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

Elhassan Idm’handa*, Fouad Msanda, Khalil Cherifi

Laboratory of Biotechnology and Valorization of Natural Resources, Faculty of sciences, Ibn Zohr University, Agadir, Morocco

a*idmhand-h@hotmail.com, bfmsanda@gmail.com, ccherifi@yahoo.com

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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.

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 = number of citations of a species / 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 tripartita* (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.
| No | Botanical name & voucher no. | family | Vernacular name | Parts used | Preparation | FC  | RFC | Reported Literatures |
|----|-----------------------------|--------|----------------|------------|-------------|-----|-----|---------------------|
| 1  | Acacia senegal (L.) Willd. LBVRN 180 | Leguminosae | Aalelk | Gum | Decoction | 22 | 0.13 | No reference |
| 2  | Adamsonia digitata L. LBVRN 139 | Malvaceae | Tajmakht | Fruit | Infusion | 14 | 0.08 | No reference |
| 3  | Ajuga iva (L.) Schreb. LBVRN 142 | Lamiaceae | Chendgora | Aerial part | Decoction | 21 | 0.12 | [4, 11] |
| 4  | Allium cepa L. LBVRN 145 | Amaryllidaceae | Lbesla | Bulb | Raw | 35 | 0.2 | [11, 17] |
| 5  | Allium sativum L. LBVRN 140 | Amaryllidaceae | Touma | Bulb | Raw | 48 | 0.28 | [11, 12, 25] |
| 6  | Alosya citriodora L. LBVRN 146 | Verbenaceae | Lwiza | Leaf | Decoction | 15 | 0.09 | [9, 12] |
| 7  | Ammodaucus leucotrichus Coss. LBVRN 144 | Apiaceae | Kamoun Souofi | Seed | Decoction | 25 | 0.15 | No reference |
| 8  | Artemisia absinthium L. LBVRN 141 | Compositae | Chiba | Aerial part | Decoction | 15 | 0.09 | [9] |
| 9  | Artemisia herba-alba Asso LBVRN 143 | Compositae | Chih | Leaf | Powder | 16 | 0.09 | [9, 11, 12] |
| 10 | Atriplex halimus L. LBVRN 147 | Amaranthaceae | Lgtef | Leaf | Decoction | 16 | 0.09 | No reference |
| 11 | Capparis spinosa L. LBVRN 148 | Capparaceae | LKebar | Fruit | Maceration | 15 | 0.09 | [11] |
| 12 | Carum carvi L. LBVRN 179 | Apiaceae | Elkarwiya | Seed | Powder | 24 | 0.14 | [9, 11] |
| 13 | Citrullus colocynthis (L.) Schrad. LBVRN 149 | Cucurbitaceae | Lhdej | Fruit | Maceration | 23 | 0.13 | [11, 18] |
| 14 | Coriandrum sativum L. LBVRN 150 | Apiaceae | Kasbour | Seed | Decoction | 18 | 0.11 | [9, 11] |
| 15 | Cynodon dactylon (L.) Pers. LBVRN 182 | Poaceae | Njem | Aerial part | Decoction | 15 | 0.09 | [11] |
| 16 | Dysphania ambrosioides (L.) Mosyakin & Clemants LBVRN 131 | Amaranthaceae | Lmkhinza | Leaf | Infusion | 21 | 0.12 | [9, 11] |
| 17 | Eucalyptus globulus Labill. LBVRN 132 | Myrtaceae | Kalitus | Leaf | Decoction | 13 | 0.08 | [11, 12] |
| 18 | Glycyrrhiza glabra L. LBVRN 133 | Leguminosae | Arq souss | Stem | Decoction | 15 | 0.09 | [9] |
| 19 | Harniaria glabra L. LBVRN 181 | Caryophyllaceae | Harass iljar | Aerial part | Decoction | 18 | 0.11 | [9, 11] |
| 20 | Hibiscus sabdariffa L. LBVRN 134 | Malvaceae | Bissam | Chalices of flowers | Infusion | 20 | 0.12 | [2, 17] |
| 21 | Laurus nobila L. LBVRN 135 | Lauraceae | Wnak sidna Musa | Leaf | Decoction | 14 | 0.08 | [12] |
| 22 | Lavandula dentata L. LBVRN 126 | Lamiaceae | Lokhzama | Aerial part | Powder | 18 | 0.11 | [4, 9, 12] |
| 23 | Lawsonia inermis L. LBVRN 137 | Lythraceae | Lhana | Leaf | Infusion | 13 | 0.08 | No reference |
| 24 | Lepidium sativum L. LBVRN 138 | Brassicaceae | Hab rehad | Seed | Decoction | 22 | 0.13 | [4] |
| 25 | Linum usitatissimum L. LBVRN 160 | Linaceae | Zarriuat likettane | Seed | Powder | 14 | 0.08 | [9] |
| 26 | Mentha pulegium L. LBVRN 176 | Lamiaceae | Fliyou | Seed | Decoction | 22 | 0.13 | [4, 11] |
| 27 | Mentha spicata L. LBVRN 171 | Lamiaceae | Likama | Stem | Infusion | 19 | 0.11 | [9, 11] |
