Journal of Ethnopharmacology 246 (2020) 112217

Contents lists available at ScienceDirect

Journal of Ethnopharmacology

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

Ethnobotanical study of medicinal plants in the Adrar Province, Mauritania

Cheikh Yebouk[a], Fatima Zahrae Redouan[a], Guillermo Benítez[b,*], Mohamed Bouhbal[a], Mohamed Kadiri[a], Ahmed Ismail Boumediana[c], Joaquín Molero-Mesa[b], Abderrahmane Merzouki[a]

[a] Flora Research, Ethnobotany and Ethnopharmacology Group, Laboratory of Applied Botany, Department of Biology, Faculty of Sciences, University Abdelmalek Essaâdi BP 2121, Tetouan, 93000 Morocco
[b] Department of Botany, University of Granada, Campus Universitario de Cartuja, 18071 Granada, Spain
[c] ENS of Nouakchott, National Herbarium of Mauritania, Mauritania

A B S T R A C T

Ethnopharmacological relevance: Mauritania is a country in which few ethnobotanical studies have been conducted and consequently the ethnomedical data is scarce. Since the geographical region reflects the transition between tropical and Northern Africa, influenced by the Mediterranean floristic region, the traditional knowledge was influenced by several cultures from tropical Africa as well as Arab, Berber and Islamic societies.

Aim of the study: This paper aims to explore and compile the diversity of ethnomedical knowledge in one of the regions of Mauritania and to compare the data with similar studies from surrounding territories.

Materials and methods: Surveys and interviews were carried out in 11 villages of Adrar province in northern Mauritania. Data were collected through open, semi-structured interviews (with individuals and focus groups). A sample of 120 people aged between 20 and 70 years, including 24 herbalists and 28 traditional healers was included.

Results: Ethnomedical data for 68 plant species belonging to 27 families were obtained. They are used to treat 50 health conditions grouped in 14 pathological groups. Remedies for digestive system disorders, skin problems and respiratory ailments were among the most frequent indications. Leaves were the most frequently used plant part and remedies generally used as a powder for the various applications and a total of 2'317 use reports were gathered. About 55% of the reported species were not cited previously in the literature focusing on Mauritania and neighbouring countries. Moreover, only 6 species are also cited by Ibn al-Baytar (13th century CE).

Conclusions: This work shows a promising perspective for future studies, shedding light on the richness and the risk for conservation of traditional knowledge of herbal medicine in Mauritania.

1. Introduction

1.1. Traditional medicine and ethnobotanical research in Mauritania

In 2001, the World Health Organisation (WHO) performed a Worldwide Review on the legal status of Traditional Medicine and Complementary/Alternative medicine. In this report, with regards to Mauritania, we established a working group to examine problems concerning traditional medicine and traditional pharmacopoeia, in particular: 1) to examine the most appropriate and realistic methods and means of establishing an honest dialogue between the official health services and traditional practitioners and 2) to propose the most appropriate mechanisms for identifying traditional practitioners who are amenable to such dialogue in order to determine and acknowledge the part that they can play in the system of comprehensive health care (WHO, 2001). Still, today, Mauritania has no official legislative/regulatory texts governing the practice of traditional medicine, any licensing processes for traditional practitioners or procedures for official approval of traditional medical practices and remedies (Gueye, 2009). Traditional medicine practitioners are not involved in Mauritania's primary health care program (WHO, 2001), and Mauritania authorises, at a small scale, the production and marketing of substances related to traditional medicine (ARSO, 2019). Nevertheless, this traditional medicine, unlike in other countries such as China or India, is not officially recognised by the national health committee and requires further organisation, regulations and adequate integration into the national health system (Amadou, 2011). In fact, the state of traditional medicine in Mauritania is little known and suffers from an almost total absence of bibliographical references (The African Health Monitor, WHO-AFRO, 2010).

In a study conducted by Groulard (1991) on traditional medicine in Mauritania (not focused on plants, but on traditional healing practices, diagnosis and symptoms), it has been shown that several conditions were treated with a number of traditional remedies. The author concluded that the diversity and the impacts of these traditional healing practices need to be integrated in a rational way into the national

* Corresponding author.
E-mail address: gbcruz@ugr.es (G. Benítez).

https://doi.org/10.1016/j.jep.2019.112217
Received 30 April 2019; Received in revised form 2 September 2019; Accepted 2 September 2019
Available online 11 September 2019
0378-8741/

health system. The traditional Mauritanian medicine has been defined by Graz (2010) as a "classical Greco-Arab medicine", i.e. related to the ancient Greek medical theory based on balance or imbalance of humours. He also concluded that practitioners of Traditional Arabic Medicine in this country use a prognosis/follow-up method to evaluate the safety and effectiveness of the treatment. This allows the comparison between progress and what the traditional 'tabib' had anticipated, and therefore compares the traditional healing methods with those of modern medicine.

As in most countries without a developed public and accessible modern health system, traditional medicine is socio-culturally highly popular in Mauritania. Apart from being extremely common, traditional medicine uses a large diversity of remedies, generally based on mineral, animal and plant origins (Groulard, 1991). However, traditional medicine has a huge socio-economic impact, since 42% of the constantly growing population of Mauretania live below the poverty line (Oxfam International, 2018). Undeniably, the socio-economic interest for medicinal plants is reaching the traditional healers. As some studies have pointed out, their commercial side could be a valuable source of income for local dwellers (Vall, 2009).

As the country is located approximately in-between the 15th and 27th parallels, with highly different environmental conditions and ecosystems, different approaches associated with the practice of traditional medicine exist within the country. While the population of the southern provinces is more attracted to the Tropical Africa animistic practices and rituals, the population of the northern provinces is more inclined to practice the Moorish medical tradition, influenced by the Arabo-Islamic medicine (Thouzery, 1998). In this sense, traditional medical practices in Mauritania can be seen as a crossroad of Sub-Saharan-African and Arabo-Berber cultures (Bellakhdar, 1997).

The importance of traditional medicine and its viability in Mauritania are high, since still today, it is used by large parts of the Mauritanian population (Graz, 2010). Mauritania is rich in ethnobotanical resources, medicinal plants and traditional healing practices. Nevertheless, the methods of work and the theories can be compared to Greek medicine, but are not known by the neighbouring countries (Graz, 2010).

Due to the geographical position of Mauritania, with a desert climate and harsh living conditions, its flora is quite poor in terms of species numbers. There are about 1400 vascular plant species (Barry and Celles, 1991), unevenly spread across the territory. More precisely, our studied area, Adrar Province, contains 250 species per 100,000 km^2 (Monod, 1952). Among other studies on the flora and vegetation of the country, we highlight those of Sauvage (1949), Monod (1952), Boudet et al. (1961), Adam (1966), Toupet (1966) and Vall et al. (2011, 2015).

Several studies have been published to deepen the knowledge of traditional medicine, but unfortunately, they are hardly known to the scientific community (Adje, 1998; Awfa, 1983, 1996; Dubief, 1937; Hamidoun, 1952; Mame N'Diak, 1977). This list could be enriched by other published works about ethnobotany in Mauritania (Leriche, 1953; Fortin et al., 1990; Vall, 2009) and by some books on the useful plants within a wider geographical area (Bellakhdar, 1978; Boulos, 1983; Maydell, 1983; Burkill et al., 1985; Pousset, 1989).

Additional ethnobotanical data of interest for this region can be found in nearby territories, such as South Morocco and the Saharian regions (Barrera et al., 2007), the Algerian Sahara (Miara et al., 2019, 2018; Hammiche and Maiza, 2006), Senegal (Diop et al., 2018; Benoit-Vical et al., 2008; Stauble, 1986; Le Grand, 1989; Le Grand et al., 1988; Le Grand and Wondergem, 1987; Bonati, 1980; Kerharo and Adam, 1974) and Mali (Wangensteen et al., 2015; Diarra et al., 2015; Bah et al., 2006; Bizimana et al., 2006; Maiga et al., 2005; Nergard et al., 2005; Inngjerdingen et al., 2004). Interesting data on desert plant species can be found in the eastern part of the Sahara Desert (e.g. Khalid et al., 2012; El-Kamali and Khalid, 1998).

This points to the need for more in-depth studies on the traditionally used medicinal plants in this region. In this context, we hypothesise that a long-term and well-driven study based on local healers and inhabitants using traditional healing practices in Mauritania can increase our knowledge of this topic, thereby facilitating the development of better policies for the regulation and exploitation of plant resources. Moreover, as will be discussed in this paper, some of the previous studies lack a critical assessment of the included names and contain several taxonomic and nomenclatural errors, mostly because of inadequate botanical literature and a lack of new research tools dealing with plant nomenclature and taxonomy (e.g. the websites of the African Plant Database, the International Plant Names Index, theplantlist.org or tropicos.org).

1.2. Aim of the study

This study aims to significantly deepen the knowledge of traditional plant-based medicine as practiced in the province of Adrar, an important region of North Mauritania, bordering Morocco, Algeria and Mali. We compiled an annotated list of the plants traditionally used as medicine, together with information on the specific herbal drugs traditionally used in this province, recorded through anthropological field surveys focusing on ethnomedicine. By performing a bibliographical comparison with other ethnobotanical studies in Mauritania and the above mentioned nearby territories, we aim to know for each of the included uses if they have previously been reported in the region or in nearby areas or if they are reported for the first time in this context.

2. Materials and methods

2.1. Study area

This work was performed in the province of Adrar (Fig. 1), named after the Adrar Plateau, a large administrative region in northern Mauritania covering about 235,000 km^2 and accounting for 22.8% of the country (ONS, 2011). In 2010, its estimated population size was 76,082 inhabitants (ONS, 2011), with a density of about 0.3 inhabitants per km^2, classifying Adrar as the second lowest populated province. Its capital, Atar, was populated by 38,877 inhabitants in 2013 (ONS, 2013). Eleven different villages of Adrar were surveyed in this work, selected according to the presence of traditional healers and potential informants.

According to the Köppen-Geiger climatic classification (Rubel and Kottek, 2010), the climate in Adrar is categorised as a hot desert climate (BWh code), with hot and arid conditions, intense sunshine, a typical desert precipitation and hot summers with temperatures exceeding 42 °C. In Atar, the average annual rainfall is 111 L/m^2, with an average temperature of 28 °C (with 5 months, between May and September, with over 30°; www.globalbioclimatics.org). The rainy season extends from July to October, with most of the rain being concentrated in August and September.

The population of this region usually migrates to the capital (Nouakchott) for job opportunities, to obtain higher education or to escape from the drought and harsh climatic conditions. Economically, the province of Adrar is based on agriculture and mainly on regular farming, with an increasing touristic activity. Agricultural activities are practiced on many fertile oases, since this province contains the largest number of oases in the country (over 63). Besides being a self-sufficient territory with regards to agricultural support, it participates in the food supply for the capital, Nouakchott, particularly in terms of vegetables and dates (*Phoenix dactylifera* L.). The cultivation of date palms in these oases is, as in other Saharan territories, common and culturally and economically important (ONS, 2011). Tourism is clearly progressing thanks to the beauty of the desert landscape, the mountain ranges and the historic towns with a rural lifestyle (such as Chinguitty and Ouadane), which have led to the development of this industry sector, making this province the most important tourist destination. These reasons, together with our interest in developing an ethnobotanical

Fig. 1. Study area representing Adrar Province with its four provinces Atar, Ouadane, Aoujeft and Chinguetti. Trarza, Tagant, Inchiri and Tiris zemour are surrounding provinces.

study, led us to choose this region as our study area.

