Moroccan medicinal plants with potential antidiabetic activity

Hajar El Ouadni, Aziz Drioiche, Soukaina Saidi, Firdaous Remok, Hanane Touijer, Boutaina Louafi, Amanallah Gourich, Ayoub Asbabou, Fadoua El Makhoukhi, Yahya Cherrah, Latifa Bouissane,Touriya Zair, Katim Alaoui

Correspondence

Hajar El Ouadni[1,2], Aziz Drioiche[2,3], Soukaina Saidi[2,4], Firdaous Remok[2], Hanane Touijer[5], Boutaina Louafi[6], Amanallah Gourich[2], Ayoub Asbabou[2], Fadoua El Makhoukhi[1], Yahya Cherrah[1], Latifa Bouissane[4], Touriya Zair*[2], Katim Alaoui[1]

[1]Research team on the Toxicity and Pharmacodynamics of Aromatic and Medicinal Plants (ERTP.PAM), Pharmacology and Toxicology Laboratory, Rabat Faculty of Medicine and Pharmacy (FMPR), Mohammed V University (UMV), Morocco.
[2]Research Team of Chemistry of Bioactive Molecules and the Environment, Laboratory of Innovative Materials and Biotechnology of Natural Resources, Faculty of Sciences, Moulay Ismaïl University, B.P. 11201 Zitoune, Meknes 50070, Morocco.
[3]Higher Institute of Nursing Professions and Health Techniques of Fez, Regional Health Fez-Meknes, EL Ghassani Hospital, Fez 30050, Morocco.
[4]Molecular Chemistry, Materials and Catalysis Laboratory, Faculty of Sciences and Technologies, Sultan Moulay Slimane University, BP 523, 23000 Beni-Mellal Morocco.
[5]Laboratory of Biotechnology, Environment and Geo-resources, Superior School of technology, University of sultan Moulay Slimane, P.O. Box 170, Khenifra 54000, Morocco.
[6]Laboratory of Functional Ecology and Environmental Engineering, Faculty of Sciences and Technology, Sidi Mohamed Ben Abdellah University, Fez, 30000, Morocco.

*Corresponding Author: t.zair@umi.ac.ma

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Research

Abstract

Background: Type II diabetes is a major public health concern worldwide, especially in resource-limited countries like Morocco. In these areas, it is common for patients to use aromatic and medicinal plants either as alternative treatments or to complement standard medical therapies. This research aims to catalog the medicinal flora traditionally employed in Morocco for diabetes management, compiling relevant therapeutic data to support future research in phytochemistry and pharmacology.

Methods: The goal is to discover and file medicinal flora historically used in the management of diabetes within the Moroccan population using different scientific sources inlcusive of Elsevier, Medline, and Pubmed in ethnobotanical and bibliographic research during 2020.

Results: The analysis identified a total of 212 different plant species from 62 plant families, with the highest representation being Asteraceae (15.09%), Lamiaceae (11.32%), Fabaceae (6.6%), Apiaceae (6.13%), and Poaceae (4.72%). Among the various plant parts utilized, leaves were the most commonly used (30.45%), followed by seeds (16.26%). The primary methods of preparation included decoction (53.96%) and infusion (25.18%). In addition to smaller quantities of alkaloids, tannins, coumarins, fatty acids, and saponins, the phytochemical examination revealed many bioactive secondary metabolites that might help control diabetes, especially terpenoids (25. 80%), flavonoids (25. 60%), and phenolic acids (12. 20%).

Conclusion: The floristic diversity of Morocco, shaped by its unique physiographic and bioclimatic conditions, underpins a rich repository of medicinal herbs with potential antidiabetic effects. This study establishes a crucial database for further scientific exploration of plant-based antidiabetic compounds in phytochemistry, biology, and pharmacology.

Keywords: Phytotherapy, Secondary Metabolites, Ethnopharmacology, Diabetes Management, Natural Remedies.

Background

Diabetes is a chronic disease with a multifactorial origin, whose prevalence continues to rise worldwide (Fouad & Lahcen 2020). It currently affects approximately 588.7 million people with diabetes in 2024, and projections estimate 852.5 million by 2050 (IDF DIABETES ATLAS 2025). In 2024, the number of deaths attributed to diabetes is projected to be 3.4 million. By 2050, due to projections from IDF diabetes atlas 2025, diabetes will likely increase in low and middle income-countries, such as those in Africa, because of urbanization and population aging. According to the International Diabetes Federation (Thomas *et al.* 2019), 463 million individuals worldwide had diabetes in 2019; by 2030 and 2045, that number is expected to reach 578 million and 700 million, respectively. According to projections, the number of reported cases of diabetes reported to the IDF in Morocco in 2017, which was over 1. 6 million, would reach 2. 7 million by 2045 (Saeedi *et al.* 2019). Due to its rapid global spread and impact, the WHO has identified diabetes as one of the major health emergencies of the 21st century (Hossain *et al.* 2024). Diabetes comprises a heterogeneous group of metabolic disorders primarily characterized by hyperglycemia, defined as a fasting blood glucose level exceeding 1.26 g/L. This metabolic abnormality is due to a lack of secretion by the pancreas of insulin, the hormone responsible for degrading glucose from the diet, or the inability of the body to effectively use the insulin it produces (Assaly 2020). It is ultimately associated with specific organic complications (metabolic, degenerative, infectious, acidocetosis, cardiovascular, and renal diseases) particularly affecting the eyes, kidneys, nerves, heart, vessels, high blood pressure and disruption of heart activity (Gnagne *et al.* 2017; Apema *et al.* 2012).

Based on etiology and pathophysiological mechanisms, diabetes mellitus is classified into several types, among which type II diabetes, typically manifests in individuals in their fifties and accounts for approximately 85 to 90% of all diabetes cases. It is characterized by an alteration of insulin secretion and abnormalities in the action of insulin on its target tissues (insulin sensitivity) (Fouad & Lahcen 2020; Eddouks *et al.* 2007; Chahrazed 2017).

Recognizing that research is moving to new therapeutic alternatives today, that lead to few side effects and bacterial resistances, which are less dangerous than the antidiabetic agents derived from prescribed medications (Barkaoui *et al.* 2017). Products naturally derived from medicinal plants, such as essential oils, flavonoids, terpenes, and alkaloids, are considered potential therapeutic alternatives (Apema *et al.* 2012) various herbs are used for their hypoglycemic proprieties by the antidiabetic population globally. For instance, metformin, a commonly prescribed medication for type II diabetes, is derived from guanidine, a natural compound originally extracted from the medicinal plant *Galega officinalis* L. (Ouchfoun 2011).
In Morocco, as in all other Maghreb countries and developing countries, the use of traditional pharmacopoeial plants is of particular interest to scientists seeking to validate their therapeutic potential for the development of alternative diabetes medications. Numerous studies have described the antidiabetic capability of Herbs as natural remedies for managing this widespread disease (Benkhnigue *et al.* 2014; Ghourri *et al*. 2013; Lahsissene *et al.* 2009; El Hilaly *et al.* 2003). It is estimated that over 80% of prescribed antidiabetic medications are either derived directly from medicinal plants or developed through semi-synthetic processes based on plant compounds (Barkaoui *et al.* 2017).

In order to examine the significance of medicinal flora employed for diabetes treatment across various regions of Morocco, this study aims to contribute to the identification of a catalog of aromatic and medicinal herbs with antidiabetic potential, compiling reports of surveys and documents published in Morocco about antidiabetic plants. It also seeks to preserve the acquired knowledge of the Moroccan population, to aid scientific investigations in phytochemistry and pharmacology (Idm'hand *et al.* 2020).

Materials and Methods

Overview of Research Design

The study employed a thorough literature review conducted for the period January 2019 - November 2020, focusing on identifying aromatic and medicinal plants with antidiabetic properties used by the Moroccan population in 2019. A comprehensive bibliographic database was assembled by consulting diverse sources, including reports and scholarly articles, accessed via established scientific databases such as ScienceDirect and PubMed throughout 2020. Searches were performed in both French and English, employing specific keywords to ensure comprehensive coverage: "ethnobotanical survey,"

"ethnopharmacological survey," "medicinal herbs," "antidiabetic medicinal plants in Morocco," "hypoglycemic herbs in Morocco," and "Diabetes in Morocco and phytotherapy".

Geographical and Environmental Context

Morocco is situated in the northwest corner of Africa and is bordered by the North Atlantic Ocean and the Mediterranean Sea. It shares its southern boundary with Mauritania and its eastern boundary with Algeria. The country features an extensive coastline of about 3,500 km and diverse landscapes, including the snow-capped High Atlas Mountains, the Rif range, expansive forests, arid highlands, and the oases and dunes of the Sahara. This geographical and climatic diversity contributes to Morocco's rich faunal and floral biodiversity, with 12 administrative regions each showcasing unique socio-cultural characteristics (El-Hilaly *et al.* 2003). The ethnobotanical surveys conducted for this study encompassed the entire kingdom, reflecting its diverse cultural heritage.

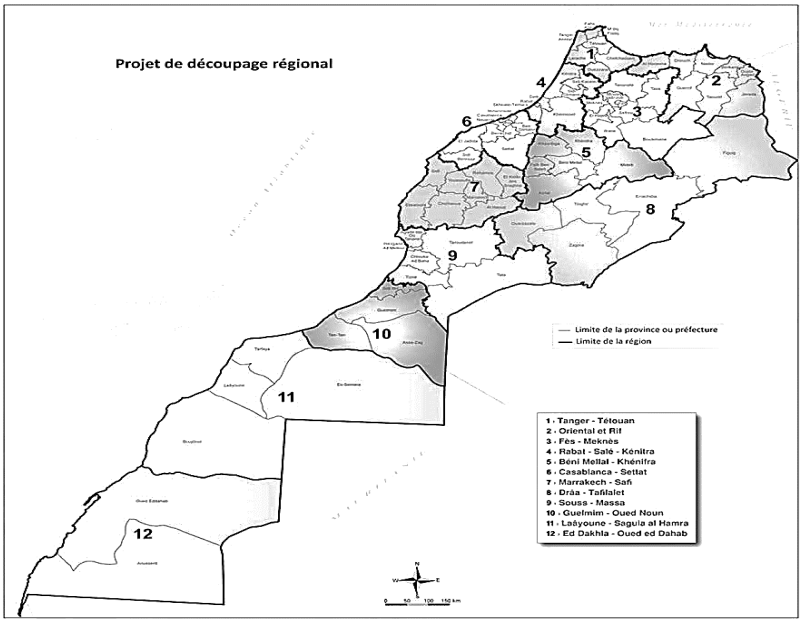

Figure 1. administrative framework of Morocco

Ethnobotanical Research Methodology

The ethnobotanical investigation drew from the extensive bibliographic research results, focusing on species that have been understudied (Lahsissene *et al.* 2009). This enabled the identification and experimental validation of plants traditionally utilized for diabetes treatment. A comprehensive database was created, consolidating findings from various studies, articles, and scientific research pertaining to the primary plants known for their antidiabetic activity.

Pharmacological Evaluation Approach

The pharmacological assessment aimed to facilitate the discovery of active compounds in the selected plants, thus enhancing the potential for identifying new natural drugs. The analysis utilized SPSS software for statistical processing, enabling the categorization of plants with antidiabetic potential according to their mechanisms of action and methods of application.

Data Analysis Techniques

Data analysis was performed using SPSS software, with results expressed in frequency distributions to illustrate significant findings.

Results and Discussion

Moroccan traditional medicine has long relied on a variety of plants for their therapeutic properties. The following table 1 summarizes key medicinal plants commonly used in Morocco, highlighting their scientific names, traditional medicinal applications, and the active compounds responsible for their pharmacological effects.

Table 1. Moroccan Medicinal plants used as antidiabetic

Family	Scientific Name	Common Name		Part Used	Operation	Mechanism of Action	Bioactive Components	References
		English	Arabic					
Amaranthaceae	*Haloxylon scoparium* Pomel	Haloxylon	Assay, Remth	Seed	Decoction		Carvacrol; isorhamnetin-xylose-galactose, quercetin-xylose-rhamnose - galactose, quercetin-glucose-rhamnose, rutin	(Kharchoufa et al. 2018) (Bourogaa et al. 2011)
	Fredolia aretioides (Moq. & Coss. ex Bunge) Ulbr.		Sherjra li ma idihach errih	Aerial parts	Powder or decoction	Stimulates insulin release and blocks glucose formation in the blood	Saponosides, tannins, alkaloids	(Bellakhdar et al. 1991) (Bentabet et al. 2014)
Anacardiaceae	*Pistacia atlantica* Desf.	Mt. Atlas mastic tree	Btem, Igg, Drou	Fruit	Decoction		Tannins, α-tocopherol, fat Acid, Sterol	(El Haouari et al. 2018) (Pourya et al. 2018)
	Pistacia lentiscus L.	Mastic tree, Lentisc	Adru	leaves	Decoction and infusion	Insulin stimulation aids in glucose absorption, pancreatic islet regeneration, and the prevention of dementia related to vascular and neurodegenerative conditions.	Tannins, Gallic acid, 3-O-glucoside delphinidin, Galloyl derivatives of glucose, quinic acid, myricetin, quercetin glycosides, anthocyanin, and 3-O-glucoside cyanidin.	(Bozorgi et al. 2013) (Romani et al. 2002)
Apiaceae	*Ammi visnaga* (L.) Lam.	Toothpick plant	Bachnikha	seed / fruit	Decoction of fruits	Stimulation of beta-pancreatic cells triggers the secretion of insulin.	Alpha-pyrones, khellin, visnagin, khellinol, ammiol, khellol, khellinin, fixed oils, coumarins; pyranocoumarin visnadin.	(Bellakhdar et al. 1991) (Ziyyat et al. 1997) (Bellakhdar et al. 1997) (Al-Snafi 2013)
	Ptychotis verticillata Duby		Nunkha	Aerial parts	Infusion	Promotes the hypoglycemic effect	Thymol, D-limonene, gamma-terpinene and m-cymene, carvacrol	(Ziyyat et al. 1997) (El Ouariachi et al. 2011

Ammodaucus leucotrichus var. leucotrichus		kammûnes-sofi	Seed	Powder		Monoterpenes, sesquiterpenes, tannins, anthracene compounds, sterols, triterpenes, reducing compounds, alkaloids, phenolic acid, saponin, flavonoids and coumarins	(Idm'hand et al. 2020)
Carum carvi L.	Caraway	Karwia	seed	decoction of seeds		Essential oils, resin, carvone, oleoresins	(Eddouks et al. 2002) (Malhotra et al. 2012)
Cuminum cyminum L.	Cumin		Seeds	Powder	Inhibits the alpha glucosidase, decreases glucose transport through the intestinal epithelium, Suppression of glucose levels , significant reduction in plasma cholesterol, triglycerides and increased liver activity and glucokinase, probably by increasing insulin release from pancreatic islets	α-terpinene, γ-terpinene, phenols, flavonoids, anthocyan, alkaloids, beta-carotene and lycopene	(Ghasemi et al. 2019) (Bettaieb et al. 2010)

	Coriandrum sativum L.	Coriander	Kasbour	seeds / aerial part	Decoction of seeds	Stimulation of insulin secretion	The identified compounds include flavonoids and their derivatives such as pinocembrin, apigenin, pseudobaptigenin, galangin-5-methyl ether, quercetin, baicalein-trimethyl ether, apigenin-C-glucoside, kaempferol dimethyl ether, pinobanksin-5-methyl ether-3-O-acetate, quercetin dimethyl ether-3-O-rutinoside pinobanksin-3-O-pentenoate, isorhamnetin-3-O-rutinoside, luteolin, pinobanksin-3-O-pentanoate, apigenin-7-O-glucuronide, quercetin-3-O-glucoside, apigenin-3-O-rutinoside, rutin, pinobanksin-3-O-phenylpropionate, pectolinarigenin, , daidzein and kaempferol-3,7-dimethyl ether-3-O-glucoside.	(Jaouhari et al. 2002) (Hussain et al. 2020)
	Daucus carota L.	Wild carrot	Khizzou	Roots	Decoction, infusion, uncooked.	Stimulating effects on insulin secretion	p -coumaric acid, ferulic acis, hydroxybenzoïc acid, glycoside of quercetin, caffeic acid, chlorogenic acid, 4- O -cafeoylquinic acid, hydroxycinnamic acid	(Kahouaji 1995) (Kammerer et al. 2004)
	Ferula assa-foetida L.	asafoetida	Hentit	Resin	decoction of resin	Activation of pancreatic beta cells resulting in increased insulin release.	β-pinene, (Z) -1-propenyl sec-butyl disulfide α-pinene, Coumarins, (E) -1-propenyl sec-butyl disulfide.	(Hassanabadi et al. 2019) (Merzouki et al. 2000)
	Foeniculum vulgare Mill.	Fennel	Nafaâ	Seeds	Decoction of fruits, leaves and roots	Promotes the hypoglycemic effect	(E) -anethol, fatty acids, hydrocarbons, bergapten, sterols, furocoumarins, kaempferol, psoralen, , xanthotoxin and isopimpinellin, isorhamnetin 3 - O - α - rhamnoside, quercetin, , and imperatorin	(Jouad et al. 2001) (Nassar et al. 2010) (Koşar et al. 2007) (Eddouks et al. 2002)
	Pastinaca sativa L.	Wild parsnip	Leftlmahfour	Roots	Uncooked	Stimulation of pancreatic beta cells leading to the subsequent secretion of insulin.	Coumarins	(Barkaoui et al. 2017) (Berenbaum et Zangerl 1986)

