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MEDICINAL PLANTS USED FOR THE TRADITIONAL MANAGEMENT OF DIABETES MELLITUS IN THE REGION OF TIARET, ALGERIA

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ABSTRACT

Traditional and complementary medicines constitute an important source for the management of various illnesses including diabetes, one of the major endocrine problems that is very prevalent worldwide. The aim of this study is to identify and document medicinal plants used by diabetic patients in Algerian ethnopharmacology for the management of diabetes mellitus. Semi-structured interviews with 260 diabetic patients were realized in in the region of Tiaret (Algeria) during the period 2018-2022. Results revealed the use of 45 medicinal plants belonging to 43 genera and 26 families. The most represented botanical families are Lamiaceae, Apiaceae, and Fabaceae. However, the most cited plant species are *Cinnamomum verum* J. Presl, *Olea europaea* L., *Trigonella foenum-graecum* L., *Coriandrum sativum* L., *Artemisia herba-alba* Asso., *Lupinus albus* L., *Berberis vulgaris* L., *Boswellia sacra* Flueck, and *Ajuga iva* (L.) Schreb. Aerial part and seeds represent the most used plant parts. The indicated plants are consumed raw directly or are taken in form of infusion or decoction. Our findings are relevant to deliver background base to search for novel molecules for diabetes therapy.

Key words: Aromatic and medicinal plants; Diabetes; Traditional medicine; Ethnopharmacology; Tiaret; Algeria.

INTRODUCTION

Diabetes is one of the most common chronic diseases and its rate of occurrence has increased significantly over the past decades (Bullard et al., 2018). Diabetes mellitus is a group of metabolic diseases characterized by chronic hyperglycemia resulting from a defect in insulin secretion or insulin action or both associated abnormalities (Rodier, 2001). Chronic hyperglycemia is a major cause of blindness, kidney failure, myocardial infarction, strokes and lower limb amputation (Drouin et al., 1999).

According to the World Health Organization (WHO), age-specific diabetes mortality rates increased by 3% between 2000 and 2019 while diabetes and diabetic kidney disease caused approximately two million deaths in 2019 (WHO 2022). In addition, the percentage of deaths from high blood sugar or diabetes occurring before the age of 70 is higher in low- and middle-income countries than in high-income countries (WHO 2016).

Algeria is also experiencing an epidemiological transition where diabetes poses a real public health problem through its chronic complications dominated by cardiovascular problems, diabetic foot, chronic renal failure and retinopathy (Belhadj 2005). The number of diabetics in Algeria rose from one million people in 1993 to more than 2,500,000 in 2007, which represent nearly 10% of the population in 2010 (Dali-Sahi et al., 2012).

Despite the advancement in the chemical synthesis of drugs in the last 100 years, traditional medicine based on the use of aromatic and medicinal plants for the treatment of many diseases, including diabetes mellitus, is increasing in popularity. Plants serve as a major source of dietary supplements in regulating blood glucose and reducing long-term problems in type II diabetes (Gallagher et al. 2003). Due to their efficacy, availability, accessibility, and relatively low cost, herbal medications are commonly used worldwide (Nasri 2013). According to the WHO (2018), nearly 80% of the populations from African developing countries use traditional medicine. This is why WHO (2000) has recommended the evaluation of the safety and efficacy of herbal medicines in order to standardize their use and integrate them into conventional healthcare systems.

The use of traditional medicine is widespread in Algeria and several herbal remedies used individually or in combination are recommended to treat diabetes mellitus. The present study is an ethnopharmacological search directed in the aim to document medicinal plants used by diabetic patients to manage traditionally and treat diabetes mellitus in the region of Tiaret (Algeria). Such studies are required to enrich and safeguard the local traditional knowledge regarding medical practices. In addition, the identification of the used plants in medicinal practices can provide insight into their properties for further exploration.

