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Review article

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A Review of Moroccan Medicinal Plants Used in the Treatment of Hypertension

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Abstract
The incidence of hypertension is very high in human societies and its treatment is the most important priority in many countries. Knowledge of the plants that are used may provide insight on their properties, for further exploration. This study aimed to collect the knowledge on traditional medicine for the treatment of hypertension in different regions of Morocco. We reviewed 145 research publications based on data from the six explored regions of Morocco published until August 2021 in various journals. This was achieved using literature databases: Google, Google Scholar, PubMed, Medline, Science Direct and Researchgate. The findings of this study indicated that 23 plants have been reported to possess antihypertensive activities in *in vivo* / *in vitro* experiments, while 81 plants had not been studied for such an activity. Plants from the Lamiaceae, Asteraceae and Apiaceae families were used most often. Leaves were the plant parts used most often. Decoction was the main preparation method. Twenty three plants have been explored experimentally for their antihypertensive activity. This review provides baseline data for plant species used to treat hypertension in Morocco and provides new areas of research on the antihypertensive effect of these plants.

Key words: Medicinal plants, Hypertension, Ethnobotany, Pharmacology, Morocco

1. Introduction

Hypertension which is also called "high blood pressure" is one of the principal health problems in the society in various communities worldwide, particularly in developing countries where health systems are weak (De Wet et al., 2016). This condition affects nearly 54% of the world's population and complications caused by hypertension account for approximately 17 million deaths annually (De Wet et al., 2016; Karou et al., 2011). Hypertension is often called "the silent killer" because many people may suffer from the disease without knowing it (Mansley et al., 2016). Hypertension was described as a health condition that results in a diastolic blood pressure higher than 90 mmHg and/or systolic blood pressure higher than 140 mmHg (Paramore et al., 2001). Stage 1 hypertension is defined as 140 to 159 mmHg systolic or 90 to 99 mm Hg diastolic, and stage 2 hypertension as 160/100 mmHg or higher (Valderrama et al., 2013). Several factors contribute to the increased

incidence of hypertension. These include unhealthy diets including the excessive consumption of salty and sweet foods, harmful use of alcohol, smoking, excess body weight, lack of physical activity, hypercholesterolemia, diabetes and persistent stress (Baharvand-Ahmadi and Asadi-Samani, 2017; De Wet et al., 2016; Poorolajal et al., 2016). Uncontrolled high blood pressure increases the risk of a number of cardiovascular diseases such as heart attacks, heart failure, strokes, ischemic and hemorrhagic brain strokes, angina, myocardial infarction, development of thrombosis, coronary heart disease, and kidney failure (De Wet et al., 2016; Gbekley et al., 2018; Niazi et al., 2019). There are two important approaches for treatment of hypertension. First, health behavior management through consistent exercise, maintenance of a healthy body weight, reducing alcohol consumption, dietary approaches, reducing sodium, calcium and magnesium intakes and increase dietary potassium intake. Second, drug therapy through use of the chemical and synthetic agents including diuretics, sympathetic and vasodilatative drugs, beta blockers, calcium channel blockers and aldosterone antagonists (De Wet et al., 2016; Leung et al., 2017; Niazi et al., 2019). Some of chemical drugs may lead to potential adverse side effects and some of them fail to meet patients all needs, thus the need for new molecules arises today with acuity. The current trend of people is toward using alternative therapies especially natural products with minimal side effects and high compatibility with human nature (Baharvand-Ahmadi and Asadi-Samani, 2017; De Wet et al., 2016; Gbekley et al., 2018; Niazi et al., 2019). Hence, the purpose of this review article was to pool data on the plants used to treat hypertension in various areas of Morocco.

2. Materials and Methods

This review article was carried out by searching studies in Google, Google Scholar, PubMed, Medline, Science Direct, Researchgate, and other online databases. The keywords Morocco, ethnobotany, ethnopharmacology, phytopharmacology, phytomedicine, ethnomedicine and traditional medicine in combination with hypertension, high blood pressure, hypotensive and antihypertensive were used to search for the literature inside the databases. In this study, the articles published until August 2021 are considered. The papers without accessible full text were excluded from this review article. One hundred and forty five ethnobotanical and pharmacology papers were retained. All scientific names of the plants were checked in theplantlist.org. Data were organized a by using Microsoft Word and Microsoft Excel.

3. Results and Discussion

3.1. Ethnobotanical studies

Comparison of medicinal plants used to treat hypertension in different regions of Morocco has shown that different cultures of Morocco use different plants to treat hypertension however, some plants have been used in different areas. Of all the medicinal plant species used for treating hypertension in Morocco, 4 plants were used in all the explored regions (6 regions). They are: *Petroselinum crispum*, *Tetraclinis articulata*, *Rosmarinus officinalis* and *Olea europaea*. 4 plants were used in 5 regions. They are: *Allium sativum*, *Syzygium aromaticum*, *Peganum harmala* and *Aloysia citriodora*. Most of these plants are from various plant families; Lamiaceae (18

species); Asteraceae (10 species); Apiaceae (8 species); Amaranthaceae and Fabaceae (4 species); Caryophyllaceae, Malvaceae, Myrtaceae and Solanaceae (3 species).

The majority of these plants have already been cited in the literature for similar use in the traditional medicine. Thus, we can consider these medicinal herbs as alternative agents for treatment of hypertension. However, studies have reported some problems of misdiagnosis by traditional healers for hypertension because it shows no early symptoms and as very few of them collaborate with the modern medicine (Niazi et al., 2019). Accepted names for each of the mentioned plants, family name, vernacular name, plant part used and preparation method are compiled in Table 1.

In Tarfaya province (South of Morocco), an ethnobotanical study was undertaken in order to inventory the main medicinal plants used in folk medicine to treat hypertension. In this province, the most frequently used plants include *Allium sativum*, *Allium cepa*, *Olea europaea*, *Searsia tripartita*, *Ammodaucus leucotrichus and Myrtus communis*. The survey revealed that leaves were the most frequently used part in herbal preparations (Idm'hand et al., 2019).

Thirty six species of plants were reported for the treatment of hypertension in the Errachidia province in south-eastern Morocco (Tahraoui et al., 2007). The most prominent plants reported were *Ajuga iva*, *Allium cepa*, *Allium sativum*, *Artemisia herba-alba*, *Carum carvi*, *Nigella sativa*, *Olea europea*, *Rosmarinus officinalis*, *Origanum majorana*, *Peganum harmala*, and *Phoenix dactylifera*. The local people have a relative knowledge of the toxic plants, which are *Citrullus colocynthis*, *Datura stramonium*, *Nerium oleander*, *Nigella sativa*, *Peganum harmala* and *Tetraena gaetula* (Tahraoui et al., 2007).

In the North center region of Morocco (Fez–Boulemane), a survey reported that 90 medicinal species were cited by 1527 patients for the treatment of diabetes, cardiac and renal diseases. Among these species, 9 plants are toxic at high doses. For hypertension, 19 plants were cited, of which the most cited were: *Allium sativum*, *Olea europaea*, *Arbutus unedo*, *Urtica dioica*, *Petroselinum crispum*, *Rosmarinus officinalis* and *Trigonella foenum-graecum* (Jouad et al., 2001).

In oriental Morocco, a survey was undertaken in order to inventory the main medicinal plants used in folk medicine to treat hypertension and diabetes. The results obtained allowed an inventory of 18 medicinal plant species used against hypertension. The most cited plants for the treatment of hypertension were: *Allium sativum*, *Olea europea*, *Arbutus unedo*, *Urtica dioica* and *Petroselinum crispum*. The survey revealed that proportions of the plant users remain high and appear to be independent of sex, age and socio-cultural level of the patients (Ziyyat et al., 1997).

In Northern Morocco reported that 30 plant species were cited by the riverside population of the forest of Izarène for management of hypertension (Douira and Zidane, 2015). Nine plants, *Allium sativum*, *Olea europaea*, *Rosmarinus officinalis*, *Nigella sativa*, *Petroselinum crispum, Ajuga iva*, *Tetraclinis articulata*, *Thymus vulgaris* and *Dittrichia viscosa*, were most used. The survey revealed that overexploitation threatens some scarce species such as, *Origanum compactum*, *Centaurium Erythraea*, and *Salvia verbenaca* disappearance of the Izarène forest.

In the south-east region of Morocco (Tafilalet), a survey was carried out to catalog the plants traditionally used in the treatment of diabetes mellitus, hypertension and cardiac diseases. The authors have inventoried 92 species, of which 73 plants were used in the treatment of hypertension and cardiac diseases. The most frequently cited plant species are *Allium sativum*, *Olea europaea*, *Pimpinella anisum, Artemisia herba-alba*, *Globularia alypum*, *Artemisia absinthium*, *Citrullus colocynthis* and *Fumaria officinalis*. Some toxic plants have also been reported. These were: *Nerium oleander*, *Citrullus colocynthis*, *Ferula assa-foetida*, *Papaver somniferum*, *Mandragora officinalis*, *Tetraena gaetula*, *Ricinus communis*, *Peganum harmala* and *Datura stramonium* (Eddouks et al., 2002).

