



Ethnopharmacological survey of plants used in the traditional treatment of hypertension and diabetes in south-eastern Morocco (Errachidia province)

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Abstract

This survey was undertaken in the Errachidia province in south-eastern Morocco in order to inventory the main medicinal plants used in folk medicine to treat arterial hypertension and diabetes mellitus. Four hundred individuals who knew about and/or had used the medicinal plants for the indicated diseases, including some herbal healers, were interviewed throughout different regions of the province. The inventory of medicinal plants is summarized in a synoptic table, which contains the scientific, vernacular and common name of the plant, its ecological distribution, the part of the plant and the preparation used and the therapeutic indication. Extensive investigations have brought to light 64 medicinal plants belonging to 33 families; of these, 45 are used for diabetes, 36 for hypertension, and 18 for both diseases. Of these plants, 34% grow in the wild, 44% are cultivated, and 22% are not indigenous to the area and are brought from other parts of Morocco or from outside the country. The survey shows that 78% of the patients regularly use these medicinal plants. In this region, the most frequently used plants to treat diabetes include *Ajuga iva*, *Allium cepa*, *Artemisia herba-alba*, *Carum carvi*, *Lepidium sativum*, *Nigella sativa*, *Olea europaea*, *Peganum harmala*, *Phoenix dactylifera*, *Rosmarinus officinalis*, and *Zygophyllum gaetulum*, and those to treat hypertension include *Ajuga iva*, *Allium cepa*, *Allium sativum*, *Artemisia herba-alba* Asso, *Carum carvi*, *Nigella sativa*, *Olea europea*, *Rosmarinus officinalis*, *Origanum majorana*, *Peganum harmala*, and *Phoenix dactylifera*. The local people recognize the toxic plants and are very careful in using such plants, which are *Citrullus colocynthis*, *Datura stramonium*, *Nerium oleander*, *Nigella sativa*, *Peganum harmala* and *Zygophyllum gaetulum*. Our survey shows that traditional medicine in the south-eastern Moroccan population has not only survived but has thrived in the transcultural environment and intermixture of many ethnic traditions and beliefs.

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1. Introduction

Morocco is fortunate to have such a varied climate that almost any medicinal plant can grow and be cultivated economically. The heterogeneous ecologic conditions have favored the proliferation of more than 42,000 species of plants, divided into 150 families and 940 genus (Jahandiez and Maire, 1931/1934; Maire, 1952/1980; Negre, 1961; Ozenda, 1977; Hmamouchi, 1999), spread out the entire country with an area of 715,000 km². Since ancient times, this diverse flora has constituted the main source of products used in folk medicine. The Moroccan pharmacopoeia dates back to 711 AD (92nd year of the Hegira), which

marks the expansion of Moslem influence into Europe. The Moroccan pharmacopoeia was further developed and enriched by the knowledge brought in by various ethnic groups that migrated to Morocco from many areas, including the Arabs from the Middle-East, the Andalusians and Jews from Europe, and the Blacks from Sudan, Senegal and Niger (Bellakhdar, 1997).

Noteworthy, the Arabo-Moslem medicine was taught in the Moroccan Islamic universities, such as Quarawin and Zaytouna, until 1893, when the practice was stopped by the French colonialists (Bellakhdar, 1997). The common ethnopharmacological legacy of the various Moroccan ethnic groups (such as the Sahraouis, Soussis, Rifains and Arabs) is well preserved being passed on from generation to generation by oral tradition and through written records, and is still flourishing. In the last decades, some institutions of higher learning have shown great interest in the field of ethnopharmacology, and their efforts have

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borne fruit by bringing to light the main medicinal plants found in several regions of Morocco (Bellakhdar, 1978; Bellakhdar et al., 1982, 1991; Ziyat et al., 1997; Hmammouchi, 1999; Eddouks et al., 2002; El-Hilaly et al., 2003). These studies are not complete, since many areas of Morocco, especially the southern part of the country, still remain unexplored. Therefore, the purpose of the present investigation was to establish an inventory of medicinal plants that grow and/or are available in the Errachidia province in southern Morocco and are used traditionally to treat diabetes and hypertension.

2. Materials and methods

2.1. Study area and its climate

In preparation for the field trips, a literature review was conducted to learn about the geographic and cultural data on the study area. Errachidia, one of the wide provinces of Morocco, covers 8.55% of the total area of the country. Geographically, Errachidia has three physiographic sections: it is criss-crossed from north to west by the mountain range of the high Atlas; an arid plateau which spreads towards Sahara in the south and extending to the Algerian border; and a rocky and infertile plateau in the eastern section. The climate is arid, with an average yearly precipitation of 120 mm. There are large fluctuations in the daily (day and night) and the yearly (summer and winter) temperatures. Winds from Sahara blow constantly all year around.

2.2. The population of Errachidia province and living conditions

According to the 1994 National Census, 522,117 inhabitants populated an area of 6000 km². Administratively, Errachidia province was created in 1956 and it has been divided into seven Circles, namely, Errachidia, Rich, Goulmima, Arfoud, Errissani, Assoul and Imilchil. The province is inhabited mainly by two ethnic groups, Arabs and Berbers (Amazigh people who also speak Tamazight, an Afro-Asiatic language). The former group lives mostly in Errachidia, Erfoud and Errissani, while the later lives in the other Circles. Both groups are Moslems and co-exist peacefully. Although intermarriage is quite common, the two ethnic groups maintain their own traditions and practices, such as agricultural methods, food preparation, body care, folklores, ritual beliefs, etc. The population of Errachidia is mainly rural (66%) and very few services are available to the people. Most of the houses in this region are made of local inexpensive materials and are comfortable for the local weather. One may see conglomerates of houses called “Kssours and Kasba”, which characterize this region by their special architecture. Most of the houses (82%) have no sanitary services. Often-times, several rural families live in one house, where an elder woman acts as the head and manages the family with the help of her daughters and/or daughters-in-law. The major activity of men in Errachidia is agriculture and animal breeding, while the women take care of the house and children. The main business is handicrafts and tourism.