	Petroselinum crispum (Mill.) Fuss	Parsley	Maâdnous s	Seed, leaves	Decoction		Pabulenol, oxypeucedanin, N- (2 -phenylethyl) hexanamid, oxypeucedanin hydrate,	(Mahmood et al. 2014) (Sbai et al. 2016)
	Pimpinella anisum L.	Aniseed	Habbathla wa	Seed	Decoction		Palmitic acids, etroselinic, naringin, gallic acid, rosmarinic acid, ellargic acid	(Jouad et al. 2001) (Bettaieb Rebey et al. 2019)
	Ridolfia segetum Moris	false fennel, false caraway	Asluj, aslus, Tebch	Seed	Powder		α-phellandren, terpinolen, ß-phellandren dillapiol, myristicin	(Cabral et al. 2015) (Marongiu et al. 2007)
Apocynaceae	*Apteranthes europaea* (Guss.) Murb.	wolf's chumberill o or mount penquilla	Deghmou s	Aerial part	Decoction, infusion and uncooked	starts insulin secretion	Luteolin 4′-neohesperidoside, luteolin-3′-O- (6′-O-sinapoylglucoside) -4′-O-neohesperidoside and luteolin-3′-O- (6′-O- feruloylglucoside) -4'-O-neohesperidoside ; α -terpinen; linalol; terpinolen	(Barkaoui et al. 2017) (Youssef et al. 2016) (Amrati et al. 2020)
	Nerium oleander L.	Oleander	Defla	leaves	Decoction of leaf		2-methoxy-5-methyl phenol and isomers, 2, 6-dimethoxyphenyl ester, trans-Isogenol,5-ter-butylpyrogallol, 2-hydroxy-4-isopropyl-7 methoxytropone,l-(+)-ascorbic-acid-2,6-dihexadecanoate,trans-Isogenol,2,3,5-trimetho oxyamphetamine, 2-hydroxy-4-isopropyl-7-methoxytropone, Oleic acid, 2-(9,12- octadecadienyloxy)-, (Z,Z)- ethanol, 9-hexadecenoic acid, 9-octadecenamide, α-amyrin, betulin, betulinic scid,, stigmasterol	(Ziyyat et al. 1997) (Jaouhari 2002) (Eddouks et al. 2002) (Hase et al. 2017) (Merzouki et al. 2003)
	Periploca angustifolia Labill.	cornical	Wolf bane	Fruit	Decoction		2-hydroxy-4-methoxybenzaldehyde, tannins, carotenoids, anthocyanes, flavonoids	(Fairouz et al. 2013)
Arecaceae	*Phoenix dactylifera* L.	Date palm	Tmar	seeds	Powder, decoction	The treatment led to a decrease in blood glucose levels, a notable reduction in plasma cholesterol and triglycerides, an increase in hepatic glucokinase activity,	Gallic acid, anthocyanes, phenolic compounds, sterols, carotenoids, procyanidines, flavonoids, glucides, dietary fibres, vitamines, essential minerals.	(Baliga et al. 2011)

						and a probable enhancement of insulin secretion		
	Chamaerops Humilis L.	Mediterranean or european fan palm	Nkhal	seed	Powder, decoction	Hypoglycemic and hypolipidemic effects	Quercetin, isorhamnetin, luteolin, tricin, chrysoeriol, flavonic aglycons	(Left et al. 2013) (Gaamoussi et al. 2010)
Aristolchiaceae	*Aristolochia longa* L.	birthwort, pipevine or Dutchman's pipe	Bereztem	Rhizoma	Powder and decoction		β-caryophyllen, caryophyllen oxyd, linalol and aristolochic acid, Lycopene, Diisoctylftalate, s-Indacen-1- (2H)-one, 3, 5, 6,7-tetrahydro3, 3, 5,5- tetramethyl-8- (3- methylbutyl)-, Stearic acid	(El-Hilaly et al. 2003) (Cherif et al. 2009)
Asteraceae	*Chamaemelum nobile* L.	Chamomile	Babounj	Flower	Infusion		Chamaemeloside, 3-hydroxy-3-methylglutaric acid, angelate isobutyle, 2-methylbutyl angelate	(FALLAHI et al. 2018) (Antonelli & Fabbri 1998)
	Cladanthus arabicus (L.) Cass.	Cladanthus	Taafs	Flower	Infusion		Sabinen, β-pinene, myrcene	(Aghraz et al. 2017)
	Artemisia abrotanum L.	southern wormwood	Chih	aerial part, flower head	Decoction	Increases plasma insulin levels, hypoglycemic effect, Increases peripheral use of glucose or inhibits the reabsorption of glucose	Sitosterol, stigmasterol, 24-ethylcholesta-6,22-dien-3-ol, artabrosterol-B, artabrosterol-A, artemisinine	(Derwich et al. 2009) (Serkerov et Ibragimova 2014) (Nigam et al. 2019) Jaouhari 2002)
	Artemisia absinthium L.	Absinthe or wormwood	Chiba	Aerial parts	Decoction /infusion		Thujone, glucides, saponin, phenolic compounds sterol, proteins, amino acid, tannins, and flavonoids,	(El Haouari et al. 2018) (Eddouks et al. 2002) (Ziyyat et al. 1997) (Hassan et al. 2018)
	Artemisia herba-alba Asso	The white warmwood	Izri/Chih dwidi	leaves / stems	Decoction /infusion/ powder	Increases plasma insulin levels, hypoglycemic effect, Increases	Verbenone, camphor, α- and β-thujone, 1,8-cineole and chrysanthenyl	(Aljaiyash et al. 2018)

					peripheral use of glucose or inhibits the reabsorption of glucose		(Bellakhdar et al. 1997) (Ziyyat et al. 1997) (Bellakhdar et al. 1991) (Eddouks et al. 2002) (Jaouhari, 2002) (Merzouki et al. 2003)
Artemisia mesatlantica Maire.		Ifsi	Aerial parts	Decoction	Increases plasma insulin levels, hypoglycemic effect, Increases peripheral use of glucose or inhibits the reabsorption of glucose	β-thuyone, 1,8-cineole and camphor, anthocyanine, saponine, lactones, tannins, flavones, guaianolides γ-lactone	(Jouad et al. 2001) (El Meskaoui et al. 2008) (Ghazi et al. 2015)
Carthamus tinctorium L.	Safflower	Kartam	Seed	Powder, decoction		Flavonols, flavanone, polyacetylenesserotonin derivatives steroides, lignanes, lignanes glucosides and trachelosides, kinobeon, alcanes diols, triterpenes alcools and faty acids, carthamine, safflomine A and safflor B, carthamoside, precarthamine	(Jouad et al. 2001) (Rammal et al. 2009)
Cichorium intybus L.	Chicory	Chicouria, hindaba, timerzouga, seriss, mersag, Bouaggad	The entire plant	Decoction, infusion	Stimulation of pancreatic beta cells leading to the subsequent release of insulin.	Anthocyanes, Tannins , saponin, flavonoid, proteines, glucides, minerals , inuline, quercetine , coumarin , cinnamic acid.	(Hasan et al. 2018) (Nejad et al. 2018) (El-Hilaly et al. 2003) (Street et al. 2018)
Cynara cardunculus L.	Cardoon or artichoke thistle	Kharchouf	Roots ,	Decoction, in kind		Flavonoides, phenolic acid, hydroxycinnamic acids derivatives, lignanes, Taraxasterol, Lupeol, (-) - arctigenine, (-) - arctigenine 4'-glucoside, hentriacontane and eicosyldocosanoate	(Jouad et al. 2001) (Khabbach et al. 2012) (Koubaa et al. 1999)
Echinops spinosus L.	Echinops	Taskra	Flower	Decoction		Sesquiterpenoides, Tannins, reducing sugar , Flavonoides, Alcaloides	(Bellakhdar et al. 1991)

							(Merzouki et al. 2000) (Merzouki et al. 2003) (Bellakhdar et al. 1997) (Abderrahim et al. 2013) (Lemriss et al. 2003)
Launaea arborescens (Batt.) Murb		Iferskel/ Oumlbina	Stem leaf and flower	Decoction, infusion	Stimulating effects on insulin secretion	Triterpenoides oleanane, Triterpenoides ursanes, Sesquiterpenoides germacrane, Guaiane, Sesquiterpenoides of Eudesmane, luteoline, lutéoline-7-O-glucoside, lutéoline-7-O-rhamnoside, aesculetine, glycoside cichoriine, ethylcaffeoate and ferulic acid	(El Mansouri et al. 2011) (BITAM-F 2011)
Matricaria chamomilla L.	Wild Chamomile or German chamomile	Mansania	Leaves and flower	Decoction and infusion	Stimulation of pancreatic beta cells resulting in the subsequent secretion of insulin	The compounds identified include herniarine, ombelliferone, luteolin, chlorogenic acid, apigenin-7-O-glucoside caffeic acid, apigenin, quercetin, rutin, naringenin, luteolin-7-O-glucoside.	(Mouhajir et al. 2011) (Singh et al. 2011)
Scorzonera undulata Vahl		Tamtla	Flower	uncooked	Stimulates insulin release and blocks glucose formation in the blood	Methyl hexadecanoate, methyl linolenate, heneicosane, β-amyrine acetate, methyl oleanate, methyl ursolate, stigmasterol, β-sitosterol, galangustin, coumarin-O-βglycoside and acetoside.	(Barkaoui et al. 2017) (Harkati et al. 2010)
Tanacetum vulgare L.	Golden buttons, tansy		leaf	Infusion	Increase in insulin release from pancreatic islets	Alcohol of artemisia, γ-campholenol, davanone, lyratol, lyratyle acetate and 4-thujen-2α-yle acetate, apigenine, acacetine, luteoline, cinaroside, eupatiline, jaceidin and jaceoside	(Bichra et al. 2013) (Kurkina et al. 2011)
Warionia saharae Benth. & Coss.	Warionia	Afssas, Afezdad	leaf	Infusion		Hexadecanoic acid, ethenyloxy-1-ocatdecane, tridecene, eicosene-9, octadecanoic acid, (E) -2 -decenol, eicoene-3, eicosane, eudesmol, linalol and nerolidol.	(El Mansouri et al. 2011) (Mouhajir 2002) (Ramaut et al. 1995)

Achillea odorata L.	Yarrow	Korte	leaf	Decoction		Camphor, 1,8-cineole, α-pinene, thymol, iso-thymol et flavonoides	(Kahouaji 1995) (Bekhechi et al. 2011)
Antennaria dioïca (L.) Gaertn.	Mountain everlasting	Ouden lfar	leaf	Decoction		Luteoline, luteoline 7-glucoside, luteoline 4'-glucoside, apigenine, apigenine 7-glucoside, apigenine 4'-glucoside, luteoline 7,4'-diglucoside, ursolic acid and chlorogenic acid	(Jaouhari 2002) (Meriçli 1983)
Artemisia negeri A. Ouyahya		Chih Chih al-atlass	Aerial part and stem	Decoction			(Jouad et al. 2001)
Artemisia arborescens L.	Tree wormwood	Chih Chih al-atlass	Aerial part and stem	Decoction	Stimulates hypoglycemic effect	Camphor, chamazulene, β-thuyone and germacrene D, β-thuyone, chamazulene, Kaempferol of myricetin, hydroxycinnamic acids	(Costa et al. 2016)
Artemisia flahaultii Emb. & Maire	Mugwort	Chih Chih al-atlass	Aerial part and stem	Decoction			(Ouyahya & Viano 1984)
Artemisia ifranensis J. Didier	Wormwood	Chih Chih al-atlass	Aerial part and stem	Decoction		β-Thujone	(Elazzouzi et al. 2018)
Cynara scolymus L.	The globe artichoke	Kharchouf	Roots and flower head	Decoction	Stimulates insulin secretion blocks glucose formation in the blood	apigenine 7- O- glucuronide, acide hydroxycinnamique, cynarine, luteoline 7- O - glucuronide 3- O- glucoside, saponines, proteines, glucides, lipids and vitamin C	(Jouad et al. 2001) (Merzouki et al. 2003) (Jaouhari 2002) (Tsevegsuren et al. 2014)
Helianthus annuus L.	Common sunflower	Nouarat chams	Root	Powder		The identified compounds include 4,5-dihydroniveusine A, niveusine B, argophylline A and B, grandifloric acid, ciliaric acid, and 17-hydroxyent-isokaur-15(16)-en-19-oic acid.	(Melek et al. 1985) (Bellakhdar 1997)

Inula viscosa (L.) Aiton	False yellowhead	Terrehla	Flower and leaves	Decoction	Reduction of blood glucose levels, marked decreases in plasma cholesterol and triglycerides, upregulation of hepatic glucokinase activity, and a probable stimulation of insulin secretion by pancreatic islets.	Apigenine, Genkwanin Hispidulin, Rhamnocitrin, 3-O-Methylkaempferol, Quercetine, Naringenin, Sakuranetin, 7-0-Methylaromadendrin, 3-0-A cetylaromadendrin, 3-0 -A cetyl-7-0-methylaromadendrin, 3-0-Acetyltaxifolin, Padmatine, 3-0 -A cétylpadmatine, férulaldéhyde, 2-methyiphioroacetophenone, sesquiterpene lactone.	(Jaouhari 2002) (El-Hilaly et al. 2003) (Grande et al. 2007) (Zeouk et al. 2020)
Inula conyza DC.	Ploughman's spikenard	Terrehla	Flower and leaves	Decoction		Eudesmanolides, Guaianolides, Pseudoguaianolides, Germacranolides, Xanthanolides, Sesquiterpenes dimériques, Flavonoides	(Seca et al.)
Inula helenium L.	Elecampane	Terrehla	Flower and leaves	Decoction		Eudesmanolides,Guaianolides, Pseudoguaianolides,Germacranolides, Xanthanolides,dimeric sesquiterpenes, Flavonoids	(Seca et al.)
Lactuca sativa L.	Lettuce	Khouss	Aerial parts			The compounds identified include fatty acids such as, stearic acid, palmitic acid, myristic acid, cis-palmitoleic acid, behenic acid, oleic acid and lignoceric acid, as well as bioactive molecules like β-sitosterol, β-amyrin, phytols, carotenoids, polyphenol oxidase, phenolic compounds, micronutrients, and proteins.	(Eddouks et al. 2002) (Han et al. 2009) (Said et al. 1996)
Launaea arborescens (Batt.) Maire	Arborescent launaea	Sekkûm	Seeds	Infusion	Increase in insulin release from pancreatic islets	The compounds identified include taraxast-20-ene-3β,30-diol, luteolin, luteolin-7-O-rhamnoside, aesculetin, the glycoside cichoriin, ethylcaffeate, luteolin-7-O-glucoside and ferulic acid.	(Bellakhdar, 1997) (Kahouaji 1995) (Dibi et Bitam, 2012) (Bitam et al. 2008)
Santolina africana Jord. & Fourr.		Irzgi, gartûfa	Leaves	Decoction	Stimulates insulin secretion blocks glucose formation in the blood	Acenaphtane, calaren, ocimen, terpinen-4-ol, borneol, camphor, α-terpineol, coumarins and flavonoids	(Bellakhdar 1997) (Tundis & Loizzo 2018) (Béjaoui et al. 2017)

	Cladanthus scariosus (Ball) Oberpr. & Vogt		Irzgi, gartûfa	leaves	Decoction		germacren D, α-pinene, sabinene, (E) acetate -chrysanthenyle, farnesyl (E, E) acetate -, chamazulene.	(Katiri et al. 2017) (Spadaro et al. 2014)
	Pallenis spinosa (L.) Cass.	Spiny starwort	Nougd	Aerial parts	Decoction	Increase in the hypoglycemic effect	germacra-1 (10), 5-diene-3,4-diol, α-cadinol, 3-acetoxygermacra-1 (10), 5-diene-4-ol, T-cadinol, δ -cadinene, 3-OI ~ -D-galactoside, 7-O-6-o-galactoside et 3-O-0 ~ -L-rharnnosyl (1-6) -I ~ -D- patuletin galactoside, le 5-O-]] -D-glucoside and 7-OI ~ -mglucoside de tricine, le 3-O-6-D-quercetin galactoside and aglycones kaempferol 3-methyl ether, quercetine 3-rnethyl ether, patuletin and 3,5, 6,7,3'-pentarnethylic ether and ether 3,5,6,7,3 ', 4'-hexamethylic quercetagetin	(Jaouhari 2002) (Terrab et al. 2003) (Senatore & Bruno 2003)
	Taraxacum officinale F.H Wigg	Dandelion	Garnina	Leaves and roots	Decoction		taraxasterol, arnidiol, taraxasterol, faradiol, taraxacin, taraxinic acid, α-amyrin, β-amyrin, quercetin, luteolin, hesperetin, apigenin, artemetin, isoetin and genkwanin	(Jouad et al. 2001) (Hu 2018) (Lee et al. 2011)
Berberidaceae	*Berberis vulgaris* L.			Leafy stem	Decoction	Stimulates insulin secretion blocks glucose formation in the blood	Saponins, berberin, chlorogenic acid, cafeoylglucaric acids, quercetin, dihydro-roseoside	(Youbi et al. 2011) (Fernández-Poyatos et al. 2020)
Brassicaceae	*Brassica oleracea* L.	Calabrese	Kroumb	Aerial parts	in nature	Increase in insulin release from pancreatic islets	Deacylated Flavonoids, acylated flavonoides, hydroxycinnamic acids, progoitrin, gluconapin, sinapic acid	(Jouad et al. 2001) (Šamec et al. 2017) (Velasco et al. 2011)

