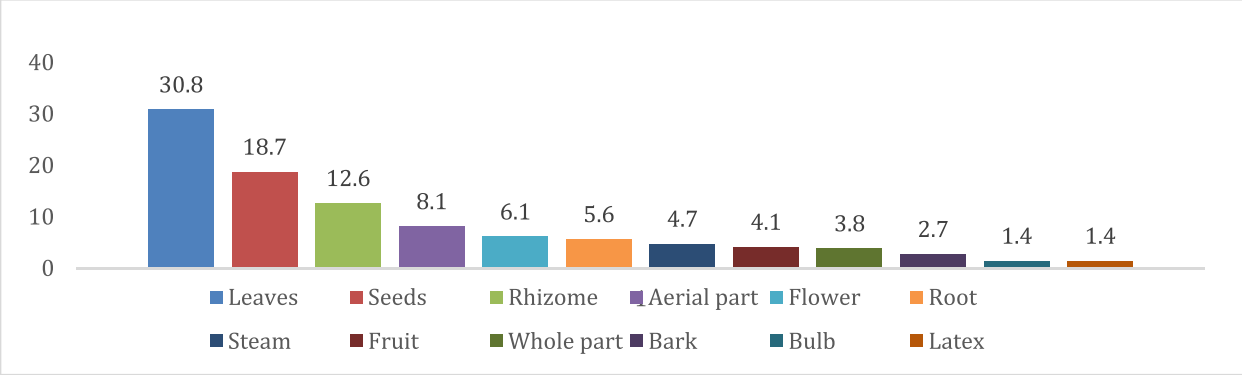


Fig. 3. Plant parts used.

resources available for the treatment of inflammation and pain. It provides a range of choices for the local community seeking alternatives to conventional medicines in Morocco.

The Informant Consensus Factor (IFC) proved to be a relevant parameter for our study, to prioritize the different categories of inflammatory and painful diseases identified by participants in our study area (Table 4). The greatest IFC values were observed for inflammations and inflammatory pains of the digestive system (IFC=0.729), followed by disorders of otorhinolaryngological with oral system (IFC=0.578) and dermatological inflammations (IFC=0.571) (Table 4). The least type of inflammation with a frequency of 0.447 was observed for pain of the nervous system. According to several ethnopharmacological surveys carried out nationally and internationally in several areas of the world, digestive diseases represent a primary use of medicinal plants due to the local population's acquired knowledge [3,40,41].

Indigenous people of the Fez- Meknes region use multiple constituents of medicinal plants for preparation of natural remedies: In this study leaves were the primary part used (30.8 %), followed by seeds (18.7 %), then rhizomes (Fig. 3). Traditional use of leaves has also been observed during other surveys [42,43]. In this study, inhabitants indicated their preference to use leaves, seeds, rhizomes, and aerial parts for the preparation of natural remedies to treat inflammation, because these parts are accessible and easily collected. In fact, these parts are rich in secondary metabolites due to the photosynthetic mechanism. Obviously, the conservation of roots avoids extirpation of plant species, those that are endemic [44]. Our results are consistent with those of previous study [45], which mentioned the importance of the leaves utilization based on the plant part value (PPV). The same study showed a PPV = 0.364 for the leaves and PPV=0.2263 for the seeds.

Concerning the methods used for preparation, decoction (38.3 %) and infusion (19.2 %) were applied most frequently by the population of the Fez- Meknes region, because decoction was considered as the most effective and rapid method for the extraction of active components from different parts of the plant (Fig. 4). The main solvent for extraction was water, but lemon juice, honey, milk and vegetable/essential oils were also used as ingredients of the remedies. In addition, the inhabitants indicate the use of honey to increase the tolerance of plant species having an undesirable bitter and sour taste. The dominance of decoction for the preparation of remedies in the region of Fez-Meknes is in agreement with the majority of ethnopharmacological studies previously conducted [46,

