Ethnopharmacological Documentation of Medicinal Plants Used in the Traditional Treatment of Hypertension in Tarfaya Province, Morocco

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Abstract. The use of plants to treat chronic diseases is part of an ancient Moroccan tradition. This study will present the first relevant documentation on medicinal plants used in the treatment of hypertension in Tarfaya province. This study aimed to collect and document information on medicinal plants traditionally used by the local population of Tarfaya province for the treatment of hypertension. Ethnobotanical surveys were conducted using 150 questionnaires in the study area. Documented data were evaluated using the quantitative ethno-botanical indices of frequency citation (FC) and Relative Frequency of Citation (RFC). The results obtained allowed to inventory 52 species of medicinal plants belonging to 29 families traditionally used against hypertension. The species were rich in diverse chemical constituents. The most cited families are Lamiaceae (9 species), Apiaceae (5 species), Compositae (3 species), Leguminosae (3 species) and Myrtaceae (3 species). Ten plants are reported for the first time as used in the treatment of hypertension. The most cited plant species are *Allium sativum* (RFC = 0.28), *Allium cepa* (RFC = 0.2), *Olea europaea* (RFC = 0.18), *Searsia tripartita* (RFC = 0.16), *Ammodaucus leucotrichus* (RFC = 0.15) and *Myrtus communis* (RFC = 0.15). Leaves were the most used organs. The decoction was the dominant method of preparation. This study showed that the inhabitants of Tarfaya use a wide variety of plants for the treatment of hypertension. This work is a source of information that can serve as a basis for phytochemists and pharmacologists interested in research on plants with antihypertensive effect.

Introduction

Cardiovascular diseases are the largest cause of mortality worldwide, in both developed and developing countries. The number of adults with increased blood pressure from 594 million in 1975 to 1.13 billion in 2015, with the increase in low-and-middle income countries [1]. Many people in developing countries do not seek treatment for hypertension that could significantly reduce the risk of death or disability due to heart disease or stroke [2]. In these countries, social factors such as low level of education, lack of housing and unemployment with other risk factors have led to an increased prevalence of hypertension [3]. Population growth, the harmful use of alcohol, the increase in saturated fat consumption, the reduction of fiber consumption, obesity, reduced physical activity, the stress of modern life, have a negative impact on behavioral risk factors, which could influence the development of hypertension [3, 4].

A person with a pressure equal to or more than 140/90 mm Hg suffers from high blood pressure [5, 6]. Its frequency increases with age, but nowadays it affects younger population too. When not properly controlled, its consequences can be very serious such as stroke, and other cardiovascular complications [7].

In fact, one of three people in the world suffers from hypertension [6]. Hypertension in Morocco affects more than 34% of adults over the age of 20 and 53.8% of people over 40 and 72.2% of those aged 65 and over [4].

Currently, there are several types of antihypertensive drugs with various mechanisms of action. Although they are effective, some of them have side effects and in some cases they are unavailable to people in rural areas who have difficulty accessing medications [7]. Therefore, the

use of traditional medicine for the treatment of hypertension is a very common practice in African countries and several investigations have targeted the discovery of new hypotensive agents from plants [2]. The best use of medicinal plants is through ethnobotanical surveys which make it possible to draw up a list of plant species used in traditional medicine by the population [8]. This type of knowledge has a real cultural value and may eventually allow the development of new pharmaceutical drugs. Ethnobotanical surveys conducted in different regions of Morocco have shown that several plant species are used in the traditional treatment of hypertension [4, 9-12]. Therefore, an ethnobotanical survey was carried out in the province of Tarfaya to collect as much information as possible about how to use and exploit plants in the traditional treatment of hypertension in order to valorize them, to keep and use them in a rational way.

Materials and Methods

Study area

The province of Tarfaya is located in southern Morocco. It is bounded on the north by the province of Tan-Tan, on the south by the province of Laayoune, on the east by the province of Smara, on the west by the Atlantic Ocean. This region covers an area of 15450 km² with a population of 13082 inhabitants (**Fig. 1**).

The province is characterized by a semi-arid climate marked by the scarcity of rainfall. Rainfall amounts are generally low and unevenly distributed over the province. This rainfall is generally less than 60 mm / year. In the province, temperatures are moderate and influenced by the proximity of the Atlantic Ocean, generally around 30 ° C in summer and 20 ° C in winter, and there are not large annual variations.

Fig. 1. Location of study area

In terms of vegetation, the province is characterized by some isolated tufts or solitary trees; The appearance is that of a landscape left bare, covered only by some herbs that grow after the occasional rainfall.

The province of Tarfaya has significant economic potential, particularly in the sectors of sea fishing, livestock, tourism and renewable energy. While its potential in agriculture is very limited because of the unfavorable weather conditions. On the other hand, Overgrazing is practiced in the province because of the nomadic life that has marked the lives of the local population. The herd consists mainly of goats, sheep and camels.

Ethnobotanical survey

This work was carried out on the basis of ethnobotanical surveys to gather as much information as possible on the floristic diversity and therapeutic uses of medicinal plants used in the treatment of hypertension in the province of Tarfaya.

In a random sample of 150 people, the population of Tarfaya province was surveyed between August 2018 and December 2018. Using a questionnaire, the surveys collected information on the profile of the people surveyed (age, sex, level of education, family situation, and origin of the information) and to collect precise information on the therapeutic practices used by the population of this province in the treatment of hypertension, in particular the vernacular name of each species, the parts of the plant used and the method of preparation. The time spent on each interview was approximately one hour and all interviewees were informed about the purpose of this study.