Brassica nigra (L.) W.D.J.Koch	Black mustard	Alkhardal	Flower head	Powder	Administration of aqueous extract once daily for 1 month lowers blood sugar levels	sinapoylgentiobiose, sinapoylglucose, kaempferol-3- (sinapoyl) sophorotrioside-7-glucoside, sinapoylcholine, aconitic acids, kaempferol-3,7-diglucoside-4 ′ - (sinapoyl) glucoside, desinapoylgentiobiose, 1,2,2′-trisinose desinapoylglucose, , citric acid, ascorbic acid, malic acid, quinic acid, shikimic acid and fumaric acid, 9,12-octadécadiénoic (Z, Z) acid -, tetracaine, 5-hydroxymethylfurfural, campesterol.	(Fatiha et al. 2019) (Krishnaveni & Saranya 2016)
Brassica rapa L.	Chinese cabbage	Left beldi	Leaves and roots	Cooked		Glucosinolates, isothiocyanates, flavonoids, indols, sulfur and phenolic compounds, , glucides, terpenes, esters, aldehydes et ketones	(Walters et al. 2018)
Diplotaxis pitardiana Maire			Flower head	Powder	Insulin stimulation for glucose absorption, pancreatic islet regeneration	5- methylthiopentanenitrile, 1-isothiocyanatobutane, Quercetin-3,4′-di-O-glucoside, isorhamnetin-3,4′-di-O-glucoside, kaempferol-3,4′-di-O-glucoside.	(Benkhnigue et al. 2014) (Nasri 2016)
Eruca vesicaria Cav. ssp. *sativa* (Mill.) Thell.	Rocket or arugula	Fjel	leaves	Salades and cooked		Erucic acid ,oleic acid, and cis11-eicosenoic acid, glucosinolates, isothiocyanates, phenolic acid, carotenoides and glucides	(Jouad et al. 2001) (Marwat et al. 2020)
Lepidium sativum L.	Cress or garden cress	Hab err-chad	seed	Decoction		Cardia Glycoside, alkaloides, phenolic, flavonoides, glycosides cardiotonic, coumarins, glucosinolates, glucides, proteines and amino acids, mucilage, resins, saponins, steols, tannins, volatile oils, triterpene, sinapic acid and uric acid	(Eddouks et al. 2002) (Kahouaji 1995) (Merzouki et al. 2003) (Hmammouchi 1999) (Eddouks et al. 2005)
Raphanus sativus L.	Radish	Jirjir	Seed	Infusion	Stimulating effects on insulin secretion	β-sitosterol; stigmasterol; daucosterol, S - (+) - déhydrovomifoliol, kaempferol 3,7-di- O-α-l-rhamnopyranoside ; quercetin 3,7-di-O-α-l - rhamnopyranoside, ferulic, anthocyanins	(Jouad et al. 2001) (Ricardo et al. 2018) (Otsuki et al. 2002)

Burseraceae	*Boswellia carteri* Bridw.		Loubane	Resin	Infusion and decoction		Resin oléo-gum ; boswellic acid	(Kahouaji 1995) (Sharma et al. 2009) (Woolley et al. 2012)
Buxaceae	*Buxus balearica* Lam.	Balearic boxwood	Azazer /Ibakous	Leaves	Decoction	It inhibits alpha-glucosidase activity and reduces glucose transport across the intestinal epithelium.	Alkaloides	(Benkhnigue et al. 2014) (Ata & Andersh, 2008)
Cactaceae	*Opuntia ficus-indica* (L.) Mill.	Indian fig, Barbary fig	Hendiya	Stem, leaf	Decoction	Significant decrease in blood glucose	Polysaccharides, catechin, quercetin, kaempferol, isorhamnetin and chlorogenic acid, ferulic and p-coumaric acids. α-, β- and γ-tocopherols α-tocophérol	(Lanuzza et al. 2017) (Jaouhari 2002) (Merzouki et al. 2003) (Jouad et al. 2001)
Capparaceae	*Capparis spinosa* L.	Flnders rose	Kebbar	Fruit	Decoction	Hypoglycemic, hypolipidemic.	rutin ,resveratrol , coumarin , epicatechin , luteolin ,catechin ,kaempferol , vanillic acid and gallic acid, cis- vaccenic acid.	(Ziyyat et al. 1997) (Eddouks et al. 2002) (Jaouhari, 2002) (Kahouaji 1995) (Tlili et al. 2016) (Argentieri et al. 2012)
Caryophyllaceae	*Corrigiola littoralis* subsp. *Telephiifolia* (Pourr.) Briq.	Strapworts	Sarghina / Tawsarghine	Roots	In nature			(Ennabili et al. 2000)
	Herniaria glabra L.	Smooth rupturewort	Hrasset Lahjer	Aerial parts	Decoction		medicagene acid glycosides and zanhic acid, narcissine, rutine, apiorutine, nicotiflorine, licoagroside B, maltoglabrosides AC, benzyl β-gentiobioside, herniarine, scopoletine, pinitol, myo -inositol, mannitol, saponines, glucuronide oleanane 3,28- O -bidesmosides	(Jouad et al. 2001) (Kozachok et al. 2020)
	Herniaria hirsuta L.	Hairy rupturewort	Hrasset Lahjer	The whole plant	Decoction	Stimulates insulin secretion blocks glucose formation in the blood	Phenolic compounds, flavonoides, flavonols and saponins	(Jouad et al. 2001) (Al-Snafi 2018)

	Spergularia purpurea (Pers.) G.Don	Sea spurreys or sandspurrys	Zehret Arrimal	Leaf	Decoction	Liver action on glucose metabolsim.	Triterpenoids, saponins	(Jouad et al. 2001)
Chenopodiaceae	*Anabasis aretioides* Moq. & Coss. ex Bunge	Anabasis	Sellaâ	The entire plant	Decoction		Alkaloides, saponine	(Zarrouq 2015) (Eddouks et al. 2002)
	Chenopodium ambrosioides L.	Mexican tea	Mkhinza	Flower and leaves	Decoction, poudre, infusion et masque		Stigmasterol, β-sitosterol, octadecanoic acid, scopoletin, 1- piperoylpiperidin, sterols, terpenoides , phenols	(Ziyyat et al. 1997) (Jouad et al. 2001) (Shah & Khan 2017) (Kokanova-Nedialkova et al. 2009)
Cistaceae	*Cistus albidus* L.	Rock Rose	Tarkalla	Fruits	Decoction	Stimulates insulin secretion blocks glucose formation in the blood	α-zingiberen, curcumen, (E) -β-caryophyllen, α-cadinol, α-bisabolol, oxyde de caryophyllen, allo- aromadendren, δ-cadinen, germacren D	(Merzouki et al. 2003) (Robles & Garzino 1998) (Paolini et al. 2008)
	Cistus creticus L.	Hairy rockrose	Irgel	Leaves	Decoction	Stimulates insulin secretion blocks glucose formation in the blood	oxygenated labdane terpenes, 13- epi- manoyl oxyd, δ-cadinene, α-cadinene, α-copaene , bulnesol, viridiflorol and ledol, kaempferol , quercetine, myricetine, esculin	(Ouhaddou et al. 2014) (Karim et al. 2016) (D. C et al. 1989)
	Cistus salviifolius L.	Sage leaved rock rose	Tirgelt	Leaves	Decoction	Stimulates insulin secretion blocks glucose formation in the blood	oxygenated labdane diterpenes, camphoe, viridiflorol, longiborneol, phyllocladene, abietatriene and cis-feruginol, kaempferol, quercetin, myricetin	(Eddouks et al. 2017) (Gürbüz et al. 2015)
	Cistus ladanifer L.	Gum rockrose	Laftah	seeds	Decoction	Stimulates insulin secretion blocks glucose formation in the blood	Tannins, flavones, saponines, 2,2,6-trimethylcyclohexanone, α-pinene, β-pinene, camphène, limonene, p-cymene, Pinocarveol Pinocarvone, Myrtenol, Myrtenal, Verbenone, Borneol, Bornyl Terpinen-4-ol acetate, Norisoprenes, apigenine and kaempferol	(Kahouaji 1995) (Merzouki et al. 2003) (Frazão et al. 2018) (Fernández-Arroyo et al. 2010)
	Cistus libanotis L.		Yazir lahmir	Leaves	Decoction or infusion	Stimulates insulin secretion blocks	Luteoline, quercetine, Diterpenes type clerodane	(Kahouaji 1995) (Venditti et al. 2015)

						glucose formation in the blood		
Cucurbitaceae	*Citrullus colocynthis* (L.) Schrad.	Bitter apple	Aferziz/lhdej	Seeds, fruits	Maceration		gallic acid, benzoic acid, acid protocatechuic, p-hydroxybenzoic aicd, vanillic acid, acid ferulic, caféic, p-coumaric acid, t-cinnamic acid, catechine, quercetine and kaempferol	(Bellakhdar et al. 1991) (Bellakhdar et al. 1997) (Eddouks et al. 2002) (Jaouhari 2002) (Merzouki et al. 2000) (Merzouki et al. 2003) (Gacem et al. 2020)
	Cucurbita maxima Duchesne	Giant pumpkin	Gueraaha mra	Seeds	Poudre/ infusion		Glucides, glycosides, saponine, steroids and alkaloids	(Abouri et al. 2012) (Alamgir et al. 2016)
	Cucurbita pepo L.	Marrow, pumpkin	L'krâa Takhsait/curjt	seeds, Fruit	Powder, decoction	Stimulates insulin secretion blocks glucose formation in the blood	Tannins, cardia glycosides, terpenoids, glucides, resins, saponines, phytosterols, carotenoids, saponosids	(Jouad et al. 2001) (Mouhajiret al. 2001) (Shokrzadeh et al. 2010) (Matus et al. 1993)
	Cucumis sativus L.	Cucumber	Khiyar	Fruit, seed	Eaten like a vegetable		Cucurbitabcine A, B, C, D; Cucumerine A & B; Vitexine & Isovitexine; Orientin & Isoorientin	(Jouad et al. 2001) (Mukherjee et al. 2013)
	Momordica charantia L.	Bitter melon	Karela	Fruit	Eaten like a vegetable	Reduces the blood sugar	Alkaloide (momordicine), ascorbic acid, Charantine	(Arayne et al. 2007) (Daniel et al. 2014)
Cupressaceae	*Juniperus phoenicea* L.	The Phoenician juniper	Arâar, Azouka	Leaves and cones	Maceration	Enhances peripheral glucose uptake and stimulates insulin secretion.	Isocupressic acid, Catechine, myricetine-hexose, myricetine-rhamnoside, quercetine-3-O-rhamnoside	(Bellakhdar, 1997) (Ziyyat et al.1997) (Eddouks et al. 2002) (Dane et al. 2016)

	Tetraclinis articulata (Vahl) Mast.	Sandarac, barbary thuja	Arâar	Leaves and cones	Maceration		kedrenos, thymol, 3-tert-butyl-4-methoxyphenol, cedrenol, murolen, sclarene, Jaceidin, Jaceidin-7-O-methylether, quercetin	(Ziyyat et al. 1997) (El Moussaouiti et al. 2010) (Maatooq et al. 1998)
	Thuja occidentalis L.	Eastern or northern white cedar, arborvitae	Thuya	Aerial parts	Decoction		α-thuyone, isothujone, fenchone, sabinenes, α-pinene, diterpenes beyerene and rimuene	(Jarald et al. 2008) (Küpeli Akkol et al. 2015)
Convolvulaceae	*Cuscuta epithymum* (L.) L.	Thyme dodder, love vine	Zîtra	Leaves and fruits	Decoction	I It inhibits alpha-glucosidase and decreases glucose transport across the intestinal epithelium.	Alkaloids ; saponins ; tannins ; triterpenoids ; steroids ; glucides; aromatic compounds ; flavonoids, derivated hydroxycinnamic acid	(Jouad et al. 2001) (Chabra et al. 2019)
Cyperaceae	*Scirpus maritimus* L.	Cosmopolitan bulrush	Alawshhat albahria	Seeds	Decoction		Sulfates flavonoids, flavons C and C- / O-glycosides and aglycons, rutin, myricetin and vitexin	(Daoud et al. 2016) (Mitra et al. 2012)
Ephedraceae	*Ephedra altissima* Desf.	Ephedra	Tougel argan	stem, leaf	Decoction	Inhibits alpha-glucosidase activity and reduces glucose absorption through the intestinal epithelium.	ALkaloids, flavonoids, tannins, polysaccharides, Lignans, esters, phenolic acids, quinones	(Barkaoui et al. 2017) (Ibragic et Sofić, 2015) (Zhang et al. 2018)
	Ephedra alata Decne.		Alanda, Tamatrt	Leaf and stem	Decoction	It suppresses the activity of alpha-glucosidase and limits the uptake of glucose through the intestinal lining.	ALkaloids, flavonoids, tannins, polysaccharides, Lignans, esters, phenolic acids, quinones	(Abouri et al. 1997) (Ibragic & Sofić 2015) (Zhang et al. 2018)
Equisetaceae	*Equisetum ramosissimum* Desf.	Branched horsetail	Daylhisan	Stems	Decoction	The hypoglycemic effect	Flavonoids (kaempferol), alkaloids, phenolic proteines, triterpenoids, saponins, phytosterols	(Agelet et al. 2000) (Yusuf et al. 2020)
Ericaceae	*Arbutus unedo* L.	Strawberry tree	Sasnou	Stems	Decoction of leaves		Tannins, flavonoids, phenolic glycosides, α-tocopherol	(Ziyyat et al. 1997) (Jouad et al. 2001)

								(Malheiro et al. 2012)
Euphorbiaceae	*Croton tiglium* L.	Croton oil plant	Habbat almolk	Leaves, roots	Decoction of fruits		Alkaloids, flavonoids, tannins, phlobatannin, terpenoid, saponine, steroids and cardiac glycosides	(Merzouki et al. 2003) (Koche et al. 2010)
	Mercurialis annua L.	Annual mercury	Harrayga malsa	Leafy stem	Infusion		Rutin, narcissin, quercetin, piperidinic alkaloids, terpenes, triacylglycerols and sterols	(El Alami et al. 2016) (Chaachouay et al. 2019)
Fabaceae	*Faidherbia albida* (Delile) A.Chev.	Ana tree, apple ring acacia	Talh	Racines	Decoction	Stimulates insulin release and blocks glucose formation in the blood	Terpenes, glycosides, monosaccharides and glucides, coumarins, alkaloids and saponins	(Chaachouay et al. 2019) (Ismail et al. 2016)
	Acacia tortilis (Forssk.) Hayne	Umbrella thorn, Israeli babool	Telh/Tadoute	Roots	Decoction		5,7-dihydroxy-4'-p-méthylbenzylisoflavone ; apigenine ; luteoline ; quercetin ; apigenin glycoside; quercetin glycoside ; isorhaminetine glycoside, n-hexacosanol, betuline ; α-,β-amyrine; β-sitosterol	(Boufous et al. 2017) (Muhaisen et al. 2002)
	Ceratonia siliqua L.	Caroubier	Tikida/Lkharoub	Leaves and seeds	Decoction and powder		Glucides, dietary fibres , minerals, polyphenols , flavonoids	(El-Neketi et al.2013) (Rtibi et al. 2017) (Ennabili et al. 2000)
	Cicer arietinum L.	Locust bean, Ripening beans	Homous	Seeds	Powder		Phytosterols, flavonoids, phenolic compounds, tannins, glucides, proteines, amino acids, oils and fats	(Abouri et al. 2012) (Al-Snafi, 2016) (Arora et al. 2013)
	Glycyrrhiza glabra L.	Licorice or Liquorice	Arq souss	Fruits and roots	Decoction		Glycyrrhizin, Licoisoflavanon, Glabridin, Isoliquiritigenin, Glycyrin, Liquiritigenin, glycyrrhetimic acid.	(Saxena 2005) (Eddouks et al. 2002)
	Glycine max (L.) Merr.	Soya bean	Soja	Seeds	Decoction	Stimulate the hypoglycemic effect	Caffeic acid, 5- O- cafeoylquinic acid, p-coumaric acid and ferulic acid, quercetin-3-O-rutinosid, kaempferol-3-O-glucoside and kaempferol-3-O-rutinoside, quercetin-3-O-rutinoside	(Jouad et al. 2001) (Merzouki et al. 2000) (Silva et al. 2013)