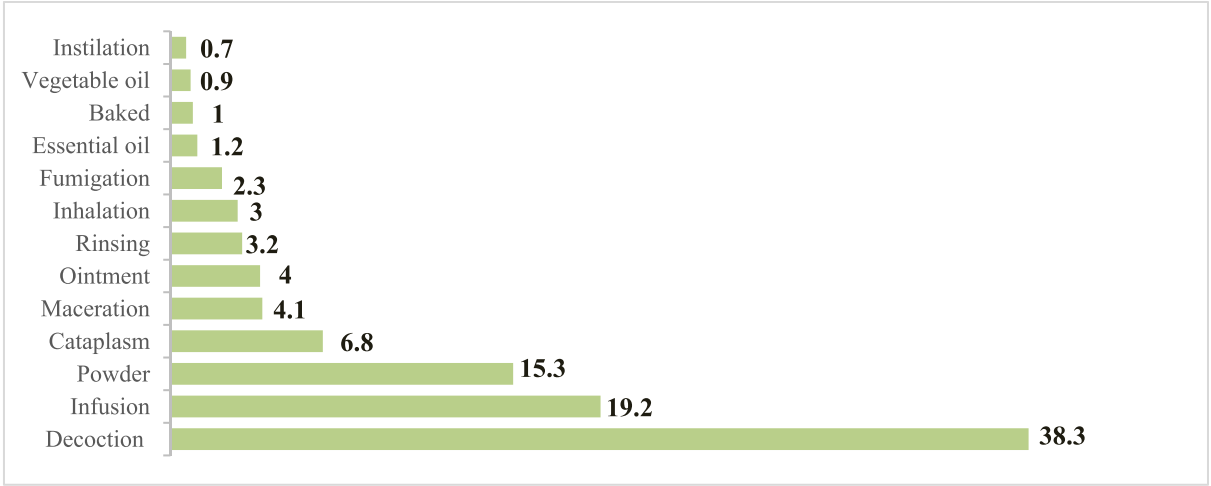


Fig. 4. Methods of preparation.

Table 5
Literature on medicinal plants used in traditional medicine to fight against various types of inflammation and pain in the region of Fez-Meknes.

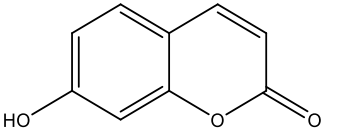
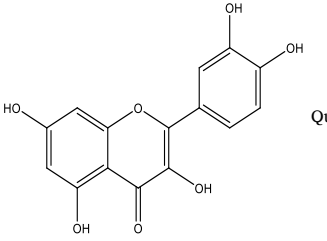
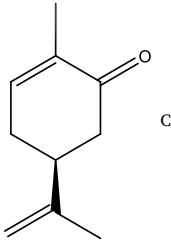
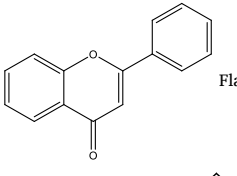
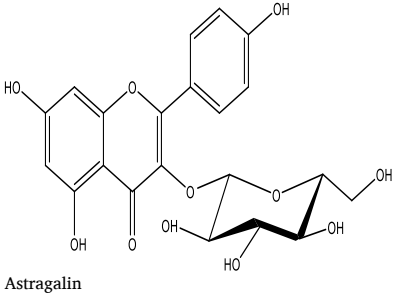
Species (Family)	Activity	Experimental Methodology	Results	Identification of key active compounds	Refs.
Apiaceae *Apium graveolens* L.	Anti-nociceptive	Stimulation of abdominal torsion by intraperitoneal injection of 0.3 % acetic acid	Celery extract has a central and peripheral antinociceptive effect	 Umbelliferone	[48, 49]
	Anti-inflammatory	Inflammation is induced by injecting formalin into the subcutaneous area of the right paw of mice.	Observation of an anti-inflammatory effect with a greater concentration of 400 mg/kg.	 Quercetin	[50]
Apiaceae *Carum carvi* L.	Anti-inflammatory	Induction of inflammation by an injection of 50 µl of 2.5 % formalin solution subcutaneously in the plantar region of the right hind leg	Diminution of the synthesis of leukotrienes and prostaglandins.	 Carvon	[51, 52]
Apiaceae *Petroselinum sativum Hoffm.*	Anti-inflammatory	Induction of inflammation by carrageenan injection in the paw of rats	Protective effect on inflammation with a dose of 220 mg/kg for polyphenols and with a dose ranging from 500 mg/kg to 1000 mg/kg for the hydroethanol extract	 Flavone	[53, 54]
Asteraceae *Artemisia herba-alba*	Anti-nociceptive	Induction of thermal pain of tail flick meter	Action on the spinal cord, medulla and/or greater levels of the CNS by the aqueous extract of A. h.a which allows to act against pain	 Astragalin	[55]