The province of Errachidia also includes Tafilalt region, which is known as one of the most important historical region of Morocco. Its history dates back to 8th century when it was the commercial and spiritual capital, and from where the Islamic culture was extended over the whole of Africa. At the end of the 16th century, it became the caravan route between Sub-Sahara Africa, Egypt and Europe.

2.3. Ethnobotanical survey

The ethnopharmacological survey, started in 2003 and completed at the end of October 2005, was performed in all seven Circles of Errachidia province following the administrative map (Fig. 1). A multidisciplinary team was assembled, and political and health authorities were contacted for permission and for guidance. A questionnaire was prepared modelled after our previous survey (El-Hilaly et al., 2003). This form was designed to obtain information in the following areas: (a) general data on the informant, (b) school attendance, (c) housing and living conditions, (d) accessibility to health services, (e) use of plants for medicinal purposes, (f) source of plant material, part of the plant used, the method of medicinal preparation, and route of administration. Information was gathered verbally from each subject after explaining the purpose of the research and recorded on a card by the interviewer after verbal consent.

If plants were mentioned for medicinal purposes, a botanical sample was collected. These specimens were pressed and preserved for later identification by Prof. M. Fennane, an expert botanist from the Scientific National Institute, Rabat, and a voucher specimen of each plant was deposited in the herbarium of the Institute. Scientific names were cited according to the North Africa flora (Maire, 1952/1980; Fennane et al., 1999).

The questionnaire basically addressed two groups of people: those who knew and used the plants for medicinal purposes and those who did not. Based on the information gathered, plants mentioned three or more times in the treatment of diabetes and hypertension were selected from the synoptic table, which contained a list of hundreds of medicinal plants used for various ailments.

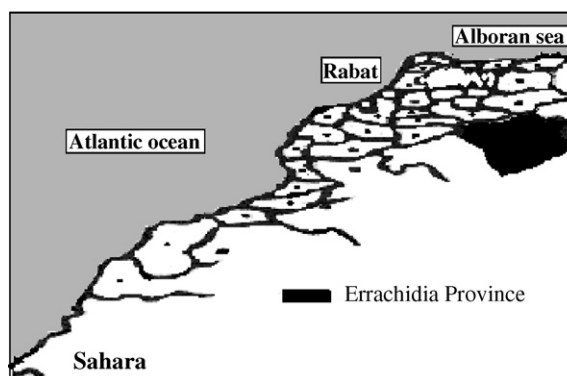


Fig. 1. Geographic location of Errachidia province in Morocco.

3. Results and discussion

The inquiry showed that modern medicine is scarcely used (23%) in Errachidia province, because of inaccessibility to the majority of the population (87%) as a result of high cost and long travel time to a Health Center (averaging about 3 h). On the other hand, traditional medicine remains the main recourse for a large segment of the population (78%) in Errachidia province as is the case in other regions of Morocco and some countries, where medicinal plants/plant products are readily available to the public without a prescription and at a low cost. Previous studies have reported a wide range of the rate of plant use (50–95%), which varied from region to region according to ethnology, richness of medicinal plant sector, and home environment (El Beghdadi, 1991; Nabih, 1992; Sijelmassi, 1993; Bellakhdar, 1997; Ziyat et al., 1997; Hmammouchi, 1999; Eddouks et al., 2002; El-Hilaly et al., 2003).

In the present survey, information was collected for hundred of plants used for various indications in the Errachidia province. Of these, the plants used as folk remedy for hypertension and diabetes are presented in Table 1 (see below). The local pharmacopoeia consists of not only the medicinal plants but also materials derived from minerals and animals such as honey, wax, horns, bones, eggs, inorganic substances, etc.

3.1. Inventory, source(s), and use of medicinal plants

Four hundred individuals, including herbal dealers, who knew about the ethnomedical use of the plants and/or had used them for diabetes and/or hypertension were identified and interviewed throughout different regions of the province. The inventory of the plants (with a minimum frequency of three) is summarized in a synoptic table, which contains the scientific, vernacular and common name of the plant, its ecological distribution, the part of the plant and the preparation used (orally), the therapeutic indication and the frequency (number of informants). A total of 64 medicinal plants belonging to 33 families were identified, with 45 being used for diabetes, 36 for hypertension, and 18 for both diseases (Table 1). Of these plants, 34% grow in the wild, 44% are cultivated, and 22% are not indigenous to the area and are brought from other parts of Morocco or outside the country (Table 1). In comparison, the majority of medicinal plants used for various indications in the Errachidia province grow in the wild (57%), while the rest (43%) are cultivated (unpublished data). Many of the plants are collected in the open fields and plantations by patients, healers and folk medicine practitioners, while others are purchased from herbal healers who procure them locally or import them from outside the area.

The plants/products are consumed raw or in the form of decoction, macerate or infusion for oral treatment (Table 1). Often, people use a mixture of plants for their disease. Grandparents, healers, neighbours or friends teach the art/science of folk medicine.