2.2. Ethnobotanical approach and surveys

Our approach towards the ethnobotanical field study is based on previous works of our research group (Merzouki et al., 1997, 2000). The first phase consisted of visiting the villages and looking for traditional healers and inhabitants with high knowledge on the traditional use of plants. Classic methods to locate informants were followed, such as the snowball or participant observation on festivities and culturally important days, trying to locate traditional healers and practitioners as key informants. Once some informants were located and selected, our ethnobotanical data gathering was essentially based on open semi-structured interviews (Martin, 2004). Interviews were performed in "*Hassanya*", the Mauritanian Arabic dialect, after obtaining a verbal informed consent, and lasted for 1 or 2 h. We focused on the Maures ethnicity since Adrar people are mostly Arabs who speak Arabic, with some being of Amazigh (Berber) origin, and are locally known as the people with the higher traditional knowledge on medicinal plants. Through these interviews, information on both informants and medicinal plant use and knowledge was collected. The gathered information included local names of plants, parts of the plant used, preparation methods, modes of administration and health conditions or symptoms treated. During the fieldwork with our informants or from their own previous collections, plant material was also collected. While doing the interviews, a closed and structured questionnaire was also compiled with the help of the participants (supplementary Table 1; in French). The first part included data about the interviewed herbalist (sex, age, family situation, level of study), and the second part was dedicated to the collection of data on the plants and their uses, data which were enlarged and deepened in the oral interviews.

The ethnobotanical field work was carried out over a period of 2 years. A total of 120 informants were interviewed during the field work, including 24 herbalists (H) and 28 traditional healers (TH). The surveyed villages were Atar (31 informants; including 7 H and 6 TH), Tawaz (9 informants; 1 H and 1 TH), Ain ehltaya (11 informants; 2 H and 2 TH), Choum (7 informants; 2 H and 2 TH), Aoujeft (13 informants; 2 H and 2 TH), El Medah (7 informants; 1 H and 3 TH), Maeden (5 informants; 1 H and 1 TH), N'terguent (10 informants; 1 H and 3 TH), Chinguitti (9 informants; 1 H and 3 TH), Ain savra (8 informants; 2 H and 1 TH) and Ouadane (10 informants; 4 H and 4 TH). Our interviewees were native from different localities of Adrar, mainly from Atar, Awjeft, Chinguetti and Ouadane.

Subsequently, plant samples were identified at the Laboratory of the École Normale Supérieure-ENS of Nouakchott, Mauritania, and voucher specimens were prepared and conserved in its herbarium (international herbarium code HNM; for all non-cultivated species). For plant identification, we used the Flora of Mauritania (Barry and Celles, 1991) and, as suggested by Rivera et al. (2014), all scientific names were reviewed using a standardised database (www.theplantlist.org, Version 1.1) and Dobignard and Chatelain (2010–2013); some important synonyms were included. In a final fieldwork phase, to complete or check the data and, in some cases, to clearly state the correlation of vernacular and scientific names, a part of the plant or a whole plant was shown again in certain cases to our previous interviewees. They were asked if they recognised it and if they knew vernacular name, medicinal use, parts used, preparation methods, mode of administration, etc., as described in Merzouki et al. (1997, 2000). For each plant sample, a specific code was given (e.g. "HNM00001", as the international herbarium code for this herbarium is HNM). Vernacular names were included as they were

Table 1
Medicinal plants with families, voucher, local names, traditional use (with ICPC-2 code), similar previous references in nearby territories and use reports. For Al-Baytar, we consulted both Al-Baytar (1992) and Leclerc (1877–1883).

Family	Species (Vouchers)	Local Names	Diseases treated	Part used	Mode of preparation	Mode of administration	Similar use references	UR
Alliaceae	*Allium cepa* L.	لبصل Lebṣal	Back symptom L02	Bulbs	Cooked with sheep fat	Cataplasm	Bellakhdar (1997)	10
			Skin injury S19	Bulbs	Mashed with sheep fat	Cataplasm	–	7
			Musculoskeletal disease L99	Bulbs	Cooked with sheep fat	Cataplasm	Bellakhdar (1997)	3
			Worms D96	Bulbs	Macerated in water and mixed with honey	Oral	–	4
	Allium sativum L.	الثوم Thoum	Worms D96	Bulbs	Mashed and mixed with honey	Oral	–	3
			Loss of appetite T03	Bulbs	Decoction	Oral	–	3
			Skin injury S19	Bulbs	Mashed	Cataplasm	Bellakhdar (1997)	4
Apiaceae	*Ammodaucus leucotrichus* Coss. & Durieu	الكمون kemmoun	Asthma R96	Seeds	Infusion	Oral	Fakchich and Elarouchi (2014)	3
			Intoxication A86	Seeds	Infusion	Oral	–	2
			Acne S96	Seeds	Powder with water	Cataplasm	–	3
			Skin injury S19	Seeds	Powder	Cataplasm	–	2
			Measles A71	Seeds	Powder with water	Cataplasm	–	4
Apocynaceae	*Adenium obesum* (Forssk.) Roem.& Schult.(HNM00006)	اتويديمت الذيب Twydymet dhyb	Teeth ache D19	Leaves	Powder	Cataplasm	–	3
Apocynaceae			Boil S10	Latex	Extraction	Cataplasm	Leriche, 1954	4
	Calotropis procera (Aiton) Dryand. (HNM01522)	تورجة Tourjah	Whooping cough R71	Leaves	Powder mixed with honey	Oral	Al-Baytar, Malik et al., 2015; Fasola et al. (2004)	3
			Pain respiratory system R01	Woods	Powder mixed with olive oil	Massage	Ghulam et al. (2015); Bahadur et al., 2018	15
			Teeth ache D19	Latex	Extraction	Cataplasm	–	3
Apocynaceae	*Leptadenia pyrotechnica* (Forssk). Decne (HNM01919)	تيتارك Tytaryk	Abdominal pain epigastric D02	Stems	Mashed with fruits of *Phoenix dactylifera* and water	Oral	Malik et al. (2015)	16
			Diarrhoea D11	Stems	Infusion	Oral	–	8
			Skin colour change S08	Stems	Powder with water	Cataplasm	–	13
Apocynaceae	*Pergularia tomentosa* L. (HNM01532)	ام اجلود Oum-jloud	Skin injury S19	Leaves	Powder	Cataplasm	Bellakhdar (1997)	3
			Foreign body in skin S15	Latex	Extraction	Cataplasm	Bellakhdar (1997)	4
			Teeth ache D19	Latex	Extraction	Cataplasm	Vall (2009)	5
			Boil S10	Latex	Extraction	Cataplasm	Bellakhdar (1997); Hammiche and Meiza (2006)	8
Arecaceae	*Phoenix dactylifera* L.(HNM00008)	انخل Ankhal	Anaemia B81	Fruits	Mixed with gum of *Senegalia senegal* and macered in water	Oral	Vall (2009)	10
			Jaundice D13	Fruits	Fresh	Oral	–	4
			Abdominal pain epigastric D02	Fruits	Fresh	Oral	–	5
			Constipation D12	Fruits	Fresh	Oral	Gruca et al., 2015; Vall (2009)	16
			Non insulin dependent diabetes T90	Fruits	Fresh	Oral	Tahraoui et al. (2007)	13
Asteraceae	*Pulicaria undulata* (L.) C.A. Mey. (HNM01168)	الطفصة Tsafsa	Abdominal pain epigastric D02	Leaves	Infusion	Oral	–	6
Bignoniaceae	*Stereospermum kunthianum* Cham. (HNM10013)	فركاكة Ferkakah	Syphilis X70	Leaves	Infusion	Oral	–	3
Boraginaceae	*Heliotropium bacciferum* Forssk. (HNM01425)	لحبالية lḥbaliya	Eye pain F01	Leaves	Juice	Eye drop	–	10
			Burn (S14)	Leaves	Powder with water	Cataplasm	Bellakhdar (1997)	5
Brassicaceae	*Anastatica hierochuntica* L. (HNM01193)	الكمشة Alkemchah	Abdominal pain epigastric D02	Whole plant	Infusion	Oral	–	4
			Non insulin dependent diabetes T90	Whole plant	Maceration	Oral	–	3
			Musculoskeletal disease L99	Whole plant	Infusion	Oral	–	5

(*continued on next page*)

Table 1 (*continued*)

Family	Species (Vouchers)	Local Names	Diseases treated	Part used	Mode of preparation	Mode of administration	Similar use references	UR
Brassicaceae	*Schouwia purpurea* (Forssk.) Schweinf. (HNM00061)	جرجير Jir –jir	Impotence Y07	Leaves	Infusion	Oral	–	10
Burseraceae	*Commiphora africana* (A.Rich.)Endl (HNM00060)	أدرس Address	Breast cancer X76	Gum	Mashed	Cataplasm	–	2
			Constipation D12	Fruits	Fresh	Oral	–	3
			Mouth symptom D20	Rods	Mashed	Oral	Bellakhdar (1997)	3
			Laceration S18	Gum	Mashed mixed with water	Cataplasm	Bellakhdar (1997)	5
			Abdominal pain epigastric D02	Leaves	Infusion	Oral	Fasola et al. (2004)	3
			Teeth ache D19	Gum	Powder	Cataplasm	–	2
Capparaceae	*Boscia senegalensis* Lam. (HNM00988)	ايزن Eyzen	Heartburn D03	Leaves	Powder with water	Oral	–	12
			Non insulin dependent diabetes T90	Fruits	Maceration/powder	Oral	–	20
			Back symptom L02	Leaves	Mashed	Cataplasm	Vall (2009)	19
Capparaceae	*Maerua crassifolia* Forssk. (HNM01452)	اتيل Atil	Asthma R96	Leaves	Powder with gum of *Senegalia senegal*	Oral	–	6
			Teeth ache D19	Leaves	Powder	Cataplasm	Bellakhdar (1997); Rahman et al. (2004); Hammiche and Meiza (2006)	50
			Abdominal pain epigastric D02	Leaves	Infusion	Oral	–	48
			Constipation D12	Fruits	Fresh	Oral	–	26
			Jaundice D13	Fruits	Fresh	Oral	Bellakhdar (1997)	5
			Non insulin dependent diabetes T90	Leaves	Powder with gum of *Senegalia senegal*	Oral	–	5
Capparaceae	*Capparis decidua* (Forssk.) Edgew. (HNM00706)	اكنين Igunin	Fever A03	Roots	Powder with water	Oral	–	59
			Abdominal pain epigastric D02	Fruits	Fresh	Oral	–	34
Capparaceae	*Cleome arabica* L.(HNM01443)	لمخينزة Limkhynzah	Menstrual pain X02	Whole plant	Macerated in milk	Oral	Leriche, 1954	12
			Impotence Y07	Leaves	Infusion	Oral	–	10
			Infertility Y10	Leaves	Infusion	Oral	–	11
			Bronchitis R78	Whole plant	Decoction	Oral	–	6
Celastraceae	*Gymnosporia senegalensis* (Lam.)Loes. (Syn. *Maytenus senegalensis* (Lam.) Exell)(HNM01466)	ايش Aych	Viral hepatitis D72	Seeds	Infusion	Oral	–	10
			Jaundice D13	Leaves	Infusion	Oral	–	10
			Non insulin dependent diabetes T90	Leaves	Infusion	Oral	–	4
Combretaceae	*Combretum aculeatum* Vent. (HNM02328)	إكيك Ikyk	Diarrhoea D11	Leaves	Mached	Oral	Kankara et al. (2015)	3
			Worms D96	Leaves	Powder with water	Oral	–	3
Combretaceae	*Combretum glutinosum* Perr. ex DC. (HNM00134)	تيكفيت Tykefyt	Non insulin dependent diabetes T90	Leaves	Powder with water	Oral	Holaly et al. (2018)	27
			Abdominal pain epigastric D02	Leaves	Powder with gum of *Senegalia senegal* and sugar	Oral	–	25
			Diarrhoea D11	Leaves	Powder with gum of *Senegalia senegal* and sugar	Oral	–	18
			Teeth ache D19	Leaves	Fresh	Oral	Vall (2009)	11
Combretaceae	*Guiera senegalensis* J.F.Gmel. (HNM01400)	اللينة Alleynah	Diarrhoea D11	Leaves	Mached	Oral	–	6
			Asthma R96	Leaves	Decoction	Oral	–	4
			Cough R05	Leaves	Decoction	Oral	–	3