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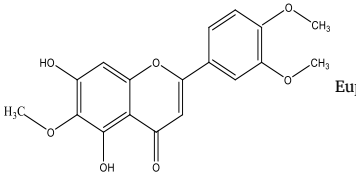
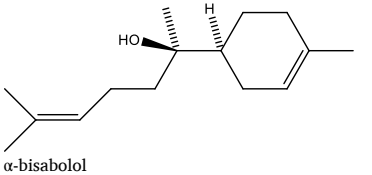
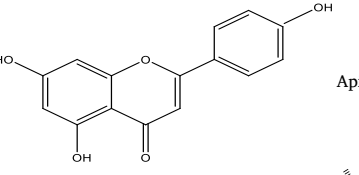
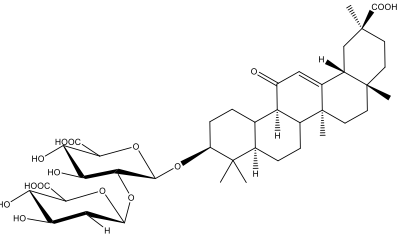
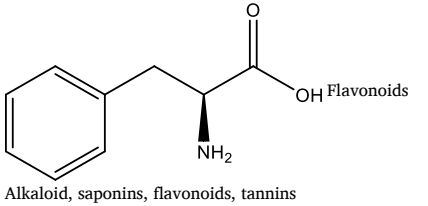
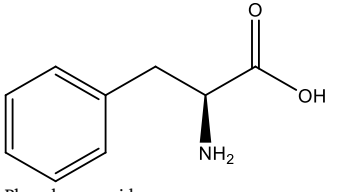
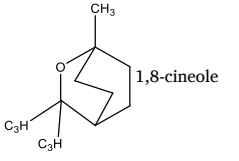
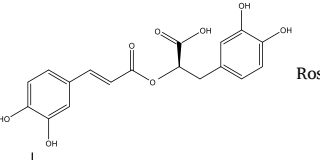
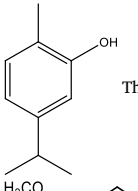
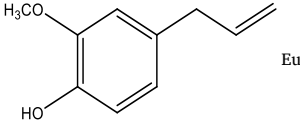
Table 5 (*continued*)

Species (Family)	Activity	Experimental Methodology	Results	Identification of key active compounds	Refs.
	Anti-inflammatory	Induction of inflammation by carrageenan injection in the paw of rats	Effects of the extract were almost the same as those of indomethacin (a non-selective COX inhibitor used as a reference drug)	 Eupatilin	
Asteraceae *Chamaemelum nobile* L.	Anti-inflammatory	Induction of acute inflammation by injection of fresh egg albumin into the hind paw of rats	*C. nobile* oils inhibit all stages of the inflammation.	 α-bisabolol	[56, 57]
	Analgesic	Induction of thermal pain of tail flick meter	Inhibition of the transmission of the pain to the spinal cord using essential oils of *C. nobile*.	 Apigenin	[58]
Fabaceae *Glycyrrhiza glabra* L.	Anti-inflammatory	Induction of inflammation by corneal burn in the rabbit eye.	Almost complete elimination of the inflammation accompanying the burn	 Glycyrrhizin	[59]
Fabaceae *Trigonella foenum-graecum* L.	Anti-inflammatory	Induction of inflammation by carrageenan injection in the paw of rats	Reduction of the paw edema due to the inihibiton of prostaglandins and bradykinin	 Flavonoids	[60, 61]
Lamiaceae *Laurus nobilis* L.	Anti-inflammatory	Induction of inflammation by carrageenan injection in the paw of mice.	Inhibition of the synthesis of pro-inflammatory substances	Alkaloid, saponins, flavonoids, tannins	[62]

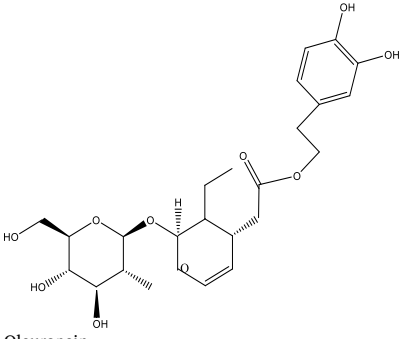
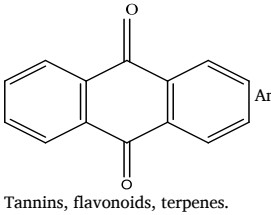
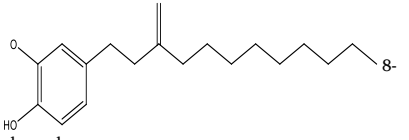
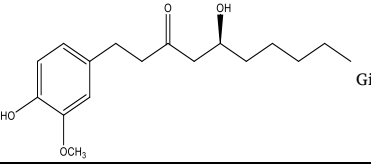
(*continued on next page*)

Table 5 (*continued*)