Table 1. Moroccan medicinal plants documented for hypertension control.

Plant species	Family	Vernacular name	Parts used	Preparation	References
Acacia senegal (L.) Willd.	Fabaceae	Aalelk	Gum	Decoction	(Idm'hand et al., 2019)
Adansonia digitata L.	Malvaceae	Tajmakht	Fruit	Infusion	(Idm'hand et al., 2019)
Ajuga iva (L.) Schreb.	Lamiaceae	Chendgora	Aerial part	Decoction	(Douira and Zidane, 2015; Idm'hand et al., 2019; Tahraoui et al., 2007)
Allium cepa L.	Amaryllidaceae	Lbesla	Bulb	Raw	(Idm'hand et al, 2019; Tahraoui et al., 2007)
Allium sativum L.	Amaryllidaceae	Touma	Bulb	Raw	(Douira and Zidane, 2015; Idm'hand et al, 2019; Jouad et al., 2001; Tahraoui et al., 2007; Ziyyat et al., 1997)
Aloysia citriodora Palau	Verbenaceae	Lwiza	Leaf	Decoction	(Eddouks et al., 2002; Idm'hand et al., 2019; Jouad et al., 2001; Tahraoui et al., 2007; Ziyyat et al., 1997)
Ammodaucus leucotrichus Coss.	Apiaceae	Kamoun Sooufi	Seed	Decoction	(Douira and Zidane, 2015; Idm'hand et al., 2019)
Anabasis aretioides Moq. & Coss. ex Bunge	Amaranthaceae	Sallaa	Aerial part	-	(Eddouks et al., 2002)
Arbutus unedo L.	Ericaceae	Sasnu	Leaf and root	Decoction	(Douira and Zidane, 2015; Jouad et al., 2001; Ziyyat et al., 1997)
Arctostaphylos uva-ursi (L.) Spreng.	Ericaceae	Inad edib	Aerial part	-	(Eddouks et al., 2002)
Artemisia absinthium L.	Asteraceae	Chiba	Aerial part	Decoction	(Eddouks et al., 2002; Idm'hand et al., 2019; Tahraoui et al., 2007)
Artemisia herba-alba Asso	Asteraceae	Chih	Leaf	Powder	(Eddouks et al., 2002; Idm'hand et al., 2019; Tahraoui et al., 2007; Ziyyat et al., 1997)
Atriplex halimus L.	Amaranthaceae	Lgtef	Leaf	Decoction	(Idm'hand et al.,, 2019)
Bellis perennis L.	Asteraceae	Ghedala, Zhar rabiae	Aerial part	-	(Eddouks et al., 2002)
Berberis vulgaris L.	Berberidaceae	Hamida	Leaf, seed and fruit	-	(Eddouks et al., 2002)
Betula pubescens Ehrh.	Betulaceae	Batoula	Aerial part	-	(Eddouks et al., 2002)
Borago officinalis L.	Boraginaceae	Lisan attur	Leaf and flower	Decoction	(Douira and Zidane, 2015; Eddouks et al., 2002; Tahraoui et al., 2007)
Calystegia sepium (L.) R. Br.	Convolvulaceae	Tarbouche laghrabe	Aerial part	-	(Eddouks et al., 2002)
Capparis spinosa L.	Capparaceae	LKebar	Fruit	Maceration	(Idm'hand et al., 2019; Tahraoui et al., 2007)
Carum carvi L.	Apiaceae	Elkarwiya	Seed	Powder	(Eddouks et al., 2002; Idm'hand et al., 2019; Tahraoui et al.,

					2007)
Centaurium erythraea Rafn	Gentianaceae	Gossat alhayaa	Aerial part	Infusion and decoction	(Douira and Zidane, 2015)
Chamaemelum nobile (L.) All.	Asteraceae	Babounge	Aerial part	-	(Eddouks et al., 2002)
Citrullus colocynthis (L.) Schrad.	Cucurbitaceae	Lhdej	Fruit	Maceration	(Eddouks et al., 2002; Idm'hand et al., 2019; Tahraoui et al., 2007)
Citrus × aurantium L.	Rutaceae	Zhar limoun	Fruit	-	(Eddouks et al., 2002)
Coriandrum sativum L.	Apiaceae	Kasbour	Seed	Decoction	(Eddouks et al., 2002; Idm'hand et al., 2019)
Crataegus rhipidophylla Gand.	Rosaceae	Admam,Tamzah	Aerial part	-	(Eddouks et al., 2002)
Cuminum cyminum L.	Apiaceae	Nafaa	Seed	Decoction and powder	(Douira and Zidane, 2015)
Cymbopogon schoenanthus (L.) Spreng.	Poaceae	Idghir	Seed and lef	-	(Eddouks et al., 2002)
Cynodon dactylon (L.) Pers.	Poaceae	Njem	Aerial part	Decoction	(Eddouks et al., 2002; Idm'hand et al., 2019; Tahraoui et al., 2007)
Cytisus scoparius (L.) Link	Fabaceae	Ifsdad	Leaf	-	(Eddouks et al., 2002)
*Datura stramoniu*m L.	Solanaceae	Sdag jmel, Metal	Seed	Decoction	(Eddouks et al., 2002; Tahraoui et al., 2007)
Dittrichia viscosa (L.) Greuter	Asteraceae	Terehla, Bagraman	Leaf	Decoction	(Douira and Zidane, 2015; Eddouks et al., 2002; Tahraoui et al., 2007; Ziyyat et al., 1997)
Dysphania ambrosioides (L.) Mosyakin & Clemants	Amaranthaceae	Lmkhinza	Leaf	Infusion	(Eddouks et al., 2002; Idm'hand et al., 2019; Tahraoui et al., 2007)
Equisetum arvense L.	Equisetaceae	Dnab lkhil	Aerial part	-	(Eddouks et al., 2002)
Eucalyptus globulus Labill.	Myrtaceae	Kalitus	Leaf	Decoction	(Idm'hand et al., 2019; Jouad et al., 2001; Ziyyat et al., 1997)
Filipendula ulmaria (L.) Maxim.	Rosaceae	Boukissi	Aerial part	-	(Eddouks et al., 2002)
Fumaria officinalis L.	Papaveraceae	Elbakoula	Aerial part	-	(Eddouks et al., 2002)
Glycyrrhiza glabra L.	Fabaceae	Arq souss	Stem	Decoction	(Eddouks et al., 2002; Idm'hand et al., 2019)
Haloxylon scoparium Pomel	Amaranthaceae	Eremt, Assay	Leaf and fruit	-	(Eddouks et al., 2002)
Helianthus annuus L.	Asteraceae	Bayaa chems	Seed	-	(Eddouks et al., 2002)
Heracleum sphondylium L.	Apiaceae	Awli	Aerial part	-	(Eddouks et al., 2002)
Herniaria glabra L.	Caryophyllaceae	Harass lhjar	Aerial part	Decoction	(Eddouks et al., 2002; Idm'hand et al., 2019; Jouad et al., 2001; Tahraoui et al., 2007)
Hibiscus sabdariffa L.	Malvaceae	Bissam	Chalices of flowers	Infusion	(Idm'hand et al., 2019)
Juglans regia L.	Juglandaceae	Swak, Gargaa	Leaf and bark	Infusion and decoction	(Tahraoui et al., 2007)
Lactuca serriola L.	Asteraceae	Khouss	Aerial part	-	(Eddouks et al., 2002)
Launaea arborescens (Batt.) Murb.	Asteraceae	Oum Lbina	Latex	-	(Eddouks et al., 2002)
Laurus nobilis L.	Lauraceae	Wrak sidna Musa, Rend	Leaf	Decoction	(Idm'hand et al., 2019; Ziyyat et al., 1997)
Lavandula dentata L.	Lamiaceae	Lokhzama	Aerial part	Powder	(Douira and Zidane, 2015; Eddouks et al., 2002; Idm'hand et al., 2019; Jouad et al., 2001; Ziyyat et al., 1997)
Lavandula stoechas L.	Lamiaceae	Lhalhal	Leaf	Infusion and decoction	(Douira and Zidane, 2015)
Lavandula angustifolia Mill.	Lamiaceae	Elkhzama zerqa, Elkhzama Fassiya	Aerial parts and leafy stem	Infusion and decoction	(Tahraoui et al., 2007)
Lawsonia inermis L.	Lythraceae	Lhana	Leaf	Infusion	(Idm'hand et al., 2019)

