

Ethnopharmacology Forum

Medicinal plants used in the treatment of diabetes in Morocco

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Abstract

The present review shows a listing of medicinal plants used in phytotherapy of diabetes and those experimentally studied as hypoglycaemic in Morocco. The review is presented as 3 tables. The first one includes the taxonomic classification of the plant, the popular names in Morocco, the parts used, the mode of preparation and the other medicinal uses and toxicity. The second table summarises the experiments done by Moroccan researchers to confirm the hypoglycemic activity of the medicinal plants. It also describes the methodology used, and the magnitude of the hypoglycemic activity. The third table lists the toxicological studies carried out with plants reported to be toxic. The large number of plants described in this review (94 species belonging to 38 families) demonstrated the prevalence of phytotherapy in Morocco. The plant families which contained the most commonly used species for their antidiabetic effects are: Compositae (18 species), Lamiaceae (14 sp.), Leguminosae (8 sp.), Liliaceae (5 sp.), Apiaceae (5 sp.), and Graminae (4 sp.). Among these medicinal plants, 17 are toxic, the most known being: *Daphne gnidium*, *Nerium oleander*, *Ferula communis*, *Peganum harmala* and *Citrullus colocynthis*.

Keywords : *Hypoglycemia, Medicinal plants, phytotherapy, diabetes mellitus, Morocco.*

Introduction

Diabetes mellitus is one of the most common metabolic diseases in Morocco. Indeed, its incidence is about 10 % in this country. In certain regions of Morocco the incidence of diabetes mellitus has reached 13.3%.¹ In a recent survey in eastern Morocco, about 60 % of non-insulin-dependent diabetics were found to resort to the use of medicinal plants to treat their disease.² In fact, phytotherapy

has been widely used by the Moroccan population since time immemorial. This practice continues to be prevalent in the cities as well as in the rural environment because of the low cost and the easy availability of medicinal plants in all the markets in the country. However, the studies on antidiabetic plants used in Morocco are relatively recent and has begun to evolve in the last few years. Moreover, until recently, there has been no extensive documentation of data on antidiabetic plants in Morocco.

The aim of the review is to make a list of work done on plants considered as antidiabetic in Morocco. This index is a collection of experimental studies, reports of investigations and

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documents published in Morocco on hypoglycemic and antidiabetic plants.

Results and discussion

In this review, a listing of data on medicinal plants used in the treatment of diabetes is presented in three tables. The first one contains a list of plants used in phytotherapy in Morocco, the scientific name and the family of the plant, its popular names in Morocco, the parts used, the mode of preparation, other medicinal uses and toxicity. The second table represents the informations on experimental work done to confirm hypoglycemic activity. It describes the methodology used, the animal models, the doses and the magnitude of the hypoglycemic activity of the plant. The third table represents a listing of the plants reported to be toxic and some toxicological studies.

In Morocco, a wide range of medicinal plants is used in folk medicine for the treatment of different diseases. There are several dozen botanical species widely used for the treatment of diabetes. Some of these are now well known by the scientific community; for example *Trigonella foenum grecum*, *Allium sativum*, *Artemisia herba alba* and *Citrullus colocynthis*.

The families which contain the species of medicinal plants most used for their antidiabetic effects are the following: Compositae (18 species), Lamiaceae (14 sp.), Leguminosae (8 sp.), Liliaceae (5 sp.), Apiaceae (5 sp.), and Graminae (4 sp.).

There are two types of diabetes, the insulin-dependent diabetes with hypo-insulinemia and non-insulin-dependent diabetes with hyper-insulinemia. One

can also induce a transient hyperglycemia orally or subcutaneously. On the other hand one can produce insulin-dependent diabetes experimentally using agents such as alloxan (actually this drug is seldom used because it doesn't selectively destroy the β cells of Langerhans) and streptozotocin that destroys β cells selectively. Many authors have explained the antidiabetic effect of plants. They may stimulate insulin secretion from β cells and induce regeneration, revitalization and/ or hyperplasia of the β cells. Moreover, extracts of antidiabetic plants can act by imitating the action of insulin, an "insulin-like action". Antidiabetic plants can act by supplying β cells with the necessary elements (Cu^{++} , Mg^{++} , Ca^{++}). These plant extracts can also reduce the action of insulinase, an enzyme that destroys the insulin in the liver.

On the other hand, extracts from antidiabetic plants may act on glucose homeostasis in a non-insulin-dependent diabetes model. They can decrease the level of glucagon, induce a decrease in the intestinal absorption of glucose and/or reduce the peripheral use of glucose. Moreover, they may act on liver enzymes causing stimulation of glucogenogenesis and/or inhibition of the glycogenolysis.

The following antidiabetic medicinal plants, cited in this review,¹⁷ are toxic: *Daphne gnidium*, *Nerium oleander*, *Ferula communis*, *Peganum harmala*, *Globularia alypum*, *Lupinus albus*, *Aloe socotrina*, *Androcymbium garmineum*, *Androcymbium intermedium*, *Nigella sativa*, *Crataegus oxyacantha*, *Ruta montana*, *Artemisia herba alba*, *Chenopodium ambrosioides*, *Haloxylon scoparium*, *Launea arborescens* and *Citrullus*

Table 1: Presentation of hypoglycemic plants used in traditional medicine as anti-diabetics, with scientific name, popular name, used parts, preparation, other medicinal uses and the toxicity.