MATERIAL AND METHODOLOGY

Data was gathered using semi-structured interviews conducted in the region of Tiaret (Algeria) during the period June 2018-July 2022. The study was approved by the scientific committee of the department of natural and life sciences, University of Tiaret (Algeria), and was carried out in accordance with the guidelines of the Helsinki declarations.

A total number of 260 diabetic patients was interviewed. Patients assisted in the collection of the medicinal plants, which were then identified using the local flora along with various resources and bibliography (Quézel 1962–1963; Ozenda 1977). Care was used while identifying the samples because local names could not be totally trusted. The scientific names of plant species were confirmed by the International Index of Plant Name (http://www.ipni.org) and the Plant List database (http://www.theplantlist.org).

RESULTS

Overall, 45 medicinal plants belonging to 26 botanical families and 43 genera have been documented for the traditional treatment of diabetes mellitus in the region of Tiaret (Algeria) (Table 1). The most represented botanical families were Lamiaceae (5 species), Apiaceae (4 species), and Fabaceae (4 species). However, the other botanical families are represented by two or one species.

However, the most cited plant species are *Cinnamomum verum* J. Presl, *Olea europaea* L., *Trigonella foenum-graecum* L., *Coriandrum sativum* L., *Artemisia herba-alba* Asso., *Lupinus albus* L., *Berberis vulgaris* L., *Boswellia sacra* Flueck, and *Ajuga iva* (L.) Schreb. These plant species belong to 39 dicots and 6 monocots, and are distributed among 27 herbs, 13 trees, and 5 shrubs.

The most used organ parts in diabetes remedy are represented by the aerial part (25 %), seeds (22 %), leaves (16 %), and fruits (12 %). The indicated plant parts are used in form of infusion (38 %), raw (21 %), or decoction (18 %).

Table 1. Medicinal plants used by diabetic patients for the management of diabetes in the region of Tiaret (Algeria).

Plant family & species	Common name	Local name	FC	Plant part	Mode of preparation	Application
Amaryllidaceae						
Allium cepa L.	Onion	Bassel	3	Bulb	Raw	Daily with meals
Allium sativum L.	Garlic	Thoum	3	Bulb	Raw	Daily on an empty stomach
Anacardiaceae						
Anacardium occidentale L.	Cashew	Djouz el Kadjou	2	Fruit	Raw	Daily 2 or 3 times
Pistacia vera L.	Pistachio	El fostok	2	Fruit	Raw	Daily
Apiaceae						
Ammodaucus leucotrichus Coss.	Ammodaucus	Kemoune m'saoueff	3	Leaf, seed	Infusion	Daily 2 or 3 times
Coriandrum sativum L.	Coriander	Kosbor	12	Seed	Maceration, infusion, powder	Daily on an empty stomach or after meals
Petroselinum crispum (Mill.) Fuss	Parsley	Maadnous	5	Aerial part	Raw, decoction	Daily with meals
Cuminum cyminum L.	Cumin	Kemmoune	4	Seed	Powder, infusion	Daily
Berberidaceae						
Berberis vulgaris L.	Barberry	Aoud ghriss	7	Bark, stem	Infusion	Daily 2 or 3 times
Brassicaceae						
Brassica oleracea L.	Broccoli	Kromb	4	Leaf	Decoction	Daily 2 or 3 times during 2 months
Lepidium sativum L.	Cress	Hab errachad	3	Seed	Raw	Daily 2 or 3 times
Burseraceae						
Boswellia sacra Flueck	Boswellia	Loubane dhakar mor	8	Gum-resin granules	Maceration, decoction	Daily 2 or 3 times
Caryophyllaceae						
Polycarpaea repens (Forssk.) Asch. & Schweinf.	Kameela	Maker	2	Aerial part	Infusion	Daily 2 or 3 times
Compositae						
Artemisia absinthium L.	Wormwood	Chehaiba	8	Aerial part	Infusion	Daily on an empty stomach
Artemisia herba-alba Asso	White wormwood	Chiḥ	14	Aerial part	Decoction, infusion	Daily 2 or 3 times
Cucurbitaceae						
Cucurbita pepo L.	Pumpkin	Kabouya	2	Fruit	Decoction	Daily after meals
Euphorbiaceae						
Euphorbia guyoniana Boiss. & Reut.	Spurge	Loubayna	3	Aerial part	Infusion, powder	Daily 2 or 3 times
Gentianaceae						
Centaurium erythraea Rafn	Centaury	Mararet el h'nech	4	Flower and leaf	Infusion	Daily 2 or 3 times
Juglandaceae						
Juglans regia L.	Walnut	Ain el Jamel	3	Fruit, leaf	Raw, infusion	Daily 2 times
Lamiaceae						
Ajuga iva (L.) Schreb.	Herb Ivy	Chendgoura	6	Aerial part	Decoction, infusion	Daily 2 or 3 times after meals
Lavandula stoechas L.	Lavender	Khozama	5	Aerial part	Raw, infusion	Daily 2 times
Mentha × *piperita* L.	Peppermint	Naânaâ	6	Aerial part	Infusion	Daily 2 or 3 times