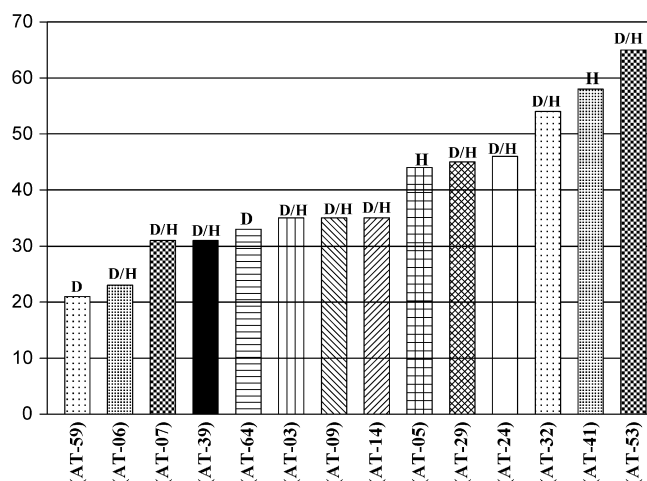


Fig. 2. Frequency of use of plants to treat diabetes/hypertension. [AT-03 *Olea europaea* var. *oleaster* (D/H); AT-05 *Origanum majorana* (H); AT-06 *Carum carvi* (D/H); AT-07 *Phoenix dactylifera* (D/H); AT-09 *Peganum harmala* (D/H); AT-14 *Artemisia herba alba* (D/H); AT-24 *Olea europaea* var. *sativa* (D/H); AT-29 *Ajuga iva* (D/H); AT-32 *Rosmarinus officinalis* (D/H); AT-39 *Allium cepa* (D/H); AT-41 *Allium sativum* (H); AT-53 *Nigella sativa* (D/H); AT-59 *Zygophyllum gaetulum* (D); AT-64 *Lepidium sativum* (D)].

3.2. Gender differences in the use and/or knowledge of medicinal plants

Women are the major consumers (75%) as well as the prescribers of the medicinal plants. Previous studies have also reported a higher proportion of women (61–69%) than men taking herbal medicine (Hamdani, 1984; El Beghdadi, 1991; Jaouad, 1992; Nabih, 1992; Ziyat et al., 1997; Jouad et al., 2001). This may be due to fact that compared to men, more women are well-versed in traditional knowledge (Hamdani, 1984; Jaouad, 1992; Nabih, 1992), and they are more often at home during the hours of the survey (Jouad et al., 2001). As an added incentive, being knowledgeable in the art of healing with plants adds to the status of women, who are primarily involved in domestic chores.

3.3. Frequency of use of medicinal plants

Fig. 2 shows the frequency of use of the more popular plants (frequency of 20 or more) to treat diabetes/hypertension in the Errachidia province. The most frequently used plants to treat diabetes include *Ajuga iva*, *Allium cepa*, *Artemisia herba-alba*, *Carum carvi*, *Lepidium sativum*, *Nigella sativa*, *Olea europaea*, *Peganum harmala*, *Phoenix dactylifera*, *Rosmarinus officinalis*, and *Zygophyllum gaetulum*, and those to treat hypertension include *Ajuga iva*, *Allium cepa*, *Allium sativum*, *Artemisia herba-alba*, *Carum carvi*, *Nigella sativa*, *Olea europaea*, *Rosmarinus officinalis*, *Origanum majorana*, *Peganum harmala*, and *Phoenix dactylifera*.

It is tempting to speculate that a high frequency of use is related to high efficacy and safety of the plant material, although, there are no studies to indicate such, and there is no monitoring of glucose and hemoglobin A_{1c} levels in diabetic patients, and systolic/diastolic blood pressure in hypertensive patients using

Table 1
List of medicinal plants used in traditional medicine in the treatment of hypertension and diabetes in the Errachidia province, Morocco