Lupinus angustifolius L.	Narrowleaf lupine	Ibawn dekouk	Seeds	Decoction	By reversing, induces insulin resistance in pancreatic cell	β-conglutin	(Jaouhari 2002) (Grande et al. 2007)
Lupinus albus L.	The white lupin or field lupine	Foul mesri, Attarmas	Seeds	Decoction	Hypoglycemic effect	Alkaloid, herbal oil, asparagine	(Bellakhdar 1991) (Bellakhdar 1997) (Jouad et al. 2001) (Eddouks et al. 2002) (Merzouki et al. 2000) (Merzoukiet al. 2003)
Medicago sativa L.	Lucerne	Fessa	Leaves	Decoction /infusion	Stimulates insulin release and blocks glucose formation in the blood	Saponins and flavonoids	(El-Hilaly et al. 2003) (El Mansouri et al. 2011) (Rafińska et al. 2016)
Phaseolus vulgaris L.	Common bean	Faswlya	Beans	Cooked	Stimulate insulin for glucose absorption, regeneration of pancreatic islets and prevent dementia associated with vascular and neurodegenerative disorders	The identified flavonoids include quercetin-3-rutinoside, quercetin-3-glucuronide, quercetin-3-glucoside, kaempferol-3-rutinoside, luteolin-7-rutinoside, phloretin-3,5′-di-C-β-glycopyranoside, quercetin-3-acetylglycoside, kaempferol-3-glucoside, and kaempferol-3-acetylglycoside.	(Chaachouay et al. 2019) (Ramabulana et al. 2015)
Retama raetam (Forssk.) Webb	White broom	R'tm	Leaves	Decoction	It blocks alpha-glucosidase enzyme function and impairs glucose absorption in the intestinal epithelium.	Isoflavones, quinolizidine, bipiperidyl, furanoflavonoids, alkaloids	(Jaouhari 2002) (Hammouche-Mokrane et al. 2017) (Alharbi et al. 2015)
Trigonella foenum-graecum L.	Fenugreek	Halba	Seeds	Decoction or maceration	Stimulate insuline secretion, Action hepatic in the metabolism of glucose.	Trigonelline, coumarin, nicotinic acid, protein, fats, essential oils, herbal oil, glucides, alkaloids, flavonoides, steroids, saponines.	(Eddouks et al. 2002) (Ziyyat et al. 1997)

								(Merzouki et al. 2000) (Merzouki et al. 2001) (El-Hilaly et al. 2003) (Bahmani et al. 2014)
	Vicia sativa L.	Common vetch		Seeds	Powder		Essential oils, proteines, ashes, fibres, aliphatic hydrocarbons, aldehydes, ketons.	(El Mansouri et al. 2011) (Francis et al. 1994) (Qasim et al. 2016)
	Vigna unguiculata (L.) Walp.	Cowpea	Foul gnawa	Seeds	Maceration of seeds		Flavonoids, lignine, calcium oxalate, amino acid, alkaloid, tannin, proteine, cyanogenetic glycoside.	(Jaouhari 2002) (Merzouki et al. 2000) (Merzouki et al. 2003) (Kolhe et al. 2012)
Fagaceae	*Quercus coccifera* L.	Kermes oak	Elqermez	Leaves	Decoction	Prsentes an hypoglycemic effect using glucoe uptake, regeneration of pancreatic islets and preventes dementia associated with vascular and neurodegenerative disorders	Quercetin ; kermesosid; cocciferosid; (-) - 8-chlorocatchin; the 3-hydroxy-1- (4-hydroxy-3-methoxyphenyl) -propan-1-one (4) and 3-hydroxy-1- (4-hydroxy-3,5-dimethoxyphenyl) -propan-1-one; trans-resveratrol-3-O-β-glucopyranoside; the lyoniresinol-9-O-β-xylopyranoside; lyoniresinol-9-O-β-glucopyranoside	(Benkhnigue et al. 2014) (Söhretoglu et al. 2014)
Fumariaceae	*Fumaria officinalis* L.	Common fumitory	Hachichat sebiane	Roots	Decoction		Alkaloids, cynarin, chlorogenic acids, isochlorogen and ferulic acid, isovitexine, rutin, isoquercitrin and quercitrin	(Jaouhari 2002)
Gentiana ceae	*Centaurium erythraea* Rafn.	Common centaury	Gosset l-hayat	Aerial parts	Aerial parts infusion.		Alkaloids, coumarins, phenolic acids, secoiridoids, triterpenes and derivated xanthones	(Bellakhdar et al. 1991) (Bellakhdar 1997) (Jaouhari 2002)

								(Jouad et al. 2001) (Merzouki et al. 2003) (Kumarasamy et al. 2003)
	Centaurium spicatum (L.) Fritsch	Small centaury	Gosset l-hayat	Stems / flowers/	Infusion of aerial parts		Gentiopicrine, swertiamarine and sweroside, eustomine, demethyleustomine, decussatine, methylbellidifoline and mangiferine	(Bellakhdar et al. 1991) (Bellakhdar 1997) (Šiler et al. 2013)
Geraniaceae	*Pelargonium roseum* (Andrews) Aiton	Rose geranium	Laatarcha	Leafy stem	In nature		linallol; citronnellol; geraniol; 6-octen-1-ol; 3,7-dimethyle; formiate; selinene ; tannins, flavonoïdes, phenolic acids, saponines and alkaloids	(Hachi et al. 2016) (Pradeepa et al. 2016)
	Geranium robertianum L.	Robert's géranium	Laatarcha	Flowers and leaves	Infusion		Tanins , flavonoïdes, phenolic acid	(Kahouaji 1995) (Graça et al. 2016)
Globulariaceae	*Globularia alypum* L.	Globulaias, globe daisies	Ain Larneb	leaves	Infusion or decoction	Increases the insulin liberation of pancreatic islets	flavonoids , tanins, anthocyanes, iridoids	(Bellakhdar et al. 1991) (Bellakhdar, 1997) (Ziyyat et al. 1997) (Eddouks et al. 2002) (Jaouhari 2002) (Merzouki et al. 2000) (Merzouki et al. 2003) (Hajji et al. 2018)
Poaceae	*Avena sativa* L.	Oat	Khartal	Seeds	Powder		apigenine, luteolin, tricine, kaempferol, linarine (6), tilianine, myricitrine, quercitrin, rutin, tricine 7-O-β-D-glucopyranoside, tricine, kaempferol and luteolin	(Katiri et al. 2017) (Popovici et al. 1977) (Zhang et al. 2012)
	Catapodium tuberculosum Moris	Tuberous catapodium	Zwan l-mkarkeb	Seeds	Decoction			(Jaouhari 2002)

Hordeum vulgare L.	Barley	Shaeir	Seeds	Maceration	Hypoglycemic effect	β-glucanes	(Laadim et al. 2017) (Sinha et al. 2012)
Panicum miliaceum L.	Proso millet	Tafsout	Seeds	Decoction		Miliacine	(Jaouhari 2002) (Smetanina et al. 2001)
Pennisetum typhoides (Burm.f.) Stapf & C.E.Hubb.	Pearl millet	Illan	Seeds	Boiled		Tricine; acacetine; luteolin 3, 4 Di-OMe and tricine 4-OMe; vanilic acid; syringic acid; melilotic acid; para-hydroxyl benzoic acid; salicylic.	(Laadim et al. 2017) (Nambiar et al. 2012)
Phalaris paradoxa L.	Hood canary grass, owned canary hood	Zouane	Seeds	Decoction	Stimulating effect of insulin secretion	Gallic acid, protocatechuic acid, p-hydroxybenzoic acid, vanillic acid, caffeic acid, syringic acid, p-coumaric acid, ferulic acid, and sinapinic acid.	(Eddouks et al. 2002) (El-Hilaly et al. 2003) (Balah 2014)
Phalaris canariensis L.	Alpiste des Canaries	Zwan	Seeds	Decoction	Stimulating effect of insulin secretion	Gallic acid, protocatechuic acid, p-hydroxybenzoic acid, vanillic acid, caffeic acid, syringic acid, p-coumaric acid, ferulic acid, and sinapinic acid.	(Bnouham et al. 2002) (Chen et al. 2015)
Sorghum bicolor (L.) Moench	Milo	Bachna	Seeds	Decoction of seeds		Flavonoids	(Ziyyat et al. 1997) (Awika 2011)
Triticum repens L.		Njem, til	The entire plant e or rhizo ma	Decoction	Hypoglycemic Effect	Meshes	(Bruneton 2009) (Eddouks et al. 2005)
Zea mays L.	Maize	Dra	Plant, seed, root, fruit, silk, style and	Infusion, decoction, maceration	Hypoglycemic effect due to insulin stimulation for absorption of glucose, the regeneration of pancreatic islets and prevent dementia	Alpha-tocopherol, quercetine, isorhamnetine, saponosides, tricine , salcoline, alcaloids , phenols , steroids , glycosides , glucides , terpenoids and tannins.	(Jouad et al. 2001) (Ceska et E. D. Styles, 1984) (Bhaigyabati et al. 2011)

				stigma, spike, leaf, oil		associated with vascular diseases and Neurodegenerative disorders. .		
Hypolepidaceae	*Pteridium aquilinum* (L.) Kuhn	Bracken	Farsiw	Aerial part	Decoction		Glucides, proteines, amino acids, flavonoids, phenolic compounds, tannins, glycosides, terpenoids, saponines, volatile oils, alkaloids, phlobatannins	(Merzouki et al. 2003) (Mir et al. 2014)
Iridaceae	*Crocus sativus* L.	Safron crocus	Zâafran Lhor	Stigmates	Infusion		Crocin ; crocetin; safrana; picrocrocin; zeaxanthin; 3,5-β-diglucosids de delphinidin; petunidin; anthocyans	(Merzouki et al. 2003) (Gohari et al. 2013)
Juglandaceae	*Juglans regia* L.	Persian walnut	Guergae, guz	Leaves, cortex	Decoction	Stimulating effects on insulin secretion	Megastigmane glycosides , tetralon , phenylpropanoid , neolignan, juglone, sinapic acid, ferulic acid, coumaric acid, benzoic acid; caryophyllene, β -pinene, germacrene D, α -pinene, α - humulene, α -zingiberene, α -copene	(Bellakhdar 1997) (Ziyyat et al. 1997) (Jouad et al. 2001) (Jaouhari 2002) (Schwindl et al. 2017)
Juncaceae	*Juncus maritimus* Lam.	The sea rush	Smar	leaves	Decoction		Flavonoids, coumarins, terpenes, stilbenes, sterols, phenolic acid, carotenes, derivatives of phenanthrenes (monomers and dimers)	(Idm'hand & Msanda 2020) (El-Shamy et al. 2015)
Lamiaceae	*Ajuga iva* (L.) Schreb.	Herb ivy	Chendgoura	Aerial part	Decoction	Hypoglycemic effect of aqueous extracts, Reduce lipid peroxidation, and strenghthen the antioxidant and enzymatic activities in plasma erythrocytes and tissue	Naringenine, phyto-ecdysteroids, clerodane, iridoids, flavonoids, cirilisiol, chlorogenic acid, cirsilineol, hyperosid, syringic acid, quinic acid.	(Bellakhdar 1997) (Ziyyat et al. 1997) (Jouad et al. 2001) (Jaouhari 2002) (Merzouki et al. 2003) (El-Hilaly et al. 2003) (Bennaghmouch et al. 2002) (Khatteli et al. 2020)

Ballota hirsuta (Willd.) Benth.	Ballote hirsute	Hashishat alkalb	Leafy stem	Decoction	Hypoglycemic effect due to insulin stimulation for absorption of glucose, the regeneration of pancreatic islets and prevent dementia associated with vascular diseases and Neurodegenerative disorders.	Apigenine, Ballonigrin, β-caryophyllene, Oxyd caryophyllene, Dehydrohispanolone, Germacrene D, Hispanolone , Luteolin, Quercetin	(Benkhnigue et al. 2014) (Morteza-Semnani & Ghanbarimasir 2019)
Calamintha officinalis Moench	Calament	Manta	Aerial parts	Decoction and infusion		Vitamins (A, C, E et K), carotenoids, terpenoids, flavonoids, Polyphenols, alkaloids, tanins, saponines, enzymes and minerals	(El Haouari et al. 2018) (Boudjema et al. 2018) (Singh et al. 2012)
Lamium album L.	Ortie blanche	Harriga	Aerial parts	Decoction	Promotes the hypoglycemic effect	The phytochemical constituents identified include tannins, alkaloids, iridoids, essential oils, p-hydroxybenzoic acid, protocatechuic acid, vanillic acid, p-coumaric acid, caffeic acid, ferulic acid, syringic acid, chlorogenic acid, various phenylpropanoids and glycosides, steroids, phytoecdysteroids, vitamins, saponins, acylglycosides, and flavonoids such as kaempferol, quercetin, isoscutellarein, 4′-O-methylisoscutellarein, 7-O-glucosides of luteolin and apigenin, as well as 7-O-rutinosides of naringenin, apigenin, and quercetin.	(Bahmani et al. 2014) (Botirov 2019) (Shah et al. 2019)
Lavandula officinalis L.	Lavande officinale	Khzama	Aerial parts	Infusion or decoction	Reduce the glycemia	Coumarins, tannins, flavonoids, faty acids; borneol; 1,8-cineol; camphor; α-cadinol; caryophyllen oxyd	(Jaouhari 2010) (Shafaghat et al. 2012)
Lavandula dentata L.	Lavande dentée	Timzeria/Lakhzama/ Jaada	Stem, leaves and	Infusion or decoction	Reduce the blood sugar	Coumarins, tannins, flavonoids, faty acids ; 1, 8 cineol; sabinen; bicycle [3.1.0] hexan-3-Ol, 4-methylene-1-(1-methylethyl); myrtenal; α-pinene	(Ziyyat et al. 1997) (Eddouks et al. 2001) (Ferreres et al. 2020)

			flowers				(Imelouane et al. 2009)
Lavandula mairei Humbert	Lavande	Timzoria	Aerial parts	Decoction, Infusion	Reduce the blood sugar	Coumarins, tannins, flavonoids, fat acids ; carvacrol; terpinolen; octene-3-ol; cis -β-ocimen; le p -cymene-8-ol; le β-caryophyllen; ether methylic of carvacrol	(Abouri et al. 2012) (El Hamdaoui et al. 2018)
Lavandula maroccana Murb.	Lavande marocaine	Igazioen	Stem and leaf	Decoction	Reduce the blood sugar	Coumarins, tannins, flavonoids, faty acids ; Carvacrol; 2-methoxy-4-vinylphenol; Spathulenol	(Abouri et al. 2012) (Soulaimani et al. 2019)
Lavandula multifida L.	Lavande	Khilt lkheyl/ Kohayla	Leaf	Decoction, infusion, powder, bouillon and mask	Reduce the blood sugar	Coumarins, tannins, flavonoids, fat acids ; carvacrol / β- bisabolene / dodecylic ester, acrylic acid	(M'hamed Aneb et al. 2016) (Sosa et al. 2005) (Chograni et al. 2010)
Lavandula stoechas L.	French lavender	Imzeria/Tikenkert/Lhalhal	Leaf	Infusion or decoction of leaves	Reduce blood sugar	Coumarins, tannins, flavonoids, faty acids ; camphre, fenchone	(Jaouhari 2002) (Merzouki et al. 2003) (Ennabili et al. 2000) (Angioni et al. 2006) (Zrira & Benjilali 2003)
Lavandula abrotanoides Lam.	English lavender	Khzama	Leaf	Infusion of inflorescences	Reduce blood sugar	Coumarines, tannins, flavonoids, faty acids ; Linalol, camphor, linalol acetate, borneol	(Merzouki et al. 2000) (N'dédianhoua et al. 2014)
Marrubium vulgare L.	White horehound	Marrîwa	Leaf, stems	Decoction of aerial parts	Inhibits increased blood sugar levels	Flavonoids, steroids, terpenoids, tannins, saponins, marrubiol, Eugenol, β-ionone, β-bisabolen, marrubiine, associeted to ursolic acid and choline	(Bellakhdar et al. 1991) (Ziyyat et al. 1997) (Eddouks et al. 2002) (Merzouki et al. 2003) (Lodhi et al. 2017)