| 28 | Mesembryanthemum cryptanthum Hook.f. LBVRN 170 | Aizoaceae | Afzo | Seed | Powder | 13 | 0.08 | No reference |
| 29 | Myrtus communis L. LBVRN 161 | Myrtaceae | Rihan | Leaf | Decoction | 25 | 0.15 | [9, 11] |
| 30 | Nerium oleander L. LBVRN 178 | Apocynaceae | Defla | Leaf | Infusion | 19 | 0.11 | [9] |
| 31 | Nigella sativa L. LBVRN 169 | Ranunculaceae | Sanouj | Seed | Powder | 15 | 0.09 | [4, 9, 11] |
| 32 | Octimum basilicum L. LBVRN 162 | Lamiaceae | Lahbak | Aerial part | Decoction | 19 | 0.11 | [4] |
| 33 | Olea europea L. LBVRN 167 | Oleaceae | Zitoun | Leaf | Decoction | 30 | 0.18 | [4, 11, 12] |
| 34 | Origanum compactum Benth. LBVRN 168 | Lamiaceae | Zaatar | Leaf | Infusion | 19 | 0.11 | [4, 12] |
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.
| No | Botanical name          | Family          | Chemical constituents                                                                 | References | Pharmacological activities                                      | References |
|----|-------------------------|-----------------|----------------------------------------------------------------------------------------|------------|-----------------------------------------------------------------|------------|
| 1  | *Acacia senegal*        | Leguminosae     | Galactose, arabinose, rhamnose, glucuronic acid and 4-O-Me-Glucuronic acid              | [27]       | Effective role in preventing weight gain, antiatherosclerotic and  | [28, 29]   |
|    |                         |                 |                                                                                        |            | Cardioprotective                                                |            |
| 2  | *Adansonia digitata*    | Malvaceae       | Glutamic acid, aspartic acid, oleic acid, linoleic acid and palmitic acid               | [30]       | Analgesic, antioxidant, hepatoprotective                        | [31-33]   |
| 3  | *Ajuga iva*             | Lamiaceae       | Dienestrol, eucalyptol, α-xylene, 1-octadecanol, 3-carene, (E)-2,3,6-trimethoxypentafulvene-1-carbonitrile, (→)-spathulenol, nonanal | [34]       | Antioxidant, antibacterial, antiviral and hypoglycaemic           | [35, 36]   |
| 4  | *Allium cepa*           | Amaryllidaceae  | Quercetin, cycloallnin, S-methyl-L-cysteine, S-propyl-L-cysteine Sulfoxide, N-acetylcysteine, alliuocuore, dimethyl triisulfide, 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 anti diabetic                     | [37, 39]   |
| 5  | *Allium sativum*        | Amaryllidaceae  | diallyl triisulfide, diallyl disulfide, allyl methyl triisulfide, allyl (E)-1-propenyl disulfide, allyl methyl disulfide, alliin, alliin, (E)-ajoene, allyl sulf ide, (Z)-ajoene and 1,2-vinylthiin | [40, 41]   | Anti-tubercular, antimicrobial, anti-inflammatory, antibacterial, anti protozoal, anticancer, antifungal, antihelmintic and cholesterol-lowering effects | [42, 43]   |
| 6  | *Aloysia citriodora*    | Verbenaceae     | β-spathulenol, Ar-curcumen, trans-caryophyllene oxide, neral, alphapine, sabine, 6-methyl-5-hepten-2-one, para-cymene, limonene, 1,8-cineo, cis-sabine hydrate, cis-thujone, citronellal, pipertone, geranial, geranyl acetate, betacaryophyllene, ar-curcumen, epicubebol, spathulenol, caryophyllene oxide and tau-cadinol | [44, 45]   | Antioxidant, anxiolytic, neuroprotective, anticancer, anesthetic, antimicrobial, and sedative | [46, 47]   |
| 7  | *Ammodaucus leucotrichus* | Apiaceae       | Perillaldehyde, limonene, perilla alcohol, methyl perillate and shibinol                 | [48, 49]   | Antihyperglycemic, antibacterial and antimicrobial               | [50-52]   |