In addition, medicinal plants have been identified by the botanists of the Laboratory of Biotechnology and Valorization of Natural Resources (LBVRN), Faculty of Sciences, Ibn Zohr University, Agadir, with the help of the standard floras of the area and the online database (www.theplantlist.org). Voucher specimens were prepared for all plants and deposited at the herbarium of our laboratory.

The information on the ethnobotany records was transferred to a database, processed and analyzed to obtain standardized data. The phytotherapeutic importance of each species was assessed by calculating the Relative Frequency of Citation ($RFC = \text{number of citations of a species} / \text{total number of respondents}$).

$$RFC = FC / N \quad (0 < RFC < 1)$$

Results and Discussion

Demographic features

Ethnobotanical surveys conducted in the field made it possible to interview 150 people (**Table 1**), 56.7 % of whom were female compared to 43.3% of men. Similarly, the results show that it is women who use medicinal plants much more than men. These results confirm the results of other ethnobotanical studies conducted nationally [9-14]. This is an indicator of women's attachment to traditional knowledge [9, 11].

Analysis of the data obtained showed that the age of the respondents varied between 22 and 80 years, with a majority of the age group [41-50] at 34%. Then come the age groups [51-60], [31-40], [21-30] and finally those over 61, with a rate of 26%, 18.7%, 11.3% and 10% respectively. On the one hand, this could be explained by the ignorance of the traditional medicinal uses of plants by the younger generation. On the other hand, the loss of memory and ancestral know-how among the elderly. The knowledge of the uses of medicinal plants and their properties are generally acquired after a long experience accumulated and transmitted from one generation to another. The transmission of this knowledge is in danger at present because it is not always assured [15]. Previous studies have shown that the use of medicinal plants is greater among age groups between 30 and 60 years of age and have reported that these age groups are more prone to heart disease [4, 10, 12].

In this region, the majority of users of medicinal plants are illiterate with a rate of 53.3%. This reflects the low level of schooling of the local population. People with primary education level have a percentage of 32.6% while people with secondary and university level use very little medicinal plants with a rate of respectively 11.3% and 2.7%.

Most of the respondents, 69.3%, reported having acquired knowledge in a hereditary way. Herbalists are ranked as the second source of information (22.7%). These percentages reflect the image of the transmission of traditional practices from one generation to another.

Table 1. Demographic profile of the informants included in the survey (N = 150)

Item	Demographic feature	Number of people	Percent (%)
Gender	Male	65	43.3 %
	Female	85	56.7%
Age	21-30	17	11.3%
	31-40	28	18.7%
	41-50	51	34%
	51-60	39	26%
	61 and above	15	10%
Education	Illiterate	77	53.3%
	Primary education	52	32.6%
	Secondary education	17	11.3%
	Universitaire	4	2.7%

Diversity of medicinal plants and their applications

The study of medicinal plants made it possible to identify 52 species belonging to 29 families (**Table 2**). The most represented families are Lamiaceae (9 species) and Apiaceae (5 species), followed by Compositae, Leguminosae and Myrtaceae (3 species). The remaining families have only one or two species. The high representativeness of these families has also been noted in ethnobotanical surveys conducted in other regions of the country [4, 10].

In our study, the most cited species for the treatment of hypertension are *Allium sativum* (RFC = 0.28), *Allium cepa* (RFC = 0.2), *Olea europaea* (RFC = 0.18), *Searsia tripartite* (RFC = 0.16), *Ammodaucus leucotrichus* (RFC = 0.15), *Myrtus communis* (RFC = 0.15), *Carum carvi* (RFC = 0.14), *Pistacia lentiscus* (RFC = 0.13), *Petroselinum crispum* (RFC = 0.13), *Citrullus colocynthis* (RFC = 0.13), *Lepidium sativum* (RFC = 0.13), *Mentha pulegium* (RFC = 0.13), *Acacia senegal* (RFC = 0.13), *Ziziphus lotus* (RFC = 0.13), *Solanum lycopersicum* (RFC = 0.13), *Dysphania ambrosioides* (RFC = 0.12), *Tetraclinis articulata* (RFC = 0.12) *Ajuga iva* and *Coriandrum sativum* (RFC = 0.12). Some of the plants have been reported by recent ethnobotanical surveys in the treatment of hypertension in Morocco [4, 10, 11] in Algeria [16], in Nigeria [17] and in Pakistan [18]. These plants include *Olea europaea*, *Myrtus communis*, *Carum carvi*, *Petroselinum crispum*, *Citrullus colocynthis* and *Mentha pulegium*. The antihypertensive activity of some plants has also been experimentally proven. This is the case of *Allium sativum* [19, 20] of *Coriandrum sativum* [21], of *Lepidium sativum* [22], of *Pistacia lentiscus* [23] and *Olea europaea* [24].

The comparison of our results with those of other ethnobotanical surveys in neighboring regions showed that ten plant species (*Acacia senegal*, *Adansonia digitata*, *Ammodaucus leucotrichus*, *Atriplex halimus*, *Lawsonia inermis*, *Mesembryanthemum cryptanthum*, *Saussurea costus*, *Searsia tripartita*, *Solanum lycopersicum* and *Ziziphus lotus*) have been cited for the first time to treat hypertension.

