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Antidiabetic Potential of Selected Medicinal Plants: A Literature Review

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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Review Article

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ABSTRACT

Aims: To investigated for any scientific evidence indicating traditional use of different plant species in the management of diabetes.
Study Design: Review Article.
Place and Duration of Study: Conducted in Saudi Arabia from December 2020 to August 2021.
Methodology: The literature was thoroughly investigated for any scientific evidence indicating traditional use of different plant species in the management of diabetes. The search was done in databases of Google Scholar, Saudi Digital Library and PubMed. Accordingly, the used plant species are classified into six groups. These are: Plants with antidiabetic activity, Plants with hypoglycemic activity, plants with alpha-glucosidase activity, Plants with alpha-amylase activity, Plants with glucose tolerance test, Plants with hypolipemic, anti-cholesterol, LDL and HDL activity.
Conclusion: We have done in vitro and in vivo evaluation of *M. arvensis L*. for antidiabetic activity.

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The leaves extracts of *M. arvensis L*. showed significant antioxidant potential and significantly inhibited protein glycation, which correlated well with its phenolics along with other phytoconstituents. the methanolic extract of *M. arvensis L*.

Keywords: Medicinal plants; antidiabetic potential; diabetes.

1. INTRODUCTION

Diabetes mellitus is perhaps the most widely recognized metabolic problems. It is an expanding medical issue all through the world which can prompt grave intricacies in the body after some time. Type 2 diabetes mellitus (T2DM), by and large named as diabetes, is one of the significant endocrine illnesses which influences a great many individuals in the modern and agricultural nations. Diabetes is a metabolic sickness portrayed by inadequate insulin discharge, debilitated cell activity of the insulin or both. The trademark manifestations of diabetes are polydipsia, weight reduction, polyphagia, obscured vision, polyuria, tachycardia and hypotension. Dietary and way of life factors (Obesity, weight acquire, actual dormancy and low fiber diet with a high glycemic list) assume a huge part in the advancement of diabetes.The treatment of diabetes mellitus depends on insulin, diet change and oral hypoglycemic specialists [1]. Natural medication has created as an option for the treatment of diabetes since oral hypoglycemic specialists are costly and labeled with a few results. There are various therapeutic plants portrayed for treatment of diabetes. Present review is focused on information for species well known for their antidiabetic impact. Different sorts of Ocimumtenuiflorum are alluded to and utilized as drug arrangements in the Indian course of action of medication. Different accommodating things for instance fundamental oils, natural tea, wood is gotten from this restorative plant. Basil (*Ocimumbasilicum L*.) is a sweet-smelling plant developed for strict, restorative, and culinary purposes just as for its fundamental oil (EO). The species is not endemic to Brazil, despite the fact that during the servitude time frame, it was brought to the nation by subjugated Africans, and Afro-Brazilians keep on utilizing it in the regular day to day existences [2]. Lavender (*Lavandula angustifolia*) is a plant with various useful properties for the human body. Other than its application in natural treatment, lavender is generally utilized in the restorative, fragrance, food, and aromatherapeutic ventures [3]. P. frutescens regularly known as Perillais a yearly spice found in China, Korea, Japan and the Himalayan locale of India and Nepal. Natural examination of Perilla plant uncovered that this plant showed anti-microbial, hostile to hypersensitive, against malignancy, against tumor, against discouragement, hostile to viral, anti-asthmatic and cell reinforcement activities [4]. Satureja hortensis L. addresses a yearly herbaceous harvest species, emphatically stretched, with straight leaves having a place with the Lamiaceae family. The primary biomolecules found in concentrates and fundamental oils of S. hortensis are the unpredictable oils, phenolic compounds, flavonoids, tannins, steroids, acids, gums, adhesive and pyrocatechols, prompting distinctive likely applications in treating some intense issues, like diabetes, cardiovascular sicknesses, malignancy, Alzheimer's, close by the cell reinforcement, antimicrobial and mitigating properties [5]. Calamintha officinalis have a long history of utilization in current medication and in specific frameworks of conventional medication, and are the wellsprings of significant medications like atropine, codeine, digoxin, morphine, quinine and vincristine. The therapeutic plants contain a few phytochemicals, for example, Vitamins (A, C, E, and K), Carotenoids, Terpenoids, Flavonoids, Polyphenols, Alkaloids, Tannins, Saponins, Enzymes, and Minerals and so on. Ballota species are perpetual spices or little bushes with expanded and additionally straightforward hairs, toothed and petiolate leaves, the inflorescence thyrsoid or racemoid now and again has long and spinose bracteoles (order. Acanthoprasium), and the calyx is generally campanulate, purple to white [6]. Origanum vulgare L. has a place with Lamiaceae family and it is a fragrant suffering spice found in all aspects of Europe. During the blooming season, the gathered elevated parts contain impressive measures of unpredictable oil (0.18-1.02%) (Robu and Milica, 2004). The properties of the oregano extricate result from its bioactive segments that act in a synergistic way and incorporate diuretic, antispasmodic, stomachic, antimicrobial (bactericidal, fungicidal, and viricidal), antiparasitic and immunomodulator exercises. Lamiaceae is likewise systematically known as mint group of blooming plants [7]. *Mentha longifolia L*. [Lamiaceae (Labiatae)],