Voucher	Scientific name	Local name	Common name	Eco-Distr	Part used	Preparation used (p.o.)	Therapeutic use		Frequency
							Diabetes	HTA	
Apiaceae									
(AT-10)	<i>Ammi visnaga</i> (L.) Lam.	bū šnīḥa	Bishop's weed	W	Seed, stem, fruit	Decoc	X		14
(AT-06)	<i>Carum carvi</i> L.	el-qarwiya	Caraway	Cu	Seed	Decoc	X	X	23
(AT-16)	<i>Coriandrum sativum</i> L.	qasbūr	Coriander	Cu	Seed, leaf	Decoc	X		12
(AT-11)	<i>Foeniculum vulgare</i> Mill.	nāfae	Sweet fennel	Cu	Seed	Decoc	X		7
(AT-58)	<i>Petroselinum crispum</i> Mill.	Maâdnouss	Parsley	Cu	Seed, leaf	Decoc		X	11
(AT-22)	<i>Pimpinella anisum</i> L.	h,abbat h,lāwa	Anise	Cu	Seed	Decoc		X	9
Apocinaceae									
(AT-43)	<i>Nerium oleander</i> L. [T]	defla	Oleander	W	Leaf	Decoc	X		7
Borraginaceae									
(AT-01)	<i>Borago officinalis</i> L.	lisān at-tūr	Borage	W	Leaf, flower	Decoc		X	8
Cactaceae									
(AT-61)	<i>Opuntia ficus-indica</i> Mill.	hindiya	Prickly pear	Cu	Flower, fruit	Powder	X		3
Capparaceae/Apparaceae									
(AT-08)	<i>Capparis spinosa</i> L.	l-kebār	Caper	Imp	Flower, fruit	Macer	X	X	9
Caryophyllaceae									
(AT-52)	<i>Herniaria glabra</i> L.	harass hjar	Rupture wort	Imp	AP	Decoc		X	12
Chenopodiaceae									
(AT-63)	<i>Chenopodium ambrosioides</i> L.	mḥinza	wormseed	Cu	Leaf, flower	Infus/fresh juice		X	11
Compositae									
(AT-48)	<i>Artemisia absinthium</i> L.	šība	Wormwood	Cu	Leaf, AP	Decoc	X	X	5
(AT-14)	<i>Artemisia herba-alba</i> Asso. [T]	Chih	White mugwort	W	Leaf, root	Powder	X	X	35
(AT-18)	<i>Inula viscosa</i> (L.) Ait.	terreklān	Inula	W	Leaf, root	Decoc		X	7
(AT-62)	<i>Cynara cardunculus</i> L.	Khourchouf	Artichoke thistle	Cu	Root	Decoc	X		8
Cruciferae/Brassicaceae									
(AT-64)	<i>Lepidium sativum</i> L.	Hebb rechad	Gardencress, Pepperwood	Cu	Seed	Decoc/Powder	X		33
Cucurbitaceae									
(AT-19)	<i>Citrullus colocynthis</i> (L.) Schrad. [T]	Hantel	Bitter apple, Colocynth	Imp	Fruit/pulp	Macer	X	X	17
Cupressaceae									
(AT-20)	<i>Tetraclinis articulata</i> Masters.	el-εareār	Berber thuya, Arar tree	Cu	Leaf, AP	Macer/Powder	X	X	9
Graminaceae									
(AT-46)	<i>Cynodon dactylon</i> (L.) Pers.	njem	Bermudagrass	W	AP, root	Decoc		X	5
(AT-30)	<i>Phalaris paradoxa</i> L.	zūan	Hood canarygrass	Cu	Seed	Powder	X		10
(AT-21)	<i>Zea mays</i> L.	dra šqūbi	Maize, Corn	Cu	Seed	Dried/Scorched		X	5
Juglandaceae									
(AT-23)	<i>Juglans regia</i> L.	el-gargae	Walnut	Cu	Leaf, fruit	Macer		X	8
Lamiaceae									
(AT-29)	<i>Ajuga iva</i> (L.) Schreb.	šendgora	French ground pine	W	Leaf, stem, AP	Decoc	X	X	45
(AT-31)	<i>Lavandula officinalis</i> L.	h,zāma	English lavender	Cu	Leaf, WP	Decoc/Infus	X	X	18

(AT-37)	<i>Lavandula stoechas</i> L.	el-h*alhāl	French lavender	W	Flower, leaf		X		3
(AT-40)	<i>Marrubium vulgare</i> L.	merrīwa	Horehound	Imp	Leaf, stem, AP	Decoc	X		12
(AT-34)	<i>Mentha pulegium</i> L.	flayū	Pennyroyal	W	Leaf, stem	Infus	X	X	8
(AT-27)	<i>Mentha spicata</i> L.	liqama, ena'an'e	Spearmint	Cu	Leaf, stem			X	5
(AT-36)	<i>Origanum vulgare</i> L.	zaetār	Oregano	W	Leaf, stem	Infus	X	X	13
(AT-05)	<i>Origanum majorana</i> L.	Merdadūš	Sweet marjoram	Cu	Leaf	Infus		X	44
(AT-32)	<i>Rosmarinus officinalis</i> L.	azīr	Rosemary	Cu	Leaf, AP	Decoc/Infus	X	X	54
(AT-25)	<i>Salvia officinalis</i> L.	salmiya	Sage	Cu	Leaf	Infus	X		8
(AT-51)	<i>Thymus vulgaris</i> L.	zeitra	Thyme	W	Leaf	Infus/Powder		X	17
(AT-44)	<i>Thymus satureioides</i> Cosson.& Balam.	Azoukni	Moroccon thyme	W	Leaf, flower	Decoc	X		19
Leguminosae									
(AT-33)	<i>Glycine max</i> (L.) Mer.	Soja, A'ssoja	Soybean	Cu	Seed, fruit	Fried seed	X		11
(AT-54)	<i>Retama sphaerocarpa</i> (Boiss.) L.	r̄tem	Common retama	W	Root	Decoc	X		6
(AT-28)	<i>Trigonella foenum-graecum</i> L.	el-halba	Fenugreek	Cu	Seed	Decoc/Mac/Powder	X		13
Liliaceae									
(AT-39)	<i>Allium cepa</i> L.	el-bes,la	Onion	Cu	Bulb	Raw	X	X	31
(AT-41)	<i>Allium sativum</i> L.	Tūma	Garlic		Bulb	Raw/Scorched		X	58
(AT-45)	<i>Aloe vera</i> Burm.	Siber	Aloe	Imp	AP, Leaf		X		3
Moraceae									
(AT-35)	<i>Ficus carica</i> L.	el-bakūr	Fig	Imp	Fruit, Leaf	Powder	X		5
Myrtaceae									
(AT-42)	<i>Eucalyptus</i> spp.	Kalitūse	Eucalyptus	Cu	Leaf	Decoc/Infus	X	X	12
(AT-47)	<i>Eugenia caryophyllata</i> Thunberg	qrenfel	Clove	Imp	Flower	Decoc/Infus		X	9
(AT-26)	<i>Myrtus communis</i> L.	rih,ān	Myrtle	Imp	Leaf, Fruit	Decoc/Infus	X	X	13
Oleaceae									
(AT-03)	<i>Olea europaea</i> L. var. <i>oleaster</i> Hoffm.	el-berri, zebūj	Grafted olive	W	Leaf	Decoc	X	X	35
(AT-24)	<i>Olea europaea</i> L. var. <i>sativa</i> Loud.	zaytūn	Wild olive	Cu	Leaf	Decoc	X	X	46
Palmaceae									
(AT-07)	<i>Phoenix dactylifera</i> L.	Tmar, Nkhil	Date palm	Cu	Leaf, fruit, pulp	Infus/Powder/Pulp	X	X	31
Pedaliaceae									
(AT-49)	<i>Sesamum indicum</i> L.	jenjlan	Sesame	Imp	Seed	Decoc	X		12
Punicaceae									
(AT-38)	<i>Punica granatum</i> L.	remān	Pomegranate	Imp	Pericarp	Decoc/Powder	X		8
Ranunculaceae									
(AT-53)	<i>Nigella sativa</i> L. [T]	sanūj	Black seed, Black cumin	Cu	Seed	Powder	X	X	65
Rhamnaceae									
(AT-13)	<i>Ziziphus lotus</i> (L.) Lam.	nbek	Lotus tree, Jujube	W	Fruit, leaf	Decoc/Powder	X		8
Rosaceae									
(AT-15)	<i>Cydonia oblonga</i> Mill.	Sferjel	Quince	Imp	Fruit	Raw/Cooked	X		5
(AT-65)	<i>Prunus dulcis</i> Mill.	Louz har	Almond	Cu	Seed	Decoc/Infus/Raw	X		11
Rutaceae									
(AT-55)	<i>Ruta montana</i> L.[T]	Fijel, awermi	Common rue	W	AP	Decoc/Infus/Powd	X		6
(AT-17)	<i>Citrus aurantium</i> L. var. <i>amara</i> Link.	tranj	Bitter orange	Imp	Leaf, fruit	Decoc/Infus/Raw	X		17
Solanaceae									