Table 2. Plants use to treat hypertension in Tarfaya province

No	Botanical name & voucher no.	family	Vernacular name	Parts used	Preparation	FC	RFC	Reported Literatures
1	<i>Acacia senegal</i> (L.) Willd. LBVRN180	Leguminosae	Aalelk	Gum	Decoction	22	0.13	No reference
2	<i>Adansonia digitata</i> L. LBVRN139	Malvaceae	Tajmakht	Fruit	Infusion	14	0.08	No reference
3	<i>Ajuga iva</i> (L.) Schreb. LBVRN142	Lamiaceae	Chendgora	Aerial part	Decoction	21	0.12	[4, 11]
4	<i>Allium cepa</i> L. LBVRN145	Amaryllidaceae	Lbesla	Bulb	Raw	35	0.2	[11, 17]
5	<i>Allium sativum</i> L. LBVRN140	Amaryllidaceae	Touma	Bulb	Raw	48	0.28	[11, 12, 25]
6	<i>Aloysia citriodora</i> Palau LBVRN146	Verbenaceae	Lwiza	Leaf	Decoction	15	0.09	[9, 12]
7	<i>Ammodaucus leucotrichus</i> Coss. LBVRN144	Apiaceae	Kamoun Sooufi	Seed	Decoction	25	0.15	No reference
8	<i>Artemisia absinthium</i> L. LBVRN141	Compositae	Chiba	Aerial part	Decoction	15	0.09	[9]
9	<i>Artemisia herba-alba</i> Asso LBVRN143	Compositae	Chih	Leaf	Powder	16	0.09	[9, 11, 12]
10	<i>Atriplex halimus</i> L. LBVRN147	Amaranthaceae	Lgtef	Leaf	Decoction	16	0.09	No reference
11	<i>Capparis spinosa</i> L. LBVRN148	Capparaceae	LKebbar	Fruit	Maceration	15	0.09	[11]
12	<i>Carum carvi</i> L. LBVRN179	Apiaceae	Elkarwiya	Seed	Powder	24	0.14	[9, 11]
13	<i>Citrullus colocynthis</i> (L.) Schrader LBVRN149	Cucurbitaceae	Lhdej	Fruit	Maceration	23	0.13	[11, 18]
14	<i>Coriandrum sativum</i> L. LBVRN150	Apiaceae	Kasbour	Seed	Decoction	18	0.11	[9, 11]
15	<i>Cynodon dactylon</i> (L.) Pers. LBVRN182	Poaceae	Njem	Aerial part	Decoction	15	0.09	[11]
16	<i>Dysphania ambrosioides</i> (L.) Mosyakin & Clemants LBVRN131	Amaranthaceae	Lmkhinza	Leaf	Infusion	21	0.12	[9, 11]
17	<i>Eucalyptus globulus</i> Labill. LBVRN132	Myrtaceae	Kalitus	Leaf	Decoction	13	0.08	[11, 12]
18	<i>Glycyrrhiza glabra</i> L. LBVRN133	Leguminosae	Arq souss	Stem	Decoction	15	0.09	[9]
19	<i>Herniaria glabra</i> L. LBVRN181	Caryophyllaceae	Harass lhjar	Aerial part	Decoction	18	0.11	[9, 11]
20	<i>Hibiscus sabdariffa</i> L. LBVRN134	Malvaceae	Bissam	Chalices of flowers	Infusion	20	0.12	[2, 17]
21	<i>Laurus nobilis</i> L. LBVRN135	Lauraceae	Wrak sidna Musa	Leaf	Decoction	14	0.08	[12]
22	<i>Lavandula dentata</i> L. LBVRN136	Lamiaceae	Lokhzama	Aerial part	Powder	18	0.11	[4, 9, 12]
23	<i>Lawsonia inermis</i> L. LBVRN137	Lythraceae	Lhana	Leaf	Infusion	13	0.08	No reference
24	<i>Lepidium sativum</i> L. LBVRN138	Brassicaceae	Hab rchad	Seed	Decoction	22	0.13	[4]
25	<i>Linum usitatissimum</i> L. LBVRN160	Linaceae	Zarriaat lkettane	Seed	Powder	14	0.08	[9]
26	<i>Mentha pulegium</i> L. LBVRN176	Lamiaceae	Fliyou	Seed	Decoction	22	0.13	[4, 11]
27	<i>Mentha spicata</i> L. LBVRN171	Lamiaceae	Likama	Stem	Infusion	19	0.11	[9, 11]
28	<i>Mesembryanthemum cryptanthum</i> Hook.f. LBVRN170	Aizoaceae	Afzo	Seed	Powder	13	0.08	No reference
29	<i>Myrtus communis</i> L. LBVRN161	Myrtaceae	Rihan	Leaf	Decoction	25	0.15	[9, 11]
30	<i>Nerium oleander</i> L. LBVRN178	Apocynaceae	Defla	Leaf	Infusion	19	0.11	[9]
31	<i>Nigella sativa</i> L. LBVRN169	Ranunculaceae	Sanouj	Seed	Powder	15	0.09	[4, 9, 11]
32	<i>Ocimum basilicum</i> L. LBVRN162	Lamiaceae	Lahbak	Aerial part	Decoction	19	0.11	[4]
33	<i>Olea europaea</i> L. LBVRN167	Oleaceae	Zitoun	Leaf	Decoction	30	0.18	[4, 11, 12]
34	<i>Origanum compactum</i> Benth. LBVRN168	Lamiaceae	Zaatar	Leaf	Infusion	19	0.11	[4, 12]