(*continued on next page*)

Table 1 (*continued*)

Family	Species (Vouchers)	Local Names	Diseases treated	Part used	Mode of preparation	Mode of administration	Similar use references	UR
Cucurbitaceae	*Citrullus colocynthis* (L.) Schrad. (HNM02009)	حدج لحمار Hdaj-lehmar	Non insulin dependent diabetes T90	Seeds of fruits	Fresh with water	Oral	Bellakhdar (1997); Malik et al. (2015); Eddouks et al., 2017; Fakchich and Elachouri (2014); Ghulam et al. (2015); Aziz et al. (2012); Ahmad et al., 2017; Vall (2009); Hammiche and Meiza (2006)	11
			Skin injury S19	Fruits	Fresh	Cataplasm	–	10
Cucurbitaceae	*Citrullus lanatus* (Thunb.) Matsum. & Nakai(HNM00138)	دلاح Dallah	Constipation D12	Fruits	Fresh	Oral	Bahassan et al., 2014; Vall (2009)	10
Cucurbitaceae	*Cucumis prophetarum* L.(HNM00190)	تكسراريت Tagasraryt	Abdominal pain epigastric D02	Fruits	Powder with sugar	Oral	Leriche, 1954; Vall (2009)	11
			Diarrhoea D11	Fruits	Powder with water	Oral	–	8
			Worms D96	Fruits	Powder/infusion	Oral	–	5
			Cough R05	Fruits	Infusion with milk	Oral	–	3
Cucurbitaceae	*Momordica balsamina* L.(HNM00194)	تمبهرة Tumbahra	Worms (D96)	Fruits	Powder/maceration	Oral	Vall (2009)	4
Euphorbiaceae	*Euphorbia balsamifera* Aiton (HNM00623)	افرنان Afarnan	Rash localized S06	Latex	Extracted mixed with oil	Cataplasm	Bellakhdar (1997)	5
			Scabies S72	Latex	Extraction	Cataplasm	–	3
Euphorbiaceae	*Euphorbia calyptrata* Coss. & Kralik (HNM00254)	الرمادة El -ramadah	Bronchitis R78	Leaves	Infusion	Oral	–	3
Euphorbiaceae	*Euphorbia scordiifolia* Jacq. (HNM01120)	ام البينة Oumlbina	Skin injury S19	Leaves	Powder	Cataplasm	–	33
			Constipation D12	Leaves	Powder with milk	Oral	Rahman et al. (2004); Vall (2009)	9
Fabaceae	*Acacia ehrenbergiana* Hayne (HNM01592)	تمات Tamat	Abdominal pain epigastric D02	Leaves	Powder with milk	Oral	–	5
			Eye pain F01	Gum	Powder with water	Eye drop	–	11
			Dyspepsia D07	Leaves	Infusion	Oral	–	3
			Diarrhoea D11	Leaves	Maceration	Oral	Bellakhdar (1997)	2
Fabaceae	*Acacia senegal* (L.) Willd. (Syn. *Senegalia senegal* (L.) Britton) (HNM00320)	اوروار Awerwar	Abdominal pain epigastric D02	Leaves	Powder with milk	Oral	Bahassan et al. (2014); Kankara et al., 2015; Hammiche and Meiza (2006)	30
			Skin injury S19	Gum	Powder with water	Cataplasm	–	11
			Heartburn D03	Gum	Powder with sugar mixed with water	Oral	–	14
Fabaceae	*Arachis hypogaea* L. (HNM00261)	كرتة Gertah	Jaundice D13	Seeds	Mashed and mixted with water	Oral	–	21
			Skin injury S19	Seeds	Mashed	Cataplasm	–	25
			Rash localized S06	Seeds	Mashed	Cataplasm	–	10
			Non insulin dependent diabetes T90	Seeds	Infusion	Oral	–	15
Fabaceae	*Bauhinia rufescens* Lam.(HNM01550)	ندرن N'dern	Diarrhoea D11	Leaves	Powder with water	Oral	Vall (2009)	3
			Mouth symptom D20	Leaves	Powder with water	Gargle	–	5
Fabaceae	*Cullen plicatum* (Delile) C.H. Stirt. (HNM01983)	تاطرارت Tatrarit	Constipation (D12)	Leaves	Powder/infusion	Oral	Vall (2009)	9
			Heartburn D03	Seeds	Fresh	Oral	Bellakhdar (1997)	7
			Abdominal pain epigastric D02	Seeds	Fresh	Oral	Bellakhdar (1997)	5
			Bronchitis R78	Leaves	Infusion	Oral	Bellakhdar (1997)	3
	Kebirita roudairei (Bonnet). Kramina & D. D. Sokoloff(HNM00299)	اكبيدت الظب Kbydit-dhab	Abdominal pain epigastric D02	Leaves	Powder with water	Oral	–	3
Fabaceae			Breathing problem R04	Stems	Fumigation	Inhalation	–	4
Fabaceae	*Prosopis juliflora* (Sw.) DC.	كرون لمحادة Groun-lymhada	Fever A03	Leaves	Powder with water	Oral	–	3
			Abdominal pain epigastric D02	Leaves	Maceration	Oral	–	4
			Muscle pain L18	Leaves	Powder	Cataplasm	Ghulam et al. (2015)	4

(*continued on next page*)

Table 1 (*continued*)

Family	Species (Vouchers)	Local Names	Diseases treated	Part used	Mode of preparation	Mode of administration	Similar use references	UR
Fabaceae	*Senna italica* Mill.(HNM01562)	فلجيط Valajyt	Constipation D12	Leaves	Mashed	Oral	Bahassan et al. (2014); Vall (2009); Malik et al. (2015)	25
			Abdominal pain epigastric D02	Leaves	Powder/maceration	Oral	Eddouks et al., 2017	16
			Skin colour change S08	Leaves	Powder	Cataplasm	–	11
Fabaceae	*Senna occidentalis* (L.) Link (HNM01570)	سرسار Sar'sar	Worms D96	Leaves	Powder/maceration	Oral	–	4
Fabaceae	*Tamarindus indica* L. (HNM00116)	اكنات Aganat	Vomiting D10	Fruits	Macerated mixed with sugar	Oral	Al-Baytar	20
			Headache N01	Fruits	Macerated mixed with gum of *Senegalia senegal*	Oral	–	10
Fabaceae	*Vachellia nilotica* (L.) P.J.H.Hurer & Mabb. (HNM00614)	امور Amour	Eye pain F01	Leaves	Juice	Eye drop	Malik et al. (2015)	13
			Haemorrhoids K96	Pods	Powder/maceration	Oral	–	15
			Skin injury S19	Pods	Powder	Cataplasm	–	17
Fabaceae	*Vachellia tortilis* (Forssk.) Galasso & Banfi. (HNM00620)	الطلح Talh	Abdominal pain epigastric D02	Leaves	Powder/maceration	Oral	Bellakhdar (1997)	98
			Diarrhoea D11	Leaves	Powder	Oral	Bellakhdar (1997); Hammiche and Meiza (2006)	111
			hypertension K86	Bark	Mashed/macered	Oral	–	45
Fabaceae	*Vigna unguiculata* (L.) Walp. (HNM00252)	آدلكان Adlagan	Anaemia B81	Seeds	Cooked	Oral	Vall (2009)	8
			Jaundice D13	Seeds	Infusion	Oral	–	7
			Cough R05	Seeds	Infusion	Oral	Al-Baytar	3
Fabaceae	*Vachellia seyal* (Delile) P.J.H.Hurter. (HNM01584)	صدرة بيظة Sadra beydha	Abdominal pain epigastric D02	Bark	Infusion	Oral	Al-Baytar	30
			Worms D96	Leaves	Powder with sugar and arabic gum mixted whit water	Oral	–	10
			Menstrual pain X02	Bark	Powder/infusion	Oral	–	5
Lamiaceae	*Mentha spicata* L.	النعناع Naana	Vomiting D10	Leaves	Decoction	Oral	Al-Baytar	12
			Teeth ache D19	Leaves	Mashed	Oral	Al-Baytar	4
			Dyspepsia D07	Leaves	Decoction	Oral	–	3
			Hypertension K86	Leaves	Decoction	Oral	Tahraoui et al. (2007); Hendel et al. (2012)	3
Lamiaceae	*Ocimum basilicum* L. (HNM01553)	لحبق Lhbaq	Non insulin dependent diabetes T90	Leaves	Decoction	oral	Holaly et al. (2018)	7
			Asthma R96	Leaves	Infusion	Oral	Ghulam et al. (2015)	11
Loranthaceae	*Tapinanthus globiferus* (A. Rich.) Tiegh.(HNM00626)	عرش اعلندة Arsh-alanda	Dysuria U01	Leaves	Powder/maceration	Oral	–	4
Lythraceae	*Lawsonia inermis* L. (HNM00344)	الحنة Al-hanna	Headache N01	Leaves	Powder/maceration	Cataplasm	Bellakhdar (1997)	11
			Jaundice D13	Leaves	Powder with water	Oral	Ahmad et al., 2017; Vall (2009)	6
			Burn S14	Leaves	Powder	Cataplasm	–	18
	Adansonia digitata L.(HNM01538)	التيدوم Teydoum	Diarrhoea D11	Leaves	Powder with water	Oral	Kankara et al. (2015); Vall (2009)	40
Malvaceae			Hypertension uncomplicated K86	Fruits	Powder with sugar	Oral	–	89
			Abdominal pain epigastric D02	Leaves	Powder with sugar	Oral	Leriche, 1954	80
Malvaceae	*Hibiscus sabdariffa* L. (HNM00351)	بصام Byssam	Abdominal pain epigastric D02	Flowers	Decoction	Oral	–	7
			Cough R05	Flowers	Decoction	Oral	–	12
Malvaceae	*Grewia damine* Gaertn.(Syn. *Grewia bicolor* Juss.)(HNM01752)	امجيج Imijyj	Malaria A73	Leaves	Decoction	Body lotion	Vall (2009)	11
			Diarrhoea D11	Seeds	Fresh with water	Oral	–	9
Malvaceae	*Sterculia setigera* Del. (HNM01741)	بافريوة Bav-rywa	Cough R05	Leaves	Powder/infusion	Oral	Vall (2009)	5
Meliaceae	*Azadirachta indica* A.Juss.	كنين Quinin	Malaria A73	Leaves	Powder with water	Body lotion	Hilonga et al., 2018; Kankara et al. (2015); Vall (2009)	3
Poaceae	*Hordeum vulgare* L.	اشعير Sha-yr	Viral hepatitis D72	Seeds	Infusion	Oral	Vall (2009)	6
			Jaundice D13	Seeds	Infusion	Oral	Malik et al. (2015); Bahadur et al., 2018	5
			Non insulin dependent diabetes T90	Seeds	Powder	Oral	Malik et al. (2015); Fakchich and Elachouri (2014)	6

