Chemical Composition, Antioxidant, and Enzyme Inhibitory Activities of the Essential Oils of Three *Phlomis* Species as well as Their Fatty Acid Compositions

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Abstract This study aimed to investigate the chemical composition, antioxidant, and enzyme inhibitory activities of the essential oils of *Phlomis armeniaca* WILLD., *P. nissolii* L., and *P. pungens* WILLD. var. *pungens* as well as their fatty acid contents. Germacrene D was found as the major compound in the oils (24.7, 15.1, and 7.2%, respectively). Additionally, *n*-hexadecanoic acid, hexahydrofarnesyl acetone, β -caryophyllene, and linalool were the other main compounds in the oils. Among the fatty acids, C18:3 ω 3 and C18:2 ω 6 were determined in high quantities in *P. armeniaca* (23.14 and 18.01%, respectively) and *P. pungens* var. *pungens* (24.64 and 17.51%, respectively). The essential oils of *P. armeniaca* and *P. pungens* var. *pungens* showed remarkable antioxidant and metal chelating activities as well as great reducing power potentials. These oils also showed a moderate scavenging effect on ABTS radicals. The oils also exhibited various degrees of inhibitory activities on AChE, BChE, α -amylase, α -glucosidase, and tyrosinase.

Keywords: *Phlomis armeniaca*, *Phlomis nissolii*, *Phlomis pungens* var. *pungens*, β -caryophyllene, palmitic acid

Introduction

Essential oils are known as complex secondary metabolites produced by aromatic plants and characterized by their strong odors. Biological potentials of essential oils such as antitumor, anti-inflammatory, antioxidant, and antibacterial activities have attracted the attention of scientists (1,2). Today, approximately 3000 varieties of essential oils are known. About 10% of these oils have commercial importance in the pharmaceutical, agriculture, food, sanitary, cosmetic, and perfumery industries. Some essential oil components have been used in the production of perfume and cosmetics and sanitary products as well as in the dentistry, agriculture, and food additive industries (3,4). Essential oils have also been used in aromatherapy when mixed with vegetable oils (particularly in massages and baths) (5). Some essential oils have potential in the treatment of various organ dysfunctions and systemic diseases due to their medicinal properties (6).

Nowadays, scientists try to develop different strategies for the treatment of Alzheimer's disease. In this disease, due to the degeneration and atrophy of cholinergic neurons in the basal

forebrain, neuropathological symptoms and cognitive deficits occur (7). According to this view, known as cholinergic hypothesis, the basis of the treatment is inhibition of acetylcholinesterase (AChE). galantamine, rivastigmine, and donepezil are well-known AChE inhibitors used in clinical treatments (8). According to studies conducted in recent years, some plants have been found to be significant sources of AChE inhibitors (9,10). Galantamine and rivastigmine are plant-derived alkaloids. These substances provide symptomatic relief, even though they cannot prevent the progression of disease (11). AChE inhibition plays an important role in the treatment of dementia, myasthenia gravis, Parkinson's disease, and glaucoma as well as Alzheimer's disease (12). Currently, natural and alternative AChE inhibitors with less side effects and long-term efficiency are needed. For this purpose, several plant species from different parts of the world have been screened for their cholinesterase inhibitory activities (13).

The most effective way of keeping blood sugar levels under control is to inhibit the absorption of glucose by suppressing carbohydrate-hydrolyzing enzymes such as α -amylase and α -glycosidase (14). Acarbose, miglitol, and voglibase are important enzyme inhibitors

used in clinical treatments (14). However, as a result of the use of these substances, various side effects such as liver diseases, flatulence, abdominal fullness, and diarrhea have been observed (15). Therefore, there is an increasing interest in nontoxic and readily available natural enzyme inhibitors (16).

In recent years, the number of studies on α -glycosidase and α -amylase inhibitors derived from natural resources has increased. By suppressing the activities of these enzymes, hydrolysis of starch or disaccharides into monosaccharides can be retarded. This event leads to a decrease in blood sugar level. Therefore, food-derived enzyme inhibitors play an important role in the treatment of type 2 diabetes. Several studies have been published on the inhibitory activities of sorghum, foxtail millet, praso millet (15), guava leaves (17), and eggplant (18) against α -glucosidase and α -amylase.

Tyrosinase is frequently used in cosmetic and food industries and in medications as an anti-browning agent (19). It is well known that melanin is the primary compound responsible for skin color and is synthesized by tyrosinase. Melanin plays a critical role in the protection of skin cells against harmful UV rays. This process is known as "ultrafast internal conversion" (20). On the other hand, in some cases, melanin accumulation can cause severe esthetic problems such as freckles, age spots, and melisma (21). Modulation of melanin production process is an important strategy for managing skin problems associated with abnormal skin pigmentation (22). Tyrosinase catalyzes several steps in melanogenesis. Therefore, identification of tyrosinase inhibitors is of considerable interest (19).