commonly known as wild mint or pony mint. Numerous species are developed for their therapeutic properties like sterile, antispasmodic, sedative, antimicrobials and, it is additionally utilized for culinary, scent, flavor and fragrance based treatment. Thymus zygis is an endemic Portuguese plant. In spite of the fact that T. zygis is generally utilized as a fixing and as a restorative spice, a definite portrayal of the polyphenol creation of hydroethanolic (HE) and watery decoction (AD) separates isn't accessible. In this work, we depict interestingly a point-by-point phenolic arrangement of T. zygis. Nonetheless, the significant phenolic compound is rosmarinic acid, and high measures of salvianolic acids K and I were likewise distinguished. T. zygis removes displayed huge searching movement of hydroxyl (•OH), and nitric oxide (NO) extremists [8]. Melissa officinalis L. is a restorative plant that has for some time been utilized in various ethno-clinical frameworks particularly in the European Traditional Medicine and the Iranian Traditional Medicine for the treatment of a few sicknesses. It is additionally broadly utilized as a vegetable and to add flavor to dishes Aim of the survey: This audit intended to give a rundown on the plant portrayal, customary utilizations, phytochemistry, pharmacological exercises, pharmacokinetics and poisonousness of M. officinalis, and examines research holes and future freedoms for examinations on this plant [9].About 800 plant species have been reported to possess antidiabetic properties. Several oral hypoglycemic agents are the primary forms of treatment for diabetes [10]. In this review, selected species that have been validated for their hypoglycemic or antihyperglycemic properties using laboratory diabetic animal models and in clinical trials using human subjects, and published in refereed journals are presented.The aim of this studyto investigated for any scientific evidence indicating traditional use of different plant species in the management of diabetes.

To compile maximum information published for anti-diabetic medicinal plants.

2. MATERIALS AND METHODS

2.1 Methods

The literature was thoroughly investigated for any scientific evidence indicating traditional use of different plant species in the management of diabetes. The search was done in databases of Google Scholar, Saudi Digital Library and PubMed. Accordingly, the used plant species are classified into nine groups. These are:

1. Plants with antidiabetic activity
2. Plants with hypoglycemic activity
3. Plants with alpha-glucosidase activity
4. Plants with alpha-amylase activity
5. Plants with glucose tolerance test
6. Plants with antidiabetic and cardiovascular activity
7. Plants with hypolipemic, anti-cholesterol, LDL and HDL activity
8. Plants with antidiabetic and antioxidant activity
9. Plants with antidiabetic and Kidney/renal protective activity

3. RESULTS AND DISCUSSION

3.1 Antidiabetic Medicinal Plants

3.1.1 Antidiabetic activity

Origanum vulgare: The defensive movement of Origanum vulgare against the carbon tetra chloride instigated hepatotoxicity was accounted for by Sikander et al. (2013). Moghaddam et al. (2013) recognized an incomplete decline of the glomular development and oxidative pressure in kidney of diabetic mice by delayed treatment of O. majorana. In addition, Habibi et al. (2015) examined the defensive impacts of O. vulgare against the hepatotoxicity brought about by cyclophosphamide in mice [11].