(*continued on next page*)

Table 1 (*continued*)

Family	Species (Vouchers)	Local Names	Diseases treated	Part used	Mode of preparation	Mode of administration	Similar use references	UR
Poaceae	*Cenchrus americanus* (L.) Morrone (HNM00437)	متري Mutry	Breathing problem R04	Seeds	Mashed and mixed with water	Oral	–	7
			Rash localized S06	Seeds	Mashed	Cataplasm	–	8
Poaceae	*Panicum turgidum* Forrsk. (HNM01331)	ام ركبة Oum-rekba	Constipation D12	Stems	Infusion	Oral	Hammiche and Meiza (2006)	9
			Jaundice D13	Seeds	Powder	Oral	–	8
Poaceae	*Sorghum bicolor* (L.) Moench. (HNM00441)	زرع Zraa	Viral hepatitis D72	Seeds	Infusion	Oral	Vall (2009)	17
			Abdominal pain epigastric D02	Seeds	Maceration	Oral	–	15
Poaceae	*Stipagrostis pungens*(Desf.)DeWinter (HNM01285)	صبط Sbat	Dysuria U01	Thactch	Powder whit water	Oral	–	17
Poaceae	*Triticum aestivum* L.	الكمح AlGhamih	Diarrhoea D11	Seeds	Powder/infusion	Oral	Fakchich and Elaouchi (2014); Bahassan et al. (2014)	3
Poaceae	*Zea mays* L.	مكة Mekkah	Abdominal pain epigastric D02	Seeds	Infusion	Oral	–	9
Rhamnaceae	*Ziziphus mauritiana* Lam.(HNM01711)	سدر لهبيل Sdar-lahbyl	Abdominal pain epigastric D02	Leaves	Fresh	Oral	Miara et al. (2019)	3
			Fever A03	Leaves	Macered whit water	Body lotion	Ahmad et al., 2017	2
			Hypertension (K86)	Leaves	Powder/maceration	Oral	Vall (2009)	2
			Non insulin dependent diabetes T90	Leaves	Infusion	Oral	–	3
Rhamnaceae	*Ziziphus lotus* (L). Lam.(HNM01705)	سدر هريتك Sdar-hreytek	Abdominal pain epigastric D02	Leaves	Mashed	Oral	Eddouks et al., 2017	35
			Fever A03	Leaves	Macerated whit water	Body lotion	Hammiche and Meiza (2006)	27
			Hypertension K86	Leaves	Powder/maceration	Oral	Miara et al. (2013); Chermat and Gharzouli (2015)	7
			Non insulin dependent diabetes T90	Leaves	Infusion	Oral	Bellakhdar (1997); Aziz et al. (2012); Tahraoui et al., 2007; Hammiche and Meiza (2006)	12
			Skin injury S19	Leaves	Powder	Cataplasm	Bellakhdar (1997)	6
			Teeth ache D19	Leaves	Mashed	Oral	–	5
			Kidney symptom U14	Fruits	Powder	Oral	Fakchich and Elaouchi (2014)	11
Rubiaceae	*Mitragyna inermis* (Willd.) Kuntze (HNM00526)	اكلال Aglal	Complications of puerperium W96	Leaves	Decoction	Oral	–	3
Salvadoraceae	*Salvadora persica* L. (HNM01729)	إفرشي Ivar-shy	Anaemia B81	Leaves	Infusion	Oral	Vall (2009)	2
			Malaria A73	Leaves	Mashed/macerated	Body lotion	–	2
			Fever A03	Leaves	Mashed/macerated	Body lotion	Ghulam et al. (2015); Fasola et al. (2004); Vall (2009); Hammiche and Meiza, 2006	3
Solanaceae	*Hyoscyamus muticus* L. (HNM01745)	لبثيمة Lebtheyma	Skin injury S19	Leaves	Powder with water	Cataplasm	–	3
Tamaricaceae	*Tamarix senegalensis* DC. (HNM00859)	الطرفة Tarva	Constipation D12	Stems	Mashed	Oral	–	6
	Balanites aegyptiaca (L.) Delile (HNM00634)	تيشط Teyshyt	Abdominal pain epigastric D02	Leaves	Infusion	Oral	Hilonga et al., 2018; Kankara et al. (2015)	120
Zygophyllaceae			Non insulin dependent diabetes T90	Fruits	Macerated with water/ fresh	Oral	Vall (2009); Hammiche and Meiza (2006)	101
			Skin disease S99	Fruits	Powder with animal oil	Cataplasm	Hammiche and Meiza (2006)	57
Zygophyllaceae	*Fagonia glutinosa* Delile (HNM00609)	اطليحة Tly-ha	Oral abscess D83	Leaves	Powder/infusion	Oral	–	3
			Teeth ache D19	Leaves	Mashed	Oral	–	4
Zygophyllaceae	*Tribulus terrestris* L. (HNM00973)	تمكلصت Tymo-glyst	Teeth ache D19	Leaves	Mashed	Oral	–	3

referred to by our informants in both Arabic and Roman alphabets. For the transliteration of the vernacular names from Arabic into the Roman alphabet, we followed Bellakhdar (1997). For families of flowering plants, we followed the APGIV system (Stevens, 2019). The treated diseases were classified according to the international classifications of diseases (ICPC-2, International Classification of Primary Care, 2015) of the WHO (as suggested by Staub et al., 2015).

2.3. Citation in previous manuscripts

With the aim to analyse the use of medicinal plants through time and across civilisations (Arabo-Islamic, African-Sahel), we performed a comparative study of the medicinal plants and their uses in our study area, based on previous references. The Adrar region contains two historic cities, Chinguitti and Ouadane, and, over time, many convoys from neighbouring Islamic countries have enabled the sharing and exchange of cultural knowledge in this region, while the south of the country was influenced by the culture of African-Sahel origin. This study was therefore performed through previous ethnobotanical researches in Mauritania (Leriche, 1953; Vall, 2009), Morocco (Bellakhdar, 1997; Tahraoui et al., 2007; Rahman et al., 2004; Fakchich and Elachouri, 2014; Eddouks et al., 2002, 2016), Algeria (Miara et al., 2019; Chermat and Gharzouli, 2015; Hendel et al., 2012; Hammiche and Maiza, 2006) or in territories with a similar climate and flora, such as Yemen (Bahassan et al., 2014), Nigeria (Fasola et al., 2004) or Pakistan (Ghulam et al., 2015; Ahmad et al., 2018). We also consulted an important historical text, the *Compendium of Simple Medicaments and Foods* from Ibn Al-Baytar, using a modern Arabic transcription (Al-Baytar, 1992) and the French translation from Leclerc (1877–1883), written in the 13th century (see El Gharbaoui et al., 2017 for more details).

2.4. Data analysis

With the gathered information, we developed a database on Microsoft Access and Microsoft Excel. The consistency of the information was checked according to the data comparison technique of El Gharbaoui et al. (2017); the information of medicinal uses was considered coherent when it was reported at least twice, in two different localities, and by at least two different informants. In this study, only coherent information was integrated into our database.

As suggested by Weckerle et al. (2018), we only reported primary data in our results, with the total numbers of use reports (UR).

3. Results and discussion

The ethnobotanical fieldwork allowed to gather information on 68 plant species (in 57 genera) and from 27 different botanical families (Table 1). The distribution within botanical families can be consulted in Fig. 3, highlighting Fabaceae (14 species, 20.5%), as in other ethnobotanical researches in Africa (e.g. Naceiri Mrabti et al., 2019; Inngjerdingen et al., 2004). We also highlight the families Poaceae (seven species; 10%), Malvaceae, Capparaceae and Cucurbitaceae (four species each; 6%). In fact, the total amount of species in these five families accounted for 48% of the total species. The dominance of Fabaceae is related to ecological factors: the most diverse families in Mauritania are Poaceae (190 species) and Fabaceae (128 species; Barry and Celles, 1991). Similar results for the most used botanical families have been reported by Vall et al. (2015), Bibi et al. (2015) or Hilonga et al. (2019), but not in other studies focusing on the Mediterranean region (e.g. Merzouki et al., 1997, 2000; Gonzalez-Tejero et al., 2008; El-Gharbaoui, 2017; Gras et al., 2017), where Asteraceae and Lamiaceae were the most important families (Benítez et al., 2010; Martínez-Lirola et al., 1997; Fernández, 2000; Verde, 2002; Tahraoui et al., 2007; Fakchich and Elachouri, 2014). Nevertheless, considering the proportion of medicinal species from this research (Table 2) and the total number of species in the Mauritanian flora per family, Rhamnaceae, Combretaceae, Cucurbitaceae and Apocynaceae stand out (with 50, 42.9, 36.4 and 28.6% of the total flora reported as medicinal in Adrar; Fig. 2).

Table 2
Conditions and pathological groups with number of species and UR.

P.G.	Health conditions/symptoms	SP	UR
A	Fever	5	94
A	Intoxication	1	2
A	Malaria	3	16
A	Measles	1	4
B	Anaemia	3	20
D	Abdominal pain epigastric	24	612
D	Constipation	9	113
D	Diarrhoea	11	211
D	Dyspepsia	2	6
D	Heartburn	3	33
D	Jaundice	8	66
D	Mouth symptom	2	8
D	Oral abscess	1	3
D	Teeth ache	10	90
D	Viral hepatitis	3	33
D	Vomiting	2	32
D	Worms	7	33
F	Eye pain	3	34
K	Haemorrhoids	1	15
K	Hypertension	5	146
L	Back symptom	2	29
L	Muscle pain	1	4
L	Musculoskeletal disease	2	8
N	Headache	2	21
R	Asthma	4	24
R	Breathing problem	2	11
R	Bronchitis	3	12
R	Cough	5	26
R	Pain respiratory system	1	15
R	Whooping cough	1	3
S	Acne	1	3
S	Boil	2	12
S	Burn	2	23
S	Foreign body in skin	1	4
S	Laceration	1	5
S	Rash localized	3	23
S	Scabies	1	3
S	Skin colour change	2	24
S	Skin disease	1	57
S	Skin injury	11	121
T	Non-insulin dependent diabetes	13	227
T	Loss of appetite	1	3
U	Dysuria	2	21
U	Kidney symptom	1	11
W	Complications of puerperium	1	3
X	Breast cancer	1	2
X	Menstrual pain	2	17
X	Syphilis in women	1	3
Y	Impotence	2	20
Y	Infertility	1	11
	TOTAL	**177**	**2317**

A total of 177 medicinal uses have been reported for the included plants. These species are used to treat up to 50 conditions, classified into 14 pathological groups (Table 2). We collected 2317 use reports, with an average of 13 UR for each use.