Lepidium sativum L.	Brassicaceae	Hab rchad	Seed	Decoction	(Douira and Zidane, 2015; Idm'hand et al., 2019; Jouad et al., 2001)
Linum usitatissimum L.	Linaceae	Zarriaat lkettane	Seed	Powder	(Eddouks et al., 2002; Idm'hand et al., 2019)
Mandragora officinalis Mill.	Solanaceae	Bayd alghoul	Root	Decoction and powder	(Douira and Zidane, 2015)
Marrubium vulgare L.	Lamiaceae	Merriwa, Merriwta	Aerial part	-	(Eddouks et al., 2002)
Matricaria chamomilla L.	Asteraceae	Babounge alhmir	Fruit	-	(Eddouks et al., 2002)
Mentha pulegium L.	Lamiaceae	Fliyou	Seed	Decoction	(Douira and Zidane, 2015; Eddouks et al., 2002; Idm'hand et al., 2019; Tahraoui et al., 2007)
Mentha spicata L.	Lamiaceae	Likama	Stem	Infusion	(Eddouks et al., 2002; Idm'hand et al., 2019; Tahraoui et al., 2007)
Mesembryanthemum cryptanthum Hook.f.	Aizoaceae	Afzo	Seed	Powder	(Idm'hand et al., 2019)
Myrtus communis L.	Myrtaceae	Rihan	Leaf	Decoction	(Eddouks et al., 2002; Idm'hand et al., 2019; Tahraoui et al., 2007)
Nerium oleander L	Apocynaceae	Defla	Leaf	Infusion	(Eddouks et al., 2002; Idm'hand et al., 2019)
Nigella sativa L.	Ranunculaceae	Sanouj	Seed	Powder	(Douira and Zidane, 2015; Eddouks et al., 2002; Idm'hand et al., 2019; Tahraoui et al., 2007)
Ocimum basilicum L.	Lamiaceae	Lahbak	Aerial part	Decoction	(Douira and Zidane, 2015; Idm'hand et al., 2019; Jouad et al., 2001)
Olea europaea L.	Oleaceae	Zitoun, Zebbouj	Leaf	Decoction	(Douira and Zidane, 2015; Eddouks et al., 2002; Idm'hand et al., 2019; Jouad et al., 2001; Tahraoui et al., 2007; Ziyyat et al., 1997)
Origanum compactum Benth.	Lamiaceae	Zaatar	Leaf	Infusion	(Douira and Zidane, 2015; Idm'hand et al., 2019; Ziyyat et al., 1997)
Origanum majorana L.	Lamiaceae	Merdedouch	Leaf	Infusion	(Idm'hand et al., 2019; Tahraoui et al., 2007)
Origanum vulgare L	Lamiaceae	Zaatar	Leaf	Infusion	(Eddouks et al., 2002; Tahraoui et al., 2007)
Peganum harmala L.	Nitrariaceae	Lharmel	Seed	Powder	(Eddouks et al., 2002; Idm'hand et al., 2019; Jouad et al., 2001; Tahraoui et al., 2007; Ziyyat et al., 1997)
Pennisetum glaucum (L.) R.Br.	Poaceae	Illan	Leaf	-	(Eddouks et al., 2002)
Petroselinum crispum (Mill.) Fuss	Apiaceae	Maadanous	Seed	Decoction	(Douira and Zidane, 2015; Eddouks et al., 2002; Idm'hand et al., 2019; Jouad et al., 2001; Tahraoui et al., 2007; Ziyyat et al., 1997)
Phoenix dactylifera L.	Arecaceae	Tmer	Fruit	Infusion	(Idm'hand et al., 2019; Tahraoui et al., 2007)
Pimpinella anisum L.	Apiaceae	Habbat hlawa	Seed	Decoction	(Eddouks et al., 2002; Idm'hand et al., 2019; Tahraoui et al., 2007)
Pinus sylvestris L.	Pinaceae	Sanawbar	Leaf	-	(Eddouks et al., 2002)
Pistacia lentiscus L.	Anacardiaceae	Adru	Leaf	Decoction	(Douira and Zidane, 2015; Idm'hand et al., 2019)
Ptychotis verticillata Duby	Apiaceae	Nunkha	Aerial part	-	(Ziyyat et al., 1997)
Quercus suber L.	Fagaceae	Dbagh	Bark	Powder	(Douira and Zidane, 2015)
Rosmarinus officinalis L.	Lamiaceae	Azir	Leaf	Decoction	(Douira and Zidane, 2015;

					Eddouks et al., 2002; Idm'hand et al., 2019; Jouad et al., 2001; Tahraoui et al., 2007; Ziyyat et al., 1997)
Rubia tinctorum L.	Rubiaceae	Lfouwa	Root	Decoction	(Douira and Zidane, 2015; Eddouks et al., 2002; Idm'hand et al., 2019)
Ruta montana (L.) L.	Rutaceae	Fijel,Awermi	Aerial part	-	(Eddouks et al., 2002)
Salvia officinalis L.	Lamiaceae	Salmiya	Leaf	Infusion	(Douira and Zidane, 2015; Eddouks et al., 2002; Idm'hand et al., 2019)
Salvia verbenaca L.	Lamiaceae	Alkhiyata	Aerial part	Decoction and infusion	(Douira and Zidane, 2015)
Satureja montana L.	Lamiaceae	Zoukni	Leaf	-	(Eddouks et al., 2002)
Saussurea costus (Falc.) Lipsch.	Asteraceae	Lkist lhandi	Root	Powder	(Idm'hand et al., 2019)
Searsia tripartita (Ucria) Moffett	Anacardiaceae	Zewaya	Fruit	Juice	(Idm'hand et al., 2019)
Solanum lycopersicum L.	Solanaceae	Maticha	Fruit	Juice	(Idm'hand et al., 2019)
Sorghum halepense (L.) Pers.	Poaceae	Edra	Aerial part	-	(Eddouks et al., 2002)
Syzygium aromaticum (L.) Merr. & L.M.Perry	Myrtaceae	Qronfel	Clove	Maceration	(Douira and Zidane, 2015; Eddouks et al., 2002; Idm'hand et al., 2019; Tahraoui et al., 2007; Ziyyat et al., 1997)
Tamarix aphylla (L.) H.Karst.	Tamaricaceae	Aarich, Elaadba	Leaf	Decoction	(Eddouks et al., 2002; Tahraoui et al., 2007)
Tetraclinis articulata (Vahl) Mast.	Cupressaceae	Laaraar	Leaf	Powder	(Douira and Zidane, 2015; Eddouks et al., 2002; Idm'hand et al., 2019; Jouad et al., 2001; Tahraoui et al., 2007; Ziyyat et al., 1997)
Tetraena gaetula (Emb. & Maire) Beier & Thulin	Zygophyllaceae	Aggaya	Leaf	-	(Eddouks et al., 2002)
Thymus mongolicus (Ronniger) Ronniger	Lamiaceae	Azoukni, Zaatar	Leaf	-	(Eddouks et al., 2002)
Thymus vulgaris L.	Lamiaceae	Zaitra	Aerial part	Decoction	(Douira and Zidane, 2015; Eddouks et al., 2002)
Thymus zygis L.	Lamiaceae	Aduchen, Azukni, Zaitra	Stem and leaf	Decoction	(Tahraoui et al., 2007)
Tilia sylvestris Desf.	Malvaceae	Zaizafoun	Leaf	-	(Eddouks et al., 2002)
Trigonella foenum-graecum L.	Fabaceae	Lhalba	Seed	Powder	(Douira and Zidane, 2015; Idm'hand et al., 2019; Jouad et al., 2001; Ziyyat et al., 1997)
Urtica dioica L.	Urticaceae	Lhoriga	Aerial part	Decoction	(Idm'hand et al., 2019; Tahraoui et al., 2007; Ziyyat et al., 1997)
Urtica pilulifera L.	Urticaceae	Hurriga	Leaf	Decoction	(Jouad et al., 2001)
Vaccaria hispanica (Mill.) Rauschert	Caryophyllaceae	Hamret errass	Seed	-	(Eddouks et al., 2002)
Verbena officinalis L.	Verbenaceae	Baymout	Leaf	-	(Eddouks et al., 2002)
Vinca minor L.	Apocynaceae	Al-aanakia	Aerial part	-	(Eddouks et al., 2002)
Viscum album L.	Santalaceae	Dbake	Aerial part	-	(Eddouks et al., 2002)
Vitis vinifera L.	Vitaceae	Inab	Leaf and fruit	-	(Eddouks et al., 2002)
Zea mays L.	Poaceae	Zghb kbal	Stigma	Decoction	(Idm'hand et al., 2019; Tahraoui et al., 2007)
Ziziphus lotus (L.) Lam.	Rhamnaceae	Ssder	Leaf	Infusion	(Idm'hand et al., 2019)

3.2. Pharmacological studies

The exact mechanism producing the antihypertensive effect of medicinal plants is not well understood. The phytochemical studies have found that many of these plants contain flavonoids, tannin, polyphenol, alkaloids and terpenoides. Polyphenols have been known as a protective factor against cardiovascular diseases and a preventive factor for hypertension. Antioxidant activity of medicinal plants is attributed to the presence of secondary metabolites, especially phenolic compounds. Therefore, the hypertensive effect of medicinal plans may be related to this activity (Baharvand-Ahmadi and Asadi-Samani, 2017; Baharvand-Ahmadi et al., 2016; Niazi et al., 2019).

The review of the available literature showed that of all the medicinal plant species used to treat hypertension in different provinces of Morocco, 81 plants have neither been explored experimentally for antihypertensive activities and only 23 species were reported as antihypertensive plants (Table 2). These plants are discussed in detail below.