Ballota hirsute: Tyrosinase was additionally adequately repressed by 2 mixtures secluded from the AP concentrate of B. cinerea from India: 4-methoxybenzo[b]azet-2(1H)-one and 3β-hydroxy-35(cyclohexyl-5′-propan-7′-one)- 33-ethyl-34-methyl-bacteriohop-16-ene with hindrance pace of 83.0 and 58.2%, separately, at 100 μM. These mixtures were additionally successful inhibitors of α-glucosidase (78.5% and 58.4%). This inhibitory action is identified with the above talked about antidiabetic action in vivo of these mixtures. The α-glucosidase and β-glucosidase decrease exercises were assessed in an examination on the antidiabetic action in vitro and in vivo of certain concentrates of B. cinerea from India. Three divisions were discovered more dynamic, separately, got with ethyl-acetate, and MeOH extract; their movement decrease power went about from 55 to 80%, with the MeOH remove being the most dynamic. In

another work, these concentrates were tried in an in vitro inhibitory movement test against protein tyrosine phosphatase-1B, showing results going from 39 to 65% hindrance at 100 µM [6].

Salvia officinalis: Oral organization of 0.2 and 0.4 g/kg body wt. of the wise concentrate for 14 days displayed a huge decrease in serum glucose, fatty oils, all out cholesterol, urea, uric corrosive, creatinine, AST, ALT and expanded plasma insulin in streptozotocin-initiated diabetic rodents yet not in ordinary rodents. Glibenclamide was utilized as reference and showed comparative antidiabetic impact [12].

Ocimumbasilinicum: One of the remedial methodologies is to decrease postprandial arrival of glucose in the blood. Two key chemicals that are associated with lessening postprandial glucose are a-amylase and aglucosidase. In vitro and in vivo assessment of M. arvensis for antidiabetic action was done. Any awkwardness between the free radicles and cancer prevention agents prompts creation of a condition known as "oxidative pressure" that outcomes in the advancement of neurotic condition among which one is diabetes mellitus [13].

Rosmarinus officinalis: Bioactivities of rosemary removes incorporate properties, for example, mitigating, antidiabetic, hepatoprotective and antimicrobial movement. These bioactivities are identified with the phenolic compound constituents (for the most part caffeic corrosive, rosmarinic and carnosic acid). There are a couple of logical reports relating on the antidiabetic capability of different concentrates from Rosmarinus officinalis evil presence stated that the mixture of the plant has hypoglycaemic impact though its unstable oils have hyperglycaemic impacts [14].

Thymus vulgeris: α-Glucosidase are answerable for the examination of oligo-as well as disaccharides to monosaccharides. Accordingly, these proteins prompts a decline the degree of blood glucose, on the grounds that the type of starches (monosaccharides) are retained through the mucosal line in the small digestive tract. [15].

Mentha arvensis: One of the remedial methodologies is to decrease postprandial arrival of glucose in the blood. Two key chemicals that are associated with lessening postprandial glucose are a-amylase and aglucosidase. *In vitro* and in vivo assessment of M. arvensis for antidiabetic action was done. Any awkwardness between the free radicles and cancer prevention agents prompts creation of a condition known as "oxidative pressure" that outcomes in the advancement of neurotic condition among which one is diabetes mellitus [13].

3.2 Hypoglycemic Activity

3.2.1 Ocimumtenuiflorum

The hydroalcoholic concentrate of O. tenuiflorum showed huge enemy of diabetic and hostile to hyperlipidemic movement against STZ + nicotinamide prompted diabetes mellitus in rodents. Further examinations are needed to affirm the counter diabetic and hostile to hyperlipidemic exercises of individual phytoconstituents of O. tenuiflorum [16].

3.2.2 Ocimumbasilinicum

The treatment with 100 and 200 mg/kg extricate altogether ($P < 0.05$) decreased fasting blood glucose focus and somewhat expanded mean body weight in treated gatherings [17].

3.2.3 Teucrium polium

Additionally, it has hypoglycemic impacts and has been utilized in diabetic patients as a hypoglycemic specialist. Day by day consumption of this plant assists with keeping up typical degrees of glucose and can be fitting for customary drugs to control blood sugar. likewise, T. polium has calming activity, just as diminish high body weight and high blood pressure9 and has cell reinforcement and lipid-bringing down properties [18].

3.3 Alpha-glucosidase Activity

3.3.1 Origanum vulgare

In vitro measures showed that the concentrate restrained α-glucosidase movement, advanced glucose take-up, repressed glycosylation and eased oxidative pressure, which proposed that O. vulgare leaf extricate has a solid hypoglycemic limit [19].