Table 1 (Continued)

Voucher	Scientific name	Local name	Common name	Eco-Distr	Part used	Preparation used (p.o.)	Therapeutic use		Frequency
							Diabetes	HTA	
(AT-56)	<i>Datura stramonium</i> L. [T]	krenk	Jimson weed	W	Seed	Macer		X	7
(AT-12)	Tamaricaceae <i>Tamarix articulata</i> Vahl	aerîš	Athel tamarisk	W	Leaf	Decoc		X	18
(AT-57)	Thymelaeaceae <i>Thymelaea tartanraira</i> (L.) All	Talazazt	A scrub shrub	W	Leaf	Decoc	X		7
(AT-60)	Urticaceae <i>Urtica dioica</i> L.	h,orîŕqa	Stinging nettle	W	Seed, AP	Decoc/Infus		X	8
(AT-50)	Verbenaceae <i>Lippia citriodora</i> (Lam.) H.B.K.	Louiza	Lemon verbena	Imp	Leaf	Decoc/Infus		X	14
(AT-02)	Vitaceae <i>Vitis vinifera</i> L.	Adilite	Grape	Cu	Leaf	Decoc	X		15
(AT-09)	Zygophyllaceae <i>Peganum harmala</i> L. [T]	Harmel	African rue, Harmal	W	Seed	Infus/Powder		X	35
(AT-59)	<i>Zygophyllum gaetulum</i> Emb. et Maire [T]	Aggayya		W	Leaf, stem	Decoc/Infus	X		21

W: wild; AP: aerial part; p.o.: oral administration; Cu: cultivated; Imp: imported; Infus: infusion; [T]: toxic plant; Eco-Distr: ecological distribution; Macer: maceration; HTA: hypertension.

plants. Furthermore, there is no information available about protection from target organ damage by the long-term use of plant products.

3.4. Validation of the ethnomedical use of plants

The claimed therapeutic indications of many these plants have been validated by studies in experimental animals (Table 2), and in patients with diabetes [*Artemisia herba-alba* (Al-Waili, 1986, 1988a), *Coriandrum sativum* (Chithra and Leelamma, 1999; Gray and Flatt, 1999), *Ficus carica* (Serraclara et al., 1998), *Marrubium vulgare* (Herrera-Arellano et al., 2004), *Olea europaea* var. *oleaster* (Circosta et al., 1986), *Opuntia ficus-indica* (Frati et al., 1990), *Trigonella foenum-graecum* (Sharma et al., 1990; Raghuram et al., 1994; Gupta et al., 2001), and *Zygophyllum gaetulum* (Jaouhari et al., 2000b)] and hypertension [*Allium sativum* (Andrianova et al., 2002), *Artemisia herba-alba* (Al-Waili, 1988b), *Ficus carica* (Maruyama et al., 1989), *Olea europaea* var. *oleaster* (Circosta et al., 1986)].