Table 2. Plants with reported antihypertensive activity.

Family	Plant species	Parts used	Plant extracts used	Doses used	Models used in the study	References
Amaranthaceae	*Dysphania ambrosioides* (L.) Mosyakin & Clemants	Leaves	Aqueous extract, methanolic, ethyl acetate, and aqueous Soxhlet fractions	0.1, 0.25, 0.5, 1, 2.5, 5, 10 and 20 mg/kg	Anesthetized normotensive rats	(Assaidi et al., 2014)
Amaryllidaceae	*Allium cepa* L.	Bulb	Dried onion	5%	NG-nitro-L-arginine methyl ester (L-NAME) induced-hypertensive rats and stroke prone spontaneously hypertensive rats (SHRSP)	(Sakai et al., 2003)
	Allium sativum L.	Bulb	Aqueous extract	0.5 ml	The two-kidney–one-clip (2K-1C) Goldblatt model	(Al-Qattan et al., 1999)
Anacardiaceae	*Pistacia lentiscus* L.	Aerial parts	Lyophilized aqueous extract	25, 12.5 and 6.25 mg/kg	Normotensive urethane anaesthetized Wistar rats	(Villar et al., 1987)
Apiaceae	*Cuminum cyminum* L.	Seeds	Aqueous extract	200 mg/kg (b.w)	The two-kidney one-clip (2K/1C) method	(Kalaivani et al., 2013)
Asteraceae	*Artemisia herba-alba* Asso	Aerial parts	Aqueous extract	150 mg/kg	Spontaneously hypertensive rats (SHR)	(Zeggwagh et al., 2008)
	Chamaemelum nobile (L.) All.	Whole plant	Aqueous extract	140 mg/kg	Spontaneously hypertensive rats (SHR)	(Zeggwagh et al., 2009)
	Dittrichia viscosa (L.) Greuter	Whole plant	Methanolic extract	40 mg / kg	Hypertensive L-NAME rats	(Hakkou et al., 2017)
	Matricaria chamomilla L.	Aerial parts	Total alcohol extract, oil extracted, and water lifted after oil extraction	200 mg/kg	Normotensive rats	(Awaad et al., 2018)
Berberidaceae	*Berberis vulgaris* L.	Fruit	Aqueous extract	17–33 mg/100 g (b.w)	DOCA-induced hypertension in rats	(Fatehi-Hassanabad et al., 2005)
Brassicaceae	*Lepidium sativum* L.	Whole	Aqueous	20	Normotensive (WKY)	(Maghrani et al.,

		plant	extract	mg/kg	and spontaneously hypertensive rats (SHR)	2005)
Caryophyllaceae	*Herniaria glabra* L.	Whole plant	Saponins	200 mg/kg	Spontaneously hypertensive rats (SHR)	(Rhiouani et al., 1999)
Ericaceae	*Arbutus unedo* L.	Root	Aqueous extract	5, 50 and 250 mg/kg	Spontaneously hypertensive rats (SHR)	(Ziyyat and Boussairi, 1998)
Fabaceae	*Trigonella foenum-graecum* L.	Seeds	Methanol extract and its methanol fraction	30 mg/kg and 15 mg/ kg	Deoxycorticosterone acetate (DOCA)-salt-induced and fructose-induced hypertensive rats	(Balaraman et al., 2006)
Lamiaceae	*Ocimum basilicum* L.	Whole plant	Plant extract	100, 200 and 400 mg/ kg	The two-kidney one-clip (2K1C) Goldblatt model	(Umar et al., 2010)
	Thymus vulgaris L.	Leaves	Plant extract	100 mg/kg	Hypertension induced by ligation of one renal artery in the rat	(Kensara et al., 2013)
Malvaceae	*Hibiscus sabdariffa* L.	Calyx	Aqueous extract	1-125 mg/kg	Salt-induced hypertension and L-NAME (Nω-L-arginine methyl ester)-induced hypertension in rats	(Mojiminiyi et al., 2007)
Myrtaceae	*Syzygium aromaticum* (L.) Merr. & L.M.Perry	Buds	Buds extract	100 mg/kg	L-NAME-induced hypertension in rats	(Sayed et al., 2009)
Oleaceae	*Olea europaea* L.	Leaves	Leaves extract	500 or 1000 mg/day	Borderline hypertensive monozygotic twins	(Perrinjaquet-Moccetti et al., 2008)
Poaceae	*Pennisetum glaucum* (L.) R.Br.	Seeds	Aqueous-methanolic extract	250, 500 and 1000 mg/kg	Normotensive, egg-feed diet and glucose-induced hypertensive rats	(Mushtaq and Akhtar, 2015)
Ranunculaceae	*Nigella sativa* L.	Seeds	Boiled extract of the seeds	100 and 200 mg twice a day	Patients with mild hypertension	(Dehkordi and Kamkhah, 2008)
Santalaceae	*Viscum album* L.	Leaves	Crude aqueous extract	150 mg/kg	Rats under pentobarbitone anesthesia	(Ofem et al., 2007)
Urticaceae	*Urtica dioica* L.	Rhizome	Crude methanolic extract and its fractions	1, 3, 10, 30 and 50 mg/kg	Normotensive and hypertensive rats under anesthesia	(Qayyum et al., 2016)

3.2.1. Dysphania ambrosioides (L.) Mosyakin & Clemants

Dysphania ambrosioides (L.) before known as *Chenopodium ambrosioides* traditionally named "mkhinza" is an annual or short-lived perennial plant up to 1 m. The leaves are oblong lanceolate, sinuate dentate, with obscure petiolate. The flowers are small and green, produced in a branched panicle at the apex of the stem. The persistent calyx encloses the fruit (Boutkhil et al., 2009; Pavela et al., 2018). This species is an herb native to South America. It is also cultivated in subtropical and subtemperate regions, mostly for consumption as leafy vegetable and herb. It possesses a characteristic aroma and is used as dietary condiments and in traditional medicine for many centuries (Mwanauta et al., 2014; Zohra et al., 2019). *Dysphania ambrosioides* is extensively dispersed throughout Morocco and is used in traditional medicine against different diseases such as digestive, respiratory, urogenital, vascular, and nervous disorders (Bezerra et al., 2019; Zohra et al., 2019). *Dysphania ambrosioides*, revealed several pharmacological activities such as anthelmintic, antirheumatic, analgesic, antipyretic, antiviral, antimalarial, molluscicidal, anticancer, nematocidal,

emmenagogue, abortifiant, antifungal, antioxidant and many other pharmacological effects (Bezerra et al., 2019; Mwanauta et al., 2014; Zohra et al., 2019). The effect of *Dysphania ambrosioides* on blood pressure in anesthetized rats was evaluated by Assaidi et al. (2014). Intravenous administration of aqueous extract, methanolic, ethyl acetate, and aqueous Soxhlet fractions of the leaves induce a dose-dependent hypotension (Assaidi et al., 2014).

3.2.2. Allium cepa L.

Allium cepa L. (onion), commonly known by many other conventional names such as Egyptian onion, garden onion, common onion, shallot and many more, is a culinary and medicinal herb belonging to the botanical family of Amaryllidaceae (Bystrická et al., 2013; Upadhyay, 2016). This ancient cultivated plant with edible bulbs is an easily digestible aromatic vegetable widely consumed throughout the world, mainly for its distinctive flavor. It is a biennial plant attains to a height of 15-45 cm. The leaves are fleshy, hollow, cylindric, yellowish- to bluish green and grow alternately in a flattened, fan-shaped swathe (Bystrická et al., 2013; Galavi et al., 2021; Upadhyay, 2016). The previous pharmacological studies revealed that *Allium cepa* exerted anti-inflammatory, anti-diabetic, hypolipidemic, anti-obesity, antimicrobial, antioxi-dant, analgesic, anti-hypertensive, and immunoprotective effects (Galavi et al., 2021; Teshika et al., 2019; Upadhyay, 2016). The hypotensive effect of *Allium cepa* was evaluated in NG-nitro-L-arginine methyl ester (L-NAME) induced-hypertensive rats and stroke prone spontaneously hypertensive rats (SHRSP) using dried onion at 5% in their diets. Dietary onion exhibited distinct antihypertensive effects on the L-NAME induced-hypertensive rats and the SHRSP and decreased the thiobarbituric acid reactive substances in plasma in these hypertensive rats (Sakai et al., 2003).