| 8  | *Artemisia absinthium*  | Compositae      | (E)-β-farnesene, (Z)-en-yclicloeloth, (E)-β-o-cimene, alphapine, sabine, beta-pinene, alphaphellandrene, p-cymene and chamazule, Alpha-phellandrene, and chamazulen | [5, 53]    | Antibacterial, anticancer, antioxidiant, anhemlinitic and antifungal | [54-56]   |
| 9  | *Artemisia herba-alba*   | Compositae      | Camphor, α-thujene, chrysantheneone, trans-sabinyl acetate, 1,8-cineole and β-thujene, 3,5′-dimethoxyycricetin-3-O-β-d-xylopyranosyl-7-O-fucopyranosyl-(1 → 3)-β-d-glucopyranoside, 3′-methoxyycricetin-7-O-β-d-fucopyranosyl-(1 → 3)-β-d-glucopyranosyl-3-O-β-xylopyranosyl-(1 → 4)-β-sylopyranoside, 3′-methoxyycricetin-7-O-α-l-rhamnopyranosyl-3-O-α-arabinofuranosyl-(1 → 6)-β-d-glucopyranoside, 3′,5′-dimethoxyycricetin-7-O-fucopyranosyl-(1 → 3)-β-d-glucopyranoside, myricetin, quercetin, isorhamnetin glycosides, simple phenolic acids and esters | [57, 58]   | Antioxidant, bacterial, anti-inflamatory and antioxidiant         | [59, 60]   |
| 10 | *Atriplex halimus*      | Amaranthaceae   |                                                                                        | [61]       | Antioxidant and antidiabetic                                     | [62, 63]   |
| 11 | *Capparis spinosa*      | Capparaceae     | Capparolide 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, flavin, 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 antihepatotoxic | [64-66]   |
| No. | Common Name          | Family     | Chemical Constituents                                                                 | Properties                              | References |
|-----|---------------------|------------|--------------------------------------------------------------------------------------|-----------------------------------------|------------|
| 12  | Carum carvi        | Apiaceae   | γ-Terpinene, γ-Terpinene-7-al, 9-epi-(E)-Caryophyllene, cumin aldehyde, α-Terpinene-7-al, p-Cymene and limonene (4.40%), α-Pinen, β-Pinen, myrcene, limonene, cuminaldehyde, bornyl acetate, myristicin, elernicine, germacrene B and dillapiole | Anti-inflammatory, antioxidant, anti-inflammatory, diuretic and molluscicidal | [67-71]    |
| 13  | Citrullus colocynthis | Cucurbitaceae | 2-O-[β-D-glucopyranosyl-Cucurbitacin I, 2-O-β-D-glucopyranosyl-Cucurbitacin L, isosaponarin, isolutein, catechin, myricetin, quercetin, kaempferol, gallic acid, p-Hydroxy benzoic acid, chlorogenic acid, caffeic acid, vanillic acid, p-Coumeric acid, sinapic acid and ferulic acid | Antibacterial, antifungal, antioxidant, cytotoxic, anti-diabetic, antilipidemic, insecticide, antimicrobial and anti-inflammatory | [72, 73]    |
| 14  | Coriandrum sativum | Apiaceae   | Pinobenzem, apigenin, pseudobaptigenin, galangin-5-methyl ether, quercetin, baicalein trimethyl ether, kaempferol dimethyl ether, pinobanksin-5-methylether-3-O-acetate, pinobanksin-3-O-pentenoozoate, pinobanksin-3-O-phenylpropionate, apigenin-7-O-glucuronide, quercitin-3-O-glucoside, apigenin-3-O-rutinoside, rutin, isorhamnetin-3-O-rutinoside, quercetin dimethyl ether-3-O-rutinoside, daidzein, luteolin, pectolinarinigen, 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-ol, 2E-dodecenal, dodecanal, undecanol, and undecanal | Antimicrobial, antioxidant, hypoglycemic, hypolipidemic, anxiolytic, analgesic, anti-inflammatory, anti-convulsant and anti-cancer | [76-78]    |
| 15  | Cynodon dactylon    | 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 | Anticancer, antioxidant and antimarial | [80, 81]    |
| 16  | Dysphania ambrosioides | Amaranthaceae | cisipiiperitone oxide, p-cymene, isoascaridole, α-terpine, 4-hydroxy-4u or β-isopropyl-2-methyl-2-cyclohexen-1-one, 1-methyl-4β-isopropyl-1-cyclohexene-4a,5α,6α-triol, (1S,2S,3R,4S)-1-methyl-4-(prop-2-yl)cyclohexane-1,2,3,4-tetrol, (1R,2S,3S,4S)-1,2,3,4-tetrahydroxy-p-methane, (1R,2S,3S)-p-menth-1,2-diol , (1R,4S)-p-menth-2-en-1-ol and 1,4-dihydroxy-p-menth-2-ene | Antioxidant, cytotoxic, antifungal, antialtaflatoxigenic antimicrobial and anti-diabetic | [84, 85]    |