<i>Family and scientific names</i>	Popular names in Morocco	Used parts	<i>Preparation</i>	Medicinal uses and toxicity
Apiaceae				
<i>Ammi visnaga</i> Lam.	<i>Bachnikha</i>	Fruits	Decoction	Hypoglycemic ^{2,3,4} , diuretic, hypotensive, hair-care, antihelminthic, antispasmodic, antirheumatic, antiseptic, tonic. ^{3,4} Toxic, hypoglycemic, sedative. ⁵
<i>Daucus carota</i> L. <i>Ferula communis</i> L.	Khizzou, zroudia Klarh, nard	<u>Roots</u>	mashed, juice Fumigation, external use	Toxic, ⁴ hypoglycemic, sedative, aphrodisiac, amelioration of vision, antieczema. ⁵ Hypoglycemic, ritual and magic. ⁶
<i>Ferula asafoetida</i> <i>Foeniculum dulce</i> DC.	Hantit Nafa, besbas, wamsa, oumasa	<u>Resin</u> Resin Seeds, roots, leaves	Decoction Decoction, inhalation	Hypoglycemic, kidney diseases, gastro-intestinal diseases, diuretic, antispasmodic, antipyretic. ⁷
Apocynaceae				
<i>Nerium oleander</i> L.	Defla	Leaves	Decoction, infusion, maceration, fumigation	Toxic ^{3,4,7} hypoglycaemic, ³ abortive, antivertigo, itching and headache. ^{2,3,7}
<i>Ptychotis verticillata</i> L.	Nûnkha	Aerial part	<i>Infusion</i>	Hypoglycemic, hypotensive, influenza, aromatical ²
Brassicaceae				
<i>Lepidium sativum</i> L.	<i>Habb er sad, rchad, lhurf</i>	Seeds	Decoction, powder	Hypoglycemic ^{5,8} antiseptic, emmenagogue, antirheumatic, antitussive, antiasthmatic, pulmonary diseases. ⁸
Burseraceae				
<i>Boswellia cartei</i> Bridw <i>Boswellia sp</i>	Loubane dacare Salabane	Resin Resin	Infusion <i>Decoction</i>	Hypoglycemic, amnesia ⁵ Hypoglycemic, antitussive, facial paralysis. ⁵

Apparaceae				
<i>Capparis spinosa</i> L.	Kebbar	Fruits, seeds	Decoction, powder	Hypoglycemic ^{2,5} stimulant, diuretic, appetizing, antispasmodic, antirheumatismal, tonic, painful menstruation ^{3,7}
Chenopodiaceae				
<i>Chenopodium ambrosioides</i> L.	<i>Mkhinza</i>	Leaves, flowers	Infusion, fresh juice	Toxic, ⁴ hypoglycemic, ² antiasthmatic, antitussive, antihelminthic, antispasmodic, emmenagogue. ⁷
<i>Fredolia aretioides</i> Coss. & Dur.	Shejra li ma idihach errih, sella,	Aerial part	Powder,	Hypoglycemic, diuretic, antirheumatic, antidote of poison. ⁴
<i>Haloxylon scoparium</i> Pomel	âkenoud	Whole plant	infusion	Toxic, ⁴ antidiabetic, cicatrizing, headache. ^{4,8}
	<i>Rremt, âssây</i>		Powder, infusion	
Cistaceae				
<i>Cistus ladaniferus</i> L.	<i>Taouzla</i>	Leaves	Infusion, decoction	Hypoglycemic, liver diseases ⁵
<i>Cistus libanotis</i> L.	Yazir lahmir	Leaves	Decoction	Hypoglycemic, intestinal diseases. ⁵
Compositae				
<i>Achillea odorata</i> L.	Korte	Leaves, flowers	Decoction	Hypoglycemic, expectorant. ⁵
<i>Artemisia absinthium</i> L. and <i>Artemisia arborescens</i> L.	Chiba, chibat al-'ajûj	Aerial part	Infusion	Hypoglycemic, ^{2,4} antiseptic, tonic, digestive, antihelminthic, emmenagogue, diuretic, antispasmodic, abortive. ^{4,7}
<i>Artemisia herba-alba</i> Asso.	<i>Shih, ifsî, fessî</i>	Leaves, roots	<i>Powder</i>	Hypoglycemic ^{2,3,4} hypotensive, ² antimicrobial, ⁹ antidote of poison, antihelminthic, emmenagogue. ^{3,7} Diuretic, tonic, depurative, cholagogue. ⁴
<i>Artemisia Mesatlantica</i> Maire, <i>A. flahautii</i> Emb. & Maire, <i>A. ifranesi</i> Did., <i>A. negrei</i> Ouyahya		Leaves, flowers	Decoction	Hypoglycemic, antispasmodic. ⁵
<i>Artemisia campestris</i> L.	Allal	Leaves, roots, capitules	Decoction	Hypoglycemic, cholagogue, cholaretic, digestive, depurative, antilithiasic, obesity and cholesterol. ^{7,8}
<i>Cynara scolymus</i> L.	<i>Kharchouf, amazzûgh</i>	<i>tagemmut,</i>	Decoction	Hypoglycemic, diuretic, post partum care, liver disorders ^{3,4} appetizing, depurative, abortive. ⁴
<i>Echinops spinosus</i> L.	Tassekra, l-kherchouf, chouk al-himar	Roots	Infusion	Hypoglycemic, ⁷ diuretic, ³ hepatic disorders, ^{3,4} stomach disorders. ⁴
<i>Cichorium intybus</i> L.	Bouaggad, timerzuga	<u>Leaves,</u> <u>roots</u>	Infusion	Hypoglycemic, for mouth-care, ⁵ Toxic, ⁴ hypoglycemic, ¹⁰ vermifuge, anti-angina, ⁴ abortive, stomach disorders. ¹¹