3.5. Comparison of the ethnomedical use of plants in Errachidia province with that in other areas

Many of the plants most often used in the Errachidia province to treat diabetes and hypertension (cited above) are also commonly used all over Morocco (Bellakhdar et al., 1991; Ziyat et al., 1997; Jouad et al., 2001; Eddouks et al., 2002; El-Hilaly et al., 2003). However, it may be noted that the traditional use of a plant in the Errachidia province for diabetes and/or hypertension (Table 1) may or may not be the same as in other parts of the world. For example, *Cynodon dactylon*, *Juglans regia*, *Petroselinum crispum*, *Urtica dioica* and *Zea mays* are used in Errachidia to treat hypertension (Table 1), while experimental studies, likely based on the experience of people in other parts of the world, shows that these plants have hypoglycemic properties (Table 2). Similarly, *Ammi visnaga*, *Coriandrum sativum*, *Foeniculum vulgare*, *Lepidium sativum*, and *Marrubium vulgare* are used in Errachidia to treat diabetes (Table 1), while studies show that these plants have antihypertensive properties (Table 2).

3.6. Adverse effects of medicinal plants

Fortunately, most of the prescribers/users are aware of the toxic plants found in Errachidia province, the main ones being *Citrullus colocynthis*, *Datura stramonium*, *Nerium oleander*, *Nigella sativa*, *Peganum harmala*, and *Zygophyllum gaetulum*, which are used in the treatment of diabetes and/or hypertension (identified by 'T' in Table 1). Despite their toxic nature, patients do not suffer any adverse consequences, because they or the provider of the plants are skilled in recognizing the potential for toxicity and taking the appropriate precautions, such as using lower doses. In some cases, the green plant material is toxic, but it loses its toxicity after drying. A comparison with the literature dealing with folk medicine in other parts of Morocco (Bellakhdar, 1978; Bellakhdar et al., 1991; Ziyat et al., 1997; Eddouks et al., 2002; El-Hilaly et al., 2003) indicates that there are many plants in common which are toxic in nature. Differ-

Table 2
Studies in experimental animals confirming the ethnomedicinal use of some Moroccan plants listed in Table 1

Anti-diabetic plants [D] ^a (voucher specimen)	D	H	Plant part(s) used and mode of administration ^b	References
<i>Ajuga iva</i> (L.) Schreb. (AT-29)	X	X	Aq-ext (WP), p.o.	El-Hilaly and Lyoussi (2002)
<i>Allium cepa</i> L. (AT-39)	X	X	Bulb in diet Bulb powder p.o. S-MCS (bulb), p.o. S-MCS (bulb), p.o. Bulb in diet Bulb juice in diet Bulb powder in diet	Mathew and Augusti (1975) Roman-Ramos et al. (1995) Sheela et al. (1995) Kumari and Augusti (2002) Campos et al. (2003) El-Demerdash et al. (2005) Jelodar et al. (2005)
<i>Allium sativum</i> (L.) Lam. (AT-41)		X	Allyl cysteine sulphoxide (bulb) Bulb in diet Bulb in diet Bulb juice in diet Bulb juice in diet Bulb powder in diet	Chang and Johnson (1980) Sheela and Augusti (1992) Roman-Ramos et al. (1995) Bwititi and Musabayane (1997) El-Demerdash et al. (2005) Jelodar et al. (2005)
<i>Aloe vera</i> (L.) Burm. (AT-45)	X	X	Aq-ext (leaf-pulp), p.o. Aq-ext (leaf-gel), p.o. Aq-ext (leaf-gel), p.o. EtOH-ext (leaf gel), p.o.	Okyar et al. (2001) Abu Soud et al. (2004) Rajasekaran et al. (2006) Rajasekaran et al. (2004)
<i>Ammi visnaga</i> (L.) Lam. (AT-10)	X		Khelin, visnagin (fruit), i.p. Aq-ext (seed), p.o.	Alaoui et al. (1992) Jouad et al. (2002)
<i>Artemisia herba-alba</i> Asso. (AT-14)	X	X	Aq-ext (AP), p.o. Aq-ext (leaf), p.o. Aq-ext (bark, leaf), p.o. Aq-ext (AP), p.o. Aq-ext (AP), p.o.	Twajj and Al-Badr (1988) Al-Alami and Farjou (1990) Al-Khazraji et al. (1993) Al-Shamaony et al. (1994) Marrif et al. (1995)
<i>Capparis spinosa</i> L. (AT-08)	X	X	Aq-ext (fruit), p.o.	Eddouks et al. (2004)
<i>Carum carvi</i> L. (AT-06)	X	X	Aq-ext (fruit), p.o.	Eddouks et al. (2004)
<i>Citrullus colocynthis</i> (L.) Schrad. (AT-19)	X	X	Aq-ext (fruit-rind), p.o. Aq-ext (seed), p.o. Aq-ext (seed), p.o.	Abdel-Hassan et al. (2000) Nmila et al. (2000) Al-Ghaithi et al. (2004)
<i>Coriandrum sativum</i> L. (AT-16)	X		Aq-ext (seed), decoction, p.o. Aq-ext (seed), p.o. Aq-ext (seed), decoction, p.o. Aq-ext (seed), p.o.	Swanston-Flatt et al. (1990) Chithra and Leelamma (1999) Gray and Flatt (1999) Gallagher et al. (2003)
<i>Cynodon dactylon</i> (L.) Pers (AT-46)		X	Aq-ext (WP), p.o.	Roman Ramos et al. (1992)
<i>Eucalyptus</i> spp. (AT-42)	X	X	Aq-ext (leaf), p.o.; leaf in diet Aq-ext (leaf), p.o. Aq-ext (leaf), p.o.	Swanston-Flatt et al. (1990) Gallagher et al. (2003) Jouad et al. (2003)
<i>Ficus carica</i> L. (AT-35)	X		Chl-ext (leaf), p.o. Chl-ext (leaf), p.o. Oil (leaf), p.o.	Canal et al. (2000) Perez et al. (2000) Perez et al. (2003)
<i>Foeniculum vulgare</i> Mill. (AT-35)	X		Oil (seed, leaf), p.o.	Ozbek et al. (2003)
<i>Juglans regia</i> L. (AT-23)		X	Aq-ext (leaf), p.o. Aq-ext (fruit), p.o.	Neef et al. (1995) Kavalali et al. (2002)
<i>Lavandula stoechas</i> L. (AT-37)	X		Oil (AP), p.o.	Gamez et al. (1987)
<i>Lepidium sativum</i> L. (AT-37)	X		Aq-ext (seeds), p.o.	Eddouks et al. (2005)
<i>Marrubium vulgare</i> L. (AT-64)	X		Aq-ext (WP), p.o. MeOH-ext (leaf), p.o.	Roman Ramos et al. (1992) Novaes et al. (2001)
<i>Myrtus communis</i> L. (AT-26)	X	X	Aq-ext (seed), p.o. Oil (berry, leaf), p.o. Aq-ext (WP), p.o.	Elfellah et al. (1984) Sepici et al. (2004) Onal et al. (2005)
<i>Nigella sativa</i> L. (AT-53)	X	X	Oil (seed), p.o. Powder (seed) in diet Oil (seed), p.o.	Al-Hader et al. (1993) Labhal et al. (1999) Zaoui et al. (2000)