The main features to describe our informants (gender, age, ethnic group and education level) can be consulted in Table 3. We highlight that more than half of our respondents were female, nearly half of them were over 50 years old, and most belonged to the Maures ethnic group; nearly one quarter were illiterate.

In our experience, in the territory of Mauritania, knowledge on the traditional pharmacopoeia, is mostly conserved by traditional healers and inherited by their descendants. However, on the other hand, during our field ethnobotanical survey, we observed that traditional healing is also being practiced by inexperienced healers, which may lead to an

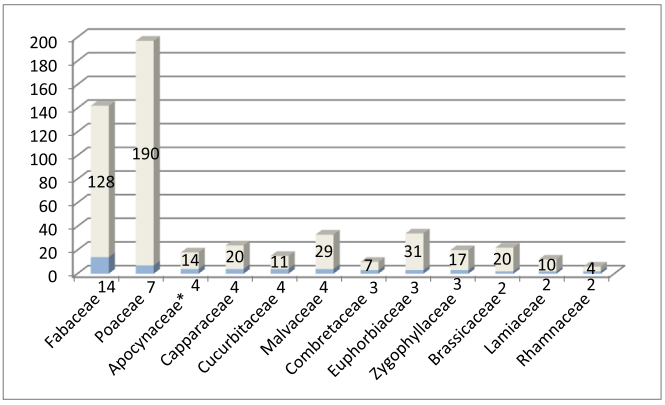

Fig. 2. Number of total species per botanical family in Mauritania (according to Barry and Celles, 1991; boxes in grey) and number of medicinal species in Adrar (below the line, boxes in blue).* Apocynaceae includes the former Asclepiadaceae.

Table 3
Demographic and socio-cultural variables of our interviewees.

Variables	Items	n	%
Gender	Male	50	41.67
	Female	**70**	**58.33**
Age classes	20 to 30	10	08.33
	30 to 40	25	20.83
	40 to 50	**30**	**25.00**
	50 to 60	26	21.66
	60 to 70	19	15.83
	More than70	10	08.33
Ethnic groups	**Maures**	**110**	**91.67**
	Peuls	10	08.33
Education levels	Illiterate	28	23.33
	Elementary	**30**	**25.00**
	Secondary	27	22.50
	University	20	16.67
	Others	15	12.50

alteration in knowledge transmission, changing some practices, used plants or parts thereof, and even potentially endangering the conservation of this invaluable knowledge, thereby decreasing the quality perception of this traditional medicine. As in several parts of the world (Ladio and Lozada, 2009; Langås-Larsen et al., 2017; Bruschi et al., 2019), in Mauritania, this knowledge is particularly important within particular families which have owned, practiced and transmitted it for several generations.

3.1. Used plants, specificity and polyvalence

Most of the included plants were gathered from the wild (56, 82.5%), while some cultivated plants were also used for medicinal purposes, such us garlic, onion, basil, melon, peanut, mint, cowpea (*Vigna unguiculata* (L.) Walp), some cereals such as wheat, barley, sorghum and maize, as well as some others, which, apart from being cultivated, also exist in the wild (such as the date palm). *Senna occidentalis* (L.) Link is also cultivated as a medicinal plant. The most cited plants were *Balanites aegyptiaca* (L.) Delile (used for three health conditions and with 278 UR), *Vachellia tortilis* (Forssk.) Galasso & Banfi. (three conditions and 254 UR) and the baobab (locally named *Teydoum*) *Adansonia digitata* L. (three conditions and 209 UR). These three species also showed a high consensus considering both the high number of UR and the low number of health conditions they are used for. Although have a high UR, but with a lower consensus due to a higher number of conditions treated, we can mention *Maerua crassifolia* Forssk. and *Acacia senegal* (L.) Willd. (six conditions each and 140 and 110 UR, respectively).

Of the 68 plant species, 50 have more than one traditional medicinal use. In terms of polyvalence, the species which is used for a higher number of conditions is *Ziziphus lotus* (L.) Lam., (seven conditions from six pathological groups: abdominal epigastric pain, fever, hypertension, non-insulin dependent diabetes, skin injury, toothache and kidney symptoms from groups D, T, S, K, A and U, see Table 1). The traditional use for this species has been highlighted in previous studies (Bellakhdar et al., 1991; Barrera et al., 2007), as well as its economic and socio-cultural value (FAO, 2010), and its potential benefits and phytochemicals have already been surveyed (Abdoul-Azize, 2016). *Commiphora africana* (A.Rich.) Endl. and *Maerua crassifolia* can also be considered as polyvalent, as they are locally used to treat six conditions from three pathological groups. The polyvalence of the genus *Ziziphus* is also seen in the other included species, the Saharan endemic *Z. mauritiana* Lam., used for four conditions, but each one in one pathologic group. Its use against hypertension has already been ethnopharmacologically assessed (Ba, 2005), as well as that of other species of this genus (Mohebbati et al., 2018). On the other hand, for 18 species, only one medicinal use was mentioned, and they can be considered to have a specific medicinal use in this region (see Table 1).

3.2. Used parts and modes of preparation and administration

Generally, the plant parts most frequently use are the leaves (51% of total cases), seeds (17%) and fruits (8%). Fig. 3 reflects the proportions of these parts and the methods of preparation. These results are similar to those reported for the entire country by Vall (2009).

In most cases, the harvested organs undergo various preparations prior to application (see also Fig. 3). Among the most common methods of preparation is powdering (69 cases), followed by infusion (39 cases) and mashing (25), while other methods (fresh intake, maceration, decoction, extraction, etc.) are less frequent. The largest proportion of remedies prepared as powder in the present study is not in concordance with some other researches in nearby territories (e.g. Miara et al., 2013,

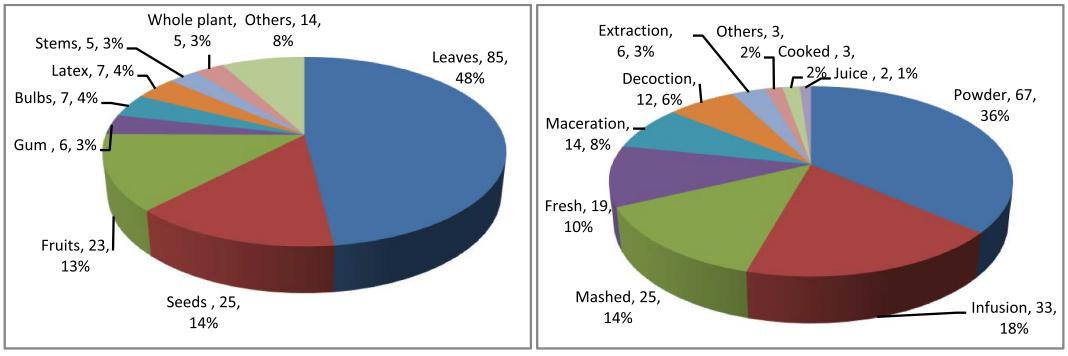

Fig. 3. Distribution of the parts of the plant used (right) and modes of preparation (left).

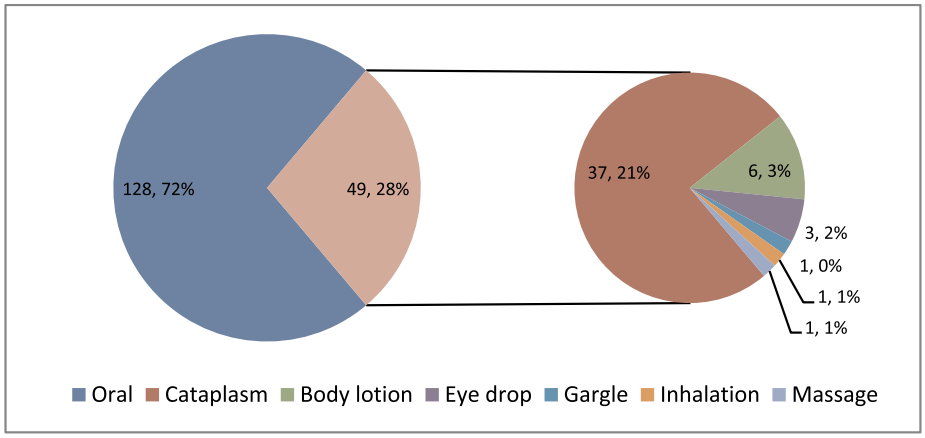

Fig. 4. Modes of administration. In blue, internal application; in pink, external, with subcategories in the small circle.

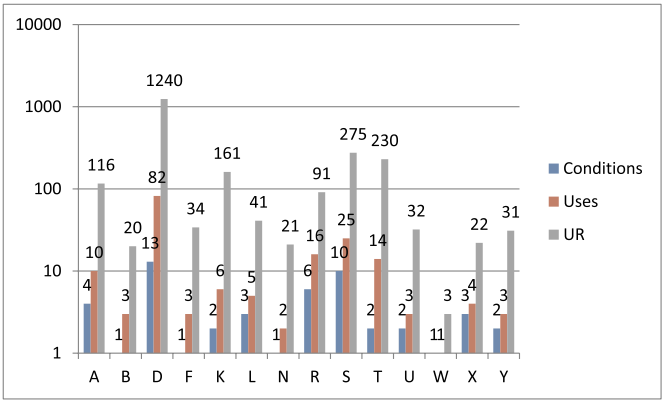

Fig. 5. Number of conditions, uses and UR per pathological group. Note the logarithmic scale.

2019; Togola et al., 2005; Eddouks et al., 2016), which reported the dominance of other modes of preparation, such as decoction. Nevertheless, similar results have been reported by Inngjerdingen et al. (2004) for Mali, Fakchich and Elachouri (2014) for oriental Morocco or Bibi et al. (2015) and Ghulam et al. (2015) for Pakistan. In our case, the majority of our informants indicated that powder is easily prepared and has the advantage that it has a minor risk of contamination compared to juices or infusions and decoctions.

With respect to the administration form, the oral route is the most frequent one (73%). Among the external administrations, the main one is cataplasm (20%), generally prepared with the powder obtained from the leaves (Fig. 4). The people of Adrar use leaf powder because they assume that the probability of contamination is lower compared with other methods, but also because the area is a desert, with a shortage of potable water. The oral route is the most used one as a mode of administration, since digestive diseases are the main treated affections.

3.3. Conditions, symptoms and pathological groups

As mentioned, the included plants are locally used to treat 50 conditions, classified in 14 pathological groups according to the ICPC-2 classification of diseases (Table 2). The most cited condition was abdominal epigastric pain, for which up to 25 plant-based remedies can be used in the study area (642 UR). Also, a high number of remedies and use reports were achieved for non-insulin-dependent diabetes (13 species and 227 UR) and diarrhoea (11 species and 211 UR). Nevertheless, hypertension is worth mentioning, with 146 UR for only five species. For 18 diseases, only one species has been reported (Table 2).