| 17  | Eucalyptus globulus | Myrtaceae  | 1,8-cineole, spathulenol and α-Terpinaol | Antioxidant and antibacterial | [87, 88]    |
| 18  | Glycyrrhiza glabra | Leguminosae | Glycyrrhizin, glabridin, saponin glycyrrhizin, 30-hydroxyglycyrrhizin, glycyrrhizin-20-methanoate , 24-hydroxyglycyrrhizin, rhaoglycyrrhizin, 11-deoxyrhaoglycyrrhizin, rhaoglycyrrhizin, rhaogalactogyicyrrhizin, 11-deoxy-20u-glycyrrhizin, 20u-galacturonolglycyrrhizin 20u-rhaoglycyrrhizin | Antimicrobial, Anti-inflammatory, hepatoprotective, sedative, neuroprotective, antidepressive antioxidant and antiviral | [91, 92]    |
| 19  | Herniaria glabra    | Caryophyllaceae | Apisoinutin, rutin, narcissin and licoagroside B | Antihypertensive and antiscalant | [94-96]    |
| 20  | Hibiscus sabdariffa | Malvaceae   | Delphinidin 3-sambubioside, 3-caffeoylquinic acid, sambubioside, cyanidin-3-sambubioside, gossypetine, hibiscetin, protocatechuic acid, eugenol, β-sitosterol and ergosterol | Anti-inflammatory, anthocyanidin, antioxidant and antimicrobial | [99, 100]   |
|   | Plant Name       | Family      | Chemical Constituents                                                                 | References                                      | Activities                                      |
|---|-----------------|-------------|--------------------------------------------------------------------------------------|------------------------------------------------|------------------------------------------------|
| 21 | Laurus nobilis  | Lauraceae   | α-terpinyl acetate, α-pinene, β-elemene, sabine, β-phellandrene, bornyl acetate, and camphene, linalool, β-pinene, sabine, terpinene-4-ol, α-terpineol and oleic acid | [101, 102]                                     | Antimicrobial, antibacterial, antifungal and antifungal [103, 104] |
| 22 | Lavandula dentata | 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 | Lavsonia inermis | Lythraceae  | Lacoumarin, fraxetin, scopoletin, esculetin, daphnside, daphnorin, agrimonolide 6-O-β-D-glucopyranoside, apiin, cosmosin, isoscutellarin, lawsochrysin, rhoifolin and catechin | [108]                                          | Anti-oxidant, anti-inflammatory, anticancer, antibacterial, anti-ulcer and antimicrobial [108, 109] |
| 24 | Lepidium sativum | Brassicaceae | 5,6-dimethoxy-2',3'-methyleneoxy-7-C-β-D-glucopyranosyl, 7-hydroxy-4',5,6-trimethoxyisoflavone, 7-hydroxy-5,6-dimethoxy-2',3'-methyleneoxyisoflavone, kaempferol-3-O-(2-O-sinapoyl)-β-D-galactopyranosyl-(1→2)-β-D-galactopyranoside-7-O-α-L-rhamnopyranoside and quercetin-3-O-(6-O-benzoyl)-β-D-galactopyranosyl-(1→3)-β-D-galactopyranoside-7-O-α-L-rhamnopyranoside | [110, 111]                                     | Hypoglycaemic, antihypertensive, prokinetic and laxative [22, 112, 113] |
| 25 | Linum usitatissimum | Linaceae | Caffeic acid, p-coumaric acid, ferulic acid, and secoisolariciresinol diglucoside | [114]                                          | Antioxidant, immunomodulatory, anti-inflammatory, antimicrobial, antiprotozoal, insecticidal, analgesic, anti-hyperlipidaemia, anti-hyperglycaemic and anti-tumor [115] |
| 26 | Mentha pulegium  | Lamiaceae   | α-pinene, 1,8-Cineole, camphor, menthone, pulegone, rosmaninic acid, eugenol, eriodictyol, naringenin and chlorogenic acid | [116, 117]                                     | Antioxidant, insecticidal and antimicrobial [118, 119] |
| 27 | Mentha spicata   | 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 | Mesembryanthemum cryptanthum | Aizoaceae | - | No reference | No reference |