Rosmarinus officinalis L.	Rosemary	Iklil el Jabal	5	Aerial part	Infusion	Daily 1 or 2 times
Salvia officinalis L.	Sage	Miramiya	4	Aerial part	Maceration	Daily 2 or 3 times
Lauraceae						
Cinnamomum verum J.Presl	Ceylon cinnamon tree	Quarfa	35	Bark	Infusion, maceration, powder	Daily 2 or 3 times after meals
Laurus nobilis L.	Bay	Rand	7	Leaf	Decoction, infusion	Daily 1 or 2 times
Leguminosae						
Acacia senegal (L.) Willd.	Sudan gum Arabic	Samgh arabi	4	Gum	Maceration	Daily 2 or 3 times after meals
Lupinus albus L.	Lupin	Filia morra	8	Seed	Raw, powder	Daily on an empty stomach
Phaseolus vulgaris L.	Bean	Loubia	5	Seed	Decoction	Daily 2 or 3 times
Trigonella foenum-graecum L.	Fenugreek	Helba	25	Seed	Infusion, decoction, powder	Daily 2 or 3 times after meals
Malvaceae						
Corchorus olitorius L.	Jute mallow	Molokheya	4	Fruit	Maceration	Daily on an empty stomach
Moraceae						
Ficus carica L.	Fig	Karmous	6	Leaf	Infusion	Daily 2 or 3 times after meals
Morus nigra L.	Blackberry	Toutt	5	Leaf	Infusion	Daily 2 or 3 times after meals
Myrtaceae						
Syzygium aromaticum (L.) Merr. & L.M.Perry	Clove	Koronfoul	4	Flower bud	Raw, powder	Daily on an empty stomach
Oleaceae						
Olea europaea L.	Olive	Zeytoune	27	Leaf, oil	Raw, infusion, powder	Daily 2 or 3 times
Plantaginaceae						
Globularia alypum L.	Globularia	Tasselgha, aynoun	3	Aerial part	Infusion, decoction	Daily 1 or 2 times
Poaceae						
Hordeum vulgare L.	Barley	Zeraa	4	Seed	Raw	Daily 1 or 2 times
Triticum turgidum L.	Durum wheat	Guemh	5	Seed	Decoction	Daily 1 or 2 times
Ranunculaceae						
Nigella sativa L.	Black caraway	Sanouj	6	Seed, oil	Decoction, raw	Daily 2 or 3 times
Rosaceae						
Amygdalus amara Hayne	Bitter almond	Louz morr	4	Seed	Raw	Daily
Prunus persica (L.) Batsch	Peach	Khoukh	5	Leaf	Infusion	Daily 2 or 3 times
Rutaceae						
Citrus limon (L.) Osbeck	Lemon	Lime	7	Fruit	Juice	Daily
Zingiberaceae						
Curcuma longa L.	Turmeric	Korkom	6	Rhizome	Infusion	Daily 1 or 2 times after meals
Zingiber officinale Roscoe	ginger	Zenjabil	5	Rhizome	Decoction, infusion	Daily 2 or 3 times after meals
Zygophyllaceae						
Tetraena alba (L.f.) Beier & Thulin	Tetraena	Aggaya	2	Aerial part	Powder, infusion	Daily during 1 month