Species (Family)	Activity	Experimental Methodology	Results	Identification of key active compounds	Refs.
Lamiaceae *Marrubium vulgare* L.	Anti-inflammatory	Induction of inflammation by carrageenan injection in the paw of rats	The methanolic extract of M. vulgare attenuates the early and late phases of inflammation induced by carrageenan by inhibiting the synthesis of cyclooxygenase and/or lipoxygenase.	 Phenylpropanoid	[63]
Lamiaceae *Ocimum basilicum* L.	Anti-inflammatory	The anti-inflammatory test is performed by the protein denaturation test	Ocimum extracts protect bovine serum albumin (BSA) from protein denaturation	Polyphenol, flavonoid	[64]
Lamiaceae *Rosmarinus officinalis* L.	Analgesic	Induction of thermal pain by the hot plate test in mice	Pain latency of 400 mg/kg of aqueous extract was better than that of superior to that of morphine for times ranging from 45 to 90 min	 1,8-cineole	[65]
Lamiaceae *Salvia officinalis* L.	Anti-inflammatory	Induction of acute inflammation by injection of carrageenan into the peritoneal cavity of rats	Inhibition of enzymes involved in inflammation.	 Rosmarinic acid	[66]
Lamiaceae *Thymus vulgaris* L.	Antinociceptive	Induction of thermal pain by the hot plate test in mice	Analgesic effect was comparable to that of paracetamol, which due to the inhibition of proinflammatory mediators	 Thymolcarvacrol	[67]
Myrtaceae *Eugenia caryophyllata Thunb*	Analgesic	Sensation of tooth pain	Inhibition of prostaglandin biosynthesis with a suppression of sensory receptors involved in pain perception	 Eugenol	[68]

(*continued on next page*)

Table 5 (*continued*)

Species (Family)	Activity	Experimental Methodology	Results	Identification of key active compounds	Refs.
Oleaceae *Olea europaea* L.	Analgesic	Induction of thermal pain of tail flick meter	Analgesic effect with the 50 mg/kg dose was superior to that of ibuprofen	 Oleuropein	[69]
Zingiberaceae *Curcuma longa* L.	Anti-inflammatory	Induction of acute inflammation by fresh egg albumin which was injected into the subplantar tissue of the right hind leg of rats	The methanolic extract has an effect comparable to that of diclofenac this suggests that the extract probably acted by inhibiting the release of vasoactive substances (histamine, serotonin, and kinins) and prostaglandins	 Anthraquinones	[70]
	Analgesic	induction of thermal pain of tail flick meter	inhibition of the pain stimulus by prolonging the latency period which was better than the negative and positive controls	Tannins, flavonoids, terpenes.	
Zingiberaceae *Zingiber officinale* Roscoe.	Anti-inflammatory	Inflammation was induced by subplantar injection into the plantar fascia (aponeurosis) of the rats' hind limb using 30 µL of AITC allyl isothiocyanate	Inhibition of the synthesis of proinflammatory agents via the blocking the activity of COX-1 and COX-2	 8-shogaol	[71]
	Analgesic	Pain induction by subplantar injection of 20 µL of a 0.5 % solution of AITC in 1,2-propylene glycol.	Use of ginger rhizome extract-based ointments results in a reduction of visceral nociceptor excitability, which allows a reduction in the time the animals spend licking their hind limbs	 Gingerol	

47].

We carried out a literature search, as a part of our study, to collect and confirm data on plants used in the treatment of inflammatory and painful diseases. The (Table 5) below provides a summary of the information obtained, highlighting the most frequently cited plants for their efficacy in relieving inflammation and pain.

Conclusions

The ultimate goal of the survey, was to explore alternative treatments for inflammation and reduce the adverse effects associated with non-steroidal anti-inflammatory drugs, thereby, providing safer options for patients. The survey provided a comprehensive database that will serve as a valuable reference for future studies on inflammation. It focused on presenting key information about the plant species used by the local population in the region of Fez-Meknes in Morocco. The results of the survey revealed that the local community of Fez-Meknes used 103 plant species belonging to 49 botanical families to treat different types of inflammation. Furthermore, medicinal plants exhibiting greater RFC (Relative Frequency of Citation) and FL (Fidelity Level) like *Pistacia lentiscus* L. (100 %), *Pimpinella anisum* L. (94 %), *Zingiber officinale* Roscoe. (90 %), and *Glycyrrhiza glabra* L. (87 %) could be further explored through experimental and clinical research. The ethnobotanical survey found that a significant number of medicinal species are utilized for treating inflammation and digestive pain, otorhinolaryngology system, and dermatological ailments. Leaves were the most frequently used plant part, and decoction was the primary method of preparation in traditional herbal medicine practices. From these results, it can be concluded that the local population of Fez-Meknes depends on the use of medicinal plants to treat inflammation and pain. Consequently, our findings provide a strong basis for future research on these plants in order to develop new drugs and treatments against this illness.

CRediT authorship contribution statement

Youssra Lefrioui: Conceptualization, Software, Data curation, Formal analysis, Writing – original draft, Writing – review & editing. **Mohamed Chebaibi:** Conceptualization, Writing – original draft, Writing – review & editing. **Mehdi Djiddi Bichara:** Methodology, Formal analysis, Software, Data curation. **Ibrahim Mssillou:** Conceptualization, Methodology, Writing – original draft, Writing – review & editing. **Hicham Bekkari:** Supervision, Validation, Resources. **John P. Giesy:** Writing – original draft, Writing – review & editing. **Dalila Bousta:** Conceptualization, Supervision, Validation, Resources, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no conflict of interest.

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