35	<i>Origanum majorana</i> L. LBVRN166	Lamiaceae	Merdedouch	Leaf	Infusion	21	0.12	[11]
36	<i>Peganum harmala</i> L. LBVRN163	Nitrariaceae	Lharmel	Seed	Powder	13	0.08	[9, 11]
37	<i>Petroselinum crispum</i> (Mill.) Fuss LBVRN164	Apiaceae	Maadanous	Seed	Decoction	23	0.13	[11, 12]
38	<i>Phoenix dactylifera</i> L. LBVRN165	Arecaceae	Tmer	Fruit	Infusion	16	0.09	[11]
39	<i>Pimpinella anisum</i> L. LBVRN154	Apiaceae	Habbat hlawa	Seed	Decoction	15	0.09	[9, 11]
40	<i>Pistacia lentiscus</i> L. LBVRN153	Anacardiaceae	Adru	Leaf	Decoction	23	0.13	[4]
41	<i>Rosmarinus officinalis</i> L. LBVRN155	Lamiaceae	Azir	Leaf	Decoction	20	0.12	[4, 11, 12]
42	<i>Rubia tinctorum</i> L. LBVRN156	Rubiaceae	Lfouwa	Root	Decoction	15	0.09	[4, 9]
43	<i>Salvia officinalis</i> L. LBVRN152	Lamiaceae	Salmiya	Leaf	Infusion	18	0.11	[4, 9]
44	<i>Saussurea costus</i> (Falc.) Lipsch. LBVRN157	Compositae	Lkist lhandi	Root	Powder	12	0.07	No reference
45	<i>Searsia tripartita</i> (Ucria) Moffett LBVRN177	Anacardiaceae	Zewayaya	Fruit	Juice	27	0.16	No reference
46	<i>Solanum lycopersicum</i> L. LBVRN158	Solanaceae	Maticha	Fruit	Juice	22	0.13	No reference
47	<i>Syzygium aromaticum</i> (L.) Merr. & L.M.Perry LBVRN159	Myrtaceae	Qronfel	Clove	Maceration	20	0.12	[4, 9, 11, 12]
48	<i>Tetraclinis articulata</i> (Vahl) Mast. LBVRN151	Cupressaceae	laaraar	Leaf	Powder	21	0.12	[9, 11, 12]
49	<i>Trigonella foenum-graecum</i> L. LBVRN174	Leguminosae	Lhalba	Seed	Powder	11	0.06	[4, 12]
50	<i>Urtica dioica</i> L. LBVRN173	Urticaceae	Lhoriga	Aerial part	Decoction	20	0.12	[11, 12]
51	<i>Zea mays</i> L. LBVRN175	Poaceae	Zghb kbal	Stigma	Decoction	13	0.08	[11]
52	<i>Ziziphus lotus</i> (L.) Lam. LBVRN172	Rhamnaceae	Ssder	Leaf	Infusion	15	0.09	No reference

Single-species remedies are mostly represented in relation to multi-species remedies. This preponderance is to the advantage of the patients because the mixing of plants is sometimes toxic that 30% of the fatal accidents in Africa are due to intoxications due to plants [26]. Indeed, these intoxications are sometimes the result of confusion with another plant or a lack of knowledge of the side effects of the plant as well as ignorance of the methods of their use, including the methods of preparation and recommended doses. The use of medicinal plants must be rationalized to take advantage of them and avoid risks. Therefore, we need more studies to achieve these goals.

Through pharmacological and phytochemical assays, the activities claimed by the present ethnobotanical study were already confirmed for several species listed by our respondents (**Table 3**). These results, which confirm the biological activity of these plants, explain the knowledge and practices in herbal medicine acquired by the inhabitants of the province. In fact, this research opens up new and interesting perspectives in the search for new therapeutic means, which can thus bring effective solutions by the manufacture of medicines sold in pharmacy for people suffering from hypertension

Table 3. Chemical constituents and pharmacological activities of the cited medicinal species