3.2.3. Allium sativum L.

Allium sativum L. (garlic) is one of the most important vegetables throughout the world belonging to the botanical family of Amaryllidaceae. It is also known as nectar of the gods, rocambole, rustic treacle, allium, clove garlic, camphor of the poor, poor man's treacle, and stinking rose. This species is native to Asia and is also known in Europe, America and Africa. It is a bulbous perennial plant with a powerful onion that characterized by its peculiar aroma and pungent taste. It has a tall, erect flowering stem that grows up to 1 m. it has four to twelve long, sword-shaped leaves attached to an underground stem. The bulb is rounded composed of up to about 15 smaller bulblets known as cloves (Alam et al., 2016; Kovarovič et al., 2019; Morales-González et al., 2019). It possesses high nutritive value. Furthermore, *Allium sativum* used to cure a vast conditions including arthritis, bronchitis, chronic fever, tuberculosis, sciatica, asthma, discoloration of the skin and itches, indigestion, lumbago, backache, rhinitis, malaria, obstinate skin disease including leprosy, leucoderma, enlargement of spleen, piles, fistula, fracture of bone, gout, urinary diseases, diabetes, kidney stone, anemia, jaundice, night blindness, epilepsy, cataract and colic pain (Alam et al., 2016; Morales-González et al., 2019). Its pharmacologically active constituents display broad-spectrum activities including antibacterial, antiviral, antifungal, antiprotozoal, antipyretic, antioxidant, anticoagulant, anticarcinogenic, antiasthmatic, analgesic, anti-inflammatory, and anticancer effects (El-Saber Batiha et al., 2020; Hussein et al., 2017; Morales-González et al., 2019). The

antihypertensive effect of aqueous extract of *Allium sativum* at dose of 0.5 ml in the two-kidney–one-clip (2K-1C) Goldblatt model was examined by Ibrahim and Islam (2011). The oral administration of single dose to 2K-1C rats showed a maximum antihypertensive effect 2–6 h after administration (Al-Qattan et al., 1999).

3.2.4. Pistacia lentiscus L.

Pistacia lentiscus L. (also termed lentisk or mastic tree) is an evergreen shrub of the Anacardiaceae family, growing in semi-arid areas of the Mediterranean area from Morocco and the Iberian peninsula in the west through southern France and Turkey to Iraq and Iran in the east. This dioecious species can reach 5 m height is cultivated for its aromatic resin. All *Pistacia lentiscus* trees share alternate, leathery, and compound paripinnate with five (Charef et al., 2008; Mehenni et al., 2016) . It's used in eczema treatment, hypertension, cough, sore throat, eczema, diarrhea, jaundice, paralysis, throat infection, stomach-ache, asthma and kidney stones (Charef et al., 2008; Ljubuncic et al., 2005; Mehenni et al., 2016). Extract of different parts of the plant shows various activities such as anti-bacterial, antifungal, anthelmintic, anti-inflammatory, anticoccidial, antioxidant, antimicrobial, hepatoprotective and anticancer effects (Charef et al., 2008; Mehenni et al., 2016; Mezni et al., 2016). A study has been carried out to scientifically evaluate the anti-hypertensive potential of *Pistacia lentiscus* in normotensive urethane anaesthetized Wistar rats. The lyophilized aqueous extract induces a dose-dependent hypotension (Villar et al., 1987).

3.2.5. Cuminum cyminum L.

Cuminum cyminum L. (Cumin), belonging to the Apiaceae family, is one of the old cultivated medicinal food herbs in in the Middle East, India, China, and several Mediterranean countries, including Morocco. The plant is a glabrous annual with a slender and branched stem that is 20–30 cm tall and has a diameter of 3–5 cm. The leaves are multifid, with long filiform segments. The flowers, small, white, or pink are overtopped by the bracts and borne in umbels (Al-Snafi, 2016b; Mittal et al., 2014; Mnif and Aifa, 2015; Singh et al., 2017). Its seeds have been commonly used for culinary and flavoring purposes and folklore therapy since antiquity in the cuisines of many different cultures. Cumin has been widely used in traditional medicine to treat a variety of diseases, including gastrointestinal problems, gynecological diseases, respiratory disorders, hypolipidemia, cancer, and diabetes (Agarwal et al., 2017; Al-Snafi, 2016b; Allaq et al., 2020). *Cuminum cyminum* was found to possess numerous pharmacological properties, including antimicrobial, insecticidal, anti-inflammatory, analgesic, antioxidant, anticancer, antidiabetic, antiplatelet aggregation, hypotensive, bronchodilatory, immunological, contraceptive, anti-amyloidogenic, anti-osteoporotic effects (Al-Snafi, 2016b; Mnif and Aifa, 2015; Singh et al., 2017). Kalaivani et al. (2013) showed anti-hypertensive activity of standardized aqueous extract of *Cuminum cyminum* seeds with dose of 200 mg/kg in renal hypertensive rats.

3.2.6. Artemisia herba-alba Asso

Artemisia herba-alba Asso., known also as "desert wormwood" belongs to the genus *Artemisia* which can generally grow in the semi-arid region of the Mediterranean North Africa, Spain, and the northwest region of

the Himalayas. It is a greenish-silver perennial herb grows 20-40 cm in height. The stems are small, erect and rigid with small and hairy leaves. The flowering begins at the end of summer (Mohamed et al., 2010; 2021). This plant is used as aromatisant for tea and in folk medicine for treatment of colds, diabetes, parasitic infection, hypertension, coughing, intestinal disturbances and stomach disorder (Asdadi et al., 2020; Mohammed et al., 2021; Mohsen and Ali, 2009). Investigations on the medicinal properties of *Artemisia herba-alba* extracts reported anti-diabetic, leishmanicidal, antibacterial, antifungal, anti-mutagenic and antioxidant effects (Asdadi et al., 2020; Mohammed et al., 2021; Mohsen and Ali, 2009). Zeggwagh et al. (2008) assessed hypotensive activity of *Artemisia herba-alba* in spontaneously hypertensive, in fact the administration of an aqueous extract at dose 150 mg/kg decreased significantly the systolic blood pressure after 8 days of oral administration ($P < 0.01$).

3.2.7. Chamaemelum nobile (L.) All.

Chamaemelum nobile (L.) All., commonly known as chamomile (also spelled camomile), is a perennial herb that belongs to the Asteraceae family. The plant is found in dry fields and around gardens and cultivated grounds and is native to southwestern Europe and now is distributed throughout Europe, South Africa and Southwest Asia. *Chamaemelum nobile* is a low-growing plant, creeping or trailing. The leaves are alternate, bipinnate, finely dissected, and downy to glabrous. The flowers are solitary on long, erect stalks, drooping when in bud (Al-Snafi, 2016a; Liu et al., 2019). This plant has been widely used in traditional medicine to treat a variety of diseases, including fever, to eliminate gases, evil tripe, heaviness of stomach, indigestion, to clear the mind, for nerves, to sties, rheum, to cooling of the eyes, gastric debility, diaphoretic, emetic, to relieve colds due to sudden cutaneous chilling, in dysmenorrhea to decrease pain and facilitate the flow, as antiemetic, antispasmodic, sedative, carminative, and for intestinal cramps and colic due to flatulency (Al-Snafi, 2016a; Camejo-Rodrigues et al., 2003; Cavero et al., 2011a; Cavero et al., 2011b). Chamomile has anti-inflammatory, deodorant, bacteriostatic, antimicrobial, carminative, sedative, antiseptic, antibacterial, anti-ulcer, anti-catarrhal, and spasmolytic properties (Al-Snafi, 2016a; Kazemian et al., 2015; Kazemian et al., 2018). Single oral administration of *Chamaemelum nobile* aqueous extract at dose 140 mg/kg to spontaneously hypertensive rats had a maximum antihypertensive effect 24 h after administration. Daily oral administration produced a significant reduction in systolic blood pressure on day 8 of treatment (Zeggwagh et al., 2009).

3.2.8. Dittrichia viscosa (L.) Greuter

Dittrichia viscosa, also known as false yellow head, woody fleabane, sticky fleabane and yellow fleabane, is a flowering plant in the Asteraceae family. It is a perennial plant, with a taproot, that grows up to 1.50 meters. It has upright stems, with bifurcation starting low on the stem. It has long, narrow leaves that are pointed at both ends inserted directly on the stem, without petioles. The fruit is a 2 mm long achene (Araniti et al., 2017; Grauso et al., 2019; Parolin et al., 2014; Zaki, 2020). This plant is widely used in traditional medicine in many Mediterranean countries for the treatment of various diseases such as bronchitis, injuries, bruises, intestinal disorders, diabetes, wounds healing, headache, stomach pain, hemorrhoids, women infertility and bronchial disorders (Grauso et al., 2019; Parolin et al., 2014; Zaki, 2020). Enumerate publications state the medicinal and

pharmacological potential of *Dittrichia viscosa* and the most important applications of its extracts which have anti-viral, anti-fungal, balsamic, healing, antipyretic, antidiabetic, antiphlogistic, anti-bacterial, antiseptic antispasmodic, antidiarrheic, anthelmintic and antirheumatic effects (Grauso et al., 2019; Parolin et al., 2014). The methanolic extract of *Dittrichia viscosa* leaves at a dose of 40 mg/kg/day has an antihypertensive activity in hypertensive L-NAME rats (Hakkou et al., 2017).