<i>Helianthus annuus</i> L. <i>Launea arborescens</i> (Batt.) Maire	<i>Nouarat chamess</i> <i>Sekkûm, mmû-lbeyna</i>	<u>roots</u> <u>Seeds</u>	Powder Extract, infusion	Hypoglycemic, gastro-intestinal stimulant, sudorific, ¹² stomach disorders, antihelminthic, emmenagogue. ⁴
<i>Ormenis africana</i> Jord. & Four <i>Ormenis scariosa</i> (Ball.)lit. & Maire. <i>Scolymus hispanicus</i> L.	<i>Îrzgi, gartôfa</i>	<u>Latex,</u> <u>roots,</u>	Decoction	Hypoglycemic, stomach disorders. ⁵
<i>Taraxacum officinale</i>	Garnina Chlada, handaba	<u>leaves</u> <u>Capitules</u>	Powder, decoction Decoction, crud	Hypoglycemic, cholagogue, against obesity and cholesterol, diuretic, tonic, appetizing, antiscorbutic. ⁷
		<u>Roots</u>		
		Leaves, roots		
Cucurbitaceae <i>Citrullus colocynthis</i> (L.) Schrad.	Handal, hdejja, tijjelt	Fruits, pulp	Crud, maceration, external use	Toxic, hypoglycemic ^{2,3,4} antidote against poison, antihelminthic, against gonorrhoea, antiepileptic, laxative, aphrodisiac, purgative, diuretic, antiasthmatic, antirheumatic, abortive, antitubercular, syphilis. ^{3, 4,7}
Cupressaceae <i>Tetraclinis articulata</i> Benth.	<i>Arâar, âzuka, imijjed</i>	Aril	Powder, maceration	Hypoglycemic, hypotensive, ² antivertigo, headache, antidiarrheal, magic, dental care adstringent, ³ cicatrizing, inflammation of eyes, facilitating of labour. ⁴
<i>Juniperus phoenicea</i> L.	Arâar, âmmes, âyfes		Decoction, powder	Hypoglycemic, broncho-pulmonary diseases, diuretic, ⁴ urinary antiseptic, aid of menstruation, stomach pain. ³
		<u>Cones,</u> <u>leaves</u>		
Ericaceae	Sasnou, el-lenj, unnîs	Leaves,	Decoction	Hypoglycemic, hypotensive, ² diuretic, ¹³ urinary antiseptic, adstringent,

<i>Arbutus unedo</i> L.		roots		antiinflammatory, depurative, antidiarrheal, blennorrhagia. ^{7,14,15, 16}
Fabaceae				
<i>Glycyrrhiza glabra</i> L.	<i>Arqsouss</i>	Fruits, roots	Decoction	Hypoglycemic, broncho-pulmonary diseases, intestinal diseases, anti-inflammatory, anuria and oliguria. ⁸
Fagaceae				
<i>Quercus faginea</i> Lam.	<i>L'aâssaf</i>	Gall	powder	Hypoglycemic, for hair care, haemostatic (external use), ophthalmia (applied on eyes). ⁶
Gentianaceae				
<i>Centaurium erythraea</i> Rafn.	Gosset l-hayat, merrâret, lehnes	Aerial part	Infusion	Hypoglycemic, ^{3,4} antipyretic, cardio-regulator, depurative, ³ cicatrizing, hair-care. ⁴
<i>Centaurium spicatum</i> (L.) Fritsch				
Geraniaceae				
<i>Geranium robertianum</i> L.	<i>laatarcha</i>	Leaves, flowers, stem	Infusion	Hypoglycemic, tonic, antispasmodic, kidney vetch, cancer. ⁵
Globulariaceae				
<i>Globularia alypum</i> L.	Ain larnab	Leaves	Infusion, decoction	Toxic, ⁴ hypoglycemic ^{2,3,4} laxative, cholagogue, stomach disorders, sudorific, purgative ^{3,7} febrifuge, magic. ⁴
Gramineae				
<i>Cynodon dactylon</i> L. Pers.	<i>Til, njem, affie, tagamait</i>	Rhizome, whole plant	Decoction	Hypoglycemic, diuretic, renal diseases, antirheumatic, hemiplegy, arthralgy. ⁸
<i>Sorghum vulgare</i> L.	<i>Bachna, tafsût</i>	Seeds	Boiled	Hypoglycemic, ² digestive disorders. ^{3, 4}
<i>Panicum miliaceum</i> L.	<i>Anili, illane, tafsût</i>	Seeds	Boiled	Hypoglycemic ^{2,7} antidiarrheal, ⁴ antianemia, diuretic, stimulant, sudorific ⁷
<i>Phalaris canariensis</i> L.	Bachna	Seeds	Powder	Hypoglycemic ⁵
Juglandaceae				
<i>Juglans regia</i> L.	Guergae, gûz, sswak	Fruits, leaves, cortex	Infusion, decoction	Hypoglycaemic ^{4,7,8} antihelmintic, antiseptic, tonic, adstringent, vermifuge, depurative, cicatrizing, stomach disorders and antidote poison. ^{3,7, 8}
Lamiaceae				
<i>Ajuga iva</i> L.	Chendgora	Aerial part	Decoction, powder	Hypoglycemic, ^{2,4} Antihelmintic, intestinal disorders, panacea, antipyretic, against cold, cicatrizing. ^{3,4}
<i>Lavandula dentata</i> L.	Khzama, taymerza	Flowers, whole plant	Infusion, decoction, powder	Hypoglycemic, hypotensive, ² antispasmodic, stomach disorders, against liver disorders, antirheumatic, antiseptic, diuretic, carminative, cholagogue, cicatrizing, headache, stimulant, antivertigo bronchopulmonary infections. ^{4,7}
				Hypoglycemic, vertigo and cough, ritual practice. ⁶