In this study, we aimed to investigate the chemical composition, antioxidant, and enzyme inhibitory activities of the essential oils of *Phlomis armeniaca* WILLD., *P. nissolii* L., and *P. pungens* WILLD. var. *pungens* as well as their fatty acid compositions. According to our literature survey, antioxidant, and enzyme inhibitory activities of herbal infusion obtained from *P. armeniaca* have been reported (23). Additionally, antioxidant activities of ethanol and water extracts of *P. pungens* var. *hispidula* (another *P. pungens* variety) have been reported (24). However, biological activities of the essential oils evaluated here have not been reported. Therefore, data presented in this study could be assumed as an original contribution to the literature.

Materials and Methods

Plant material The plant materials were taxonomically identified by Dr. Olcay Ceylan from the Department of Biology, Mugla University, Mugla-TURKEY. The voucher specimens were also deposited at the same department.

The localities and collection periods of *Phlomis* species areas were as follows:

1. *P. pungens* WILLD. var. *pungens* WILLD.: Karagöl-Çubuk highway, Ankara-Turkey on 13 July, 2013 (2 km, 40°16'27"N 33°00'52"E, 1080 m; Voucher No: MUH3544)

2. *P. nissolii* L.: Cumra-Bozkır highway, Konya-Turkey on 20 July 2013 (10-15 km, 37°32'46"N 32°40'22"E, 1026 m, Voucher No: MUH2445)

3. *P. armeniaca* WILLD.: Kemer kaya town, Tömsö castle, Bolvadin-Afyonkarahisar-Turkey on 23 June 2013 (38°53'59"N 31°06'13"E, 1520 m, Voucher No: MUH1877)

Isolation and analysis of the essential oils As the first step, in order to extract the essential oils, the air-dried and powdered plant material (500 g) was subjected to hydro-distillation by using a British-type Clevenger apparatus (ILDAM Ltd., Ankara, Turkey). Then, the oil was dehumidified by adding anhydrous sodium sulfate and filtrated. After this process, the oil was stored at +4°C until tested and analyzed. The oils were subjected to GC-FID and GC-MS analysis by using the conditions reported by Sarikurkcü *et al.* (25).

Antioxidant activity Antioxidant activities of the essential oils of *Phlomis* species were investigated by using the following assays: phosphomolybdenum, metal chelating, reducing power (CUPRAC and ferric reducing antioxidant power (FRAP)), and free radical scavenging (on DPPH, superoxide anion, and nitric oxide). All the analyses were carried out according to the conditions reported by Zengin *et al.* (26).

Enzyme inhibitory activity The enzymes were investigated for their inhibitory activities on AChE, BChE, α -amylase, α -glucosidase, and tyrosinase using methods previously reported (26).

Determination of fatty acid composition *Phlomis* species were also subjected to a screening to evaluate their fatty acid compositions by using the method given in the literature (27).

Statistical analysis All the assays were done in triplicate. Results obtained from all the assays were presented as means and standard deviations (mean $\pm$ SD). One-way analysis of variance and Tukey's honest significant difference post hoc test with $\alpha=0.05$ (SPSS v. 14.0) were used to determine the differences among the assays.

Results and Discussion

Chemical composition Essential oil composition of *P. armeniaca*, *P. nissolii*, and *P. pungens* var. *pungens* are presented in Table 1 (the chromatograms in Fig. 1). According to data presented in this table: 21, 24, and 15 compounds were identified as representing 98.4, 98.3, and 91.8% (w/w) of the essential oils, respectively. Oil yields of the species were calculated as 0.021, 0.015, and 0.022% (v/w), respectively.

In *P. armeniaca* oil, germacrene D (24.1%), *n*-hexadecanoic acid (21.8%), and hexahydrofarnesyl acetone (13.7%) were found as the major compounds (Table 1). In the case of *P. nissolii*, the major compounds were determined to be germacrene D (15.1%), β -caryophyllene (12.7%), hexahydrofarnesyl acetone (11.9%), and

Table 1. Chemical composition of the essential oils of aerial parts of *Phlomis* species