3.2.9. Matricaria chamomilla L.

Matricaria chamomilla L., commonly known as chamomile, German chamomile, Hungarian chamomile, wild chamomile, blue chamomile, or scented mayweed, is an annual plant of the Asteraceae family native to southern and eastern Europe. It is an annual plant with thin spindle-shaped roots only penetrating flatly into the soil. The long and narrow leaves are bipinnate or tripinnate. The flowers are borne in paniculate flower heads. The fruit is a yellowish brown achene (Gupta et al., 2010; Hameed et al., 2018; Murti et al., 2012). Chamomile is useful for treatment of hypercholesterolemia, knee osteoarthritis, ulcerative colitis, premenstrual syndrome, stomachache, wound, irritable bowel syndrome, neurological diseases and insomnia (Gupta et al., 2010; Hameed et al., 2018; Murti et al., 2012). It possesses anti-inflammatory, bactericidal, acaricidal, antimutagenic, anticancer, anxiolytic, hepatoprotective, antidiabetic, antiviral, antimicrobial and antioxidant properties (Gupta et al., 2010; Hameed et al., 2018; Miraj and Alesaeidi, 2016). Three different extracts of *Matricaria chamomilla* at dose 200 mg/kg were tested in normotensive rats. Single oral administration of total alcohol extract, oil extracted, and water lifted after oil extraction decreases both systolic and diastolic blood pressure after 1, 1.5, and 2 hours of the administration (Awaad et al., 2018).

3.2.10. Berberis vulgaris L.

Berberis vulgaris L., also known as common barberry, European barberry or simply barberry, is a shrub of the plant family Berberidaceae that grows in northwest Africa, western Asia, central, and southern Europe. It is a deciduous shrub growing up to 4 meters high. The flowers are yellow produced on long panicles in late spring. The leaves are small oval with a serrated margin. The fruit is an oblong red berry that ripens in late summer and autumn (Abushouk et al., 2017; Imanshahidi and Hosseinzadeh, 2008; Tabeshpour et al., 2017). In traditional medicine, barberry has been used in various diseases including hypertension, arrhythmia, tumor, diabetes, cardiovascular disease, hyperlipidemia, inflammation, bacterial and viral infections, cerebral ischemia trauma, mental disease, Alzheimer and osteoporosis (Abushouk et al., 2017; Imanshahidi and Hosseinzadeh, 2008; 2016; Tabeshpour et al., 2017). This plant was found to possess numerous pharmacological properties, including antihyperglycemic, hypolipidemic, antioxidant, anticholinergic, anticancer, antipyretic, antihistaminic, antimicrobial and hypnotic effects (Abushouk et al., 2017; Tabeshpour et al., 2017). The antihypertensive effect of the aqueous extract from *Berberis vulgaris* fruit was evaluated on DOCA-induced hypertension in the rats. Administration of extract significantly decreases the blood pressure in hypertensive rats (Fatehi-Hassanabad et al., 2005).

3.2.11. Lepidium sativum L.

Lepidium sativum L. (commonly known as cress) belonging to the family Brassicaceae is an annual herb, 15 - 45 cm in height, cultivated as a salad plant throughout India, Europe and the United States. he leaves are opposite, ovate or ovate-lanceolate, glabrous. The flowers are brownish purple, violet. The pods are obovate or broadly, ellipticrotundate, emarginated, notched at the apex and winged (Mali et al., 2007; Manohar et al., 2012; Sharma and Agarwal, 2011). Cress is useful for treatment of leucorrhoea, scurvy, diarrhea, dysentery, liver diseases, renal diseases, dyspepsia, asthma, cough, cold, leprosy, skin and eye diseases, seminal weakness, tenesmus and secondary syphilis (Mali et al., 2007; Manohar et al., 2012; Sharma and Agarwal, 2011). It possesses analgesic, diuretic anti-diabetic, hepatoprotective, anti-ashthamatic, prokinetic, hypercholesterolemic, coagulant, antihypertensive, anti-oxidant, anti-inflammatory and antipyretic activities (Falana et al., 2014; Mali et al., 2007; Manohar et al., 2012; Sharma and Agarwal, 2011). The aqueous extract from *Lepidium sativum* at dose 20 mg/kg was tested to evaluate its antihypertensive effects in normotensive and spontaneously hypertensive rats. Daily administration of aqueous extract significantly reduced the arterial blood pressure in spontaneously hypertensive rats (Maghrani et al., 2005).

3.2.12. Herniaria glabra L.

Herniaria glabra L. (Smooth rupturewort) popularly known in Morocco as “Harass lhjar” is an annual or biennial plant, a member of the Caryophyllaceae family. The plant is native of Northern Africa, Asia-Temperate and Europe, and naturalized in Japan and Northern America. The leaves are simple, lobed or unlobed but not separated into leaflets. The flower is radially symmetrical. The fruit is dry but does not split open when ripe (Kozachok et al., 2018; Kozachok et al., 2020; Rhiouani et al., 2008; Sivak and Kaukhova, 2021). In traditional medicine this plant is used for the treatment of kidney and bladder stones, dropsy, catarrh of the bladder, cystitis, gouts, urinary bladder infections, renal disease, diabetes, hernias, hypertension, cardiac decompensation, rheumatism, jaundice, nerve inflammation and respiratory disorders (Kozachok et al., 2016; , 2018; Rhiouani et al., 2008; Sivak and Kaukhova, 2021) . Investigations on the medicinal properties of *Herniaria glabra* extracts reported diuretic, spasmolytic, antioxidant, antihypertensive and hypoglycemic effects (Horner et al., 2017; Kozachok et al., 2016; Kozachok et al., 2018; Rhiouani et al., 2008). The hypertensive rats orally treated with 200 mg/kg/day of saponins from *Herniaria glabra* appeared to have significantly lower blood pressure levels after 30 days (Rhiouani et al., 1999).

3.2.13. Arbutus unedo L.

Arbutus unedo L., commonly known as the strawberry tree, is an evergreen shrub or small tree, normally between 1.5 m and 3 m tall in the flowering plant family Ericaceae. Its native to the Mediterranean region, but also found in other regions and characterized by hot summers and mild rainy winters. It grows to 9–12 m tall, but is normally between 1.5 m to 3 m tall. The leaves are alternate, simple, oblanceolate, dark green, leathery and have a serrated margin. The hermaphrodite flowers are white, bell-shaped .The fruits are conspicuous, globular, orange-red when ripe (Bento and Pereira, 2011; Miguel et al., 2014; Morgado et al., 2018). In traditional folk

medicine, *Arbutus unedo* has been used for treatment of gastrointestinal diseases, urological problems, cardiac diseases, hypertension and diabetes (Bento and Pereira, 2011; Miguel et al., 2014; Morgado et al., 2018). *Arbutus unedo* has antidiabetic, antihypertensive, antibiotic, antifungal, antiparasitic, antiaggregant, anti-inflammatory, antitumoral, antioxidant, and spasmolytic properties (Bento and Pereira, 2011; Miguel et al., 2014; Morgado et al., 2018). The antihypertensive effects of aqueous extract of the root of *Arbutus unedo* were studied both in spontaneously hypertensive conscious rats. Daily oral administration of the extracts (50 and 250 mg/kg/24 h) exhibited a significant decrease in systolic blood pressure (Ziyyat and Boussairi, 1998).

3.2.14. Trigonella foenum-graecum L.

Trigonella foenum-graecum (Fenugreek) is an annual plant in the family Fabaceae family. Native to Eastern Europe but now cultivated all over world, the plant is commonly used as leafy vegetable and condiment. Fenugreek plant is an erect annual herb a height of 40-80 cm. The leaves are alternate, compound, trifoliolate. The plants bear white or yellow flowers, which give rise to long, slender, yellow to brown pods (Ulbricht et al., 2008; Yadav and Baquer, 2014). This herb used to cure a vast conditions including bronchitis, fever, sore throat, wound, swollen glands, skin irritation, diabetes, ulcers, cancer, hypercholesterolemia and inflammation (Nathiya et al., 2014; Olaiya and Soetan, 2014; Yadav and Baquer, 2014). Fenugreek was found to possess numerous pharmacological properties, including antidiabetic, antiplasmodic; hypolipidemic, antibacterial; anthelmintic analgesic, antioxidant, hypocholesterolemic, antilipidemic, hepatoprotective, anti-inflammatory, antifungal, antiulcer, antilithigenic and anticarcinogenic effects (Nathiya et al., 2014; Olaiya and Soetan, 2014; Yadav and Baquer, 2014). Chronic administration of a methanol extract of *Trigonella foenum-graecum* seeds (30 mg/kg/day) and its methanol fraction (15 mg/kg/day) significantly reduced blood pressure in deoxycorticosterone acetate (DOCA)-salt-induced hypertensive rats (Balaraman et al., 2006).