3.3.2 Salvia hispanica

The point of this examination was the assessment of the inhibitory impact of peptide parts subordinates of the hydrolysis of Salvia hispanica against α-amylase and α-glucosidase

Table 1. List of medicinal plants

	Plant name	Synonym	Part/extract	Traditional use	Biologial activity	Reference
1	*Ocimum tenuiflorum*	*Ocimum sanctum*	Leaves	Gastrointestinal proplem. Antipyretic. Analgesic. reduce stress.	Antidiabetic activity. hypoglycemic activity. Glucose tolerance test. Cardiovascular activity. Hypolipemic activity. Antioxidant activity.	Khurana, [20] Parasuraman et al, [16] Mousari et al, [21]
2	*Ocimum basilinicum*	NA.	Leaves	Headaches. Coughs. Diarrhea. Constipation. Worms.	Antidiabetic activity. hypoglycemic activity. alpha-Glucosidase activity. Cardiovascular activity. Antioxidant activity Kidney/renal protective activity.	Pereira et al, [2] Ezeani et al, [19] Etsassala et al, [22]; Almalki, 2019.
3	*Teucrium polium*	Felty germander	-	Diuretic. Antipyretic. Antifungal. Antispasmodic. Antirheumatic. Antibacterial.	Antidiabetic activity Hypoglycemic activity Glucose tolerance test Hypolipemic activity Antioxidant activity alpha- Amylase activity	Khazaei et al, [17] Abu soud et al, [23]; Vessal et al, [24] Amraei, [25]
4	*Coleus forskohlii*	Plectranthus barbatus	Methanol	Eczema Asthma Psoriasis Hypertension	Antidiabetic activity Hypoglycemic activity Glucose tolerance test Cardiovascular activity Hypolipemic activity Antioxidant activity	Rios Silva, [26]
5	*Ballota hirsute*	Ballota ciner or Ballota hispa	Flavonoid	Antimicrobial Antispasmodic Insecticidal Anti-malaria	Antidiabetic activity Antioxidant activity Hypoglycemic activity activity alpha- Amylase activity Kidney/renal protective activity	Rosselli, [6]
6	*Origanum vulgare*	NA.	Carvacrol and thymol	Antioxidant. Antidiabetic. Antimicrobial. Antiviral. Antiparasitic. Antineoplastic.	Antidiabetic activity Hypolipemic activity Antioxidant activity Hypoglycemic activity alpha-Glucosidase activity alpha-Amylase	Alagawan, [11] Lemhadri, 2004 [27]; Huawei, 2021 [28]; Farashah, [29] Ranjbary, [30-31]
7	*Marrubium vulgare*	Marrubium.	Flavonoid Tannins	Coughs Colds	Antidiabetic activity Hypoglycemic activity alpha-Glucosidase activity	Lodhi, [7] Boudjelal, Amel, et al.,2012

			Saponins Volatile oils		alpha- Amylase activity Glucose tolerance test Cardiovascular activity Hypolipemic activity.	[32]; Abd ElMohsen, [11] Göğer, F., et al., 2019[33]; Elberry, 2015.
8	*Salvia officinalis*	NA.	Sage oils	Antispasmodic Sedative Analgesic Diuretic	Antidiabetic activity Hypoglycemic activity alpha- Amylase activity 5. Glucose tolerance test Antioxidant activity	MD, Resident of Obstetrics and Gynecology,2016[34]; Eidi, 2009[35]; Ninon, 2020; Cristovao, 2006 [36].
9	*Salvia hispanica*	Divinorum	α-linolenic acid	Hepatic protective effects Antiageing Anti-carcinogenic	Antidiabetic alpha-Glucosidase activity Glucose tolerance test Cardiovascular activity Hypolipemic activity	Rahman Ullah, 2016 [37]; Enes, Bárbara Nery, et al.2020 [38]; Sosa, 2018;
10	*Mentha arvensis*	Cornmint	Menthol	Carminative Stimulant	Antidiabetic activity alpha Amylase activity Antioxidant activity	Akram et al, [13]
11	*Rosmarinus officinalis*	Rosemary	vegetable oil	Antioxidant Antibacterial	Antidiabetic activity Antioxidant activity	Nieto et al, [14]
12	*Thymus vulgeris*	common thyme, Ger man thyme, gard en thymeor just thyme	Essential oils	Antimicrobial Antitussive Antispasmodic Antibacterial.	Antidiabetic activity Hypoglycemic activity alpha-Glucosidase activity Cardiovascular activity Hypolipemic activity, Antioxidant activity	Aljarah, Hameed, [15] Edwin, [39]; Ayşe Çivit3, 2019.
13	*Thymus zygis*	white thyme	Upper part of stems	cosmetics	Antioxidant activity	Soare et al, 1997 [40].
14	*Ajuga iva*		Aerial parts growth	Rheumatism allergy Metabolic disorders Cardiovascular disorders Respiratory disorders	Antidiabetic activity Cardiovascular activity Hypolipemic activity Antioxidant activity	Bouyahya et al, 2020 [41].