RT (min)	RI ¹⁾	Compound	Concentration % (w/w)		
			<i>P. armeniaca</i>	<i>P. nissolii</i>	<i>P. pungens</i> var. <i>pungens</i>
32.13	1532	β-Bourbonene	0.4	0.8	0.8
32.65	1548	Linalool	3.6	11.3	0.3
34.37	1602	β-Elemene	0.7	-	0.2
34.76	1615	β-Caryophyllene	4.8	12.7	0.6
36.22	1663	<i>allo</i> -Aromadendrene	-	6.9	-
36.44	1671	(Z)-β-Farnesene	5.9	0.6	1.3
37.01	1690	α-Humulene	0.6	0.5	-
37.49	1707	α-Terpineol	0.8	3.6	-
38.16	1730	Germacrene D	24.1	15.1	7.2
38.29	1735	Valencene	-	0.5	-
38.50	1742	β-Selinene	1.0	-	-
38.86	1755	Bicyclogermacrene	3.0	1.4	-
39.40	1774	δ-Cadinene	0.4	0.6	0.2
41.23	1841	(E)-β-Damascenone	-	0.6	-
41.55	1853	Geraniol	-	3.3	-
41.89	1868	(E)-Geranyl acetone	-	-	0.1
42.76	1900	Nonadecane	-	2.5	-
45.78	2018	Caryophyllene oxide	2.2	7.1	1.2
46.42	2044	(E)-Nerolidol	-	2.8	-
47.75	2100	Heneicosane	-	1.3	-
48.58	2135	Hexahydrofarnesyl acetone	13.7	11.9	4.0
48.89	2148	Spathulenol	6.0	4.0	2.2
49.82	2188	Anisketone	3.0	-	-
50.32	2209	T-Murolol	0.5	-	0.6
51.42	2255	α-Cadinol	2.0	1.8	2.3
52.52	2300	Tricosane	1.0	3.3	-
58.66	2500	Pentacosane	1.4	2.1	-
63.60	2618	Phytol	1.9	0.9	2.7
67.32	2696	Heptacosane	-	2.7	-
78.45	2912	<i>n</i> -Hexadecanoic acid	21.8	-	68.1
Total			98.4	98.3	91.8
Yield (% w/w)			0.021	0.015	0.022

¹⁾Retention index relative to *n*-alkanes on HP-innowax capillary column

linalool (11.3%). On the other hand, *P. pungens* var. *pungens* showed a different oil profile due to its interesting chemical composition. According to data given in Table 1, major compounds of the oil were determined to be *n*-hexadecanoic acid (68.1%) and germacrene D (7.2%).

The essential oil composition of *Phlomis* species evaluated here has previously been reported (28-30). Yasar *et al.* (28) have found germacrene D (35.68%), β-caryophyllene (18.08%), caryophyllene oxide (13.35%), (E)-β-farnesene (7.24%), and hexahydrofarnesyl acetone (6.99%) as the main compounds in *P. armeniaca*, while germacrene D (33.9%), bicyclogermacrene (15.3%), and (Z)-β-farnesene (10.7%) were found as the major compounds for *P. nissolii* (29). On the other hand, germacrene D (24.5%), bicyclo-germacrene (14.1%), α-pinene (13.5%), and (E)-β-farnesene (13.4%) were predominant components in the oil of *P. pungens* var. *pungens* (30).

In general, the data presented in Table 1 was found to be consistent with the literature data in terms of the major compounds

such as germacrene D, hexahydrofarnesyl acetone, and β-caryophyllene. However, the essential oil composition was found to be quite different from those published before. Chemical compositions of the essential oils can vary based on several factors such as climatic conditions, soil structure and composition, altitude, percentage of moisture, and developmental stage of the plant species. Therefore, the differences in the essential oil compositions are quite normal.

As well as the essential oil composition, the fatty acid compositions of *P. armeniaca*, *P. nissolii*, and *P. pungens* var. *pungens* were also studied (Table 2). For each of the samples, saturated (SFA), monounsaturated (MUFA), and polyunsaturated fatty acids (PUFA) were determined quantitatively.

As seen in Table 2, the highest SFA amount was determined in the essential oil from *P. armeniaca* (45.52%). The amounts of SFA in the essential oil from *P. nissolii* and *P. pungens* var. *pungens* were found to be almost equal. Among the saturated fatty acids, C16:0 represented the highest amount in all the samples, followed by

Fig. 1. Total ion chromatograms of essential oils from (A) *Phlomis armeniaca*, (B) *P. nissolii*, and (C) *P. pungens* var. *pungens*

C14:0 and C12:0.

In the case of MUFA, *P. nissolii* had the highest content with 27.62%, followed by *P. pungens* var. *pungens* (17.54%) and *P. armeniaca* (13.34%). As seen in the Table 2, all the samples were found to be rich in C18:1 when compared with the other MUFA. As expected, *P. nissolii* had the highest C18:1 (23.69%).

The highest PUFA content was determined in *P. pungens* var. *pungens* (42.15%). PUFA in *P. armeniaca* was found to be almost equal to that of *P. pungens* var. *pungens* (41.15%). C18:3 ω 3 and C18:2 ω 6 were the fatty acids determined in this study.