No	Botanical name	Family	Chemical constituents	References	Pharmacological activities	References
1	<i>Acacia senegal</i>	Leguminosae	Galactose, arabinose, rhamnose, glucuronic acid and 4-O-Me-Glucuronic acid	[27]	Effective role in preventing weight gain, antiatherosclerotic and Cardioprotective	[28, 29]
2	<i>Adansonia digitata</i>	Malvaceae	Glutamic acid, aspartic acid, oleic acid, linoleic acid and palmitic acid	[30]	Analgesic, antioxidant, hepatoprotective	[31-33]
3	<i>Ajuga iva</i>	Lamiaceae	Dienestrol , eucalyptol , o-xylene , 1-octadecanol ; 3-carene , (E)-2,3,6-trimethoxypentafulvene-1-carbonitrile , (-)-spathulenol , nonanal	[34]	Antioxidant, antibacterial, antiviral and hypoglycaemic	[35, 36]
4	<i>Allium cepa</i>	Amaryllidaceae	Quercetin, cycloalliin, S-methyl-L-cysteine, S-propyl-L-cysteine Sulfoxide, N-acetylcysteine, alliuocide, dimethyl trisulfide, S-methyl-L-cysteine sulfoxide, quercetin-3,4'-di-O- β -D-glucoside, quercetin-4'-O- β -D-glucoside, and isorhamnetin-4'-O- β -D-glucoside	[37, 38]	Antioxidant, antimicrobial and antidiabetic	[37, 39]
5	<i>Allium sativum</i>	Amaryllidaceae	diallyl trisulfide, diallyl disulfide, allyl methyl trisulfide, allyl (E)-1-propenyl disulfide, allyl methyl disulfide, alliin, allacin, (E)-ajoene, allyl sulf ide, (Z)-ajoene and 1,2-vinyldithiin	[40, 41]	Anti-tubercular, antimicrobial, anti-inflammatory, antibacterial, antiprotozoal, anticancer, antifungal, anthelmintic and cholesterol-lowering effects	[42, 43]
6	<i>Aloysia citriodora</i>	Verbenaceae	β -spathulenol, Ar-curcumen, trans-caryophyllene oxide, neral, alpha-pinene, sabinene, 6-methyl-5-hepten-2-one, para-cymene, limonene, 1,8-cineol, cis-sabinene hydrate, cis-thujone, citronellal, piperitone, geranial, geranyl acetate, beta-caryophyllene, ar-curcumen, epicubebol, spathulenol, caryophyllene oxide and tau-cadinol	[44, 45]	Antioxidant, anxiolytic, neuroprotective, anticancer, anesthetic, antimicrobial, and sedative	[46, 47]
7	<i>Ammodaucus leucotrichus</i>	Apiaceae	Perillaldehyde, limonene, perilla alcohol, methyl perillate and shybinol	[48, 49]	Antihyperglycemic, antibacterial and antimicrobial	[50-52]
8	<i>Artemisia absinthium</i>	Compositae	(E)- β -farnesene, (Z)- α -yn-dicycloether, (Z)- β -ocimene, alpha-pinene, sabinene, beta-pinene, alpha-phellandrene, p-cymene and chamazulene. Alpha-phellandrene, and chamazulene	[5, 53]	Antibacterial, anticancer, antioxidant, anthelmintic and antifungal	[54-56]
9	<i>Artemisia herba-alba</i>	Compositae	Camphor, α -thujone, chrysanthenone, trans-sabinyl acetate, 1,8-cineole and β -thujone,	[57, 58]	Antibacterial, anticancer, antiinflammatory and antioxidant	[59, 60]
10	<i>Atriplex halimus</i>	Amaranthaceae	3',5'-dimethoxymyricetin-3-O- β -d-xylopyranosyl-7-O-fucopyranosyl-(1 $\rightarrow$ 3)- β -d-glucopyranoside , 3'-methoxyquercetin-7-O- β -d-fucopyranosyl-(1 $\rightarrow$ 3)- β -d-glucopyranosyl-3-O- β -xylopyranosyl-(1 $\rightarrow$ 4)- β -xylopyranoside , 3'-methoxyquercetin-7-O- α -l-rhamnopyranosyl-3-O- α -arabinofuranosyl-(1 $\rightarrow$ 6)- β -d-glucopyranoside, 3',5'-dimethoxymyricetin-7-O-fucopyranosyl-(1 $\rightarrow$ 3)- β -d-glucopyranoside, myricetin, quercetin, isorhamnetin glycosides, simple phenolic acids and esters.	[61]	Antioxidant and antidiabetic	[62, 63]
11	<i>Capparis spinosa</i>	Capparaceae	Cappariloside A, stachydrin, Hypoxanthine, uraci, 1H-indole-3-acetonitrile, 4-O- β -(60-O- β -glucopyranosyl) glucopyranoside, 1H-indole-3-acetonitrile 4-O- β -glucopyranoside, indole-3 acetonitrile glycosides, capparine A, capparine B, flazin, guanosine, 1H-indole-3-carboxaldehyde, 4-hydroxy-1H-indole-3-carboxaldehyde, apigenin, kaempferol and thevetiaflavone	[64]	Antioxidant, anti-diabetic, anti-obesity, anti-hypertensive, antimicrobial, anti-inflammatory and antihepatotoxi	[64-66]

12	<i>Carum carvi</i>	Apiaceae	γ -Terpinene, γ -Terpinene-7-al, 9-epi-(E)-Caryophyllene, cumin aldehyde, α -Terpinene-7-al, p-Cymene and limonene (4.40%), α -Pinene, β -Pinene, myrcene, limonene, cuminaldehyde, bornyl acetate, myristicin, elemicine, germacrene B and dillapiol	[67]	Antioxidant, antibacterial, antiaflatoxicogenic, diuretic and molluscicidal	[68-71]
13	<i>Citrullus colocynthis</i>	Cucurbitaceae	2-O- β -D-glucopyranosyl-Cucurbitacin I, 2-O- β -D-glucopyranosyl-Cucurbitacin L, isosaponarin, isovitexin, catechin, myricetin, quercetin, kaempferol, gallic acid, p-Hydroxy benzoic acid, chlorogenic acid, caffeic acid, vanillic acid, p-Coumeric acid, sinapic acid and ferulic acid	[72]	Antibacterial, antifungal, antioxidant, cytotoxic, antidiabetic, antilipidemic, insecticide, antimicrobial and anti-inflammatory	[72, 73]
14	<i>Coriandrum sativum</i>	Apiaceae	Pinocembrin, apigenin, pseudobaptigenin, galangin-5-methyl ether, quercetin, baicalein trimethyl ether, kaempferol dimethyl ether, pinobanksin-5-methylether-3-O-acetate, pinobanksin-3-O-pentenoate, pinobanksin-3-O-phenylpropionate, pinobanksin-3-O-pentanoate, apigenin-7-O-glucuronide, quercetin-3-O-glucoside, apigenin-3-O-rutinoside, rutin, isorhamnetin-3-O-rutinoside, quercetin dimethyl ether-3-O-rutinoside, daidzein, luteolin, pectolinarigenin, apigenin-C-glucoside, kaempferol-3-7-dimethyl ether-3-O-glucoside, apigenin-7-O-(6-methyl-beta-D-glucoside), 2E-decenal, decanal, 2E-decen-1-ol, n-decanol, 2E-tridecen-1-al, 2E-dodecenal, dodecanol, undecanol, and undecanal	[74, 75]	Antimicrobial, antioxidant, hypoglycemic, hypolipidemic, anxiolytic, analgesic, anti-inflammatory, anti-convulsant and anti-cancer	[76-78]
15	<i>Cynodon dactylon</i>	Poaceae	Phenylmethanol, propenoic acid, sesquiterpene, 2-Methoxy-4-prop-2-enylphenyl acetate, 4',5,7-Trihydroxyisoflavone, procyanidin and 3,7,11,15-Tetramethyl-2-hexadecen-1-ol	[79]	Anticancer, antioxidant and antimalarial	[80, 81]
16	<i>Dysphania ambrosioides</i>	Amaranthaceae	cispiperitone oxide, p-cymene, isoascaridole, α -terpinene, 4-hydroxy-4(α or β)-isopropyl-2-methyl-2-cyclohexen-1-one, 1-methyl-4 β -isopropyl-1-cyclohexene-4 α ,5 α ,6 α -triol, (1S,2S,3R,4S)-1-methyl-4-(propan-2-yl)cyclohexane-1,2,3,4-tetrol, (1R,2S,3S,4S)-1,2,3,4-tetrahydroxy-p-menthane, (1R,2S)-3-p-menthen-1,2-diol, (1R,4S)-p-menth-2-en-1-ol and 1,4-dihydroxy-p-menth-2-ene	[82, 83]	Antioxidant, cytotoxic, antifungal, antiaflatoxicogenic antimicrobial and antidiabetic	[84, 85]
17	<i>Eucalyptus globulus</i>	Myrtaceae	1,8-cineole, spathulenol and α -Terpineol	[86, 87]	Antioxidant and antibacterial	[87, 88]
18	<i>Glycyrrhiza glabra</i>	Leguminosae	Glycyrrhizin, glabridin, saponin glycyrrhizin, 30-hydroxyglycyrrhizin, glycyrrhizin-20-methanoate, 24-hydroxyglucoglycyrrhizin, rhaoglycyrrhizin, 11-deoxorhaoglycyrrhizin, rhaoglycyrrhizin, rhaogalactoglycyrrhizin, 11-deoxo-20 α -glycyrrhizin, 20 α -galacturonoylglycyrrhizin 20 α -rhaoglycyrrhizin,	[89, 90]	Antimicrobial, Anti-inflammatory, hepatoprotective, sedative, neuroprotective, antidepressive antioxidant and antiviral	[91, 92]
19	<i>Herniaria glabra</i>	Caryophyllaceae	Apiorutin, rutin, narcissin and licoagroside B	[93]	Antihypertensive and antiscaldant	[94-96]
20	<i>Hibiscus sabdariffa</i>	Malvaceae	Delphinidin 3-sambubioside, 3-caffeoylquinic acid, sambubioside, cyanidine-3-sambubioside, gossypetin, hibiscetin, protocathechuic acid, eugenol, β -sitosterol and ergosterol	[97, 98]	Anti-inflammatory, anthocyanidin, antioxidant and antimicrobial	[99, 100]