The main pathological group treated is that of digestive symptoms (D, with 1284 UR, 54% of the total cases; Fig. 5), where 13 conditions were mentioned and for which 49 plants can be used. As several ethnopharmacological studies have pointed out (e.g. in nearby territories Benítez, 2009; González-Tejero et al., 2008; Merzouki et al., 2000; Hammiche and Maiza, 2006), this situation is the most typical one, mainly because digestive-associated problems are frequent and not medically important (i.e. not complicated and frequently fleeting). In our study, this is because it is the group with the higher number of conditions cited in our interviews, with a high number of UR (abdominal pain, diarrhoea, toothache and constipation) and with a high prevalence in the studied area; also, these conditions can be threatened with a high number of local resources (Table 2). This high UR for digestive disorders can also be explained by the lack of domestic hygiene in some houses and the frequent consumption of non-treated water from wells. Skin symptoms (S, 286 UR, 12%) are also important in this territory, including 10 different conditions and 26 medicinal uses for their treatment.

It is worth mentioning that some frequent conditions which are usually treated by pharmaceutical drugs are treated in this region with plant remedies, which also have a high popularity. This is the case for non-insulin dependent diabetes, fever or hypertension, with high UR.

The highest use reports were obtained for *Balanites aegyptiaca* (278), *Vachellia tortilis* (254) and *Adansonia digitata* (209), most likely because all these plants are common and frequently used in the area: edible fruits from *B. aegyptiaca* and *A. digitata* are the ones most frequently sold at local markets, and *V. tortilis* timber is mainly used for furniture. We also found high UR for *Maerua crassifolia* (140) and *Ziziphus lotus* (103).

3.4. Bibliographical comparison

By comparing our data with existing bibliographical data concerning the traditional uses of plants in Mauritania and neighbouring territories, we found that 81 of the included uses (45% of total) have previously been reported, with 121 previous citations. Among these, 25 were made by Vall (2009) and 22 by Bellakhdar (1997), as these studies focused on all territories of Mauritania and Morocco. We also found a large number of citations for other arid regions such as Pakistan (Malik et al., 2015, with six coincidences) or Yemen (Bahassan et al., 2014, with five coincidences). On the contrary, more than half (55%) of the included uses were not found in our bibliographical comparison (although they may have been included in some of the works related in the introduction which are not easily accessible for the scientific community). Considering only the species, 24 of them (35%) were previously cited as medicinal by Vall (2009) and 22 (32%) by Bellakhdar (1997), but for 21 of the included species, any of the local uses have previously been reported in the consulted studies.

Only six uses (of six different included plants) have already been included by Ibn Al-Baytar in his compendium of simple medicaments from the 13th century. This low proportion points to an unknown origin date of the medicinal uses of the flora of north Mauritania which can partly be explained by the fact that Al-Baytar probably never travelled to the studied region, and his knowledge on African medicinal plants was more focused on the Mediterranean northern part than on the Saharan part. It is, however, known that he travelled through North Africa from ancient Al-Andalus to Syria, Anatolia, Palestine and Arabia (Cabo-González, 1997), but his visit to the current Mauritanian territory is not known. Also, his work, as a *compendium*, includes all the previously known medicinal plants, herbals and treatises from the classic antiquity, with mostly European plants, which he updated with his own knowledge during his travels. This can be a reason for the lower coincidence of the uses in his work with Mauritania than, e.g., in northeastern Morocco and eastern Andalusia in Spain (El-Gharbaoui et al., 2017). Nevertheless, the high percentage of uses shared with Morocco (previously cited by Bellakdar, 1997) denotes an important sharing level of both territories, and in particular with the southern part of Morocco and the Sahara, exhibiting a similar flora and a similar culture as northern Mauritania (as explained in the introduction).

While performing this review, we realised that previous studies in Mauritania contained several important mistakes regarding the science of ethnopharmacology. While the need for nomenclatural and taxonomical accuracy has been highlighted several times (Rivera et al., 2014; Bennett and Balick, 2014; Weckerle et al., 2018), some studies lack a critical assessment of the included names. For example, among the few ethnobotanical studies in Mauritania, some (e.g. Vall, 2009; Vall et al., 2011, 2015) contain several taxonomic and nomenclatural mistakes or errors in the abbreviation form of the authorities. Of a minor importance for us are those using not currently accepted names regarding the current placement of the species in a certain genus, sometimes a matter of a personal botanical opinion, or names not considered currently valid (according to the priority) in cases in which two species are currently generally considered to be the same.). Far from criticising these works, we strengthen the need for botanical accuracy, particularly in territories with a well-developed botanical knowledge (even with a Flora; Barry and Celles, 1991) and several useful databases for plant names (such as the African Plant Database, the International Plant Names Index, or Tropicos.org, from the Genève, Kew and Missouri Botanical Gardens, respectively).

4. Conclusions

As stated in the introduction, Mauritania is one of the African countries with few published information on the traditional use of plants, with a clear need for more in-depth ethnobotanical studies.

In our ethnobotanical study conducted in the Adrar province in northern Mauritania, we achieved an interesting data set, including the medicinal traditional use of 68 species belonging to 27 botanical families. Fabaceae and Poaceae were the most used and important families. Local healers and inhabitants use these plants for a high variety of health conditions and symptoms, up to 50 conditions grouped into 14 pathological groups. A high consensus was achieved from the interviews performed with 120 informants, obtaining a total number of use reports of 2317. The most important group, as usual, was that of digestive disorders, for which the highest numbers of species, uses and use reports (55%) were gathered. Most of the herbal remedies are administered orally and mainly prepared as a powder, which is not in concordance with most of the ethnobotanical studies in other territories, but is not uncommon in arid environments where water-based extraction is more susceptible to contamination.

From the bibliographical comparison, we gathered that for 19 of the identified species, none of the local uses have previously been reported, and more than half of the included uses have neither been previously reported in the consulted works.

As commented before, during our fieldwork in the territory, we realised that sometimes, traditional medicine is being practiced by inexperienced healers, and this situation may lead to changes in some practices and used plants as well as in the knowledge transmission in this region. This could also endanger the conservation of this invaluable knowledge, potentially leading to a decrease in the quality of the traditional medicine. In a country with an underdeveloped public health care system, this situation needs to be avoided. In this sense, during our fieldwork, we also tried to sensitise the general public and to valorise the use of medicinal plants. It is of considerable interest for all inhabitants, local healers and government decision-makers to have a good perception of this traditional medicine system. Based on our survey, traditional medicine in Mauritania is still being practised, despite the development of modern medicine. People still use plants in a certain way to treat some health conditions, and there is a group of people with the necessary knowledge and experience. However, and at the same time, we noted that there is no transmission of this knowledge and experience from generation to generation, as young people do not know the plants or their uses. There are well-known families in Mauritania who practice traditional medicine and preserve their inheritance for the coming generations, but they monopolise this knowledge and experience.

Acknowledgments

We would like to thank our interviewees for their time and effort dedicated to our interviews and field trips. We also thank Prof. Abderrazzak Merzouki from the École Polytechnique de Montréal for linguistic review.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jep.2019.112217.

References

Abdoul-Azize, S., 2016. Potential benefits of jujube (Zizyphus Lotus L.) bioactive compounds for nutrition and health. Journal of nutrition and metabolism, 2867470. http://dx.doi.org/10.1155/2016/2867470.

Adam, J.G., 1966. La végétation de l'Aftoutes Saheli (Mauritanie occidentale). Bull. I.F.A.N., Série A 28, 1292–1319.

Adje, M.E.O., 1998. La Phytothérapie en Mauritanie et ses praticiens. Nouakchott, Mauritanie, pp. 182 (In Arabic).

Ahmad, M., Zafar, M., Shahzadi, N., Yaseen, G., Murphey, T.M., Sultana, S., 2018. Ethnobotanical importance of medicinal plants traded in Herbal markets of Rawalpindi- Pakistan. J. Herbal Med. 11, 78–89. https://doi.org/10.1016/j.hermed.2017.10.001.

Amadou, A.B., 2011. Phytothérapie des principales maladies parasitaires rencontrées dans le Fouta en République Islamique de Mauritanie (Thèse Doct. d'Etat). Univ. Cheikh Antadiop. Dakar, pp. 116 (p. Senegal).

Al-Baytar, I.B.N., 1992. Kitab Al-Yami, Li-Mufradat Al-Adwiyawa-L-Aghdiya (Comprehensive Book of Simple Drugs and Foods).Dar Al- Kutub Al -ílmiyah. Beirut, vol. 2. Tomes, pp. 502 pages + 534 pages.

ARSO, 2019. African Standards for African Traditional Medicine, the Role of the TBT Programme. Retrieved online from. http://www.arso-oran.org/african-standards-for-african-traditional-medicine-the-role-of-the-tbt-programme-2/.

Awfa, B.O., 1983. Eléments de médecine Maure Traditionnelle au Trarza. (Mém. Fin d'étude). ENS de Nouakchott, Mauritanie, pp. 103.

Awfa, A.O., 1996. Vingt plantes utilisées en médecine traditionnelle mauritanienne. Nouakchott, Mauritanie. Unpublished work. .

Azzi, R., Djaziri, R., Lahfa, F., Sekkal, F.,Z., Benmehdi, H., Belkacem, N., 2012. Ethnopharmacological survey of medicinal plants used in the traditional treatment of diabetes mellitus in the North Western and South Western Algeria. J. Med. Plants Res. 10, 2041–2050. https://doi.org/10.5897/JMPR11.1796.

Ba, S.H., 2005. Etude de la phytochimie et des activités biologiques de Zizyphus mauritiana Lam (Rhamnaceae) utilisée dans le traitement traditionnel du diabète et de l'hypertension artérielle en Mauritanie. Thèse de Pharmacie FMPOS, 120. Bamako.

Bah, S., Diallo, D., Dembélé, S., Paulsen, B.S., 2006. Ethnopharmacological survey of plants used for the treatment of schistosomiasis in Niono District, Mali. J. Ethnopharmacol. 105 (3), 387–399. https://doi.org/10.1016/j.jep.2005.11.026.