Melissa officinalis L.	Lemon balm	Hbaqtrunj / Naanaatrunj	Leaves	Infusion		0BCitronellal, isogeaniol géranio acetate, nerol acetate, caryophyllen, β-caryophyllen oxyd, luteolin	(Shakeri et al. 2016) (Heitz et al. 2000)
Mentha pulegium L.	Pennyroyal	Fliou	Leaf	Infusion of aerial parts		pulegone, menthone, luteoline-7-rutinoside, diosmine and apigenine	(Ziyyat et al. 1997) (Jouad et al. 2001) (Elhoussine et al. 2010) (Aires et al. 2016)
Mentha suaveolens Ehrh.	Bigleaf mint	Timija	Leaf	Decoction /infusion		Alcaloids, flavonoids, saponines, sterols , tannins ; pulegone, piperitenone, oxyde de piperitenone , Carvone, limonene	(Ait-Ouazzou et al. 2012) (Zekri et al. 2014)
Ocimum sanctum L.	Holy basil	Rihane	Aerial parts	Decoction /infusion	Lowering blood sugar levels. Hepatic action of the glucose metabolism.	Vegetable oil , phenol, aldehyde, essential oils, alkaloid, tannin, ascorbic acid, Eugenol.	(Ramchoun et al. 2015) (Joseph & Nair 2013)
Origanum compactum Benth.	Oregano	Azukenni/ Zaater/ Zaatar tadlawi	Leaves	Decoction, infusion, maceration, powder and mask		Carvacrol, thymol, p-cymene et γ-terpinene, 4'-O-beta-D-glucopyranosyl-3',4'-dihydroxybenzyl protocatechuate,4'-O-beta-D-glucopyranosyl-3',4'dihydroxybenzyl 4-O-methylprotocatechuate.	(Ziyyat et al. 1997) (Eddouks et al. 2002) (Bouyahya et al. 2016)
Origanum vulgare L.	Oregano or pot marjoram	Zaater	Leaves	Decoction, infusion, maceration, powder and mask		carvacrol, thymol, γ-terpinene, p -cymene, limonène (4,68%), du caryophyllene, cymene, ledene, linalol (2,47%), α-pinene, γ-terpineol, germacrène-D ; 4'-O-beta-D-glucopyranosyl-3',4'-dihydroxybenzyl protocatechuate,4'-O-beta-D-glucopyranosyl-3',4'-dihydroxybenzyl 4-O-methylprotocatechuate.	(Eddouks et al. 2002) (Lemhadri et al. 2004) (Derwich et al. 2010)
Rosmarinus officinalis L.	Rosemary	Azir, yazir	Leaves	Decoction, infusion		α-pinene; 1,8-cineole; camphor; bornyl acid ; rosmarinic acid ; Carnosol, carnosic carnosate methyl.	(Ziyyat et al. 1997) (Eddouks et al. 2002) (Chalchat et al. 1993) (Amar et al. 2017)

	Salvia officinalis L.	Sage	Salmia	leaves	Infusion		trans-thuyone; 1,8-cineole; camphor; viridiflorol; β-caryophyllene; α-humulene; β-ursolic and β-oleanolic acids, 7-ethylrosmanol, cirsimaritin, luteolin-7-0-glucoside, apigenine-7-O-glucoside, β -sitosterol and sucrose	(Ziyyat et al. 1997) (Jouad et al. 2001) (Merzouki et al. 2000) (Bouajaj et al. 2013) (Mašterová et al. 1989)
	Salvia phlomoides Asso	Jerusalem sage, Lamwick plant	Bouftache	Leaves and seeds	Decoction		trans-thuyone; 1,8-cineol; camphor; viridiflorol; β-caryophyllen; α-humulen; β-ursolic and β-oleanolic acids, 7-éthylrosmanol, cirsimaritine, lutéoline-7-0-glucoside, apigenine-7-O-glucoside, β -sitosterol and sucrose	(Kahouaji 1995) (Nikolova & Aneva 2017) (Antal 2010)
	Thymus vulgaris L.	Common thyme	Aduchen /Azukni / Zaitra	Leaves	Decoction		Flavonoids, saponins and steroid compounds; camphor; camphene; α-pinene; 1, 8-cineole; borneol ;β-pinene	(Jaouhari 2002) (Imelouane et al. 2009) (Hossain et al. 2013)
	Thymus atlanticus (Ball) Roussine subsp. atlanticus	Thyme	Asserkna/ Ziitra	Flowers and leaves	Decoction		Flavonoids, saponins steroid compounds ; borneol; α-terpineol; camphene	(Jaouhari 2002) (Ramzi et al. 2017)
	Teucrium polium L.	Felty germander	Jaâda	Aerial parts	Infusion or decoction		3-carene; γ-muurolene; α-pinene; α-phellandren; caryophyllene; tannins, terpenoids, saponines, esterols, flavonoids; leuco-antocyanins	(El Atki et al. 2020) (Kahouaji 1995) (M. M et al. 2002)
Lauraceae	*Cinnamomum cassia* Blume.	Chinese cassia or Chinese cinnamon	L-qrfa	Aerial parts, Barks	Decoction	Improvement of the insulin sensitivity. Insulin like action	Vegetable oil, tannin, mannitol, calcium oxalate	,(Eddouks et al. 2002) (Ateş & Turgay 2003)
	Laurus nobilis L.	Bay laurel	Wraq sidna moussa	Leaves	Decoction		10-epigazaniolide ; gazaniolide ; spirafolide ; costunolide ; reynosine ; glycosides flavonoids; 1,8-cineole; myrtenyl acetate ; 1,8-cineol ; α -pinene	(Jaouhari 2002) (Merzouki et al. 2003) (Ennabili et al. 2000) (Patrakar et al. 2012) (Cherrat et al. 2014)

	Persea americana Mill.	Avocado	Avocat	leaves /Seed	Decoction / Maceration		Estragole, sabinene, 1R-α-pinene ; alkanols; glycosides terpenoids; derivatives containing a furan ring; flavonoids; coumarin	(El Mansouri et al. 2011) (Granados-Echegoyen et al. 2015) (Yasir et al. 2010)
Leguminosae	*Retama sphaerocarpa* (L.) Boiss.	The yellow broom	Rtem	Root	Decoction	Hypoglycemic effect due to insulin stimulation to absorb the glucose, regeneration of the pancreatic islets and prevention of dementia associated with vascular and neurodegenerative disorders.	Apigenin, isorhamnetin, kaempferol, quercetin, Cytisine, Retamine, sparteine	(Benbacer et al. 2012) (Touati et al. 2015)
Liliaceae	*Agave Americana* L.	Century plant	Ssabra/Sayber	Leaves	Decoction	Stimulates insulin release and blocks glucose formation in the blood	Glucides, reducing sugar, steroids, cardiac glycosides, flavonoids and saponins	(Benkhnigue et al. 2014) (Kadam et al. 2012) (Tinto et al. 2005)
	Allium sativum L.	Garlic	Touma	Bulb	Incooked	Antihyperglycemic and antinociceptive effect.	Vegetable oils, Allin, allicin	(Ziyyat et al. 1997) (Eddouks et al. 2002) (Merzouki et al. 2003) (Ziyyat et al. 1997) (Mekhfi et al. 2004)
	Allium cepa L.	Onion	Besla	Bulb	Incooked	Exhibit stimulatory effects on glucose utilization and the activity of antioxidant enzymes.	Protein, glucides, vit. A, B, C, Allyl propyldisulphide	(Jouad et al. 2001) (Eddouks et al. 2002) (Merzouki et al. 2003) (Tahraoui et al. 2007)

	Aloe socotrina Lam.	The fynbos aloe	Sibr	Leaves	Decoction	Promote the synthesis and/or secretion of insulin.	Barbaloin, isobarbaloin, resin	(Bellakhdar et al. 1991) (Bellakhdar, 1997) (Jouad et al. 2001) (Eddouks et al. 2002)
	Aloe perryi Baker	Aloe succotrina	Sibr	Leaves	Decoction	Stimulate insulin synthesis and/or release	Aloin Glycoside, glucomannans, chromone, anthraquinone or derivatives of anthrone.	(Bnouham et al. 2002) (Ibegbulem et Chikezie, 2013)
	Androcymbium gramineum (Cav.) Macbride.		Lawzet lehjel	Bulb	Infusion	Inhibe l'alpha-glucosidase et diminue le transport du glucose à travers l'épithélium intestinal	Alkaloids (colchicine)	(Bellakhdar 1997) (Moussaid et al. 2012)
	Asphodelus microcarpus L.	Asphodele	Blaluz	Tubercle	in nature		Terpenoids; Flavonoids Luteolin; luteolin-6- C-glucoside; luteolin- O- hexoside ; luteolin-7- O-glucoside; luteoline- O- acetylglucoside; luteolin- O- desoxyhesosylhexoside; methyl-luteolin, naringenine; apigenine); phenolic acids; Anthraquinone; Anthraquinones; Mucilage	(Benkhnigue et al. 2014) (Malmir et al. 2018)
	Asphodelus tenuifolius Cav.	Wild onion	Blaluz	Leaves	Decoction		Flavonoids (luteolin ; luteolin-7- O- ß- d-glycopyranoside; apigenine, chrysoeriol); Triterpenoids; Ester(1- O -17 methyl stearyl myoinositol); faty acids, Chromone, Triterpenoids	(Malmir et al. 2018)
Linaceae	*Linum usitatissimum* L.	Flaxseed	Zreat el kattan	Seeds	Infusion, decoction or powder	Effets stimulants sur la sécrétion d'insuline	Gallic acid, sinapic acid, vanillic acid, protocatechuic aicd, caffeic acid, syringic acid, p -coumaric acid, glucosides cyanogens, ferulic acid,	(Eddouks et al. 2002) (Jouad et al. 2001) (Wang et al. 2016)
Lythraceae	*Lappa communis* B.	Greater burdock	Bardane	Flowers, roots and leaves	Decoction or infusion		caffeic acid, chlorogenic aicd, arctiin, arctigenin	(Hmammouchi, 1999) (A.Al-Shammaa et al. 2013)

	Lawsonia inermis L.	Henna tree	Hanna	Leaves	Decoction or infusion		lacoumarin, scopoletin, fraxetine, esculetin, daphnorine, agrimonolide-6-O-β- d-glucopyranoside , tannic acid, daphneside, acacetin, apigenine, cosmosiine , isoscutellarine , catechine, lawsoniaside ,Xanthones, naphtoquinones	(Eddouks et al. 2002) (Badoni Semwal et al. 2014)
Malvaceae	*Hibiscus sabdariffa* L.	Roselle	Karkadil	The entire plant	Infusion	Promote insulin secretion of Beta cells	Vit.B, C, protocatechuic acid, hydroxycitric and hibiscus acids, delphinidin-3-sambubioside and cyanidin-3-sambubioside	(Bellakhdar 1997) (Carmona et al. 2005) (Da-Costa-Rocha et al. 2014)
Moraceae	*Ficus carica* L.	Common fig	Kermous / tazart	Fruits	Decoction		Flavonoids, tannins	(Ziyyat et al. 1997) (Jouad et al. 2001) (Tahraoui et al. 2007) (Lemhadri et al. 2004)
	Morus nigra L.	Black mulberry	Toute	Fruits and leaves	Infusion or decoction	Promotes increased glucose utilization.	Quercetin 3- O -glucoside, quercetin 3- O -rutinoside, kaempférol 3-O -rutinoside and 5- O -caffeoylquinic acid.	(Abdalla 2006) (Pawlowska et al. 2008)
Myristicaceae	*Myristica fragrans* Houtt.	Nutmeg	Lgouza	Seed	Powder		macelignan, carvacrol, myristicin, β-caryophyllen, β-pinene, α-pinene, p-cymene, eugenol ; 1- (3,4,5-trimethoxy phenyl) -2- (3-methoxy-5 (prop-1-yl) phenyl) -1-ol (1) , 2- (2,6-dimethoxy) -4-vinylphenoxy) -1- (3,4-dimethoxyphenyl) propyl acetate (2), 2- (4-allyl-2,6 dimethoxyphenoxy) -1- (benzo [d] [1,3] dioxol-5-yl) propyle acetate (3) , 1,3-benzodioxate-5-methanol, alpha- [1, [2,6-dimethoxy-4- (2-propenyl) phenoxy] ethyl] -acetate (4) and benzofuran, 2,3-dihydro-7-methoxy-3-methyl-5- (1E) -1 -yl-2- (3,4,5-trimethoxyphenyl)	(Ouhaddou et al. 2014) (Khabbach et al. 2012) (Gupta 2020) (Haldhar et al. 2018)

Myrtaceae	*Eucalyptus globulus* Labill.	Blue gum	Kalitûs	Flowers and leaves	Decoction	Enhances insulin secretion from clonal pancreatic beta-cell lines.	1,8- eucalyptol, α-terpineol, terpinen-4-ol, linalool, α-pinene, β-pinene, α-eudesmol, (-)-globulol, epiglobulol, α-terpineol acetate, geranyl acetate, L-pinocarveol, β-sabinene, terpinolene, borneol, linalol, cineol, geranyl acetate, anethol, safrol	(Ziyyat et al. 1997) (Eddouks et al. 2002) (Jaouhari 2002) (Hardel & Laxmidhar 2011)
	Eugenia caryophyllata thunb.	Clove	Qrûnfûl	Fruits	Decoction	Lowers plasma glucose levels	tamarixetin 3-O-b-D-glucopyranoside, ombuin 3-O-b-D-glucopyranoside and quercetin. Monoterpenes, sesquiterpenes, hydrocarbon and phénolic compounds, eugenol, eugenyle acetate, β-caryophyllène	(Ziyyat et al. 1997) (Eddouks et al. 2002) (Jaouhari, 2002) (Merzouki et al. 2003) (Nassar et al. 2007) (Mittal et al. 2014)
	Myrtus communis L.	Common myrtle	Rayhane	Leaves and fruits	Infusion or decoction	Lowers plasma glucose levels	α-pinene, limonene, 1,8-cineole, β-elemene, trans -myrtanol acetate, myricetine 3-O-β-glucopyranoside, myricetin 3-O-∝ -rhamnopyranoside gallic acid	(Ziyyat et al. 1997) (Eddouks et al. 2002) (Flamini et al. 2004) (Nassar et al. 2010)
Oléaceae	*Fraxinus angustifolia* Vahl	Narrow leaved Ash	Touzalt	Fruits, leaves	Decoction		Docosane methyl, n-pentacosane, α-cadinol, T-muurolo, α-cadinol, epi-methyl jasmonate, Phenylethanoides, calceolariosides, verbascoside, oleuropeine, ligstrosid, kaempferol 3-O-rutinoside, isoquercetrine and rutin	(Ziyyat et al. 1997) (Ayouni et al. 2016) (Zouaghi et al. 2020)
	Fraxinus excelsior L.	Common ash	Lsane ettir	Leaves	Decoction		Iridoid - glucosides secoiridoid, excelsid A and B	(Eddouks et al. 2005) (Kowalczyk & Olechnowicz-Stepień 1989)
	Olea europaea var. oleaster (Hoffmanns. & Link) A.DC.	The Olive	Zitoun	Leaves	Decoction	Glucose potentiation, induced insulin release and increase glucose's absorption	Oleuropeoside, oleuropeine, hydroxytyrosol	(Merzoukiet al. 2000) (Merzouki et al. 2003)

								(Eddouks et al. 2002) (El-Hilaly et al. 2003)
	Olea oleasis L.	Wild olive	Jabouj	Leaves	Decoction		oleuropeine, hydroxytyrosol	(Jaouhari 2002)
Palmaceae	*Chamaerops humilis* L.	Mediterranean fan palm	Doum	Leaves	Infusion	Innsulin stimulation to absorb glucose	Tannins, saponins, quercetine and isorhamnetine	(El-Hilaly et al. 2003) (Benmehdi et al. 2012) (Marouf et al. 2010)
	Phoenix dactylifera L.	Date or date palm	Tmar	Fruits and seeds	Infusion		Phytosterols, flavonoids, alkaloids, proteins, glucides, glycosides, phenolic compounds, des tannins, terpenoids, saponins, coumarins, lignine, oil and fats.	(Ziyyat et al. 1997) (Jaouhari, 2002) (Al-Samarai et al. 2018)
Pédaliaceae	*Sesamum indicum* L.	Sesame	Jenjlan	Seeds	Infusion		Sesamine, phenolic derivatives, sesamol, sesamoline	(Jouad et al. 2001) (Eddouks et al. 2002) (Nagpurkar & Patil 2020)
Portulaceae	*Portulaca oleracea* L.	Common purslane	Rejla	The entire plant	Decoction	Hypoglycemic effect due to insulin stimulation to absorb the glucose, regeneration of the pancreatic islets and prevention of dementia associated with vascular and neurodegenerative disorders.	Caffeic acid, p- coumaric and ferulic acid, apigenine, kaempferol, luteolin, quercetin, isorhamnetine, kaempfeol-3- O -glucoside, rutin, Alkaloid, saponin, tannins, cardiac glycoside, terpenoid, steroid, phobatannine, protein.	(Okafor & Ezejindu 2014) (Nemzer et al. 2020)
Punicaceae	*Punica granatum* L.	Pomegranate	Rman	Pericarp	Decoction, Infusion and Powder	Reducing blood sugar levels	Vit C, proteins, tannin, gallic acid, pelletierine	(Bellakhder et al. 1991) (Eddouks et al. 2002) (Mouhajir 2002)