21	<i>Laurus nobilis</i>	Lauraceae	α -terpinyl acetate, α -pinene, β -elemene, sabinene, β -phellandrene, bornyl acetate, and camphene, 1,8-cineole, methyl eugenol, β -linalool, β -pinene, sabinene and terpinene-4-ol, α -terpineol and oleic acid	[101, 102]	Antimicrobial, antibacterial, antibiofilm and antifungal	[103, 104]
22	<i>Lavandula dentata</i>	Lamiaceae	Hexan-1-ol, α -Pinene, camphene, β -Pinene, oct-1-en-3-ol, p-Cymene, d-Limonene, 1,8-Cineole, cis-Thujan-4-ol, cis-Linalool oxide, camphenilone, isoverbenone, isobornyl formate, carvone, terpinolene (51.13 %) and camphor	[105, 106]	Anti-inflammatory	[107]
23	<i>Lawsonia inermis</i>	Lythraceae	Lacoumarin, fraxetin, scopoletin, esculetin, daphneside, daphnorin, agrimonolide 6-O- β -D-glucopyranoside, apiin, cosmosiin, isoscutellarin, lawsochrysin, rhoifolin and catechin	[108]	Anti-oxidant, anti-inflammatory, anticancer, antibacterial, anti-ulcer and antimicrobial,	[108, 109]
24	<i>Lepidium sativum</i>	Brassicaceae	5,6-dimethoxy-2',3'-methylenedioxy-7-C- β -d-glucopyranosyl, 7-hydroxy-4',5,6-trimethoxyisoflavone, 7-hydroxy-5,6-dimethoxy-2',3'-methylenedioxyisoflavone, kaempferol-3-O-(2-O-sinapoyl)- β -D-galactopyranosyl-(1 $\rightarrow$ 2)- β -D-glucopyranoside-7-O- α -L-rhamnopyranoside and quercetin-3-O-(6-O-benzoyl)- β -D-glucopyranosyl-(1 $\rightarrow$ 3)- β -D-galactopyranoside-7-O- α -L-rhamnopyranoside	[110, 111]	Hypoglycaemic, antihypertensive, prokinetic and laxative	[22, 112, 113]
25	<i>Linum usitatissimum</i>	Linaceae	Caffeic acid, p-coumaric acid, ferulic acid, and secoisolaricresinol diglucoside	[114]	Antioxidant, immunomodulatory, anti-inflammatory, antimicrobial, antiprotozoal, insecticidal, analgesic, anti-hyperlipidemia, anti-hyperglycemic and anti-tumor	[115]
26	<i>Mentha pulegium</i>	Lamiaceae	α -pinene, 1,8-Cineole, camphor, menthone, pulegone, rosmarinic acid, ellagic acid, eriodictyol, naringenin and chlorogenic acid	[116, 117]	Antioxidant, insecticidal and antimicrobial	[118, 119]
27	<i>Mentha spicata</i>	Lamiaceae	Carvone, limonene, muurolene, myrcene, 1,8-cineole, germacrene D, β -pinene and β -caryophyllene	[120, 121]	Antioxidant, anti-inflammatory antimicrobial and antiproliferative	[122, 123]
28	<i>Mesembryant hemum cryptanthum</i>	Aizoaceae	-	No reference	-	No reference
29	<i>Myrtus communis</i>	Myrtaceae	1,8-cineole, methyl eugenol, α -terpineol, geranyl acetate, α -terpinyl acetate, methyleugenol, linalool, β -caryophyllene, α -humulene, Trans-caryophyllene oxide, and humulene epoxide II.	[124, 125]	Antioxidant, antimicrobial, antidiarrheal, antidiabetic, antispasmodic, vasodilator, antiulcer, anticancer, anxiolytic, sedative-hypnotic, and anti-inflammatory	[124, 126]
30	<i>Nerium oleander</i>	Apocynaceae	Oleanderoic acid, quercetin-5-O-[α -L-rhamnopyranosyl-(1 $\rightarrow$ 6)]- β -D-glucopyranoside and kaempferol-5-O-[α -L-rhamnopyranosyl-(1 $\rightarrow$ 6)- β -D-glucopyranoside, and oleandigoside	[127]	Hepatoprotective, anti-diabetic and antioxidant	[128, 129]
31	<i>Nigella sativa</i>	Ranunculaceae	Linoleic acid, oleic acid, palmitic acid, myristic, myristoleic, palmitoleic, margaric, margaroleic, stearic, linolenic, arachidic, eicosenoic, behenic, lignoceric, p-cymene and thymol	[130, 131]	Antioxidant, anti-inflammatory, anti-hyperlipidemic, antimicrobial, anti-cancer, anti-diabetic, anti-hypertensive analgesic and antipyretic	[132-134]
32	<i>Ocimum basilicum</i>	Lamiaceae	p-Allyl-anisole, nerol, z-citral, linalool, epi- α -cadinol, α -bergamotene, eugenol, chavicol and α -terpineol	[135-137]	Antioxidant, antifungal and antimicrobial	[136, 138]
33	<i>Olea europaea</i>	Oleaceae	oleuropein, verbascoside, luteolin-7-O-glucoside, apigenin-7-O-glucoside, hydroxytyrosol, tyrosol, hydroxytyrosol, rutin and luteolin	[139, 140]	Antidiabetic, antioxidant and antimicrobial	[141, 142]