Discussion

According to Taïbi et al. (2020-2022) and Djahafi et al. (2021), Algerian populations hold vast traditional knowledge and traditions about the use of natural products for the treatment and management of a wide range of illnesses.
In the present study, 45 medicinal plant species have been recognized traditionally used for the management of diabetes mellitus. According to the studies conducted by Chorfi and Taïbi (2011) and Taïbi et al. (2017; 2018), extreme environments modify the metabolic composition of plants and raise the synthesis of specific metabolites related to stress resistance.
Therefore, environmental stresses increase the amount and diversity of bioactive molecules in plants (Taïbi et al., 2016), which might partially account for some of the documented medicinal qualities of steppe and Saharan Algerian plants.

The diversity of flora inventoried throughout this study is distributed within 43 genera and 26 families, which demonstrates the importance of the local populational knowledge in the use of traditional medicines. The most represented families are Lamiaceae (5 species), Apiaceae (4 species), and Fabaceae (4 species) respectively. The most common plants' life-forms used for the management of diabetes mellitus were herbs (60%), trees (29%) and shrubs (11%). According to Ahmad et al. (2009), the use of herbs may be due to their abundance from a part, and to their medicinal efficacy from another part. However, the use of shrub and tree life-forms is due to their availability throughout the year for the users and practitioners (Khan et al., 2013).

Furthermore, the most common used organ parts for diabetes remedy are the aerial part (25%), seeds (22%), leaves (16%), and fruits (12%). Opportunely, the use of these parts does not threaten the life cycle of the used plants (Bhat et al., 2013). In addition, the most practiced mode of preparation are infusion (38%), direct use of raw material (21%), and decoction (18%). These modes of preparation could be suitable for some plant species but not for the others (Taïbi et al. 2020-2022).

Interestingly, the most cited plant species by patients are *Cinnamomum verum* J. Presl, *Olea europaea* L., *Trigonella foenum-graecum* L., *Coriandrum sativum* L., and *Artemisia herba-alba* Asso. It has been noted that hydro-alcoholic extract of Cinnamon can improve postprandial glycemia more than its aqueous extract (Beejmohun et al. 2014). It can rise glucose uptake by raising the number of insulin receptors, glucose transporter and activating glycogen synthase (Singh et al., 2021).

However, cinnamon aqueous extract holds antidiabetic activity in alloxan induced diabetic rat tested for thirty days through reducing fasting blood sugar, triglycerides and total cholesterol. Interestingly, a lower dose of 200 mg/kg showed maximum antidiabetic efficacy (El-Desoky et al. 2012). It has been shown that extracts rich in phenolics owned high inhibitory activity for α-glucosidase and α-amylase (Gulcin et al. 2019). Cinnamom contains derivatives like cinnamaldehyde and cinnamic acid that have an antidiabetic activity (Hariri and Ghiasvand 2016). Cinnamon polyphenols like eugenol and pyrogallol can demonstrate antidiabetic properties by renovating beta cells which leads to hypoglycemic and hypolipidemic actions (Singh et al. 2021).

In addition, Olive contains several potent active compounds that may have hypoglycemic properties in both human and rats' diabetic subjects. The antihyperglycemic activity of Olive has been confirmed both *in vivo* in alloxan and streptozotocin diabetic rats (Ahmadvand et al., 2014), alloxan diabetic rabbits (Al-Azzawie and Alhamdani, 2006), rats with type 2 diabetes (Liu et al., 2014) and *in vitro* studies (Hadrich et al., 2016).