3.2.15. Ocimum basilicum L.

Ocimum basilicum (L.), also called great basil, is a culinary herb of the family Lamiaceae (mints). Basil is possibly native to India. The plant is widely grown as an ornamental and field crop throughout the greater part of India, Burma, Cylone and several Mediterranean countries. It is an annual herb, glabrous, more or less hispidly pubescent. The leaves are simple, opposite, ovate and acute. The flowers are small and white, and grow from a central inflorescence (Bilal et al., 2012; Miraj and Kiani, 2016; Osei Akoto et al., 2020). Traditionally, it has been used in arthritis, anorexia, colds, kidney problems, earache, menstrual irregularities, fevers, coughs, flu, asthma, bronchitis, influenza and diarrhea (Osei Akoto et al., 2020; Purushothaman et al., 2018; Shahrajabian et al., 2020). Studies indicate *Ocimum basilicum* to possess antimicrobial, antioxidant analgesic, antiinflammatory, anti ulcerogenic, chemomodulatory, hepatoprotective, hypoglycemic, hypolipidemic, immunomodulator and larvicidal activities (Miraj and Kiani, 2016; Osei Akoto et al., 2020; Shahrajabian et al., 2020). Umar et al. (2010) assessed hypotensive activity of *Ocimum basilicum* extract in renovascular hypertensive rats.

3.2.16. Thymus vulgaris L.

Thymus vulgaris L. (thyme) is a flowering plant in the Lamiaceae family, native to southern Europe from the western Mediterranean to southern Italy. It is growing up to 15-30 cm tall by 40 cm wide. The leaves are terribly little, highly aromatic, grey-green and vary significantly in form and hair covering. The flowers have a tube-like calyx and tubular corolla with a three lobed lower lip (Hosseinzadeh et al., 2015; Prasanth Reddy et al., 2014; Rizwan, 2021). Thyme is helpful in treatment of laryngitis, sciatica, bug bites, acne, dermatitis, wounds, nausea, tiredness, water retention, colds, and coughs (Hosseinzadeh et al., 2015; Prasanth Reddy et al., 2014; Rizwan, 2021). Recent studies have shown that this plant has different biological properties, such as antihelminthic, antiviral, diaphoretic, antimicrobial, antihypertensive, antioxidative, sedative, antiseptic, antispasmodic, antirheumatic, antibacterial, carminative and anti-fungal effects (Hosseinzadeh et al., 2015; Prasanth Reddy et al., 2014; Rizwan, 2021). Active compounds in thyme are oils, saponins, and tannins. The composition of oxygenated monoterpenes is 56.53%, monoterpene hydrocarbons are 28.69%, sesquiterpene hydrocarbons are 5.04% and oxygenated sesquiterpenes are 1.84% in thyme essential oil (Hosseinzadeh et al., 2015; Prasanth Reddy et al., 2014; Rizwan, 2021). The antihypertensive effect of 100 mg/kg/day, orally for 8 consecutive weeks of *Thymus vulgaris* aqueous extract was studied and compared in hypertensive rats. Results suggested that the administration of aqueous extract has shown remarkable antihypertensive effect and marked improvement on hypertension-related biochemical changes in rats (Kensara et al., 2013).

3.2.17. Hibiscus sabdariffa L.

Hibiscus sabdariffa L. (Roselle) is a species of Hibiscus belongs to the family of Malvaceae, probably native to West and East Africa and South-East Asia including Northeastern India. It is an annual or perennial herb or woody-based sub-shrub, growing to 2–2.5 m tall. The leaves are alternate, green with reddish veins and long or short petioles. The flowers are auxiliary or terminal, white to paleyellow with a dark red spot at the base of each petal (Ali et al., 2005; Da-Costa-Rocha et al., 2014; Riaz and Chopra, 2018). It has received attention for its potential application in the treatment and prevention of a number of diseases, such as fever, hypercholesterolemia, hypertension, urination, indigestion, external wounds and abscesses. Roselle is known to have several pharmacological effects such as antibacterial, antifungal, antiparasitic, antipyretic, antinociceptic, anti-inflammatory, antioxidant, hepatoprotective, nephroprotective, anti-obesity, anti-diabetic, anti-hypertensive, anti-anemic activities (Ali et al., 2005; Da-Costa-Rocha et al., 2014; Riaz and Chopra, 2018). The calyces of roselle are rich in carbohydrate, dietary fibers, proteins, vitamins, minerals, organic acids, anthocyanins, polysaccharides and flavonoids (Ali et al., 2005; Da-Costa-Rocha et al., 2014; Riaz and Chopra, 2018). Intravenous injection of 1–125 mg/kg of aqueous calyx extract of *Hibiscus sabdariffa* reduced blood pressure and heart rate in the hypertensive rats than in the normotensive controls (Mojiminiyi et al., 2007).

3.2.18. Syzygium aromaticum (L.) Merr. & L.M.Perry

Syzygium aromaticum, commonly known as clove, is an median size tree from the Mirtaceae family native from the Maluku islands in Indonesia. The leaves are large oblong to elliptic, simple obovate opposite. The

flowers are small, crimson in color and are hermaphrodite (Cortés-Rojas et al., 2014; Kaur and Kaushal, 2019; Mittal et al., 2014). Since ancient times clove has been used to treat medical conditions like toothache, asthma, dyspepsia, acute or chronic gastritis, diarrhoea and various allergic disorders (Mittal et al., 2014; Pulikottil and Nath, 2015). Numerous scientists have shown various biological and pharmacological effects in *Syzygium aromaticum* essential oils, especially antioxidant, antimicrobial, antinociceptive, antiviral, antifungal, anti-inflammatory, anticancer, nematicidal, acaricidal, anesthetic, herbicidal, insecticidal properties (Mittal et al., 2014; Pulikottil and Nath, 2015). In essential oils, phenolic compound was the major components, essentially flavonoids, hidroxibenzoic acids, hidroxicinamic acids and hidroxiphenyl propens, but eugenol, β-caryophyllene, eugenol, benzyl alcohol, chavicol, acetyl salicylate and humulenes were also found in some countries (Cortés-Rojas et al., 2014; Kaur and Kaushal, 2019; Mittal et al., 2014). Sayed et al. (Sayed et al., 2009) evaluated the antihypertensive activity of *Syzygium aromaticum* on L-NAME-induced hypertension in rats. *Syzygium aromaticum* buds extracts at a dose of 100 mg/kg normalized the increment in systolic, mean and diastolic blood pressure (Sayed et al., 2009).

3.2.19. Olea europaea L.

Olea europaea L. (olive) is a small tree, which belongs to the family Oleaceae and is native to tropical and warm temperate regions of the world. The species is cultivated in all the countries of the Mediterranean, as well as South Africa, China, South America, Australia, New Zealand, United States and Mexico. The leaves are opposite, lanceolate, or ovate-lanceolate. The flowers are small, erect, axillary racemes. The fruit is a small drupe (Ghanbari et al., 2012; Khan et al., 2007; Özcan and Matthäus, 2017). Most of the plant parts of *Olea europaea* are used in traditional system of medicine in the world as a folk remedy for combating fevers, hypertension, malaria, gallstones, stomach and intestinal diseases, respiratory problems and urinary tract infections (Ghanbari et al., 2012; Khan et al., 2007; Özcan and Matthäus, 2017). Several studies have shown that olive exhibits a large spectrum of in vitro and in vivo properties, including antioxidant, radioprotective, anti-proliferative, cytotoxic , anti-HIV , antifungal , gastroprotective antioxidant, antiatherosclerotic, hypoglycemic and cardioprotective effects (Ghanbari et al., 2012; Khan et al., 2007; Özcan and Matthäus, 2017). Olive contains appreciable concentration of phenolic acids, phenolic alchohols, flavonoids, secoiridoidsand lipophilic. Main phenolic compounds in olive extracts are oleuropein, apigenin-7-glucoside, luteolin-7-glucoside, hydroxytyrosol and verbascoside, (Ghanbari et al., 2012; Khan et al., 2007; Özcan and Matthäus, 2017). The hypotensive effect of *Olea europaea* leaf extract was evaluated in borderline hypertensive monozygotic twins. Twins of each pair were assigned to different groups receiving 500 or 1000 mg/day. Blood pressure changed significantly within pairs with mean systolic differences of ≤6 mmHg (Perrinjaquet-Moccetti et al., 2008).

3.2.20. Pennisetum glaucum (L.) R.Br.

Pennisetum glaucum (pearl millet), also known as Bajra, belongs to the plant family Poaceae, is the most widely grown type of millet. It has been grown in tropical semi-arid regions of the world primarily in Africa and Asia. The height of the plant ranges from 0.5 – 4 m with ovoid grains of 3 – 4 mm length which can be slate

blue, pale yellow, brown, white, grey or purple (Dias-Martins et al., 2018; Nambiar et al., 2011) . Pearl millet can be recommended in the treatment of heart diseases, inflammatory bowel disease, celiac diseases, diabetes, arthritis, cancer atherosclerosis, constipation and several non-communicable diseases (Dias-Martins et al., 2018; Nambiar et al., 2011). The plant is reported to possess anti-inflammatory, antihypertensive, anticarcinogenic, hypoglycemic, anticancer, probiotic and prebiotic properties. Pearl millet is rich in several nutrients as well as non-nutrients such as phenolic compounds (phenolic acids and flavonoids) and natural antioxidants (Dias-Martins et al., 2018; Nambiar et al., 2011). The aqueous-methanolic extract of *Pennisetum glaucum* seeds was tested to evaluate its antihypertensive effects in normotensive, egg-feed diet and glucose-induced hypertensive rats. Administration of extract at 1000 mg/kg dose significantly reduced blood pressure and heart rate ($p < 0.5 – p < 0.001$) (Mushtaq and Akhtar, 2015).