34	<i>Origanum compactum</i>	Lamiaceae	b-Myrcene, a-Phellandrene, a-Terpinene, Limonene, 1,8-Cineole, b-Phellandrene, g-Terpinene, 3-Octanone, P-Cymene, Terpinolene, 1-Octen-3-ol, Trans-thuyanol, Camphre, Linalol, Cis-thuyanol, Terpinene-4-ol, b-Caryophyllene, Pulegone, a-Humulene, Neral, a-Terpineol, Borneol, b-Bisabolene, d-Cadinene, g-Cadinene, P-Cymene-8-ol, Piperitenone, Caryophyllene, oxide, Thymol and Carvacrol.	[143, 144]	Antibacterial, antioxidant and antileishmanial, antimicrobial, antifungal, antibacterial, anti-mutagenic, cytotoxic, anticancer, anti-dermatophytes and anti-corrosion	[143, 145]
35	<i>Origanum majorana</i>	Lamiaceae	Terpinen-4-ol, cis-sabinene hydrate, p-cymene, γ -terpinene, trans-sabinene and linalool	[146, 147]	Antifungal, antioxidant and antibacterial	[148-150]
36	<i>Peganum harmala</i>	Nitrariaceae	Tetradecanoic, pentadecanoic, tridecanoic, hexadecanoic, heptadecanoic, octadecanoic acids, 12-methyl tetradecanoic, 5,9,13-trimethyl tetradecanoic and 2-methyl octadecanoic	[151]	Antibacterial and antifungal, anti-oxidant, anti-cancer and anti-inflammatory	[60, 152]
37	<i>Petroselinum crispum</i>	Apiaceae	1,3,8-p-menthatriene, β -phellandrene, apiol, myristicin, terpinolene, malonyl-apiin and acetyl-apiin	[153, 154]	Antifungal, antioxidant and antibacterial	[155, 156]
38	<i>Phoenix dactylifera</i>	Arecaceae	3,4-dimethoxytoluene, 2,4-dimethoxytoluene, β -caryophyllene, p-cresyl methyl ether, caryophyllene oxide, carvacrol, linalool, and thymol	[157, 158]	Antioxidant, anti-Inflammatory, antimicrobial, anticancer and antitumora	[159-161]
39	<i>Pimpinella anisum</i>	Apiaceae	Trans-anetole, estragole, γ -hymachalen, para-anisaldehyde and methyl cavicol, gamma-himachalene, trans-pseudoisoeugenyl 2-methylbutyrate, p-anisaldehyde and methylchavicol	[162, 163]	Ntimicrobial, antifungal, antiviral, antioxidant, muscle relaxant, analgesic and anticonvulsant	[162]
40	<i>Pistacia lentiscus</i>	Anacardiaceae	Tannic acid, gallic acid, digalloyl quinic acid derivative, quercetin, p-coumaric acid, β -sitosterol, cycloartenol and 24-methylene-cycloartenol	[164, 165]	Antioxidant, anticancer, genotoxic, antigenotoxic and antimutagenic	[164, 166, 167]
41	<i>Rosmarinus officinalis</i>	Lamiaceae	1,8-cineole, α -pinene, camphor, camphene and β -pinene	[168, 169]	Anti-inflammatory, antioxidant, anti-biofilm, muscle relaxant and antimicrobial	[168-170]
42	<i>Rubia tinctorum</i>	Rubiaceae	Mollugin, 1-hydroxy-2-methylanthraquinone, 2-ethoxymethyl-anthraquinone, rubiadin, 1, 3-dihydroxyanthraquinone, 7-hydroxy-2-methylanthraquinone, lucidin, 1-methoxymethylanthraquinone and lucidin-3-O-primeveroside	[171]	Antifungal and antimicrobial	[172, 173]
43	<i>Salvia officinalis</i>	Lamiaceae	Camphor, α -thujone, 1,8-cineole, viridiflorol, β -thujone and β -caryophyllene	[174, 175]	Synergistic antifungal, antimicrobial, insecticida allelopatic, anti-aroliferative, anti-inflammatory and antioxidant	[174, 176, 177]
44	<i>Saussurea costus</i>	Compositae	Lactone, elemol, γ -costol, vulgareol B, valerenol and terpinen-4-ol, arbusculin B, α -cyclocostunolide, costunolide, dehydrocostuslactone, parthenolide, zaluzanin D, and eupatoriopicrin	[178, 179]	Anti-inflammatory, anti-ulcer, anti-allergic anticancer and hepatoprotective	[180, 181]
45	<i>Searsia tripartita</i>	Anacardiaceae	-	No reference	-	No reference
46	<i>Solanum lycopersicum</i>	Solanaceae	α -tocopherol, linoleic acid, oleic acid, α -linolenic acid	[182]	Antioxidant and anti-inflammatory	[183, 184]
47	<i>Syzygium aromaticum</i>	Myrtaceae	Eugenol, eugenyl acetate, caryophyllene, furan, tetrahydro-3-methyl and 2-propanone, methylhydrazone	[185, 186]	Antioxidant and antibacterial	[185, 187]
48	<i>Tetraclinis articulata</i>	Cupressaceae	Bornyl acetate, camphor, α -pinene, camphene, linalool, cedrol, carvacrol and α -acorenil	[188, 189]	Antioxidant and anti-inflammatory	[188, 189]
49	<i>Trigonella foenum-graecum</i>	Leguminosae	(2E)-Hexenal, n-Hexadecanoic acid, (E)-b-Ionone, Thymol, 6,10,14-trimethyl-2-Pentadecanone, Carvacrol, (E)-Nerolidol, (2E,6Z)-Nonadienal, linoleic acid, linolenic acid and oleic acid	[190, 191]	Antioxidant, anti-arthritis, haemato-protective and anticancer	[192-194]