								(Jaouhari 2002) (Merzouki et al. 2003) (Tahraoui et al. 2007) (El-Hilaly et al. 2003)
Ranunculaceae	*Nigella sativa* L.	Black cumin	Sanouj	Seeds	Decoction	Increasing insulin release from pancreatic islets	Oquinone, tannins, glucides, alkaloids, phenolic compounds, steroids and flavonoids	(Eddouks et al. 2002) (Ziyyat et al. 1997) (Jaouhari 2002) (Ishtiaq et al. 2013)
Rhamnaceae	*Zizyphus lotus* (L.) Lam.	Lotus jujube	Sadra, nbeg	Leaves and fruits	Decoction	Reduce Dose dependent glucose	Tannins, flavonoids, alkaloids	(Eddouks et al. 2002) (Ziyyat et al. 1997) (Jaouhari 2002) (Rached et al. 2019) (El-Hilaly et al. 2003)
Rosaceae	*Crataegus oxyacantha* Thuill.	Ringo, Pingyat, Hedge thorn	Admam	Flowers and leaves	Infusion or decoction		Procyanidines oligomers, triterpenes, fat acids, sterols, rutin, caftaric and caffeic acid, quercetine-3- O-β-glucoside, epicatechine, naringenine	(Hmammouchi 1999) (Benabderrahmane et al. 2019) (Orhan 2018)
	Cydonia vulgaris Pers.	Quince	Sferjel	Fruits	Cooked, uncooked		Carotenoids, mucilage, terpenoids, flavonols	(Jouad et al. 2001) (De Tommasi et al. 1996) (Fiorentino et al. 2006)
	Eriobotrya japonica (Thunb.) Lindl.	Loquat	Lemzah	Leaves	Decoction	Inhibits blood sugar increase	Corosolic acid, methylic ester 3-epicorosolic acid, 2-α hydroxy-3-oxo urs12-en-28-oic acid, methylic ester tormentic acid, ursolic acid	(Ziyyat et al. 1997) (Merzouki et al. 2003) (El-Hilaly et al. 2003) (Hasibuan et al. 2020)

	Prunus amygdalus Batsch	Almond	Louz mar	Seeds	Powder	Promote the hypoglycemic effect	Triterpenoids, betulinic acid, urosolic acid, oleanolic acid, flavonol glycosides, phenolic compounds, catechine, protocatechuic acid, vanillic acid, p -hydroxybenzoic acid, naringenine glucoside, galactoside, glucoside, rhamnoglucoside de 3 β-O-methylquercetine, rhamnoglucoside of kaempferol.	(Bellakhdar et al. 1991) (Bellakhdar 1997) (Ziyyat et al. 1997) (Eddouks et al. 2002) (Merzouki et al. 2003) (Esfahlan et al. 2010)
	Rubus fruticosus L.	Black berry	Tût Ikhla	Fruits, flowers and leaves	Infusion or decoction		phenolic acids, tannins, elagitanins, flavonoids, anthocyans	(Jouad et al. 2001) (Machado et al. 2015)
	Rubus idaeus L.	Raspberry	Tût berri	Fruits	Incooked		Tocopherols, phenols, sterols and carotenoids, aliphatic and aromatic hydrocarbons, aldehyds, cetons, alcools and esters, monoterpens and sesquiterpens (α- and β-ionone, α- and β-phellandrene)	(Jouad et al. 2001) (Robertson et al. 1995) (Radočaj et al. 2014)
Rutaceae	*Citrus aurantium* L.	Bitter orange	Larenj/Zenbue/trunj	Fruits and flowers	Decoction		Isonaringine, naringine, hesperidine, neohesperidine, naringenine, hesperitine, nobiletine, mandarine, mandarine, nobiletine, 4-terpineol, D-limonene, 4-carvomenthenol, linalol	(Jouad et al. 2001) (Eddouks et al. 2002) (Jaouhari, 2002) (Merzouki et al. 2003) (Okla et al. 2019) (He et al. 1997)
	Citrus limon L.	Lemon	Limoun	Fruits and flowers	Decoction	Hypoglycemic effect due to insulin stimulation to absorb the glucose, regeneration of the pancreatic islets and prevention of dementia associated with	Caffeoyl N-tryptophane ; hydroxycinnamoyl-Oglucoside acid ; Vicenin 2 ; Eriocitrine ; kaempferol-3-O-rutinoside ; quercetine-3-rutinoside	(Merzouki et al. 2003) (Makni et al. 2018)

						vascular and neurodegenerative disorders.		
	Ruta graveolens L.	Common rue	Lfijel /Iwermi	Aerial part and roots	Infusion or decoction		Furanocoumarines, 2-Undecanone, alkaloids	(Ziyyat et al. 1997) (Jouad et al. 2001) (Jaouhari, 2002) (Gulilat 2017)
	Ruta montana L.	Rue	Lfijel /Iwermi	Aerial part and roots	Infusion or decoction	Hypoglycemic activities	2-Undecanone, alkaloids	(Farid et al. 2017) (Abdelwahab et al. 2001)
Santalaceae	*Santalum album* L.	White sandalwood	A'sandal	Resin	Mixing resin with honey		santalol, lanceol, nuciferol, bisabolol, α-and β-santalenes, bergamotenes, α-, β- and γ-curcumenes, β-bisabolene, phenylpropanoids	(Merzouki et al. 2000) (Merzouki et al. 2003) (Kumar et al. 2000)
Solanaceae	*Solanum lycopersicum* var. esculentum (Mill.) Voss	Tomato	Maticha	Fruits	In nature		Carotenoids, vitamins, phenolic compounds, flavonoids, dietary glutathion	(Benkhnigue et al. 2014)
	Nicotiana tabacum L.	Common Tabacco	Tibre	Leaves	Decoction	Hypoglycemic effect due to insulin stimulation to absorb the glucose, regeneration of the pancreatic islets and prevention of dementia associated with vascular and neurodegenerative disorders.	Glucosides, tahacinine, tahaciline and isoquercitrine, 1-quinic acid, chlorogenic, caffeic and oxalic acid, terpenic and cancerogenic substances, anatabine and (+) nornicotine, quercetine, nicotinic acid	(Merzouki et al. 2000) (Rawat & R. Mali 2013)
	Solanum nigrum L.	Black nightshade	Anab deb	Leaves	Infusion	Stimulates pancreatic β-cells, leading to	Alkaloids, flavonoïdes, tannins, phenol, saponines, steroids, glycosides, quinones, coumarins.	(Benkhnigue et al. 2014) (Kumar et al. 2019)

						increased insulin secretion.		
Thymeleaceae	*Daphne gnidium* L.	Flax leaved daphne	Mathnane	Leaves	Infusion		The identified bioactive compounds include 4-hydroxybenzoic acid, 7,8-dihydroxycoumarin, 7-hydroxycoumarin, 2-(4-hydroxy-3,5-dimethoxyphenyl)-3-hydroxymethyl-2,3-dihydro-1,4,5-trioxaphenanthren-6-one, daphnetin, daphnin, acetylumbelliferone, daphnoretin, apigenin, luteolin, quercetin, orientin, isoorientin, luteolin-7-O-glucoside, apigenin-7-O-glucoside, genkwanin, 5-O-β-D-primeverosyl genkwanin, and α-tocopherol.	(Ziyyat et al. 1997)
Theaceae	*Camellia sinensis* L.	Tea	Atây	Leaves	Infusion	Hypoglycemic, glucose oxidative and insulin mimetic activities	The identified flavan-3-ols include (+)-catechin, (−)-epicatechin, (−)-epigallocatechin, (−)-epicatechin gallate, and (−)-gallocatechin gallate.	(Kim et al. 2011) (Benkhnigue et al. 2014)
Urticaceae	*Parietaria mauritanica* Durieu.	Pellitory	Harriga	Leaves	Infusion of inflorescences		HE, flavonoids	(El-Hilaly et al. 2003) (Falagiani 1989)
	Urtica dioica L.	Stining nettle	Harriga	Leaves	Decoction of aerial part	Increases insulin secretion	Fatty oil, ursolic acid and quercetin	(Bourgeois et al. 2016) (Ziyyat et al. 1997) (Jouad et al. 2001)
Verbenaceae	*Aloysia citrodora* Palau	Lemon verbena	Lwiza	Leaves	Infusion		neral, geranial, citronellal, 1,8-cineole, verbascoside, isoverbascoside, nepitrine	(Bousta et al. 2014) (Bahramsoltani et al. 2018)
Zingiberaceae	*Zingiber officinale* Roscoe	Common ginger	Zanjabil	Rhyzoma	Infusions	Increase level of insulin and Decrease fasting glucose levels	gingerols, tannins, coumarins, flavonoids, triterpenoids	(Hmammouchi 1999)

Zygophyllaceae	*Peganum harmala* L.	Wild rue	Harmal	Seeds	Infusion		Harmaline; Harmine; Harmalol; Harman; Tetrahydroharmine; Harmol l-thioformyl-8-β -Dglucopyranoside-bis2,3-dihydroisopyridinopyrrol desoxypeganine; desoxyvasicinone; Vasicine; Vasicinone; Isopeganine Pegamine; Peganol; Peganones; Vascinones; Dipegene; 9,14Dihydroxyoctaecanoicacid; Calcium; Cupper; Dipegene; Graisse; Fibre; Protein; Ruin	(Ziyyat et al. 1997) (Eddouks et al. 2002) (El-Hilaly et al. 2003) (Moloudizargari et al. 2013)
	Zygophyllum album L.	Zygophyllum,	Aggaya	Leaves	Infusion or decoction	Decrease fasting glucose levels	HE, Isorhamnetin-3-O-rutinoside, Isorhamnetin-3-O-glucoside, Rutin, Kaempferol/Luteolin 3-O-rutinoside, Protocatechuic acid glucoside	(Belakhder 1997) (Ziyyat et al. 1997) (Eddouks et al. 2002) (Jaouhari, 2002) (El-Hilaly et al. 2003) (Feriani et al. 2020)
	Zygophyllum Gaetulum Emb. Maire	Zygophyllum,	Aggaya	Leaves	Infusion or decoction	Decrease fasting glucose levels	HE, triterpenic bisdesmosidic saponins, zygophylosides, glycosides quinovic acid, Isorhamnetin-3-O-rutinoside, Isorhamnetin-3-O-glucoside, Rutin, Kaempferol/Luteolin 3-O-rutinoside, Protocatechuic acid glucoside	(Capasso et al. 1998) (Jaouhari et al. 2000)
	Zygophyllum waterloti Maire	Zygophyllum,	Aggaya	Leaves	Infusion or decoction	Decrease fasting glucose levels	HE, saponins, Isorhamnetin-3-O-rutinoside, Isorhamnetin-3-O-glucoside, Rutin, Kaempferol/Luteolin 3-O-rutinoside, Protocatechuic acid glucoside	(Jouad et al. 2001)
	Zygophyllum fontanesii Webb & Berthel.	Zygophyllum,	Aggaya	Leaves	Infusion or decoction	Decrease fasting glucose levels	HE, saponins, Isorhamnetin-3-O-rutinoside, Isorhamnetin-3-O-glucoside, Rutin, Kaempferol/Luteolin 3-O-rutinoside, Protocatechuic acid glucoside	(Hanane et al. 2010)

The wealth of families in species

The figure 2 represents the richness of families in antidiabetic species inventoried in Morocco since 1969.We have documented 212 species belonging to 62 families: Asteraceae (15, 9%), lamiaceae (11, 32%), Fabaceae (6, 6%), Apiaceae (6, 13%), Poaceae (4, 72 %), Liliaceae (3, 77%), Brassicaceae (3, 3%), and Rosaceae (2, 83%), with thirty-two, twenty-four, fourteen, thirteen, ten, eight, seven, and six for each species respectively. This is followed by three families with five species: Cistaceae (2, 36%), Cucurbitaceae (2, 36%) and Zygophyllaceae (2, 36%). Then, we find Apocinaceae, Caryophyllaceae, Oleaceae and Rutaceae with four species each. Thereafter, there are five families including three species, namely; Cupressaceae, Gentianaceae, Lauraceae, Myrtaceae and Solanaceae. The Amaranthareae, Anacardiacaea, Arecaceae, Chenopodiaceae, Ephedraceae, Euphorbiaceae, Lythraceae, Moraceae, Palmaceae, and Urticaceae, have two species each. Finally, 32 families contain one specie, namely, Aristolchiaceae, Berberidaceae, Burseraceae, Buraceae, Cactaceae, Capparaceae, Cuscutaceae, Cyperaceae, Equisetaceae, Ericaceae, Fagaceae, Fumariaceae, Geraniaceaea, Globulariaceae, Hypolepidaceae, Iridaceae, Juglandaceae, Portulaceae, Punicaceae, Ranunculaceae, Rhamnaceae, Santalaceae, Theaceae,Thymeleaceae, Verbenaceae, and Zingiberaceae.

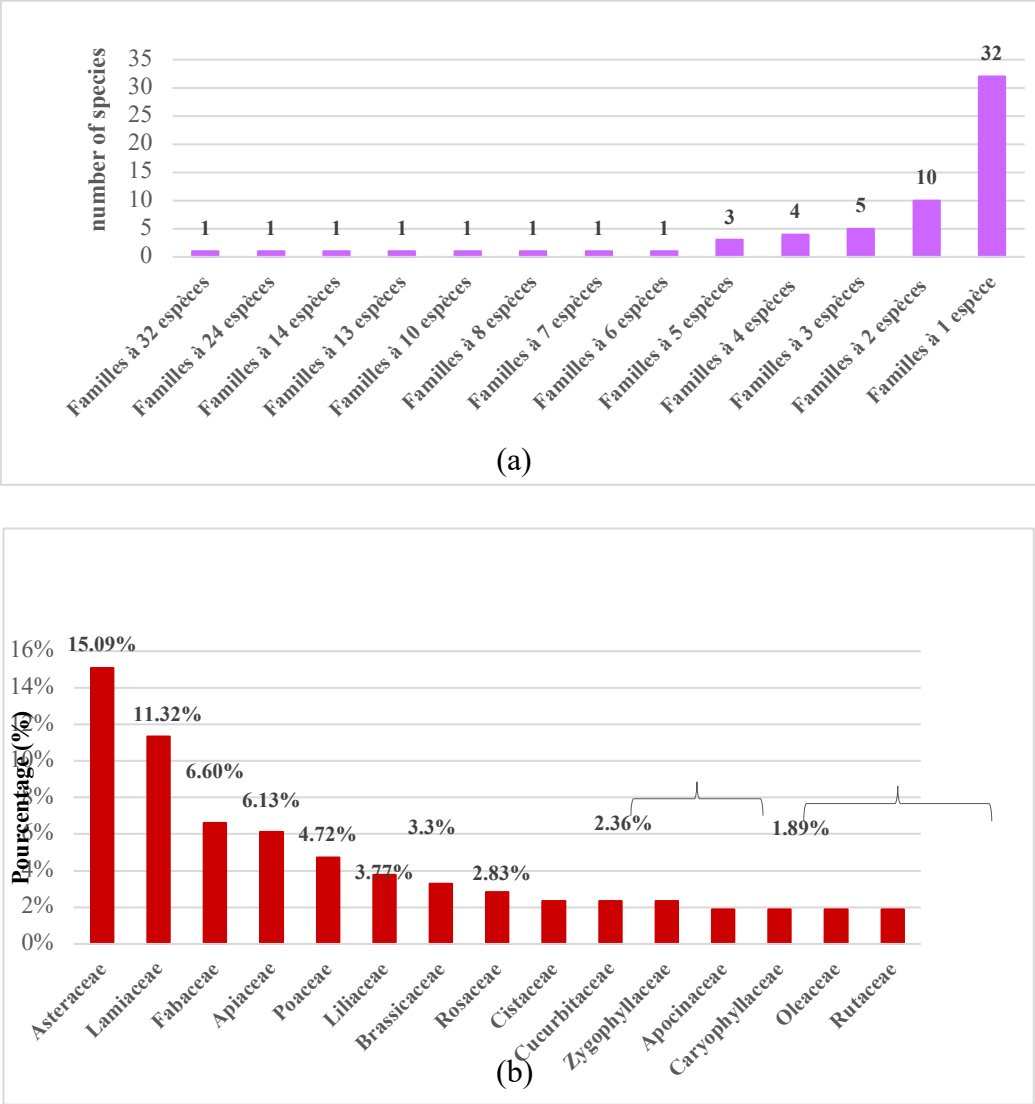

Figure 2. Wealth of families in PAMAD

Method of use

Many parts of herbs are used to manage type II Diabetes, namely: leaves, seeds, aerial parts, fruits, flowers, roots, stems, head flower, leafy stems, bulbs, resins, rhizome, cones, inflorescences, stigma, cortex, Ecorse, spike, pod, core, pericarp, silk tuber or the entire plant (Fig. 3).