proteins to know their movement on the carbs digestion. the enzymatic framework showing the most noteworthy evaluation of hydrolysis (63.53%) was pepsin-pancreatine. From the ultrafiltration, five peptide parts were gotten: 10 kDa, 5-10 kDa, 3-5 kDa, 1-3 kDa and 1 kDa. The most noteworthy protein content was for these parts: 10 kDa and 5-10 kDa, (0.90 and 0.93 mg/ml, individually) for pepsin-pancreatine. The restraint rates acquired were 85.61% and 79.19% for the 10 kDa and 5-10 kDa parts, separately, for the α-amylase chemical. Regarding the αglucosidase compound, the most noteworthy restraint was for the 10 kDa portion, with 96.91% [42].

3.3.3 Thymus vulgeris

α-Glucosidase are liable for the examination of oligo-as well as disaccharides to monosaccharides. In this manner these chemicals prompts a decline the degree of blood glucose, on the grounds that the type of starches (monosaccharides) are retained through the mucosal boundary in the small digestive system [15].

4. ALPHA-AMYLASE ACTIVITY

4.1 Origanum Vulgare

Catalyst action of alpha-amylase and beta-1,3-glucanase in sprouting seeds at 12 h after beginning of imbibition were tested. Lethargic seeds showed lower protein action and compound movement in treated seeds expanded essentially [29].

4.2 Teucrium Polium

Thirteen plant species which are professed to have against diabetic action (in light of people medication and/or logical reports) were tried for alpha amylase inhibitory action. Two of the screened plants showed critical (over 80%) alpha amylase inhibitory movement. lC50 of these plants was assessed dependent on the dried unrefined concentrate and discovered to be 0.08, and 0.2 mg/ml for Aloe Vera and Paronychia argentea individually. In A. vera the action was in all likelihood due to cinnamic corrosive subordinates. In P. argentea the action was credited to flavonoid segments. These discoveries uphold the hypoglycemic action of these species and give knowledge about the expected instrument of their hypoglycemic action [23].

4.3 Mentha Arvensis

a-Amylase and a-glucosidase and hindrance of postprandial hyperglycemia in starch initiated diabetic Wistar rodents were additionally assessed utilizing methanolic concentrate of M. *arvensis L*. leaves. Inhibition of a-amylase by methanolic concentrate of M. *arvensis L*. was seen to be over half restraint at different concentrations (mg/ml) when contrasted with the standard acarbose which showed over 90% hindrance of a-amylase at similar fixations [13].

5. GLUCOSE TOLERANCE TEST

5.1 Coleus Forskohlii

The oral glucose resistance test (OGTT) was promotion served solid rodents toward the start and at the end of the examination. After 8 h short-term quick, glucose (2 g/kg) was given orally, and blood glucose levels were estimated, as portrayed above, at 0, 30, 60, also, 120 min after glucose stacking [26].

5.2 Marrubium Vulgare

The antidiabetic action of a day by day single oral portion of 500 mg/kg/day of M. vulgare for 28 days was assessed by estimating the fasting blood glucose and the pinnacle of blood glucose level inside 120 min of oral glucose resistance test (OGTT) in diabetic rodents. Moreover, the impact of the concentrate on blood plasma insulin was estimated just as its impact on tissue glycogen substance in muscles and liver. Besides, its impact on the oxidant status was assessed [7].

5.3 Salvia Hispanica

Chia oil diminished hyperglycemia and insulin opposition. Glucose and insulin resistance were gotten to through intraperitoneal glucose resilience test (iGTT) and insulin resilience test (ITT). (A) glucose region under the bend during iGTT, (B) mean blood glucose levels after intraperitoneal implantation of glucose arrangement, (C) kITT during ITT, (D) mean blood glucose levels after insulin intraperitoneal imbuement. Information are communicated as mean and standard deviation. Various letters address huge contrasts ($p < 0.05$) by Tukey's test. HFHF: high-fat and high-fructose, chia flour (HFHF with 14.7% of chia flour) and chia oil

(HFHF with 4% of chia oil). kITT: consistent pace of glucose vanishing in ITT test [43].