<i>Lavandula x abrialis</i> L.	<i>Lakhzama</i>	flowers	Infusion	Hypoglycemic, ^{2,3,4} antiseptic, diuretic, hair-care, headache, bronchopulmonary infections, antidiarrheal, emmenagogue, aortic palpitations, sedative, tonic, expectorant, antipyretic, icterus. ^{3,7,14,17}
<i>Marrubium vulgare</i> L.	Marrîwa, merrîwut, ifzi	Aerial part	<i>Decoction</i>	Hypoglycemic, ² antitussive, antispasmodic, antiseptic, mouth hygiene, carminative, digestive, headache and chill, tonic, and bronchopulmonary infections. ^{3,7}
<i>Mentha pulegium</i> L.	Fliou	Aerial part	Infusion	Hypoglycemic, hypotensive, ² gastrointestinal antiseptic, mouth hygiene, antacid, antispasmodic, expectorant, kidney vetch, ^{3,7} aphrodisiac. ⁴
<i>Origanum compactum</i> Benth.	Zâtar	Leaves	Infusion	Hypoglycemic, hypotensive, ² antiseptic, gastrointestinal and liver disorders, emmenagogue, antispasmodic, chill, diuretic, alopecia, cicatrizing. ³ Antirheumatic, cholagogue. ⁴
<i>Rosmarinus officinalis</i> L.	Azir, yazir, barkella	Aerial part	Infusion, decoction	Hypoglycemic, ^{2,7} throat diseases, emmenagogue, diuretic, antiseptic, refreshing, stimulant, cholagogue, antispasmodic, carminative, diuretic, cholaretic and stomachic, kidney vetch. ^{3,4,7}
<i>Salvia officinalis</i> L.	<i>Salmia, tilsas, tamazzût</i>	Leaves	Infusion	Hypoglycemic, eye diseases. ⁵
<i>Salvia phlomoides</i> Asso.	<i>Bouftache</i>	Leaves, seeds	Decoction	Hypoglycemic, cold, against stoical diseases. ⁵
<i>Sideritis subatlantica</i> Doum.	<i>Garn el kabch</i>	Leaves, stems	Decoction	Hypoglycemic, ¹⁸ pulmonary disorders. ^{3,4}
<i>Thymus ciliatus</i> (Desf.) Benth.	<i>Z'atar, z'îtra, âzukenni</i>	Leaves	Decoction, powder	Hypoglycemic, antipyretic. ⁵
<i>Thymus satureioides</i> Cosson & Balam.	Touwichant	Leaves, flowers	Decoction	Hypoglycemic, sedatives. ⁵
<i>Thymus munbyanus</i> Boiss. & Reut.	Touchna	Leaves, flowers	Infusion	Hypoglycemic, antipyretic, antirabic, kidney vetch. ⁵
<i>Teucrium polium</i> L.				

	Jaâda	Aerial part	Infusion, decoction	
Leguminosae				
<i>Trigonella foenum-graecum</i> L.	Halba, tifidas	Seeds	Decoction, powder, maceration	Hypoglycemic, ^{2,3,4} hypotensive, ³ appetizing, tonic, reconstituant, hair-care, aortic palpitations, laxative, emollient, blood cleaning. ^{3,7} Bone reparation, galactagogue, anti-inflammatory. ⁴ Hypoglycemic. ⁶
<i>Glycine max</i> (L.) Mer.	<i>A'ssoja</i>	Seeds	Decoction	Toxic, ⁴ hypoglycemic, ^{3,4,7} for liver disorders, antihelmintic. ⁴
<i>Lupinus albus</i> L.	<i>Termas, semqâla beyda</i>	Seeds	Decoction, powder	Hypoglycaemic, antihelmintic. ⁴
<i>Lupinus luteus</i> L., <i>Lupinus augustifolius</i> L., <i>Lupinus pilosus</i> L., <i>Lupinus hirsutus</i> L.	Rjel ed-djaja, kîkel, fwila, îbaûn wijjan, semqala	Seeds	Decoction, powder	Hypoglycemic. ⁶
<i>Vigna sinensis</i> End.	Foul gnawa	Seeds	Maceration	
Liliaceae				
<i>Allium sativum</i> L.	Toum, touma, tiskert	Bulb	Raw	Hypoglycemic, ² hypotensive, ^{2,4} antispasmodic, antirheumatic, antiseptic, antihelmintic, diuretic, cholagogue, stimulant, pulmonary and digestive disorders, antidote of poison, alopecia. ^{3,7}
<i>Allium cepa</i> L.	Elbesla, azlim, azalim	Bulb	Raw	Hypoglycemic, antipyretic, aphrodisiac, against gastrointestinal disorders, mouth hygiene, emollient, antitussive, antiseptic, antihelmintic. ⁸
<i>Aloe socotrina</i> Lamk., A. perry Baker	<i>Sibr sidqi, sabr</i>	Leaves, juice	Powder, dry juce	Toxic, ^{4,7} hypoglycemic, ^{3,4,5} laxative, skin diseases, magic, ³ cholagogue, purgative, cicatrizing, hair-care, abortive. ^{4,7} Toxic, hypoglycemic, cold. ⁴
<i>Androcymbium garmineum</i> (cav.) Mc Bride	Ssgêat lerneb, lawzat lehjel,	Extract, dry juice, bulb	Infusion, extract	
<i>A. intermedium</i> Gatt. & Maire	gerga'at leghrab			