The leaves are the most used part to trait type II hyperglycemia, with 30, 45% followed by the seeds with 16, 26 %. Then, the aerial part, fruits, flowers, roots and stems are at 11, 42%, 9%, 7, 61%, 6, 57% and 5, 19%, respectively.

Analyzing the figure 4, there are many methods of using PAMAD in Morocco. Decoction is at the top of the list with 53, 96%, followed by infusion at 25, 18%, milling, using the plant in its natural, or uncooked form, and maceration at 9, 35%, 5,76%, and 3, 6% respectively. Finally, we find the mixing drgs with other substances like oil, or others (1, 8%), and under pression to obtain vegetable oil (0, 36%).

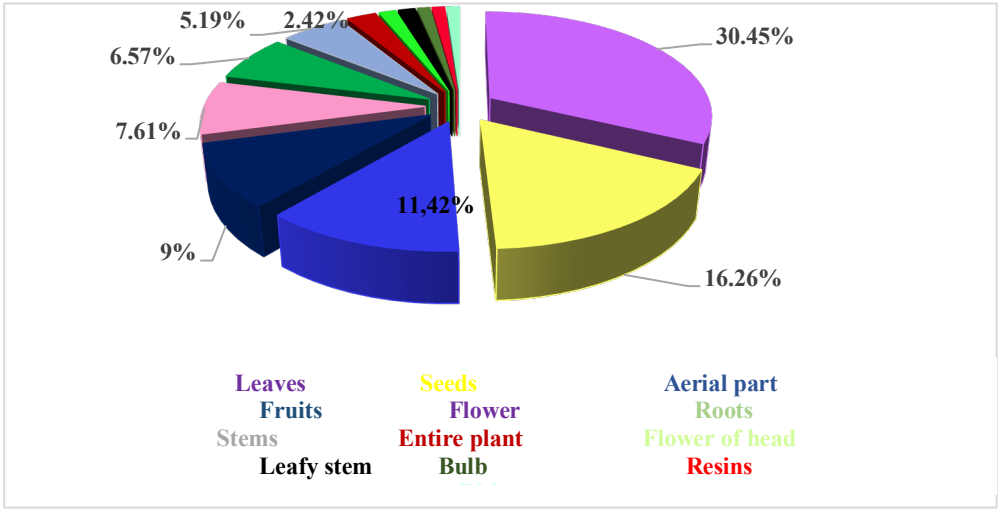

Figure 3. Used Parts of the PAMAD

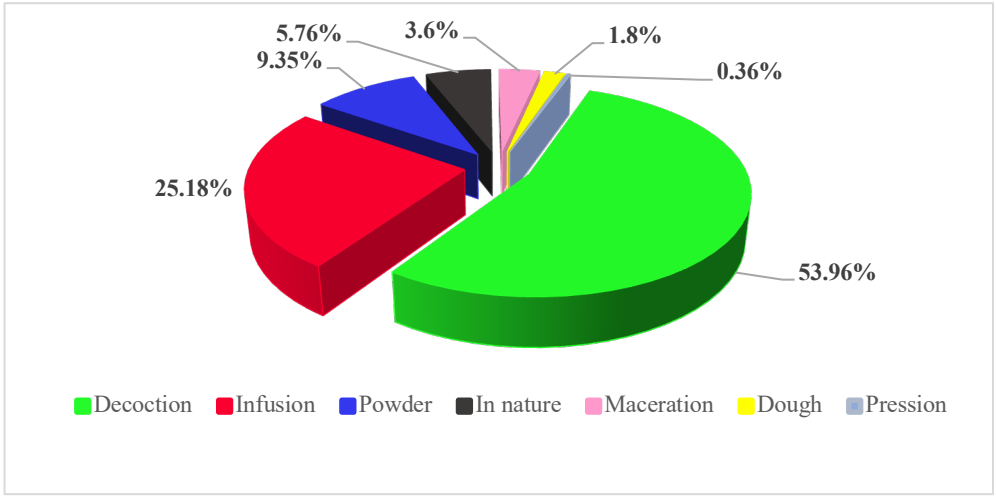

Figure 4. Method of use of the identified PAMAD

Phytochemical Profile of Moroccan Antidiabetic Medicinal Plants

Identification of secondary metabolites with anti-diabetic properties

Secondary metabolites in aromatic and medicinal plants include a diverse spectrum of bioactive substances from numerous chemical families, particularly, terpenes, phenolic acids, flavonoids, alkaloids. These molecules have been extensively studied for their antidiabetic capability, demonstrating activity on specific molecular targets involved in diabetes management. Figure 5 presents a summary of the key secondary metabolites identified in Moroccan medicinal plants traditionally used for antidiabetic purposes.

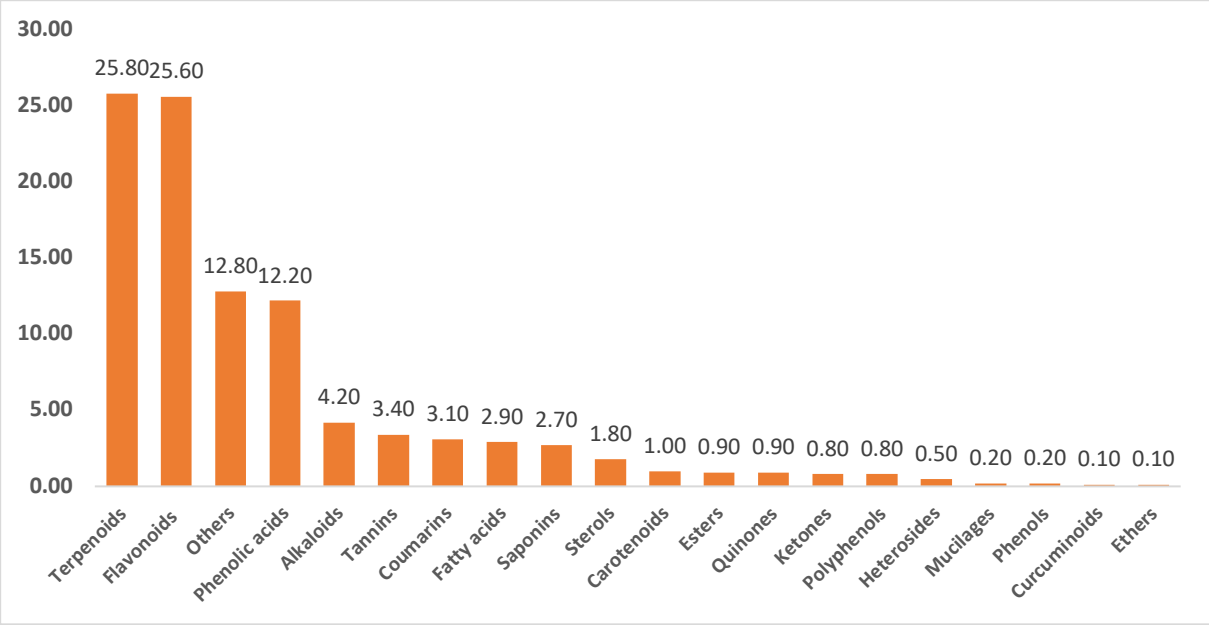

Figure 5. List of Secondary Metabolites Identified in Referenced Moroccan Antidiabetic Medicinal Plants

Based on what is shown in Figure 5, the secondary metabolites that could play an important role in antidiabetic action are terpenoids (25.80%), flavonoids (25.60%), and phenolic acids (12.20%). Alkaloids, tannins, coumarins, fatty acids, and saponins have also been identified as having antidiabetic potential, albeit to a lesser extent with percentages of (4.20%, 3.40%, 3.10%, 2.90%, and 2.70% respectively).

Description of the main metabolites that are sources of antidiabetic agents

Terpenoids

Volatile and semi-volatile organic compounds (terpenoids) are produced and released by aromatic and medicinal herbs (Flores-Gallegos *et al.* 2021). These terpenoids exhibit of chemical configurations, and essential oils, Monoterpenes, sesquiterpenes, and diterpenes fall within their categories based on the number of isoprene units. Usually containing several functional groups, including esters, alcohols, ketones, aldehydes, ethers, and peroxides, compounds such as α-pinene, (R)-limonene, p-cymene, thymol, and (R)-carvone were among the five terpenoids identified in steam-distilled black cumin seed oil by Khan *et al.* (1999). Subsequent studies discovered additional volatile compounds in *Nigella sativa* L. seeds through steam distillation and supercritical CO2 extraction methods, including pimadiene, thymoquinone, thymol, α-terpinene, pinocembrone, γ-terpinene, ocimene, carvacrol, 2,4, (10)-thujadiene, and caryophyllene. Moreover, α-para-cymene, α-thujacene, myrcene, α-pinene, γ-terpinene, γ-terpinene-4-ol, α-terpinene, limonene, sabinene/β-pinene, and thymoquinone were among the substances discovered in Black cumin essential oil in further studies conducted by Khalid *et al.* (2016). Variations in these results can mostly be explained by differences in extraction techniques, the phenological stage of the plants, and the exact plant components examined. Furthermore, the geographical source of Black cumin affects the expression of secondary metabolites. Additionally, the essential oils of *Centaurium erythraea* comprising carvacrol, menthol, tricosane, thujone, linalool, camphor, menthone, borneol, terpinene-4-ol, pulegone, and thymol have shown *in vitro* anti-diabetic effects. The range of terpenoid molecules is also observed in other species, including *Caralluma europaea*, whose essential oils contain spathulenol, (Z)-α-bisabolene, valerenol, eudesmol, and (Z)-phytol (Zito *et al.* 2010).

Two Moroccan cactus species, *Cistus creticus* and *Cistus salviifolius*, contain terpenoids and are thus considered anti-diabetic. Abu-Orabi et al. utilized GC-MS analysis in 2020 to investigate the chemical composition of the two species (Abu-Orabi et al. 2020). Monoterpene and sesquiterpene hydrocarbons, including α-pinene, camphene, and α-cubebene dominated the volatile compounds recovered from the leaves and flowers of *C. creticus* when using SPME. In hydrodistillation, oxygenated diterpenes and diterpene hydrocarbons with manoyl oxide and sclarene as major components dominated the oil extracted from leaves, while oxygenated diterpenes and diterpene hydrocarbons with manoyl oxide and abietatriene as major components dominated the oil extracted from flowers. With δ-3-carene, a-pinene, b-pinene, and E-caryophyllene, being the predominant compounds, monoterpene and sesquiterpene hydrocarbons were found to dominate the volatile compounds from the flowers and leaves of *C. salviifolius* collected via SPME. Conversely, the flower and leaf oils of *Cistus salviifolius* were primarily composed of oxygenated diterpenes, diterpene hydrocarbons, dehydroabietyl esters of abietol, manoyl oxide, and

methyl octadecenoate obtained by hydrodistillation. Manoyl oxide, E-ethyl cinnamate, and Z-ethyl cinnamate were the three main components of the oil extracted from the leaves (Abu-Orabi *et al.* 2020)

Phenolic acids

Arranged into two aromatic rings connected by a central pyran-like heterocycle, phenolic acids consist of a basic structure comprising fifteen carbon atoms, offering a C6-C3-C6 arrangement. The average daily intake of phenolic acids through diet is estimated between 1 and 2 grams, with evidence suggesting their antidiabetic properties (Choi *et al.* 2011; Gandhi *et al.* 2014). High polyphenol consumption is linked to a lower chance of getting diabetes mellitus, according to recent research, although the exact role of phenolic acids in controlling metabolic syndrome remains debated (Pandey *et al.* 2009). Numerous Moroccan medicinal plants known for their antidiabetic activity, such as *Citrus aurantium*, *Ajuga iva*, and *Anabasis aretioides*, a significant quantity of phenolic acids. For example, aqueous extracts of *Citrus aurantium* fruits have been reported quantitatively and qualitatively to contain several phenolic compounds, such as gallic, rosmarinic, caffeic, chlorogenic, p-coumaric, and ferulic acids (Benayad *et al.* 2021). Recently, Saidi et al. reported the presence of gallic, p-coumaric, ferulic, caffeic, chlorogenic and cinnamic acids (2023). Moreover, the methanolic extracts from *A. aretioides* confirmed the presence of numerous phenolic acids: chlorogenic acid, p-hydroxybenzoic acid, caffeic acid, salicylic acid, coumaric acid, syringic acid, catechol, pyrogallol, ferulic acid, 3-hydroxycinnamic acid, gallic acid, 4-hydroxycinnamic acid, vanillic acid and 3,4-dihydroxybenzoic acid (Berrani *et al.* 2018). Methanolic extracts of both *Arbutus unedo* leaves and fruits also yield additional phenolic compounds, including galloylquinic acid, dicaffeoylquinic acid, and chlorogenic acid (Maldini *et al.* 2019). Furthermore, aqueous extracts of *Ziziphus lotus* have been found to contain a varied array of phenolic compounds, such as pyrogallol, catechol, syringic, chlorogenic, 3-hydroxycinnamic, caffeic, vanillic, p-coumaric, gallic, p-hydroxybenzoic, ferulic, sinapic, salicylic, and rosmarinic acids. (Marmouzi *et al.* 2019).

Phenolic acids are renowned for their impact on carbohydrate metabolism, largely by inhibiting α-glucosidase and α-amylase activity, crucial enzymes for converting dietary carbohydrates into glucose (Hanhineva *et al.* 2010; Manzanaro *et al.* 2006). For instance, laboratory tests have demonstrated that extracts obtained from the peels and flesh of several apple varieties can effectively stop the activities of α-glucosidase and α-amylase (Barbosa *et al.* 2010). Hydroxycinnamic acids, such as chlorogenic acid (CGA) have exhibited inhibitory effects against α-glucosidase in both laboratory cultures (Matsui *et al.* 2004) and live subjects (Ishikawa *et al.* 2007). Moreover, rosmarinic acid, a phenolic acid present in Greek sage tea, has been reported to dramatically reduce levels of intestinal sodium-glucose transporter 1 (SGLT1) in diabetic rats following 14 days of daily consumption (Azevedo *et al.* 2011). Recent clinical studies have suggested that beverages such as apple juice and berries can improve short-term glycemic control (Hanhineva et al. 2010). Phenolic acids can also regulate postprandial blood glucose and inhibite glucose intolerance development by facilitating insulin response and attenuating the secretion of glucose-dependent insulinotropic polypeptide and GLP-1 (Meng *et al.* 2013).

Given the growing number of reports on blood glucose reduction by phenolic acids isolated from natural foods and medicinal plants, it is likely that bioactive principles could be present in one or more of the candidate phytochemical fractions. It is suggested that these compounds stimulate the influx of Na+ and Ca2+ ions by inhibiting the Na+-Ca2+ exchanger, thereby leading to an increase in Ca2+ influx into the inner membrane, resulting in membrane depolarization. This activates adenosine triphosphate (ATP) via oxidative phosphorylation (Vetterli *et al.* 2011).

Flavonoids

Flavonoids represent a common category of secondary metabolites found in various plants, and contribute to the colors observed in flowers, fruits, and foliage. Typically, they are stored as glycosides within cellular vacuoles or as parts of plastids such as chromoplasts. This diverse family comprises approximately 6,500 natural polyphenolic compounds, which can be categorized into 12 primary classes (Hefner *et al.* 2002). From a structural perspective, flavonoids consist of a diphenylpropane structure (C6-C3-C6), where two benzene rings (A and B) are connected through a three-carbon bridge, often linked via an oxygen-containing heterocyclic ring (C). Numerous subclasses exist, including, flavans, aurones, flavanones, chalcones, flavonols, flavan-3-ols, flavylium salts, flavanonols, flavones, isoflavones, isoflavonols, isoflavanes, pterocarpans, coumaronochromones, 3-arylcoumarins, coumestans, and rotenoids (De Rijke *et al.* 2006).

Flavonoids exhibit properties that may aid diabetes management by encouraging the regeneration of pancreatic β-cells and insulin release, enhancing glucose uptake mediated by insulin, inhibiting aldose reductase, and increasing calcium absorption (Mohan et al. 2014). Their effectiveness in combating diabetes relies largely on particular chemical characteristics, such as a double bond between C2 and C3 and a ketone group located at the C4 position on ring B, both crucial for their biological functions (Murni et al. 2017). Noteworthy flavonoids including catechin, naringin, rutin, luteolin, naringenin, quercitrin,

epicatechin, hesperidin, and hesperetin are vital for regulating blood glucose levels and enhancing insulin action (Marmouzi *et al.* 2019; Maldini *et al.* 2019; Hajiaghaalipour *et al.* 2015). Lastly, several medicinal plants in Morocco contain flavonoids with anti-diabetic properties. This group includes plants such as *Arbutus unedo, Cistus ladanifer, Calendula officinalis, Myrtus communis, Anabasis aretioides*, and *Ziziphus lotus*.