| 29 | Myrtus communis  | Myrtaceae   | 1,8-cineole, methyl eugenol, α-terpinene, geranly acetate, α-terpinyl acetate, methyleugenol, linalool, β-caryophyllene, α-humulene, Trans-caryophyllene oxide, and humulene epoxide II | [124, 125]                                     | Antioxidant, antimicrobial, anti-diarrheal, anti-diabetic, antiapoptotic, vaso-dilator, anti-ulcer, anti-inflammatory, anti-oxidant, anti-ulcer, anti-cancer, anti-inflammatory and anti-oxidant [124, 126] |
| 30 | Nerium oleander  | Apocynaceae | Oleandroic acid, quercetin-5-O-[a-L-rhamnopyranosyl(1→6)]-b-D-glucopyranoside and kaempferol-5-O-[a-L-rhamnopyranosyl(1→6)]-b-D-glucopyranoside and oleandigoside | [127]                                          | Hepatoprotective, anti-diabetic and antioxidant [128, 129] |
| 31 | Nigella sativa   | Ranunculaceae | Linoleic acid, oleic acid, palmitic acid, myristic, myristoleic, palmitoleic, margaric, margaroleic, stearic, linolenic, arachidic, eicosenoic, behenic, lignoceric, p-cymene and thynol | [130, 131]                                     | Antioxidant, anti-inflammatory, anti-hyperlipidaemia, anti-microbial, anti-cancer, anti-diabetic, anti-hypertensive analgesic and anti-pyretic [132-134] |
| 32 | Ocimum basilicum | Lamiaceae   | p-Allyl-anisole, nerol, ε-citral, linalool, α-terpineol, α-bergamotene, eugenol, chavicol and α-terpineol | [135-137]                                     | Antioxidant, antifungal and antimicrobial [136, 138] |
| 33 | Olea europaea    | Oleaceae    | oleuropein, verbascoside, lutelolin-7-O-glucoside, apigenin-7-O-glucoside, hydroxytyrosol, tyrosol, hydroxytyrosol, rutin and luteolin | [139, 140]                                     | Antidiabetic, antioxidant and antimicrobial [141, 142] |
| No. | Species                        | Family       | Constituents                                                      | References                                      |
|-----|-------------------------------|--------------|------------------------------------------------------------------|------------------------------------------------|
| 34  | Origanum compactum           | Lamiaceae    | b-Myrcene, a-Phellandrene, a-Terpine, Limonene, 1,8-Cineole, b-Phellandrene, g-Terpine, 3-Octanone, P-Cymene, Terpinene, 1-Octen-3-ol, Trans-thuylanol, Camphre, Linalol, Cis-thuylanol, Terpine-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 anti-inflammatory, antitumoral, anti-mycobacterial, antibacterial, anti-fungal, antibacterial, anti-mutagenic, cytotoxic, anticancer, anti-dermatophytes and anti-corrosion |
| 35  | Origanum majorana            | Lamiaceae    | Terpenen-4-ol, cis-sabinene hydrate, p-cymene, γ-terpinene, trans-sabinene and linalol | [146, 147] Antifungal, antioxidant and antibacterial |
| 36  | Peganum harmala              | Nitrariaceae  | Tetradecanoic, pentadecanoic, tridecanoic, hexadecanoic, heptadecanoic, octadecanoic acids, 12-methyl tetradecanoic, 5,9,13-trimethyl tetradecanoic and 2-methyl octadecanoic | [151] Antifungal and antibacterial |
| 37  | Petroselinum crispum         | Apiaceae      | 1,3,8-p-Menthatriene, Myrhhlandrene, apilon, myristicin, terpinolene, malonyl-apin and acetyl-apin | [153, 154] Antifungal, antioxidant and antibacterial |
| 38  | Phoenix dactylifera          | Arecaceae     | 3,4-Dimethoxytoluene, 2,4-dimethoxylute, β-caryophyllene, p-cresyl methyl ether, caryophyllene oxide, carvacrol, linalool, and thymol | [157, 158] Antioxidant, anti-inflammatory, antimicrobial, antitumoral and antitumour |
| 39  | Pimpinella anisum            | Apiaceae      | Trans-anetole, estragole, γ-hymachalen, para-anisaldehyde and methyl cavicol, gamma-himachalen, trans-pseudouongeyl 2-methylbutyrate, p-anisaldehyde and methylchavicol | [162, 163] Nitrofugal, anti-fungal, anti-viral, antioxidant, muscle relaxant, analgesic and anticonvulsant |