Linaceae

<i>Linum usitatissimum</i> L.	Kattan, beri, zreat el katan, el atal	Seeds	Infusion	Hypoglycemic, antihelmintic, broncho-pulmonary diseases, intestinal and renal diseases, laxative, skin diseases, aphrodisiac. ⁸
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Lythraceae

<i>Lapa communis</i> B. (= <i>Lapa major</i> G.C.)	<i>Bardane, arkitoun</i>	Roots, leaves, flowers	Decoction, infusion, fresh leaves	Hypoglycemic, for skin diseases, ^{7,8} Hair-care, antilithiasic, antirheumatic, sudorific. ⁷
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Moraceae

<i>Ficus carica</i> L.	Karma, kermôs, chriha, tin, bakûr, dukkar	Fruits, leaves	Extract, powder	Hypoglycemic, ² laxative, stimulant, throat diseases, antitussive, emmenagogue, resolvent. ^{3,7} Antiseptic, diseases of eyes and skin. ⁴
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Morus nigra L.
(= *Morus alba* L.)

Tout	Fruits, leaves	Infusion, decoction	Hypoglycemic, adstringent, laxative, antidiarrheal, anti-inflammatory, antirheumatic, antitussive. ^{5,7,8}
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Myrtaceae

<i>Eucalyptus globulus</i> Labill.	Kalitûs, kallitû	Flowers, leaves	Infusion, decoction, powder	Hypoglycemic, hypotensive, ² Hair care, cosmetic, anti-inflammatory, spleen disorders, antiseptic, antiasthmatic, febrifuge, adstringent and appetizing. ^{3,4,7}
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<i>Myrtus communis</i> L.	Raihane, tarîhant, moqqô	Leaves, fruits	Infusion, decoction	Hypoglycemic, ² antiseptic, adstringent, gastrointestinal disorders, Hair-care, antidiarrheal. ^{3,7} Antihemorrhoidal, mouth and eyes disease, cosmetic. ⁴
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Syzigium aromaticum Merr. et Perry
(= *Eugenia caryophyllata* Thunb.)

Qrûnfûl	Fruits, leaves	Decoction, powder	Hypoglycemic, hypotensive, ² hair-care, pulmonary diseases, antiseptic, mouth hygiene, ^{3,7} diuretic, stimulant, against cold. ⁴
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Oleaceae

<i>Fraxinus augustifolia</i> Vahl	Touzalt, lisân tir	Fruits, leaves	Powder	Hypoglycemic, ⁴ diuretic, antirheumatic, laxative, sudorific, ⁷ aphrodisiac. ³ Liver diseases, tonic, cold, antitussive. ⁴
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<i>Olea europea</i> L. Var. oleaster	Zitoun, zebbouj	Leaves	Decoction	Hypoglycemic ^{2,8} hypotensive, ² choloretic, cholagogue, antihelmintic,
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					antiseptic, mouth hygiene, alopecia, gastro-intestinal diseases, ^{3,7,8} antidote of poison, depurative, for broncho-pulmonary diseases, antihemorrhoidal, otitis. ⁴
Palmae					
<i>Phoenix dactylifera</i> L.	Nakhla, tayniyût, tazdâyt, ttmer, el-bluh	Fruits, seeds	Infusion powder, pulp, Infusion		Hypoglycemic, ² expectorant, asthenia, and throat diseases, tonic, aphrodisiac, mouth hygiene, antidiarrheic. ⁴ Hypoglycemic, against pulmonary diseases. ⁵
<i>Chamaerops humilis</i> L.	Doum	Resin			
<u>Polygonaceae</u>					
<i>Polygonum aviculare</i> L.	Wadmu, lbetbat	Leaves, roots	External use, fumigation		Hypoglycemic, astringent, diuretic, laxative, sudorific, kidney vetch, haemostatic. ⁵
<u>Portulacées</u>					
<i>Portulaca oleracea</i> L.	Rejla, baqla l-hamqâ, âgertîn, tazelluzt	Whole plant, seeds	Decoction, raw		Hypoglycemic, antipyretic, emollient. ⁴
Punicaceae					
<i>Punica granatum</i> L.	<i>Qchour romman</i>	Pericarp	Decoction, powder		Hypoglycemic, antiulcerous, vaginal antiseptic, gastrointestinal disorders, ³ adstringent, antihelmintic, ⁷ hair-care, diuretic, mouth hygiene. ⁴
Ranunculaceae					
<i>Nigella sativa</i> L.	Sanouj	Seeds	Powder		Toxic, ^{3,4,7} hypoglycemic, ^{2,8} hypotensive, ¹⁹ abortive, antitussive, antiasthmatic, sinusitis, broncho-pulmonary infections, carminative, against influenza, emmenagogue, antihelmintic and antidote poison. ^{3,4,7,8}
Rhamnaceae					
<i>Zizyphus lotus</i> (L.) Lamk.	Sadra, nnbeg, âzar, âmezmem Mzah	Leaves, fruits, Leaves	Powder, decoction Decoction		Hypoglycemic, ^{2,8} urinary infections, hair-care, cystitis treatment. ^{3,4} Hypoglycemic, ² hypotensive, antidiarrheal, for digestive disorders ^{3,4}
<i>Eriobotrya japonica</i> (Thunb.) Lindl.					
Rosaceae					
<i>Crataegus oxyacantha</i> L.	Saarour chaik, admam, mesnagen	Leaves, flowers, fruits	Infusion		Toxic, hypoglycemic, hypotensive, arterio-sclerosis, cardio-regulator, antispasmodic, diuretic, antidiarrheic, nervous diseases, ⁸ Hypoglycemic, cosmetic and tonic. ^{2,3,4}
<i>Prunus amygdalus</i> Stokes var. Amara DC.	Louz mar, louz harr	Seeds	Extract		Hypoglycemic, astringent, depurative, against mouth diseases. ⁷