Table 2 (Continued)

Anti-diabetic plants [D] ^a (voucher specimen)	D	H	Plant part(s) used and mode of administration ^b	References
			Oil (seed), p.o. Oil (seed), p.o. Pet-ether-ext (seed), p.o. Aq-ext (seed), p.o. Pet-ether-ext (seed), p.o. Aq-ext (seed), p.o. Aq-ext (seed), p.o.	Hawsawi et al. (2001) El-Dakhkhny et al. (2002) Kanter et al. (2003) Fararh et al. (2004) Le et al. (2004) Rchid et al. (2004) Mansi (2006)
<i>Olea europaea</i> L. var. <i>oleaster</i> Hoffm. (AT-03)	X	X	Aq-ext (leaf), p.o.	Bennani-Kabchi et al. (2000)
<i>Opuntia ficus-indica</i> Mill. (AT-61)	X		Aq-ext (fruit), i.v. Polysaccharides, i.p. Aq-ext (fruit, leaf), p.o.	Enigbokan et al. (1996) Alarcon-Aguilar et al. (2003) Shin et al. (2003)
<i>Origanum vulgare</i> L. (AT-36)			Aq-ext (leaves), p.o.	Lemhadri et al. (2004)
<i>Peganum harmala</i> L. (AT-09)	X	X	EtOH-ext (WP), p.o.	Hussain et al. (2004)
<i>Petroselinum crispum</i> Mill. (AT-58)		X	Aq-ext (WP), p.o.	Yanardag et al. (2003)
<i>Punica granatum</i> L. (AT-38)	X		Aq/EtOH-ext (flowers), p.o. MeOH-ext (flowers), p.o. MeOH-ext (flowers), p.o. MeOH-ext (flowers), p.o. MeOH-ext (flowers), p.o.	Jafri et al. (2000) Das et al. (2001) Jung et al. (2003) Huang et al. (2005) Li et al. (2005)
<i>Rosmarinus officinalis</i> L. (AT-32)	X	X	Aq-ext (leaves), p.o. Oil (leaves), p.o.	Erenmemisoglu et al. (1997) Al-Hader et al. (1994)
<i>Salvia officinalis</i> L. (AT-25)	X		Decoction (leaf), p.o. Aq-EtOH-ext (leaf), p.o. MeOH-ext (leaf), p.o.	Swanston-Flatt et al. (1989) Alarcon-Aguilar et al. (2002) Eidi et al. (2005)
<i>Trigonella foenum-graecum</i> L. (AT-28)	X		Seed powder in diet Leaves in diet Seed powder in diet Seed powder in diet Decoction (seed), p.o. Seed powder in diet	Riyad et al. (1988) Swanston-Flatt et al. (1989) Alarcon-Aguilar et al. (1998) Raju et al. (2001) Devi et al. (2003) Jelodar et al. (2005)
<i>Urtica dioica</i> L. (AT-60)		X	Decoction (WP), p.o. Decoction (WP), p.o. Aq-ext (WP), p.o. Aq-ext (leaf), p.o. Aq-ext (leaf), p.o.	Swanston-Flatt et al. (1989) Roman Ramos et al. (1992) Bnouham et al. (2003) Farzami et al. (2003) Onal et al. (2005)
<i>Vitis vinifera</i> L. (AT-02)			Aq-ext (leaf), p.o.	Orhan et al. (in press)
<i>Zea mays</i> L. (AT-21)		X	Aq-ext (stigma, hair), p.o.	Miura et al. (1996)
<i>Zygophyllum gaetulum</i> Emb. (AT-59)	X		Aq-ext (AP), p.o. Aq-ext (AP), p.o.	Skim et al. (1999) Jaouhari et al. (2000a)
Anti-hypertensive plants [H] ^a (voucher specimen)	D	H	Plant part(s) used and mode of administration ^b	References
<i>Ajuga iva</i> (L.) Schreb. (AT-29)	X	X	Aq-ext (WP), p.o.	El-Hilaly et al. (2004)
<i>Allium sativum</i> (L.) Lam. (AT-41)		X	Raw (diet) Encapsulated garlic powder in diet Aq-ext (WP), p.o.	Malik and Siddiqui (1981) Sial and Ahmad (1982) Pantoja et al. (1991)
<i>Ammi visnaga</i> (L.) Lam. (AT-10)	X		Visnagin (fruit), in vitro Visnagin (fruit), i.v.	Duarte et al. (1995) Duarte et al. (2000)
<i>Artemisia herba-alba</i> Asso. (AT-14)	X	X	Aq-ext (AP), p.o.	Al-Waili (1988b)
<i>Citrullus colocynthis</i> (L.) Schrad. (AT-19)	X	X	Aq-ext (rind), p.o.	Abdel-Hassan et al. (2000)
<i>Coriandrum sativum</i> L. (AT-16)	X		Aq-ext (seed), p.o.	Al-Ghaithi et al. (2004)
<i>Medicago sativa</i> L. (AT-17)			Aq-ext (seed), p.o.	Medhin et al. (1986)
<i>Cynodon dactylon</i> (L.) Pers. (AT-46)		X	Essential oil (rhizome), p.o.	Artizzu et al. (1996)