Alkaloids

Alkaloids are heterocyclic organic compounds of plant origin containing nitrogen and exhibiting various pharmacological activities. Alkaloids are classified based on their carbon-nitrogen skeleton. Most alkaloids exist as colorless crystalline solids, that slightly soluble in a neutral or alkaline aqueous solution, but dissolve easily in various organic solvents. Several classes of alkaloids, such as indole, isoquinoline, amino, and terpenoidal alkaloids, have been identified for their antidiabetic effect (Sato *et al.* 2007; Buckingham *et al.* 2010). Medicinal herbs in Morocco contain several alkaloids with anti-diabetic effects, including *Zizyphus lotus, Berberis hispanica, Nigella sativa*, and certain species from the genus Brassica.

Alkaloids influence insulin function by regulating the expression of multiple key molecules, including AMP-activated protein kinase (AMPK), sterol regulatory element binding protein 1 (SREBP-1), glucokinase (GK), acetyl-CoA carboxylase, glucose-6-phosphatase (G6Pase), glycogen synthase kinase-3, protein tyrosine phosphatase 1B (PTP1B), glucose transporter-4 (GLUT4), and peroxisome proliferator-activated receptor gamma (PPAR-γ) (*et al.* 2016). Protoberberines, a subset within isoquinoline alkaloids, are known to inhibit AMPK, PTP1B, and dipeptidyl peptidase-IV (DPP-IV), leading to enhanced insulin receptor expression and increased glucose uptake. For instance, trigonelline, a compound belonging to this group, has been shown to raise the GK/G6Pase ratio in the liver, decrease tumor necrosis factor-alpha (TNF-α) levels, and contribute to the regulation of glucose and lipid metabolism (Johnson *et al.* 2002). Furthermore, indole alkaloids like vindoline, vindolidine, and vindolicine suppress glucosidase and amylase enzyme activities, which helps to lower blood sugar by promoting insulin release (Tiong *et al.* 2013). Similarly, koenidine, a physiologically stable alkaloid, reduces postprandial blood glucose levels while increasing insulin levels (Singh Grewal *et al.* 2016). A crucial member of this family of alkaloids, harmine, fosters cell division and proliferation, which enhances insulin hormon expression. Aegeline, an amino alkaloid, boosts intracellular Ca2+ signaling, enhances GLUT-4 translocation, and modifies various cellular processes to manage diabetes mellitus. By promoting pancreatic insulin secretion, lowering blood sugar levels, enhancing basic glucose absorption, and activating AMPK and PPAR-γ, piperidine alkaloids provide therapeutic effects for diabetes mellitus and Type 2 diabetes (Gupta *et al.* 2016).

Tannins

Tannins have the capacity to bind carbohydrates, proteins, and digestive enzymes, resulting resulting in complex formations that decrease food digestibility. Additionally, tannins can interact with cellulose and various minerals (Ref'at *et al.* 2011). They are generally categorized into main types: hydrolyzable tannins which consist of gallate dimers attached to carbohydrates, and condensed tannins, also known as procyanidins, formed through the auto-oxidation or enzymatic polymerization of flavan-3,4-diol units. These units are primarily linked by C4-C8 bonds, though C4-C6 bonds between adjacent monomers are occasionally observed (Dykes & Rooney 2006). Tannins have been found to enhance glucose absorption by activating insulin signaling mediators such as PI3K (Phosphoinositide 3-Kinase) and p38 MAPK (Mitogen-Activated Protein Kinase), along with the translocation of GLUT-4 (Kumari & Jain 2012). Some Moroccan medicinal species studied for their antidiabetic properties, such as *Punica granatum*, *Juglans regia, Rubus fruticosus*, and *Phoenix dactylifera,* contain tannins.

Coumarins

Coumarins are secondary metabolites widely distibuted in natural Moroccan plants, including *Zea mays, Lavandula angustifolia, Pastinaca sativa*, and *Ruta graveolens*. Studies have shown that plant extracts incorporating coumarins exhibit antidiabetic activity. Specifically, both natural coumarins like umbelliferone, esculetin, and osthol, as well as coumarin derivatives, have demonstrated beneficial therapeutic effects on diabetes by repairing damage to pancreatic beta cells and improving insulin signaling (Kumar *et al.* 2013; Ojo et al. 2015; Lee *et al.* 2011).

Fatty acids

Fatty acids are essential lipid components that can exist either bound to glycerol or in a free state. They differ based on chain length, typically varying from 4 to 30 carbons, and also in the number and location of double bonds (Peter 2008)

Research conducted in Morocco has explored the anti-diabetic properties of plants like *Caralluma europaea* and *Nigella sativa*, both known to contain various fatty acids. The composition of these acids varies among species. For instance, Rahim *et al.* 2022 identified myristic, lauric, stearic, palmitic, oleic, linoleic, palmitoleic, arachidic, and erucic acids in the oil extracted

from *Nigella sativa* seeds. Meanwhile, studies on *Caralluma europaea* essential oils found the presence of hexadecanoic acids and tetradecanoic (Zito *et al.* 2010).

Principal Component Analysis: Exploration of the Relationships between Botanical Families, Plant Parts, and Secondary *Metabolites in Recorded Antidiabetic Plants*

The study of plants with antidiabetic properties is gaining recognition, as they are increasingly viewed as promising sources for developing diabetes treatments. This study analyzed the relationships among botanical families, plant parts, and secondary metabolites in recorded antidiabetic plants. Principal component analysis was used to explore these relationships and determine correlations between various parameters. The results of this study can contribute to a better understanding of the chemical composition of antidiabetic plants and identify new potential drugs for diabetes treatment.

Principal component analysis (PCA), whose matrix illustrates the intersection of all classes of identified chemical compounds in the recorded species with botanical families (Fig. 6) and with plant parts that serve as sources of antidiabetic agents (Fig. 7), allowed for the identification of two main groups at the level of Figure 6 and three groups at the level of Figure 7.

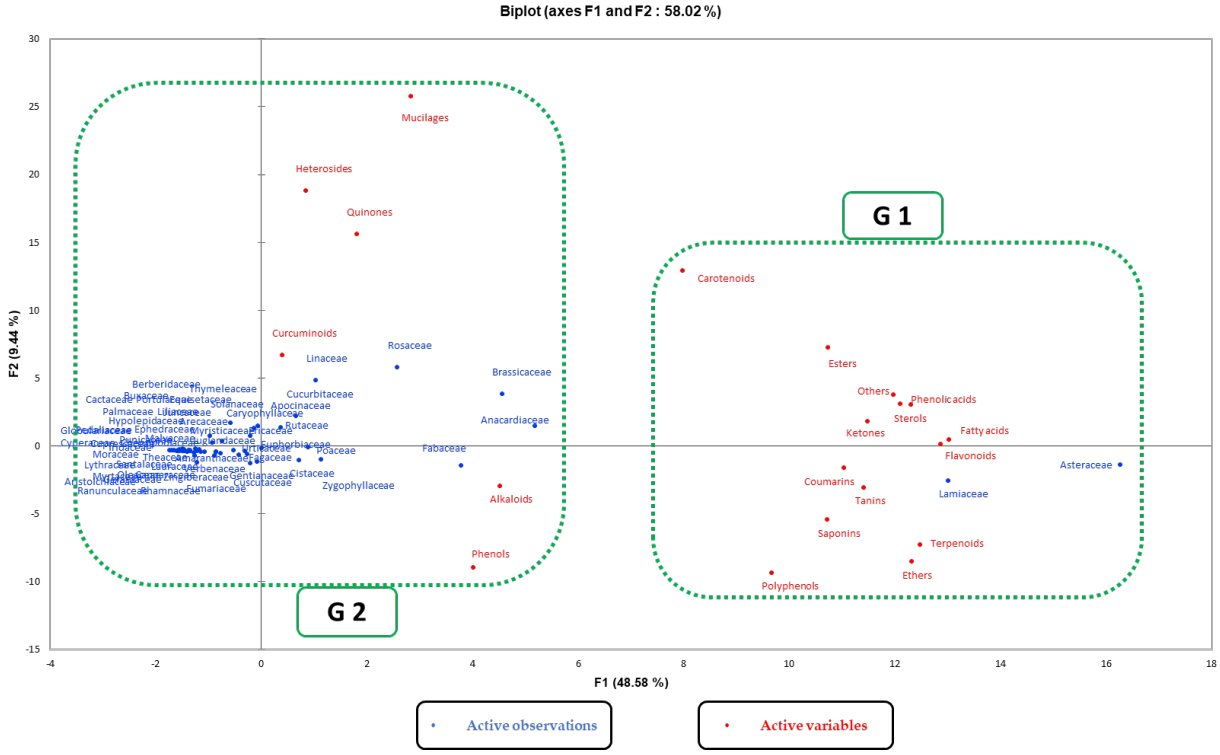

Figure 6. Graphical Representation of Principal Component Analysis of Botanical Families and Identified Compound Classes in Recorded Plants

At the level of Figure 6, on the factorial plane, axis F1 carries the most information in the PCA (48.58% of inertia), while the inertia expressed by F2 remains relatively low (9.44%) but contributes to the interpretation of this analysis. The two axes F1 and F2 oppose two groups: the first represented by the Lamiaceae and Asteraceae families along with the classes of flavonoids, terpenoids, phenolic acids, tannins, coumarins, fatty acids, saponins, sterols, esters, ketones, ethers and polyphenols. The second group represents other recorded botanical families and the classes of alkaloids, phenols, carotenoids, curcuminoids, quinones, heterosides, and mucilages.

The findings suggest that plants belonging to the Lamiaceae and Asteraceae, are the most commonly applied species in traditional Moroccan medicinal practices for managing diabetes due to their richness in terpenoids, flavonoids, and phenolic acids (Bouyahya *et al.* 2021). Notably, several species within these families, abundant in phenolic and terpenoid compounds, are widely recognized for their antidiabetic applications. These include *Ajuga iva, Calamintha officinalis, Allium cepa*, , various *Lavandula* species (such as *dentata* L., *officinalis* L. *stoechas* L., and *L. x abrialis*), *Mentha pulegium, Salvia officinalis, Mentha suaveolens, Origanum compactum, Marrubium vulgare, Rosmarinus officinalis, Teucrium polium, Thymus satureioides, Thymus vulgaris, Artemisia arborescens, Cichorium intybus, Achillea odorata, Echinops spinosus, Cynara scolymus, , Ormenis africana, Ormenis scariosa, Helianthus annuus, Matricaria chamomilla, Scorzonera undulata, Launaea arborescens,*

Taraxacum officinale, and *Tanacetum vulgare*.These families are used in different regions of Morocco, reflecting their recognized efficacy in traditional antidiabetic treatments (Barkaoui *et al.* 2017; Bellakhdar 1997; Benlamdini *et al.* 2014; Eddouks *et al.* 2017; Chaachouay *et al.* 2019; Fakchich & Elachouri 2021; Hachi *et al.* 2015; Skalli *et al.* 2019; Hmamouchi 1999; Tahraoui *et al.* 2007).

Figure 7 represents the dispersion of chemical classes about the studied plant material in the plane formed by the two axes F1 and F2 based on the selected variables. This representation captures 70.13% of the variability,with 56.34% attributed to the first axis and 13.79% to the second axis. The figure delineates three groups displaying similarities in terms of chemical composition while also indicating that the chemical composition of various species recorded as sources of antidiabetic agents is quite heterogeneous. Group 1 (G1) is characterized by leaves, seeds, flowering tops, and aerial parts alongside classes of flavonoids, terpenoids, phenolic acids, polyphenols, tannins, coumarins, fatty acids, saponins, sterols, esters, ketones, quinones, and alkaloids. Group 2 (G2), conversely, is represented by fruits, positively correlated with the classes of phenols, mucilages, carotenoids, and curcuminoids. Finally, group 3 (G3) encompasses other studied plant materials correlated with the class of ether compounds.

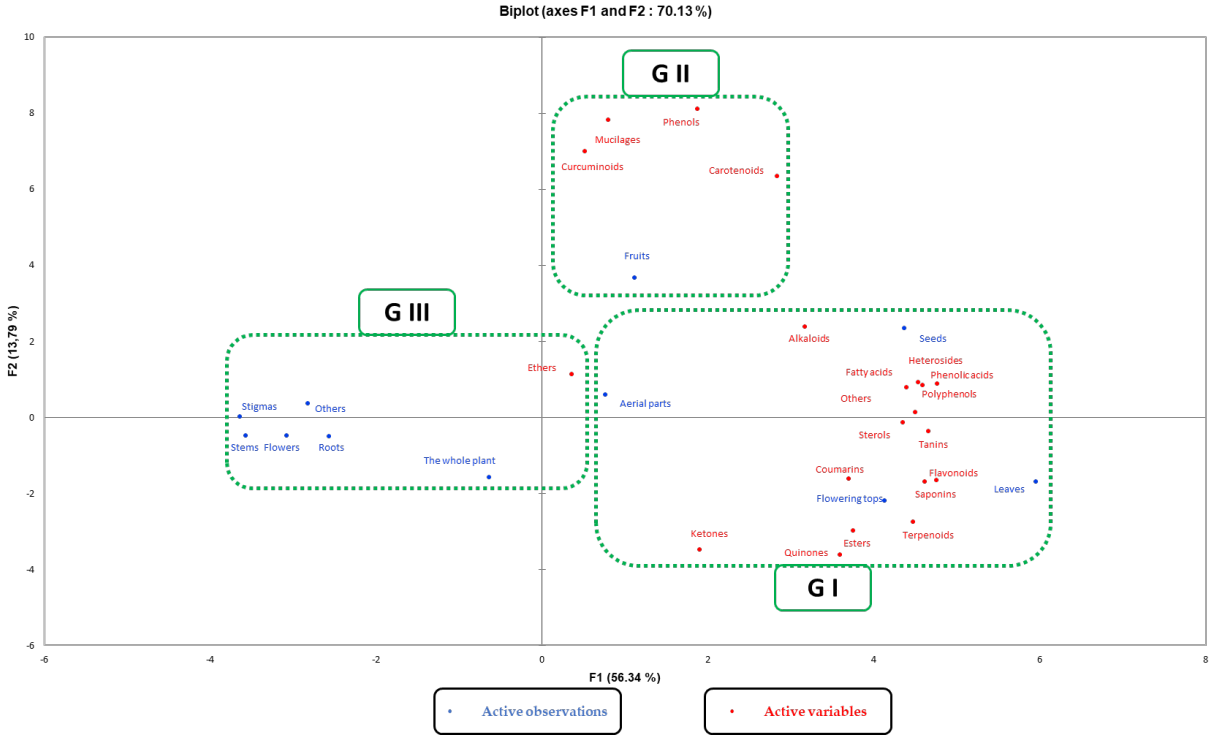

Figure 7. Principal Component Analysis between Antidiabetic Plant Parts and Identified Compound Classes in Recorded Plants

The leaves, seeds, and aerial parts of the plant are most commonly employed to treat diabetes in traditional Moroccan therapies. These plant parts are rich in terpenoids, phenolic acids, flavonoids, and alkaloids, which numerous scientific studies have identified as exhibiting antidiabetic effects. As demonstrated in Figure 7, these bioactive compounds are closely associated with the antidiabetic capacity of Moroccan medicinal herbs.

Conclusion

Emphasizing the phytochemical profiles and antidiabetic activities, this review intends to collect and analyze all Moroccan medicinal plants used for diabetes treatment. To the best of our knowledge, after a meticulous search of bibliographies, 212 plant species belonging to 62 botanical families with documented antidiabetic effects were gathered more efficiently. Many of these species belong to the Asteraceae family, with 15.09% of all documented species used in the treatment or cure of diabetes in Morocco found to be contained within this plant family.

The findings from the present review suggest that Moroccan ethnobotany is rich and promising for the treatment of diabetes. Some of these plants also have bioactive compounds that may exert hypoglycemic effects through multiple pharmacological mechanisms. However, most of these plants are employed without sufficient scientific basis. Concerns include toxic effects, misidentification, incorrect doses of plant material taken, and drug contamination with toxic plants. The present review synthesizes reported data and bridges the gap from classical reports to scientific evidence, indicating an urgent need for

additional pharmacological, toxicological, and clinical studies. Such studies are necessary to establish the safety and efficacy of Moroccan medicinal plants in health, especially when considering their future use as plant-based remedies, dietary supplements, or anti-diabetic drugs.

Declaration

Ethics approval and consent to participate: Confidentiality, anonymity, and informed approval were rigorously maintained throughout the study. Participants were thoroughly informed about the study's objectives and gave their consent before taking part.

Consent for publication: Not applicable.

Data availability: available.

Conflict of interest: no conflicts of interest.

Funding: This study was conducted without external financial support.

Author contributions: HEL, AD, HT, TZ, KA conceived the work, HEL, SS, FR, BL, AG and AA compiled the information and wrote the manuscript, FEM, YC, LB, HT and TZ reviewed the manuscript. All authors approved the final manuscript

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