This may be attributable to its high antioxidant activity (El-Amin et al., 2013), the reduction of starch digestion (Wainstein et al., 2012), the inhibition of pro-inflammatory cytokine along with the upregulation of insulin receptors (Liu et al., 2014), or through its positive impact on glucose metabolism and insulin sensitivity (Hadrich et al., 2016). By the same, the antidiabetic potential of fenugreek has been studied the most, and has been as well used widely by diabetic patients (Yadav et al., 2014). The daily consumption of fenugreek seed-derived extract improved the antioxidant status, increased liver glycogen content and decreased serum glucose in type-2 diabetic rats (Hannan et al., 2007).

The benefits of fenugreek are due to its richness in seed-derived polyphenols that decrease carbohydrate digestion and improve peripheral insulin action. Moreover, galactomannan-rich soluble fiber found in fenugreek decreases triglyceride and LDL cholesterol levels by combining with bile acid. It has also nicotinic acid, alkaloid trigonelline, and coumarin, which have all been linked to its antidiabetic effects (Olaiya and Soetan 2014).

Overall, most of the listed medicinal plants are found to be rich in phenolic compounds and vitamins, mainly folic acid, holding strong antioxidant potential which might explain the physiological antidiabetic activity arising out of the use of these medicinal plants.

CONCLUSION

Ethnopharmacological studies remain an important source for drugs discovery and for the management of various diseases worldwide including diabetes. The present study revealed the traditional use of 45 medicinal plants belonging to 43 genera and 26 families for the management of diabetes mellitus in the region of Tiaret (Algeria). These plants belong mainly to Lamiaceae, Apiaceae, and Fabaceae botanical families. However, the most frequently USED plant species are respectively *Cinnamomum verum* J. Presl, *Olea europaea* L., *Trigonella foenum-graecum* L., *Coriandrum sativum* L., *Artemisia herba-alba* Asso., *Lupinus albus* L., *Berberis vulgaris* L., *Boswellia sacra* Flueck, and *Ajuga iva* (L.) Schreb. Aerial part and seeds represent the most used plant parts. The indicated plants are consumed raw directly or are taken in form of infusion or decoction. Further *in vitro* and *in vivo* studies are needed to validate the traditional uses of these medicinal plants.

REFERENCES

1. Ahmad H., Khan S.M., Ghafoor S., Ali N. 2009. Ethnobotanical Study of Upper Siran. J. Herbs Spices Med. Plants.15(1):86–97;
2. Ahmadvand H., Noori A., Dehnoo M.G., Bagheri S., Cheraghi R.A. 2014. Hypoglycemic, hypolipidemic and antiatherogenic effects of oleuropein in alloxan induced Type 1 diabetic rats. Asia Pac. J. Trop. Dis. 4, S421–S425;
3. Al-Azzawie H.F., Alhamdani M.S. 2006. Hypoglycemic and antioxidant effect of oleuropein in alloxan-diabetic rabbits. Life Sci. 78, 1371–1377;
4. Beejmohun V, Peytavy-Izard M, Mignon C, Muscente-Paque D, Deplanque X, Ripoll C, et al. 2014. Acute effect of Ceylon Cinnamon extract on postprandial glycemia: alpha-amylase inhibition, starch tolerance test in rats, and randomized crossover clinical trial in healthy volunteers. BMC Complement Altern Med 14:351;
5. Belhadj, M. 2005. Guide de diabétologie. Ed.7. Comité médical national de diabétologie;
6. Bhat J.A., Kumar M., Bussmann R.W. 2013. Ecological status and traditional knowledge of medicinal plants in Kedarnath Wildlife Sanctuary of Garhwal Himalaya, India. J. Ethnobiol. Ethnomed. 9(1):1;
7. Bullard, K. M., Cowie, C. C., Lessem, S. E., Saydah, S. H., Menke, A., Geiss, L. S., et al. (2018). Prevalence of diagnosed diabetes in adults by diabetes type - United States 2016. Morb. Mortal. Wkly. Rep. 67, 359–361;
8. Chorfi A., Taïbi K. 2011. Biochemical Screening for Osmotic Adjustment of Wheat Genotypes under Drought Stress. Tropicultura. 29(2):82–87;
9. Dali-Sahi M, Benmansour D, Aouar A, Karam N. 2012. Étude de l'épidémiologie du diabète de type 2 dans des populations endogames de l'ouest algérien. Lebanese Science Journal, 13 (2): 17-26 ;
10. Djahafi A., Taïbi K., Aït Abderrahim L., 2021. Aromatic and medicinal plants used in the region of Tiaret, North-West of Algeria. Mediterranean botany, 42, e71465;
11. Drouin P., Blickle J., Charbonnel B., Eschwege E., Guillausseau P. et al. 1999. Rapport des experts de l'ALFEDIAM diagnostic et classification du diabète sucré les nouveaux critères. Diabetes et Metabolism Paris. France. 25, 72-83 ;