Bahassan, A., Zidane, L., El Yacoubi, H., Rochd, A., 2014. Ethnobotanique et taxonomie des plantes médicinales utilisées pour le traitement des pathologies du système digestif à Hadramaout (Yémen). Phytothérapie 12, 399–416. https://doi.org/10.1007/

s10298-014-0897-8.
Barrera, I., Ron, M.E., Pajaron, S., Sidi Mustapha, R., 2007. Sahara Occidental. Plantas y Usos. Usos y costumbres del pueblo saharaui relacionados con los recursos vegetales. Estudio etnobotánico del Sahara Occidental, vol. 4. Monografías de Botánica Ibérica, pp. 124.
Barry, J.P., Celles, J.C., 1991. Flore de Mauritanie, Tomes 1 et 2. Institut Supérieur Scientifique de Nouakchott/Université de Nice-Sophia-Antipolis, pp. 550.
Bellakhdar, J., 1978. Médecine traditionnelle et toxicologie Ouest-Sahariennes. Rabat, Editions Techniques Nord-Africaines, pp. 365.
Bellakhdar, J., 1997. La pharmacopée Marocaine Traditionnelle. Médecine Arab ancienne et savoirs populaires. Ibis Press.
Bellakhdar, J., Claisse, R., Fleurentin, J., Younos, C., 1991. Repertory of standard herbal drugs in the Moroccan pharmacopoea. J. Ethnopharmacol. 35, 123–143.
Benítez, G., 2009. Etnobotánica y Etnobiología del Poniente Granadino (PhD Thesis). University of Granada, Spain.
Benítez, G., González-Tejero, M.R., Molero Mesa, J., 2010. Pharmaceutical ethnobotany in the western part of Granada province (southern Spain): ethnopharmacological synthesis. J. Ethnopharmacol. 129, 87–105. https://doi.org/10.1016/j.jep.2010.02.016.
Bennett, B.C., Balick, M.J., 2014. Does the name really matter? The importance of botanical nomenclature and plant taxonomy in biomedical research. J. Ethnopharm. 152 (3), 387–392.
Benoit-Vical, F., Soh, P.N., Salery, M., Harguem, L., Poupat, C., Nongonierma, R., 2008. Evaluation of Senegalese plants used in malaria treatment: focus on *Chrozophora senegalensis*. J. Ethnopharmacol. 116 (1), 43–48. https://doi.org/10.1016/j.jep.2007.10.033.
Bibi, T., Ahmed, M., Tareen, N.M., Jabeel, R., Sultan, S., Zafar, M., Zain-ul-Abidin, S., 2015. The endemic medicinal plants of Northern Balochistan, Pakistan and their uses in traditional medicine. J. Ethnopharmacol. 173, 1–10. https://doi.org/10.1016/j.jep.2015.06.050.
Bizimana, N., Tietjen, U., Zessin, K.H., Diallo, D., Djibril, C., Melzig, M.F., Clausen, P.H., 2006. Evaluation of medicinal plants from Mali for their in vitro and in vivo trypanocidal activity. J. Ethnopharmacol. 103 (3), 350–356. https://doi.org/10.1016/j.jep.2005.08.023.
Bonati, A., 1980. Medicinal plants of Madagascar and Senegal: a comment. J. Ethnopharmacol. 2 (1), 91–92. https://doi.org/10.1016/0378-8741(80)90036-7.
Boudet, G., Duverger, E., 1961. Etude des pâturages naturels sahéliens. Le Hodh, Mauritanie. I.E.M.V.T.. Maisons Alfort, pp. 160.
Boulos, L., 1983. Medicinal Plants of North Africa. Référence Publications, Algonac, Inc., Michigan, USA, pp. 286.
Bruschi, P., Sugni, M., Moretti, A., Signorini, M.A., Fico, G., 2019. Children's versus adult's knowledge of medicinal plants: an ethnobotanical study in Tremezzina (Como, Lombardy, Italy). Rev. Bras. Farmacog (in press). https://doi.org/10.1016/j.bjp.2019.04.009.
Burkill, H.M., Dalziel, J.M., Hutchinson, J., 1985. The Useful Plants of West Tropical Africa, vol. 5 Botanic Gardens, Kew.
Cabo-González, A.M., 1997. Ibn al-Baytar et ses apports à la botanique et à la pharmacologie dans le Kitāb al-Ğāmï. Médiévales 33, 23–39.
Chermat, S., Gharzouli, R., 2015. Ethnobotanical study of medicinal flora in the north east of Algeria-an empirical knowledge in djebel zdimm (setif). J. Mater. Sci. Eng. 5, 50–59. https://doi.org/10.17265/2161-6213/2015.1-2.007.
Diarra, N., van'tklooster, C., Togola, A., Diallo, D., Willcox, M., De Jong, J., 2015. Ethnobotanical study of plants used against malaria in Sélingué subdistrict, Mali. J. Ethnopharmacol. 166, 352–360. https://doi.org/10.1016/j.jep.2015.02.054.
Diop, E.A., Queiroz, E.F., Kicka, S., Rudaz, S., Diop, T., Soldati, T., Wolfender, J.L., 2018. Survey on medicinal plants traditionally used in Senegal for the treatment of tuberculosis (TB) and assessment of their antimycobacterial activity. J. Ethnopharmacol. 216, 71–78. https://doi.org/10.1016/j.jep.2017.12.037.
Dobignard, A., Chatelain, C., 2010-2013. Index synonymique de la flore d'Afrique du Nord, vol. 5 Conservatoire et Jardin botaniques, Geneve.
Dubief, P., 1937. Médecine Maure, vol. 20 Bulletin d'étude historique et scientifique de l'AOF.
Eddouks, M., Maghrani, M., Lemhadri, A., Ouahidi, M.L., Jouad, H., 2002. Ethnopharmacological survey of medicinal plants used for the treatment of diabetes mellitus, hypertension and cardiac diseases in the south-east region of Morocco (Tafilalet). J. Ethnopharmacol. 82, 97–103. https://doi.org/10.1016/S0378-8741(02)00164-2.
Eddouks, M., Mohammed, A., Morad, H., 2016. Ethnopharmacological survey of medicinal plants used in daraa- tafilalet region (province of errachidia, Morocco). J. Ethnopharmacol. 198, 516–530. https://doi.org/10.1016/j.jep.
El-Gharbaoui, A., Benítez, G., González-Tejero, M.R., Molero-Mesa, J., Merzouki, A., 2017. Comparison of Lamiaceae medicinal uses in eastern Morocco and eastern Andalusia and in Ibn al-Baytar's Compendium of Simple Medicaments (13th century CE). J. Ethnopharmacol. 202, 208–224. https://doi.org/10.1016/j.jep.2017.03.014.
El-Kamali, H.H., Khalid, S.A., 1998. The most common herbal remedies in Dongola Province, Northern Sudan. Fitoterapia 69, 118–121. https://doi.org/10.4103/phrev.phrev_15_15.
Fakchich, J., Elachouri, M., 2014. Ehtnobotanical survey of medicinal plants used by people in oriental Morocco to manage various ailments. J. Ethnopharmacol. 154, 76–87.
FAO, 2010. Etat des Ressources Génétiques Forestières modiales. Rapport National, La Mauritanie. http://www.fao.org/3/i3825e/i3825e42.pdf (accesed July, 2019).
Fasola, T.R., Ogunshe, A.A., Onyeachuchim, H.D., 2004. Ethnobotanical importance of endengered species in the Arid Zones of Nigeria. Zonas Aridas 8, 57–61. https://doi.org/10.1016/j.jep.2014.03.016.
Fernández, A.M., 2000. Estudio etnobotánico en el Parque Natural de las Sierras de Cazorla, Segura y Las Villas. Investigacion quimica de un grupo de especies interesantes (PhD Thesis). Universidad de Jaén Spain.
Fortin, D., Modou, L.O., Maynart, G., 1990. Plantes médicinales du Sahel. 55 monographies de plantes utiles pour les soins de santé primaires. In: CECI, Montréal, Québec/ENDA, Dakar, Sénégal, pp. 279.
Ghulam, Y., Mushtaq, A., Shazia, S., Ahmed, S., Alharrasi, J.H., Muhammad, Z., Shafiq-Ur, R., 2015. Ethnobotany of medicinal plants in the thar desert (sindh) of Pakistan. J. Ethnopharmacol. 163, 43–59. https://doi.org/10.1016/j.jep.2014.12.053.
Gonzalez-Tejero, M.R., Casares-Porcel, M., Sanchez-Rojas, C.P., Ramiro-Gutierrez, J.M., Molero-Mesa, J., Pieroni, A., Giusti, M.E., Censorii, E., de Pasquale, C., Della, A., Paraskeva-Hadijchambi, D., Hadjichambis, A., Houmani, Z., El-Demerdash, M., El-Zayatf, M., Hmamouchi, M., El Johrig, S., 2008. Medicinal plants in the Mediterranean area: synthesis of the results of the project Rubia. J. Ethnopharmacol. 116, 341–357. https://doi.org/10.1016/j.jep.2007.11.045.
Gras, A., Gavatje, T., Ibáñez, N., López-pojol, J., Nualort, N., Vallés, J., 2017. Medicinal plants and names from the hermabium of francesc bolós (1773-1844). J. Ethnopharmacol. 204, 142–168. https://doi.org/10.1016/j.jep.2017.04.002.
Graz, B., 2010. Prognostic ability of practitioners of traditional Arabic medicine: comparison with western methods through a relative patient progress scale. Evid. Based Complement. Alternat. Med. 7 (4), 471–476. https://doi.org/10.1093/ecam/nen022.
Groulard, M., 1991. Pratiques de médecine traditionnelle et planification sanitaire (exemple de médecine traditionnelle dans l'Adrar Mauritanien). Med. Trop. 51, 37–41.
Gueye, T.H., 2009. Organisation du secteur pharmaceutique en République Islamique de Mauritanie: aspects législatifs et réglementaires. (Thèse pharm.) Dakar 77, 160p (Senegal).
Hamidoun, M., 1952. Précis sur la Mauritanie. Mauritaniennes n°4- Centre IFAN, St-Louis, Sénégal.
Hammiche, V., Maiza, K., 2006. Traditional medicine in central Sahara: pharmacopoeia of tassili N'ajjer. J. Ethnopharmacol. 105 (3), 358–367. https://doi.org/10.1016/j.jep.2005.11.028.
Hendel, N., Larous, L., Sari, M., Boudjelal, A., Sarri, D., 2012. Place of Labiates in folk medicine of the area of M'sila (Algeria). Glob. J. Res. Med. Plants Indig. Med. 1 (8), 315–322. https://doi.org/10.1016/j.phymed.2008.12.004D.
Hilonga, S.J.N., Otieno, A., Ghorbani, D., Pereus, A., Kocyan, H., de Boer, 2019. Trade of wild-harvested medicinal plant species in local markets of Tanzania and its implications for conservation. South Afr. J. Bot. 122, 121–124. https://doi.org/10.1016/j.sajb.2018.08.012.
Holaly, G.E., Karou, D.S., Gnoula, C., Agbodeka, K., Anani, K., Tchacondo, T., Agbonon, A., Batawila, K., Simpore, J., 2018. Corrigendum: Étude ethnobotanique des plantes utilisées dans le traitement du diabète dans la médecine traditionnelle de la région Maritime du Togo. Pan Afr. Med. J. 30, 186. https://doi.org/10.11604/pamj.30.186.1548.
Inngjerdingen, K., Nergård, C.S., Diallo, D., Mounkoro, P.P., Paulsen, B.S., 2004. An ethnopharmacological survey of plants used for wound healing in Dogonland, Mali, West Africa. J. Ethnopharmacol. 92 (2–3), 233–244. https://doi.org/10.1016/j.jep.2004.02.021.
International Classification of Primary Care (ICPC), 2015. International Classification of Primary Care (ICPC). http://www.who.int/classifications/icd/adaptations/icpc2/en/.
Kankara, S.S., Moham, H.I., Muskhazli, M., Rusea, G., 2015. Ethnobotanical survey of medicinal plants used for traditional maternal healthcare in Katsina state, Nigeria. South Afr. J. Bot. 97, 165–175. https://doi.org/10.1016/j.sajb.2015.01.007.
Kerharo, J., Adam, J.G., 1974. La pharmacopée sénégalaise traditionnelle, plantes médicinales et toxiques. Vigot. Paris, pp. 1011.
Khalid, H., Abdalla, W.E., Abdelgadir, H., Opatz, T., Efferth, T., 2012. Gems from traditional north-African medicine: medicinal and aromatic plants from Sudan. Nat. Prod. Bioprospect. 2, 92–103. https://doi.org/10.1007/s13659-012-0015-2.
Ladio, A.H., Lozada, M., 2009. Human ecology, ethnobotany and traditional practices in rural populations inhabiting the Monte region: resilience and ecological knowledge. J. Arid Environ. 73 (2), 222–227.
Langås-Larsen, A., Salamonsen, A., Kristoffersen, A.E., Hamran, T., Evjen, B., Stub, T., 2017. "There are more things in heaven and earth!" How knowledge about traditional healing affects clinical practice: interviews with conventional health personnel. Int. J. Circumpolar Health 76 (1), 1398010.
Le Grand, A., 1989. Les phytotherapies anti-infectieuses de la foret-savane, Senegal (afrique occidentale) III: un resume des substances phytochimiques et l'activiteantimicrobienne de 43 species. J. Ethnopharmacol. 25 (3), 315–338. https://doi.org/10.1016/0378-8741(89)90037-8.
Le Grand, A., Wondergem, P.A., 1987. Les phytotherapies anti-infectieuses de la foret savane, Senegal (Afrique occidentale) I. Un inventaire. J. Ethnopharmacol. 21 (2), 109–125. https://doi.org/10.1016/0378-8741(87)90122-X.
Le Grand, A., Wondergem, P.A., Verpoorte, R., Pousset, J.L., 1988. Anti-infectious phytotherapies of the tree-savannah of Senegal (West-Africa) II. Antimicrobial activity of 33 species. J. Ethnopharmacol. 22 (1), 25–31. https://doi.org/10.1016/0378-8741(88)90227-9.
Leclerc, L., 1877-1883. Traite des Simples d'Ibn al-Baytar 3 Vols Institut du monde arabe, Paris.
Leriche, A., 1953. Phytothérapie maure de quelques plantes et produits végétaux utilisés en thérapeutique, vol. 23 Mémoires de l'IFAN, Dakar, Sénégal.
Maiga, A., Diallo, D., Fane, S., Sanogo, R., Paulsen, B.S., Cisse, B., 2005. A survey of toxic plants on the market in the district of Bamako, Mali: traditional knowledge compared with a literature search of modern pharmacology and toxicology. J. Ethnopharmacol. 96 (1–2), 183–193. https://doi.org/10.1016/j.jep.2004.09.005.
Malik, S., Ahmad, S., Sadiq, A., Alam, K., Wariss, H.M., Ahmad, I., Mukhtar, M., 2015. A comparative ethno-botanical study of Cholistan (an arid area) and Pothwar (a semi-arid area) of Pakistan for traditional medicines. J. Ethnobiol. Ethnomed. 11, 31.