| 40  | Pistacia lentiscus            | 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 |
| 41  | Rosmarinus officinalis        | Lamiaceae     | 1,8-Cineole, α-pine, camphor, camphone and β-pine | [168, 169] Anti-inflammatory, antioxidant, anti-biofilm, muscle relaxant and antmicrobial |
| 42  | Rubia tinctorum              | Rubiaceae     | Mollugin, 1-hydroxy-2-methylnaphraquinone, 2-ethoxymethyl-anthaquinone, rubiadin, 1, 3-dihydroxyanthraquinone, 7-hydroxy-2-methylnaphraquinone, lucidin, 1-methoxymethylnaphraquinone and lucidin-3-O-primeveroside | [171] Antifungal and antimicrobial |
| 43  | Salvia officinalis            | Lamiaceae     | Camphor, α-thujone, 1,8-cineole, viridiflorol, β-thujone and β-caryophyllene | [174, 175] Synergistic anti-fungal, antimicrobial, insecticida allelopathic, anti-carcinogenic, anti-inflammatory and anti-cancer |
| 44  | Saussurea costus              | Compositae    | Lactone, elemol, γ-costol, vulgarol B, valerenol and terpinen-4-ol, arbusculin B, α-cyclocostanolide, costanolide, dehydrocostaulactone, parthenolide, zaluzan D, and eupatioripin | [178, 179] Anti-inflammatory, anti-ulcer, anti-allergic anticancer and hepatoprotective |
| 45  | Searsia tripartita           | Anacardiaceae | -                                                                | No reference                                    |
| 46  | Solanum lycopersicum         | Solanaceae    | α-tocopherol, linoleic acid, oleic acid, α-linolenic acid | [182] Antioxidant and anti-inflammatory |
| 47  | Syzygium aromaticum          | Myrtaceae     | Eugenol, eugenyl acetate, caryophyllene, furan, tetrahydro-3-methyl and 2-propanone, methyllyhydrozene | [185, 186] Antioxidant and antibacterial |
| 48  | Tetracallis articulata        | Cupressaceae  | Bornyl acetate, camphor, α-pine, camphone, linalool, cedrol, carvacrol and n-aracenol | [188, 189] Antioxidant and anti-inflammatory |
| 49  | Trigonella foenum-graecum     | Leguminosae   | (2E)-Hexenal, n-Hexadecanoic acid, (E)-b-Ionone, Thymol, 6,10,14-trimethyl-2-Pentadecanone, Carvacrol, (E)-Nerolidol, (2E,6Z)-Nonadecenal, linoleic acid, linolenic acid and oleic acid | [190, 191] Antioxidant, anti-arthritis, haemato-protective and anticancer |

Note: The references [151, 155, 156] to [192-194] correspond to the specific compounds or effects mentioned in the text.
| No. | Species          | Family    | Secondary metabolites                                                                 | Pharmacological properties                              | References                  |
|-----|-----------------|-----------|-------------------------------------------------------------------------------------|----------------------------------------------------------|-----------------------------|
| 50  | Urtica dioica    | 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 | Anti-diabetic, cardiovascular, antiinflammatory and antibacterial | [195, 196]                  |
| 51  | Zea mays         | Poaceae   | Tricin, salcolin A, salcolin B, C-glycoside, chrysoeriol 6-C-beta-boivinopyranosyl-7-O-beta-glucopiyranoside, and a known flavone C-glycoside | Aphrodisiac, antimalarial and antiplasmodial              | [199, 200]                  |
| 52  | Ziziphus lotus   | Rhamnaceae| Oleic acid, linoleic, palmitic, elaidic acid, threonine, glutamic acid, leucine, arginine and aspartic acid | Antiradical, antioxidant and antimicrobial               | [203, 204]                  |

**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 (%)](image)

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]
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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