12. El-Amin M., Virk P., Elobeid M.A., Almarhoon Z.M., Hassan Z.K., Omer S.A., Merghani N.M., Daghestani M.H., Al-Olayan E.M. 2013. Anti-diabetic effect of *Murraya koenigii* (L.) and *Olea europaea* (L.) leaf extracts on streptozotocin induced diabetic rats. Pak. J. Pharm. Sci. 26, 359–365;
13. El-Desoky GE, Aboul-Soud MAM, Al-Numair KS. 2012. Antidiabetic and Hypolipidemic Effects of Ceylon Cinnamon (*Cinnamomum verum*) in Alloxan-Diabetic Rats. J Med Plants Res. 6:1685–91;
14. Gallagher AM, Flatt PR, Duffy G, Abdel-Wahab YHA. 2003. The effects of traditional antidiabetic plant on in vitro glucose diffusion. Nutr Res 23(3): 413-424;
15. Gulcin I., Kaya R., Goren A.C., Akincioglu H., Topal M., Bingol Z., Cetin Çakmak K., Ozturk Sarikaya S.B., Durmaz L., Alwasel S. 2019. Anticholinergic, antidiabetic and antioxidant activities of cinnamon (*Cinnamomum verum*) bark extracts: Polyphenol contents analysis by LC-MS/MS. Int. J. Food Prop. 22, 1511–1526;
16. Hadrich F., Garcia M., Maalej A., Moldes M., Isoda H., Feve B., Sayadi S. 2016. Oleuropein activated AMPK and induced insulin sensitivity in C_2C_{12} muscle cells. Life Sci. https://doi.org/10.1016/j.lfs.2016.02.027;
17. Hannan J.M., Ali L., Rokeya B., Khaleque J., Akhter M., Flatt P., Abdel-Wahab Y.H. 2007. Soluble dietary fibre fraction of *Trigonella foenum-graecum* (fenugreek) seed improves glucose homeostasis in animal models of type 1 and type 2 diabetes by delaying carbohydrate digestion and absorption, and enhancing insulin action. Br. J. Nutr. 97, 514–521;
18. Hariri M., Ghiasvand R. 2016. Cinnamon and chronic diseases, Adv. Exp. Med. Biol. 929; 1e24;
19. Khan S.M., Page S., Ahmad H., Shaheen H., Ullah Z., Ahmad M., Harper D.M. 2013. Medicinal flora and ethnoecological knowledge in the Naran Valley, Western Himalaya, Pakistan. J. Ethnobiol. Ethnomed. 9(1):4;
20. Liu Y.N., Jung J.H., Park H., Kim H. 2014. Olive leaf extract suppresses messenger RNA expression of proinflammatory cytokines and enhances insulin receptor substrate 1 expression in the rats with streptozotocin and high-fat diet–induced diabetes. Nutr. Res. 34, 450-457;
21. Nasri H, Shirzad H. 2013. Toxicity and safety of medicinal plants. J Herb Med Pharmacol. 2(2), 21-22;
22. Olaiya C.O., Soetan K.O. 2014. A review of the health benefits of fenugreek (*Trigonella foenum-graecum* L.): Nutritional, Biochemical and pharmaceutical perspectives. Am. J. Soc. Issues Hum. 1, 3–12;
23. Ozenda P. 1977. Flore du Sahara. Ed CNRS, Paris, p. 622;
24. Quézel P., Santa S. 1962–1963. Nouvelle Flore de l'Algérie et des Régions Désertiques Méridionales. Paris, 2 Tomes, Centre National de la Recherche Scientifique.