https://doi.org/10.1186/s13002-015-0018-2.
Mame N'Diak, S., 1977. Médecine traditionnelle en milieu saharo - sahélien de la République Islamique de Mauritanie. L'Homme et la plante.
Martin, G.J., 2004. Ethnobotany A Methods Manual.People and Plants Conservation Series, vol. 612 WWF, Earthscan Publications, U.K.
Martinez-Lirola, M.J., Gonzalez-Tejero, M.R., Molero-Mesa, J., 1997. Investigaciones etnobotanicas en el parque natural de Cabo de Gata-Nıjar (Almerıa). Sociedad almeriense de historia natural y Conserjerıa de Medio Ambiente de la Junta de Andalucia, Spain.
Maydell, H.J.Von, 1983. Arbres et arbustes du sahel: leurs caractéristiques et leurs utilisations. In: Office Allemand de la Coopération Technique GTZ. Eschbom, R.F.A, pp. 531.
Merzouki, A., Ed-derfoufi, F., Molero Mesa, J., 2000. Contribution to the knowledge of Rifi and traditional medicine.II: folk medicine in Ksar Lakbir district (NW Morocco). Fitoterapia 71, 278–307.
Merzouki, A., Ed-Derfoufi, F., El Aallali, A., Molero-Mesa, J., 1997. Wild medicinal plants used by local Bouhmed population (Morocco). Fitoterapia 68, 444–460.
Miara, M.D., Hammou, M.A., Aoul, S.H., 2013. Phytothérapie et taxonomie des plantes médicinales spontanées dans la région de Tiaret (Algérie). Phytothérapie 11 (4), 206–218. https://doi.org/10.1007/s10298-013-0789-3.
Miara, M.D., Bendif, H., Hammou, M.A., Teixidor-Toneu, I., 2018. Ethnobotanical survey of medicinal plants used by nomadic peoples in the Algerian steppe. J. Ethnopharmacol. 219, 248–256. https://doi.org/10.1016/j.jep.2018.03.011.
Miara, M.D., Teixidor-Toneu, I., Sahnoun, T., Bendif, H., Hammou, M.A., 2019. Herbal remedies and traditional knowledge of the Tuareg community in the region of Illizi (Algerian Sahara). J. Arid Environ. 167, 65–73.
Mohebbati, R., Bavarsad, K., Rahimi, M., Rakhshandeh, H., Rad, A.K., Shafei, M.N., 2018. Protective effects of long-term administration of Ziziphus jujuba fruit extract on cardiovascular responses in L-NAME hypertensive rats. Avicenna journal of phytomedicine 8 (2), 143.
Monod, T., 1952. Contribution à l'étude du peuplement de la Mauritanie. Notes botaniques sur l'Adrar (Sahara Occidental). Bull. I.F.A.N., série A. 14, 404–449.
Naceiri Mrabti, H., Jaradat, N., Reda Kachmar, M., Ed-Dra, A., Ouahbi, A., Cherrah, Y., El Abbes Faouzi, M., 2019. Integrative herbal treatments of diabetes in Beni Mellal region of Morocco. J. Integr. Med. 17 (2), 93–99. https://doi.org/10.1016/j.joim.2019.01.001.
Nergard, C.S., Diallo, D., Inngjerdingen, K., Michaelsen, T.E., Matsumoto, T., Kiyohara, H., Yamada, H., Paulsen, B.S., 2005. Medicinal use of *Cochlospermum tinctorium* in Mali: anti-ulcer-, radical scavenging-and immunomodulating activities of polymers in the aqueous extract of the roots. J. Ethnopharmacol. 96 (1–2), 255–269. https://doi.org/10.1016/j.jep.2018.03.011.
ONS (Office National de la Statistique/Ministre des affaires économiques et du developpement), 2011. Direction des statistiques regionales (Adrar en chiffre 2007-2010), edition. pp. 71.
ONS (Office National de la Statistique), 2013. Recensement Général de la Population et de l'Habitat (RGPH), 2013. Bureau Central du Recensement (BCR). Monographie de la Wilaya d'Adrar. http://www.ons.mr/images/RGPH2013/Monographie%20r%C3%A9gionale%20de%20la%20wilaya%20de%20l'Adrar_Fr.pdf, Accessed date: August 2019.
Oxfam international, 2018. https://www.oxfam.org/es/paises/mauritania.
Pousset, J.L., 1989. Plantes Médicinales Africaines. Utilisation Pratique. Agence de coopération culturelle et technique (ACCT), Paris, France.
Rahman, M.A., Mossa, J.S., Al-Said, M.S., Al-Yahya, M.A., 2004. Medicinal plant diversity in the flora of Saudi Arabia 1: a report on seven plant families. Fitoterapia 75, 149–161. https://doi.org/10.1016/j.fitote.2003.12.012.
Rivera, D., Allkin, R., Obón, C., Alcaraz, F., Verpoorte, R., Heinrich, M., 2014. What is in name? The need for accurate scientific nomenclature for plants. J. Ethnopharmacol. 152, 393–402. https://doi.org/10.1016/j.jep.2013.12.022.
Rubel, F., Kottek, M., 2010. Observed and projected climate shifts 1901-2100 depicted by world maps of the Köppen-Geiger climate classification. Meteorol. Z. 19, 135–141. https://doi.org/10.1127/0941-2948/2010/0430.
Sauvage, Ch, 1949. Nouvelles notes botaniques sur le Zemmour oriental. Mém. h.s. Soc. Hist. nat. Afrique Nord., Trav. dédiés à R. Maire. 278–289.
Staub, P.O., Geck, M.S., Weckerle, C.S., Casu, L., Leonti, M., 2015. Classifying diseases and remedies in ethnomedicine and ethnopharmacology. J. Ethnopharmacol. 174, 514–519. https://doi.org/10.1016/j.jep.2015.08.051.
Stauble, N.I., 1986. Etude ethnobotanique des Euphorbiacées d'Afrique de l'Ouest. J. Ethnopharmacol. 16 (1), 23–103. https://doi.org/10.1016/0378-8741(86)90064-4.
Stevens, P.F., 2019. Angiosperm Phylogeny Website. Version 14, July 2017. http://www.mobot.org/MOBOT/research/APweb/ (accesed May, 2019).
Tahraoui, A., El-Hilally, J., Israili, Z.H., Lyoussi, B., 2007. Ethnopharmacological survey of plants used in the traditional treatment of hypertension and diabetes in South-eastern Morrocco. J. Ethnopharmacol. 110, 105–117. https://doi.org/10.1016/j.jep.2006.09.011.
Thouzery, M., 1998. Phytotérapie Maure: Etude Ethnopharmacologique Dans l'Adrar. Memoire D'ethnopharmacologie Appliquée. Université de Metz, France.
Togola, A., Diallo, D., Dembélé, S., Barsett, H., Paulsen, B., 2005. Ethnopharmacological survey of different uses of seven medicinal plants from Mali, (West Africa) in the regions Doila, Kolokani and Siby. J. Ethnobiol. Ethnomed. 1 (1), 7. https://doi.org/10.1186/1746-4269-1-7.
Toupet, Ch, 1966. Etude du milieu physique du massif de l'Assaba (Mauritanie). In: Introduction à la mise en valeur d'une région sahélienne. Initiatives et études africaines, vol. 20. I.F.A.N., Dakar, pp. 152.
Vall, A.O.M., 2009. Contribution à l'étude des plantes médicinales de Mauritanie. Annales de l'université de Lomé, série Sciences, Tome XVII, pp. 9–27.
Vall, A.O.M., Boumediana, A.O.I., Soule, A.O., Gueye, M., Labat, J.M., 2011. Contribution to the study of the flora of Mauritania: 1-Evaluation of plant biodiversity of Assaba (Açaba). Bulletin de l'Institut Scientifique, Rabat, section Sciences de la Vie, n° 33 (2), 53–64.
Vall, A.O.M., Taleb, M.S., Abed, N.E., Abdellahi, M.L.C., Kokou, K., Morou, B., 2015. Contribution of the Flora of Mauritania. Biodiversity and Ecosystem Importance of the Fabaceae. vol. 37. Bulletin de l'Institut Scientifique, Rabat, section Sciences de la Vie, pp. 29–37.
Verde, A., 2002. Estudio etnofarmacologico de tres areas de montaña de Castilla la Mancha. (PhDTesis). Universidad de Murcia, Spain.
Wangensteen, H., Diallo, D., Paulsen, B.S., 2015. Medicinal plants from Mali: chemistry and biology. J. Ethnopharmacol. 176, 429–437.
Weckerle, C.S., De Boer, H.J., Puri, R.K., Andel, T., Bussmanng, R.W., Leonti, M., 2018. Recommended standards for conducting and reporting ethnopharmacological field studies. J. Ethnopharmacol. 210, 125–132. https://doi.org/10.1016/j.jep.2017.08.018.
WHO (World Health Organization), 2001. Legal Status of Traditional Medicine and Complementary. No.WHO/EDM/TRM/2001.2, Geneva.