50	<i>Urtica dioica</i>	Urticaceae	5-O-caffeoylquinic acid, rutin, isoquercitrin, kaempferol 3-O-glucoside, secoisolariciresinol, 9,9'-bisacetyl-neo-olivil, carvacrol, carvone, naphthalene, (E)-anethol, hexahydrofarnesyl acetone, geranyl acetone, ionone and phytol	[195, 196]	Anti-diabetic, cardiovascular, antiinflammatory and antibacterial	[197, 198]
51	<i>Zea mays</i>	Poaceae	Tricin, salcolin A, salcolin B, C-glycoside, chrysoeriol 6-C-beta-boivinopyranosyl-7-O-beta-glucopyranoside, and a known flavone C-glycoside	[199, 200]	Aphrodisiac, antimalarial and antiplasmodial	[201, 202]
52	<i>Ziziphus lotus</i>	Rhamnaceae	Oleic acid, linoleic, palmitic, elaidic acid, threonine, glutamic acid, leucine, arginine and aspartic acid	[203, 204]	Antiradical, antioxidant and antimicrobial	[203, 205]

Plant parts used, mode of preparation and administration

A total of 11 parts of plants are used including leaf, seed, aerial part, fruit, bulb, root, Stem, gum, clove, chalices of flowers and stigma. The percentage of use of these different parts shows that the most used part of the plant is the leaf, with a percentage of 32.7% (**Fig. 2**). Several previous ethnobotanical studies have shown the predominance of leaves in the preparation of various herbal remedies [206-208]. The high frequency of use of leaves can be explained by the ease of identification and the speed of harvest [209], but also by the fact that they are the site of photosynthesis and storage of plants bioactive phytochemicals [210, 211]

Fig. 2. Plant parts used (%)

The most common methods of use are classified as follows: decoction, infusion, powder and maceration with respectively 46.1%; 21.1%; 19.2%; 5.8% (**Fig. 3**). Our results are in agreement with other studies conducted throughout Morocco [212, 213]. Herbal medicine is a rational use of medicinal plants. Rigorous selection of the most effective method of preparation to ensure the preservation of all properties while allowing the extraction and assimilation of active ingredients [214, 215]

Fig. 3. Methods of preparation of plants (%)

Conclusion

This study allowed us to inventory and identify 52 species of plants belonging to 29 families used in the province of Tarfaya to treat hypertension. Among the most commonly used species are *Allium sativum*, *Allium cepa*, *Olea europaea*, *Searsia tripartita*, *Ammodaucus leucotrichus*, *Myrtus communis* and *Carum carvi*. The results of the study also showed that the frequency of plant use is very much related to the profile of the people surveyed. The illiterates predominate with a rate of 53.3%. Women and men have knowledge and practices in herbal medicine with an advantage for women. The rate among young people aged 21 to 30 is 11.3%, while it is around 34% for people aged 41 to 50. This study also showed that the therapeutic remedies are mainly prepared by the decoction and that the leaf and the seed are the most used parts.

Ultimately, the results of this study could constitute a database for the valorization of medicinal plants in order to discover new natural active ingredients that can be used in pharmacology for the treatment of hypertension.

Conflict of Interest

The authors declare no conflict of interest.

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