<i>Rubus fruticosus</i>	Tût lakhla, achaddir	Flowers, leaves, fruits	Infusion	
Rutaceae <i>Ruta montana</i> L.	Fidjel	Aerial part	Infusion, decoction, powder, fumigation	Toxic, ^{3,4} hypoglycemic, ² abortive, antirheumatic, magic, intestinal and hepatic diseases, male sterility, vitiligo, antihelmintic, antiepileptic, antipyretic. ^{3,4}
Santalaceae <i>Santalum album</i> L.	A'sandal	Resin	Mixed with honey	Hypoglycemic. ⁶
Thymelaeaceae <i>Daphne gnidium</i> L.	Mathnane, lazaz, îrif	Leaves, stem bark	Infusion	Toxic ^{3,4,7} hypoglycemic, ² abortive, hair-care, purgative, skin diseases. ^{3,4,7,14}
Urticaceae <i>Urtica dioica</i> L.	Harrigua, tikzinin, tizmezt, timezrit	Aerial part	Infusion, decoction	Hypoglycemic, ^{2,8} hypotensive, ² diuretic, adstringent, against headache and cold, depurative, asthenia, antispasmodic and antirheumatic., ^{7,17}
<i>Urtica urens</i> L.	Harrigua, karas, takznt, timezrit	Aerial part	Infusion	Hypoglycemic, antirheumatic, kidney stones, galactagogue, aphrodisiac. ⁸
Zingiberaceae <i>Zingiber officinale</i> Roscoe.	Zanjabil, skinjibir	Rhizome	Powder	Hypoglycemic, antitussive, analgesic, appetizing, aphrodisiac, digestive disorders, antipyretic, pulmonary diseases. ⁸
Zygophyllaceae <i>Peganum harmala</i> L.	Harmal	Seeds	Powder, infusion	Toxic, ^{3,4,7} hypoglycemic, ^{2,8} hypotensive, ²⁰ hallucinogenic, magic, hair-care, antirheumatic, nervous diseases, asthenia, antalgic, antidiarrheal, bowels diseases, antihelmintic, antispasmodic, emmenagogue, antimicrobial, cicatrizing. ^{3,4,7,8}
<i>Zygophyllum album</i> L. ssp. <i>Gaetulum</i> Emb. Maire, <i>Z. waterloti</i> Maire, <i>Z. fontanesi</i> Webb.	Aggaya, l-barrâya, tazlost, tirta, tirremt	Leaves, stem	Infusion, decoction, powder	Hypoglycemic, ^{2,3,4,5,8} antiseptic, antispasmodic, anti-eczema, stomach and liver pain. ^{3,4,8}

Table 2: Presentation of hypoglycemic plants experimentally studied in Morocco, with scientific name, used parts and the methodology used for experimentation.