Table 2 (Continued)

Anti-hypertensive plants [H] ^a (voucher specimen)	D	H	Plant part(s) used and mode of administration ^b	References
<i>Foeniculum vulgare</i> Mill. (AT-35)	X		Aq-ext (seed), p.o. Aq-EtOH-ext (seeds), p.o.	Beaux et al. (1997) El Bardai et al. (2001)
<i>Herniaria glabra</i> L. (AT-52)		X	Saponin (leaf), p.o. Saponin (leaf), p.o. Saponin (leaf), p.o.	Rhiouani et al. (1999a) Rhiouani et al. (1999b) Rhiouani et al. (2001)
<i>Juglans regia</i> L. (AT-23)		X	Aq-ext (leaf), p.o.	Perusquia et al. (1995)
<i>Lavandula officinalis</i> L. (AT-31)	X	X	Aq-ext (flowers), p.o.	Elhajili et al. (2001)
<i>Lepidium sativum</i> L. (AT-64)	X		Aq-ext (WP), p.o.	Maghrani et al. (2005)
<i>Marrubium vulgare</i> L. (AT-64)	X		Aq-ext (AP), p.o. Marrubenol and marrubiin, p.o., in vitro and ex vivo	El Bardai et al. (2001) El Bardai et al. (2003) El Bardai et al. (2004)
<i>Nigella sativa</i> L. (AT-53)	X	X	Oil (seed), p.o. DCM-ext (seed), p.o. DCM-ext (seed), p.o.	El Tahir et al. (1993) Labhal et al. (1994) Zaoui et al. (2000)
<i>Olea europaea</i> L. var. <i>oleaster</i> Hoffm. (AT-03)	X	X	Aq-ext (leaf), p.o. Aq-MeOH-ext (fruit), isolated cardiovascular preparations	Circosta et al. (1986) Gilani et al. (2005)
<i>Peganum harmala</i> L. (AT-09)	X	X	Aq-ext (seed), in vitro (rat aorta) Harman (seed), in vitro Harman, harmala (seed), in vitro MeOH-ext (seed), in vitro (rat aorta)	Aquel and Hadidi (1991) Shi et al. (2000) Shi et al. (2001) Berrougui et al. (2002)
<i>Petroselinum crispum</i> Mill. (AT-58)		X	Aq-ext (AP), p.o.	Neuhaus-Carlisle et al. (1993)
<i>Rosmarinus officinalis</i> L. (AT-32)	X	X	Aq-ext (AP), p.o.	Haloui et al. (2000)
<i>Urtica dioica</i> L. (AT-60)		X	Aq-ext (AP), i.v. Aq-ext (WP), in vitro Aq/MeOH-ext (root)	Tahri et al. (2000) Legssyer et al. (2002) Testai et al. (2002)

^a The designations D and H are based on the ethnomedicinal use of the plants in treating diabetes (D) and hypertension (H) according to the present survey. AP: aerial part; Aq: aqueous; Chl: chloroform; DCM: dichloromethane; EtOH: ethanol; ext: extract; MeOH: methanol; Pet-ether: petroleum ether; S-MCS: *S*-methyl-cysteine sulfoxide; WP: whole plant.

^b Mode of administration: i.p.: intraperitoneal; i.v.: intravenous; p.o.: oral.

ent ethnic groups who live far from each other are aware of the common toxic plants, such as *Citrullus colocynthis*, *Datura stramonium*, and *Nerium oleander*. Although, some toxic plants are specific for the region, for example *Zygophyllum gaetulum* that grows only in the semi-arid and arid bioclimatic areas, yet, one can find the plant in shops and open markets all over the country. A problem, which may occur in patients who continue to take plant remedies along with conventional medication is the possibility of adverse interaction between the two types of medications.

4. Conclusions

This inquiry proved that folk medicine is still widely practiced by the population in south-east Morocco, and the use of medicinal plants constitutes the common legacy of all Moroccans. Despite the penetration of the modern medicine, traditional medicine continues to be a viable health alternative for the large underprivileged section of the Moroccan population. Thus, it is important to document and restore the remains of ancient medical practices that still exist in Morocco and other parts of the world, and preserve this knowledge for future generations.

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