3.2.21. Nigella sativa L.

Nigella sativa L. (black seed) is an annual flowering plant in the family Ranunculaceae, native to Eastern Europe and western Asia, but naturalized over a much wider area, including parts of Europe, northern Africa and east to Myanmar. It is small prostrate herb which grows to 20-90 cm tall with finely divided, linear leaves. The flowers are delicate, and usually colored white, yellow, pink, pale blue or pale purple. The fruit is a large and inflated capsule composed of three to seven united follicles (Ahmad et al., 2013; Mohebbati and Abbasnezhad, 2020; Paarakh, 2010; Sharma et al., 2009). The plant has been used to treat dyspepsia, flatulence, abdominal disorders, diarrhea, ascites, fever, paralysis, conjunctivitis, piles, skin diseases, anorexia, dysentery, hydrophobia, intrinsic hemorrhage, amenorrhea, cough and jaundice (Ahmad et al., 2013; Paarakh, 2010; Sharma et al., 2009). Various biological activities of *Nigella sativa* have been extensively studied like antidiabetic, anticancer, immunomodulator, analgesic, bronchodilator, hepato-protective, renal protective, gastro-protective antimicrobial, anti-inflammatory, spasmolytic and antioxidant properties (Ahmad et al., 2013; Paarakh, 2010; Sharma et al., 2009). Phytochemical investigations have revealed the presence of various phytochemicals including thymoquinone, thymohydroquinone, dithymoquinone, p-cymene, carvacrol, 4-terpineol, t-anethol, sesquiterpene longifolene, α-pinene and thymol (Ahmad et al., 2013; Mohebbati and Abbasnezhad, 2020; Paarakh, 2010; Sharma et al., 2009). The antihypertensive effect of *Nigella sativa* seed extract was studied in patients with mild hypertension. The decrease in SBP in the two test groups that received 100 and 200 mg of extract twice a day was statistically significant relative to the placebo group (Dehkordi and Kamkhah, 2008).

3.2.22. Viscum album L.

Viscum album (mistletoe) belongs to the family Santalaceae. It is a small greenish plant native to Europe and western and southern Asia. The leaves are in opposite pairs, thick, leathery, oval or lance-shaped and are a yellowish-green in colour (Ahmad et al., 2018; Amer et al., 2012; Khan et al., 2016). According to traditional medicine experts, mistletoe used to relieve several ailments including wounds, migraine, epilepsy, abscess, healing of fractures, rheumatism, joint pains, neuralgia, sciatica, epilepsy, rheumatic deafness, hypertension, bronchial asthma, diabetes mellitus, chronic cramps, stroke, stomach problems and for hot flush in menopause

(Ahmad et al., 2018; Amer et al., 2012; Khan et al., 2016). Numerous scientists have shown various biological and pharmacological effects in *Viscum album* extracts, especially antioxidant, antimicrobial, antitumor, anti-angiogenic and antifungal properties (Bahadır et al., 2017; Kang and Chung, 2012; Kienle and Kiene, 2010; Lyu et al., 2002). There are many chemical constituents in mistletoe, including alkaloids, glycosides, phenylpropanoids, tannins, lignins sugars, viscotoxins, quercetin, kaempferol and naringenin (Amer et al., 2012; Khan et al., 2016). Ofem et al. assessed hypotensive activity of the crude aqueous extract from *Viscum album* leaves (150 mg/kg) in albino Wistar rats under pentobarbitone anesthesia.The crude extract produced a significant decrease in blood pressure (Ofem et al., 2007).

3.2.23. Urtica dioica L.

Urtica dioica L. of family Urticaceae, is a perennial plant which is commonly known as stinging nettle. Originally native to Europe, much of temperate Asia and western North Africa. It is widely distributed throughout the temperate and tropical areas around the world. Nettle is a herbaceous plant, 1 to 2m tall and perennial with rhizomes. The leaves are simple, opposite, coarsely toothed. The flowers are dioecious or monoecious, small, and are arranged in clusters on slender, branched spikes formed in the leaf axils. The fruits are small achenes containing tiny dark brown or almost black seeds (Joshi et al., 2014; Said et al., 2015). Nettle is widely used by the traditional medicinal practitioners for curing various diseases such as jaundice, menorrhagia, arthritis, nephritis, haematuria and rheumatism (Joshi et al., 2014; Said et al., 2015). The plant has been reported having various pharmacological activities like anti-proliferative, anti-infectious, antibacterial, antioxidant, antiviral, immunomodulatory, hepatoprotective, analgesic, anti-inflammatory, anti-colitis, anticancer, hypotensive, antiulcer properties (Joshi et al., 2014; Said et al., 2015). The phytochemical investigations on *Urtica dioica* have revealed the presence of various phytochemicals including volatile compounds, fatty acids, flavonoids, terpenes, minerals, protein, vitamins, tannins, polysaccharides, isolectins and sterols (Joshi et al., 2014; Said et al., 2015). Qayyum et al. (Qayyum et al., 2016) evaluated the antihyperglycemic activities of crude methanolic extract of *Urtica dioica* and its fractions in normotensive and hypertensive rats. The extract and fractions were found more effective antihypertensive in hypertensive rats than normotensive with maximum effect exhibited by the ethyl acetate fraction (Qayyum et al., 2016).

3.3. Toxicological evidence

The use of medicinal plants is not always benign. Excessive consumption of some plants might lead to harmful effects on nervous system, bone, skin, lung, reproductive system, bladder, blood, endocrine system, liver, kidney and cardiovascular system. Toxic effects are usually dose-related. Hypertensive patients used certain toxic plants such *Citrullus colocynthis*, *Datura stramonium*, *Artemisia herba-alba*, *Peganum harmala* and *Tetraena gaetula* (Douira and Zidane, 2015; Eddouks et al., 2002; Idm'hand et al., 2019; Jouad et al., 2001; Tahraoui et al., 2007; Ziyyat et al., 1997). In high doses the seeds of *Petroselinum crispum* can be toxic, possible risk of photosensitization (a form of skin allergies). Pregnant women such as people with cirrhosis or kidney disease cannot consume it. (Agyare et al., 2017; Perelman and Kuttin, 1988; Williams and Binns, 1968). *Datura*

stramonium is a plant containing tropane alkaloids that are very toxic to humans and animals. All parts of the plant are poisonous and can cause serious or even fatal health effects (Bouzidi et al., 2011; Gaire and Subedi, 2013). In high doses, *Artemisia herba-alba* can indeed become toxic. The most frequently noted side effects are contact allergies caused by sesquiterpene lactones in the plant and pollens in its flowers. Failure to comply with prescribed doses can also cause gastric and intestinal irritation, or even poisoning (Arroyo et al., 2018; Bertella et al., 2018). The seeds of *Peganum harmala* contain indole alkaloids (vasicine and harmaline) known for their neurotoxic action in vertebrates. Ignorance of contraindications and non-compliance with doses cause this plant to become a real poison (Benbott et al., 2013; Pulpati et al., 2008).

Despite their toxic nature, the injurious consequences among the population of Morocco have not been seen. This indicates that the patients or the provider of the plants may have been well informed about the side effects of these medicinal species. Accordingly, they may have taken the necessary precautions measuring the appropriate doses and using suitable methods of preparation and administration of herbal remedies (Douira and Zidane, 2015; Eddouks et al., 2002; Idm'hand et al., 2019). The literature search showed no toxicological documentation on the other hypotensive plants used in Morocco cited here. Medicinal plants reported should be submitted to toxicity studies to identify adverse effects and reveal some of the risks that may be associated with the use of herbal medicines.

4. Conclusion

Traditional herbal medicines may be considered alternative or adjunctive drugs for the treatment or prevention of hypertension. People from Morocco made use of 104 medicinal plants from 46 families for the treatment of high blood pressure. Plants from the Lamiaceae family were used most often in Morocco. The most prominent plants reported were *Petroselinum crispum*, *Tetraclinis articulata*, *Rosmarinus officinalis* and *Olea europaea*. Leaves were the most used plant part. Decoction was the main preparation method.

Many Moroccan medicinal plants are reported having hypotensive effect that makes them useful for the management of hypertension. However, in addition to the problem of the rapid disappearance of traditional culture and natural resources there are only few pharmacological studies despite the antihypertensive effect of some of these plants. Indeed, 81 medicinal plants that are used for the treatment of hypertension in Morocco have not yet been studied in great detail for their antihypertensive activity. Furthermore, there are very few toxicological studies despite the known toxicity of some of these plants. It is, however, an urgent need to document knowledge of the use of medicinal plants from unexplored areas and to study their pharmacological and toxicological effects in more detail so as to use these plants without risks of intoxications or excessive undesirable effects.

Conflicts of Interests

Authors declare that there is no conflict of interests

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