Scientific name (Family)	Used parts	Methodology and physiological effects
<i>Ammi visnaga</i> Lam. (Apiaceae)	Fruits	Oral administration of the mixture obtained from the decoction of three plants (450 mg/kg) reduced blood glucose level by 51 % after 4 hours in normoglycemic rats. This action was compared with an oral hypoglycemic agent (tolbutamide). ¹⁸
<i>Erythrea centaurum</i> Rafn. (Gentianaceae)		
<i>Thymus ciliatus</i> (Lamiaceae)		
<i>Arbutus unedo</i> L. (Ericaceae)	Roots	Oral administration of water extract obtained from a decoction of <i>A. unedo</i> (100 mg/kg) during 4 weeks to streptozotocin-induced diabetic rats did not significantly reduce the level of blood glucose. However, when orally administered (500 mg/kg) to rats submitted to oral glucose tolerance test, it significantly reduced the level of blood glucose. ²¹
<i>Citrullus colocynthis</i> L. Schrad. (Cucurbitaceae)	Fruits	Different extracts were obtained from the seeds of <i>C. colocynthis</i> plant: RN II (crude extract), RN VI (hydro-alcoholic extract), RN X (purified extract) and RN XVII (beta-pyrazol-1-ylalanine) and the major free amino acid present in the seeds. When perfused for 20 minutes at 0.1 mg/ml, all tested extracts produced an immediate and significant insulin secretion <i>in vitro</i> in the isolated rat pancreas and isolated rat islets in the presence of 8.3 mM glucose. ²²
<i>Daphne gnidium</i> (Thymeleaceae)	Aerial part	Oral administration of water extract of the infusion of <i>D. gnidium</i> (100 mg/kg) during 4 weeks to streptozotocin-induced diabetic rats did not significantly reduce the level of blood glucose. However, when orally administered (250 mg/kg) to rats submitted to oral glucose tolerance test, it reduced the blood glucose level versus controls. ²¹
<i>Globularia alypum</i> (Globulariaceae)	Leaves	Oral and intraperitoneal administration of the infusion of <i>G. alypum</i> (0.7 g/kg) produced blood glucose lowering in normal and hyperglycemic rats. The authors suggested that this plant may act by increasing the peripheral metabolism of glucose and of insulin secretion. ²³
<i>Nigella sativa</i> (Ranunculaceae)	Seeds	Oral administration of an extract obtained from maceration of seeds of <i>N. sativa</i> (1ml/kg/day) during 3 months produced a decrease of glycemia (16.5 %). It also produced a decrease of blood level of triglycerides and cholesterol. ²⁴
<i>Olea europaea</i> var. Oleastre (Oleaceae)	Leaves	Sand rats receiving a high cholesterol diet during four months and orally treated by plant decoction (at 10 %) for two months produced hypoglycemic effect (48 %), antihyperglycemic effect (48 %) and hypoinsulinemic effect (39 %). The authors suggested that oleaster leaves possess at least two active compounds to treat hypercholesterolemia. ²⁵ <i>O. europaea</i> leaves decoction (prepared at 10 %) given orally (1.5 ml/100 g) to sand rats. These animals develop insulin resistance and became prediabetic when given standard laboratory hypercaloric chow. The treatment during three months produced a hypoglycemic effect (16 %) and antihyperglycemic effect (40 %) with a 25 % decrease in insulin blood level. This effect was compared with controls and a group treated by simvastatin. The main objective of this study is to respond to the question: did the extract of leaves of <i>O. europaea</i> improve the physiological state of these animals (decrease of cholesterolemia)? The authors have used simvastatin as hypocholesterolemiatic agent to compare with the medicinal plant treated animals. The plant extract induced a decrease in glycaemia and insulinaemia. This appears to have a contradictory effect. Therefore, the experiment cited above was in a non –insulin-dependant diabetes. Probably, the extract has an indirectly effect on the glucose metabolism (glucose

homeostasis) and improves abnormal glucose and lipid metabolism by reducing insulin resistance of diabetic animals.

<i>Ptychotis verticillata</i> L. (Apocinaceae)	Whole plant	Oral administration of water extract of the infusion of <i>P. verticillata</i> (100 mg/kg), during 4 weeks to streptozotocin-induced diabetic rats did not significantly reduce the level of blood glucose. However, when orally administered (125 mg/kg) to rats submitted to oral glucose tolerance test, it produces euglycemia. It seems that this plant may act by extrapancreatic way on glucose metabolism. ²¹
<i>Spergularia rubra</i> (Caryophyllaceae)	Whole plant	Intravenous administration of water extract obtained from the infusion of <i>S. rubra</i> (500 mg/ml perfused at a rate of 50 ml/min/100 g of body weight) produced a decrease of blood glucose level (58 %) in streptozotocin induced diabetic Wistar rats. This value was lower that obtained by a perfusion of sodium vanadate . ²⁷
<i>Spergularia purpurea</i> (Caryophyllaceae)	Whole plant	In normoglycemic rats, the water extract (WE) of the decoction of <i>S. purpurea</i> produced a significant glycemia lowering effect 4 h after single oral administration, and 1 week after repeated oral administration. In streptozotocin-induced diabetic rats, the WE produced a decrease of glycemia from 22.8 +/- 0.6 to 11.2 +/- 0.5 mmo/l. Two weeks after WE repeated oral administration the glycemia was returned to normal values in diabetic rats. ²⁸
<i>Suaeda fruticosa</i> (Chenopodiaceae)	Aerial part	The effect of the infusion of <i>S. fruticosa</i> on lipid and carbohydrate metabolism was studied in 25 sand rats after they were submitted to a treatment of high cholesterol diet for 90 days. This treatment produced hypoglycemic effect (41 %) and anti-hyperglycemic effect (53 %). Moreover the extract provoked a decrease in plasma insulin level (31 %). The authors concluded that this medicinal plant contains at least 2 compounds responsible for antihyperglycemic and hypolipidemic activities. ²⁹ In a recent study, intravenous administration of water extract obtained from the aerial part of <i>S. fruticosa</i> (192 mg/kg) induced blood glucose lowering in normal and streptozotocin-induced diabetic rats at 4 hours after the treatment. However, it did not produce any change in plasma insulin level, which suggests that this plant act by extrapancreatic way. ³⁰
<i>Zygophyllum gaetulum</i> (Zygophyllaceae)	Leaves	Oral and intraperitoneal administration of the infusion of <i>Z. gaetulum</i> (0.7 g/kg) produced blood glucose lowering in normal and hyperglycemic rats. The authors suggested that this plant may act by increasing the peripheral metabolism of glucose and insulin secretion. ²³ Moreover, in human (13 patients) with non-insulin dependent diabetes mellitus, a single oral dose (440 mg/kg) of <i>Z. gaetulum</i> water extract produced a significant decrease in blood glucose level. The maximal effect was noted at 6 hours after water extract administration. When administered twice daily, the extract produced a decrease in glycaemia at the first week. The normoglycemia was maintained during the second week of the treatment. ³¹

Table 3 : Presentation of hypoglycemic plants used in traditional medicine in Morocco as antidiabetics, reported to be toxic.