25. Rodier M. 2001. Définition et classification du diabète. Médecine Nucléaire - Imagerie fonctionnelle et métabolique - 2001 - vol.25 - n°2, 91–93;
26. Singh N, Rao AS, Nandal A, Kumar S, Yadav SS, Ganaie SA, et al. 2021. Phytochemical and pharmacological review of *Cinnamomum Verum* J. Presl-A versatile spice used in food and nutrition. Food Chem. 338:127773;
27. Taïbi K., Aït Abderrahim L., Boussaid M., Taïbi F., Achir M., Souana K., Benaissa T., Farhi K.H., Naamani F.Z., Nait Said K. 2021. Unraveling the ethnopharmacological potential of medicinal plants used in Algerian traditional medicine for urinary diseases. European Journal of Integrative Medicine, 44, 101339;
28. Taïbi K., Aït Abderrahim L., Ferhat K., Betta S., Taïbi F., Bouraada F., Boussaid M. 2020. Ethnopharmacological study of natural products used for traditional cancer therapy in Algeria. Saudi Pharm. J., 28 (11), 1451-1465;
29. Taïbi K., Aït Abderrahim L., Helal F, Hadji K, 2021. Ethnopharmacological study of herbal remedies used for the management of thyroid disorders in Algeria. Saudi Pharmaceutical Journal, 29 (1), 43-52;
30. Taïbi K., Del Campo A.D., Vilagrosa A., Bellés J.M., López-Gresa M.P., López-Nicolás J.M., Mulet J.M. 2018. Distinctive physiological and molecular responses to cold stress among cold-tolerant and cold-sensitive *Pinus halepensis* seed sources. BMC Plant Biol. 18(1):236;
31. Taïbi K., del Campo A.D., Vilagrosa A., Bellés J.M., López-Gresa M.P., Pla D., Calvete J.J., López-Nicolás J.M., Mulet J.M. 2017. Drought tolerance in *Pinus halepensis* seed sources as identified by distinctive physiological and molecular markers. Frontiers in Plant Science 8(1202);
32. Taïbi K., Taïbi F., Aït Abderrahim L., Ennajah A., Belkhodja M., Mulet J.M. 2016. Effect of salt stress on growth, chlorophyll content, lipid peroxidation and antioxidant defense systems in *Phaseolus vulgaris* L. S. Afr. J. Bot.105:306–312;

33. Wainstein J, Ganz T, Boaz M, Bar Dayan Y, Dolev E, Kerem Z, Madar Z. 2012. Olive leaf extract as a hypoglycemic agent in both human diabetic subjects and in rats. Journal of Medicinal Food 15(7):605-610.
34. WHO 2000. Principes méthodologiques généraux pour la recherche et l'évaluation relatives à la médecine traditionnelle;
35. WHO 2016. Global report on diabetes: Executive Summary. www.who.int/diabetes/global-report WHO/NMH/NVI/16.3;
36. WHO 2018. Global Health Observatory. who.int/gho/database/en/, in: Geneva, S.W.H.O. (Ed.);
37. WHO 2022. Diabète. https://www.who.int/fr/news-room/ fact-sheets/detail/diabetes;
38. Yadav U.C., Baquer N.Z. 2014. Pharmacological effects of Trigonella foenum-graecum L. in health and disease. Pharm. Biol. 52, 243–254;