6. HYPOLIPEDEMIC ACTIVITY (CHOLESTEROL, LDL, HDL)

6.1 Marrubium Vulgare

Marrubium vulgare fundamentally decreased the blood glucose level beginning the subsequent week. Moreover, the concentrate of M. vulgare showed huge expansion in plasma insulin and tissue glycogen substance. The anti-dyslipidemic impact was shown by a critical decrease in plasma complete cholesterol (TC), fatty oils (TG), and low thickness lipoprotein-cholesterol (LDL-C), while the cardio-defensive lipid, high thickness lipoprotein-cholesterol (HDL-C), was expanded [44].

6.2 Ocimumtenuiflorum

The hydroalcoholic concentrate of O. tenuiflorum showed huge enemy of diabetic and hostile to hyperlipidemic action against STZ + nicotinamide incited diabetes mellitus in rodents. Further investigations are needed to affirm the counter diabetic and against hyperlipidemic exercises of individual phytoconstituents of O. tenuiflorum [16].

6.3 Teucrium Polium

Organization of the concentrate essentially decreased the serum levels of fatty substance, cholesterol and LDL-cholesterol and fundamentally expanded the serum HDL-cholesterol levels. Moreover, the 170 mg/kg portion of TPHAE was the best in lessening serum levels of fiery and lipid markers [25].

6.4 Thymus vulgeris

It was observed that the plant leaves were enriched with chemical and nutritional properties, exerted hypoglycemic effect on diabetic rats, and normalized the high lipid profile of diabetic rats. This study showed that these spices do not just impact flavor to our foods, but may be useful in reducing the risk of cardiovascular complication arising from diabetes and other metabolic diseases [39.

6.5 Ajuga Iva

In creatures took care of with elevated cholesterol diet (hypercholester-olemic rodents), the lyophilized fluid concentrate of A. iva ethereal parts at 0.5 g/100 g diet revised dyslipidemia, diminished the oxidative pressure in hypercholesterolemic rodents and improved cell reinforcement status by bringing down lipid peroxidation and improved cancer prevention agent compounds [45].

7. CONCLUSION

We have done in vitro and in vivo evaluation of M. *arvensis L*. for antidiabetic activity. The leaves extracts *of M. arvensis L.* showed significant antioxidant potential and significantly inhibited protein glycation, which correlated well with its phenolics along with other phytoconstituents. the methanolic extract of M. *arvensis L*. significantly reduced postprandial hyperglycemia and it might be helpful in prevention of onset as well as delaying the development of long term complications of diabetes mellitus. Thus, it has been ratio-nalized that the tested extract has the potential to emerge as a new remedy for treatment of type 2 diabetes mellitus (postprandial hyperglycemia). Wild mint (M. longifolia) is a useful functional food. At the present study, M. longifolia var. calliantha (Stapf) Briq. was investigated for its phytochemicals and functional properties for the first time. Antioxidant, antidiabetic, and neuroprotective effects of wild mint were confirmed using in vitro assays. M spicata, which has effective hypoglycemia, hypolipidemia and lipid peroxidation activities in diabetic rats, may be useful for the clinical treatment of diabetes. T. polium can reduce blood sugar by increasing insulin secretion or increase hepatic metabolism or glucose. Plants of Ocimum species have great medicinal values for treating various health problems and were used throughout the world. O. tenuiflorum, O. basilicum, O. gratissimum and O. canum have reportedly shown antihyperglycemic potentials in both in vitro and in vivo studies. S. hispanica seeds may have potential cardiovascular benefits, although the results from clinical trials are contradictory. S.hispanica seeds could decrease glucose levels in humans as several clinical studies have evidenced. S. miltiorrhiza and S. officinalis, which exhibited potential cardiovascular and/or hypoglycemic effect. M. officinalis is a medicinal plant that has been long used in various ethnomedical systems. The obtained findings of Thymus serpyllum L. showing significant activity in brine shrimp lethality assay and antitumor assay provide the evidence for a very strong positive correlation between these two assays

and prediction of some valuable anti-cancerous principles of this plant extract. This study provided a comprehensive investigation of hydrophilic and hydrophobic fractures of Thymus vulgaris and Thymbra spicata for chemical composition, antioxidant activity, and antimicrobial activity. T. zygis subsp. zygis has thus a great potential to be used as a functional food, for example as decoction or herbal tea or as condiment. Furthermore, due to the biological activities presented by the phenolic compounds, especially in the HE extract, it can also be a source of bioactive ingredients with antioxidant, antiproliferative, and anti-inflammatory properties.

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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