Family	Scientific name	Toxicity
Apiaceae	<i>Ferula communis</i> L.	In animals, this plant can produce anorexia, diarrhea, hypothermia. ⁴ In human it produces diarrhea and weakness. Death can occur after 8 days. ³²
Apocinaceae	<i>Nerium oleander</i> L.	This plant can produce vomiting, shivering, gastro-enteritis, respiratory disorder and death by asphyxia. ⁴ In human it produced weakness, vomiting, shivering, bradycardia, convulsion, hyperthermia and death by heart failure. ^{11,33}
Chenopodiaceae	<i>Chenopodium ambrosioides</i> L.	The toxicity of this plant is explained by the presence of escaridol. The essential oil of this plant can produce nervous system disorder (vertigo, paralysis). It can also produce vomiting, nausea, hypotension, intestinal and meningeal haemorrhages. Chronic intoxication produces cough, pulmonary emphysema and liver, kidney, spleen injuries. ³⁴ The toxicity of this plant is due to the presence of alkaloids. It can produce nervous disorders, general weakness and death. ⁴ The latex of this plant can produce some signs of intoxication such as : gastro-intestinal disorders due to mucous-membrane inflammation . ⁴
	<i>Haloxylon scoparium</i> Pomel	
	<i>Launea arborescens</i> (Batt.) Maire	
Compositae	<i>Artemisia herba-alba</i> Asso	The toxicity particularly reported in babies is due to the presence of β -thuyone. This substance can produce convulsion, constriction of the jaws and appearance of froth in the mouth. ^{4,15}
Cucurbitaceae	<i>Citrullus colocynthis</i> (L.) Schrad.	At high doses, this plant is highly toxic for animals and humans. The signs of intoxication are : gastro-intestinal pain with diarrhea, vomiting, urine retention, weakness, hypothermia, cardiac disorder, cerebral congestion producing a fatal collapse. ¹¹
Globulariaceae	<i>Globularia alypum</i> L.	At high doses, this plant can produce oligouria, diarrhea, colic, hypothermia, shivering and decrease of pulse. ¹¹
Leguminoseae	<i>Lupinus albus</i> L.	Some variety of this plant can be toxic because of the presence of alkaloids such as : lupinidine. ⁴
Ranunculaceae	<i>Aloe socotrina</i> Lamk., A. perry Baker	At high doses, this plant can be abortive. In pregnant women, it induces stimulation of oxytocin. The sap of this plant can produce skin eczema or rash. ³³
	<i>Androcymbium gramineum</i> (cav.) Mc	The toxicity is due to the presence of colchicine. (The signs of toxicity are : hair loss, gastro-intestinal disorder, lack of coordination of movements. It can produce kidney haemorrhagia, spleen congestion and pulmonary disorder). ³⁵

	Bride <i>A. intermedium</i> Gatt. & Maire	
<i>Liliaceae</i>	<i>Nigella sativa</i> L.	Few cases of toxicity have been reported, with the following signs: dryness of mouth, oral and pharynx irritation, tongue and rhinopharyngeal inflammation. This plant contains two alkaloids, 1,4 % of toxic glucosaponine and melanthnine. ⁴
Rosaceae	<i>Crataegus oxyacantha</i> L.	Toxic. ⁸
Rutaceae	<i>Ruta montana</i> L.	This plant is abortive. It can produce gastro-enteritis, vertigo, hypothermia and finally coma. The toxicity of this plant is due to the presence of methylnonylcetone. ³⁶ The presence of furocoumarines can induce skin eruption. ¹¹
Thymelaeaceae	<i>Daphne gnidium</i> L.	This plant can be abortive. It produces also, headache, shivering, paleness, pupil dilatation, mouth and lips swelling, difficulty of deglutition, diarrhea and digestive spasms, convulsion, pulmonary disorders ; death. ^{11,37,4}
Zygophyllaceae	<i>Peganum harmala</i> L.	This plant can be toxic at high doses, particularly in children. The signs of toxicity are : vomiting, vertigo, hyperthermia, headache, deep sleep, cardiac disorder, convulsion, paralysis, anuria, hyperuremia, paralysis of the nervous system center and death by respiratory arrest. ⁴

colocynthis (see table 3). The plants described as toxic represent about 18% of the medicinal plants cited in this study. The signs of toxicity are variable. In general, the poisonous plants are known by shepherds. In the same way, animals escape the poisonous plants because in general they have a bitter taste. Very few toxicological studies have been carried out on antidiabetic plants.³⁸ It is important to note that the traditional utilization, of medicinal plants, many toxic plants are used at a low dose and/or treated before being used in order to eliminate the poisonous components of the plant (by cooking, decoction, etc.). It is notable that several toxic plants are used in traditional medicine through fumigation or by external use (cutaneous in most cases).^{4,6}

Consequently, it is necessary to carry out toxicological investigation of all plants empirically used in order to avoid the risk of the side effects related to phytotherapy.

There is a meaningful evolution of the experiments on the medicinal plants in Morocco. However, mechanism of action and toxicity of the potentially antidiabetic plants have not been studied. Finally, this review may be useful to for researchers interested in antidiabetic, plants from Morocco.

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