As is well known, linoleic acid is an essential fatty acid for the human body. The human body can produce all but two of the required PUFAs: linoleic acid (precursor to the ω 6 series) and α -linolenic acid (precursor to the ω 3 series) (31). Due to their high PUFA contents, *P. armeniaca* and *P. pungens* var. *pungens* can be considered as important dietary supplements for humans.

The fatty acid compositions of *Phlomis* species evaluated here have not previously been reported elsewhere. Therefore, data

presented in this section could be assumed as an original contribution to the literature.

Antioxidant capacity The antioxidant, metal chelating, and reducing power potentials of the essential oils of *Phlomis* species are presented in Table 3. According to the data obtained from the phosphomolybdenum assay, the *P. armeniaca* oil showed the highest antioxidant activity (3.61 mmol TEs/g oil), followed by the *P. pungens* var. *pungens* and *P. nissolii* oils. Data concerning the chelating effects of the *Phlomis* oils on ferrous ions are also presented in the table. Contrary to the phosphomolybdenum system, the *P. pungens* var. *pungens* oil was found to be the most active metal chelator (34.73 mg EDTAEs/g oil). In this system, the *P. armeniaca* oil exhibited the weakest chelating activity (21.73 EDTAEs/g oil).

The reducing power potentials of the essential oils of *Phlomis* species were determined by two different test systems named as CUPRAC and FRAP (Table 3). As seen in Table 3, the *P. armeniaca* oil showed the highest reducing capacity in the presence of cupric and

Table 2. Fatty acid composition of the aerial parts of *Phlomis* species

Fatty acids	Concentration (%) ¹⁾		
	<i>P. armeniaca</i>	<i>P. nissolii</i>	<i>P. pungens</i> var. <i>pungens</i>
C 12:0 (Lauric acid)	4.41±0.21a	3.94±0.01ab	2.97±0.44b
C 14:0 (Myristic acid)	4.41±0.04a	3.77±0.29ab	3.08±0.07b
C 15:0 (Pentadecanoic acid)	0.14±0.04a	0.18±0.04a	0.10±0.01a
C 16:0 (Palmitic acid)	33.05±0.47a	27.40±0.17b	27.80±0.23b
C 17:0 (Heptadecanoic acid)	1.97±0.41a	3.06±0.83a	0.93±0.17a
C 18:0 (Stearic acid)	1.56±0.18b	2.14±0.22b	5.46±0.13a
ΣSFA ²⁾	45.52±0.08a	40.48±1.12b	40.33±1.04b
C 14:1 ω5 (Myristoleic acid)	1.40±0.08a	1.15±0.54a	0.82±0.13a
C 15:1 ω5 (cis-10-Pentadecanoic acid)	0.68±0.16	1.26±0.08	1.19±0.47
C 16:1 ω7 (Palmitoleic acid)	0.34±0.04a	1.06±0.47a	0.36±0.07a
C 17:1 ω8 (cis-10-Heptadecanoic acid)	0.48±0.01a	0.48±0.02a	0.83±0.26a
C 18:1 ω9 (Oleic acid)	10.45±0.03c	23.69±0.08a	14.35±0.11b
ΣMUFA ³⁾	13.34±0.15c	27.62±1.20a	17.54±0.69b
C 18:2 ω6 (Linoleic acid)	18.01±0.01a	7.54±0.01b	17.51±1.01a
C 18:3 ω3 (α-Linolenic acid)	23.14±0.06a	24.37±0.06a	24.64±0.66a
ΣPUFA ⁴⁾	41.15±0.05b	31.90±0.07c	42.15±0.35a
ΣUFA ⁵⁾	54.48±0.10b	59.52±1.13a	59.68±1.03a

¹⁾Different letters in the same row indicate significant difference ($p < 0.05$)

²⁾SFA, saturated fatty acids

³⁾MUFA, monounsaturated fatty acids

⁴⁾PUFA, polyunsaturated fatty acids

⁵⁾UFA, unsaturated fatty acids

Table 3. Total antioxidant (by phosphomolybdenum method), metal chelating and reducing power potentials of the essential oils of *Phlomis* species¹⁾

Assays	<i>P. armeniaca</i>	<i>P. nissolii</i>	<i>P. pungens</i> var. <i>pungens</i>
Phosphomolybdenum (mmol TEs/g oil) ²⁾	3.61±0.22a	2.65±0.07c	3.25±0.08b
Metal chelating (mg EDTAs/g oil) ³⁾	21.73±0.87b	24.64±2.12b	34.73±2.57a
CUPRAC reducing (mg TEs/g oil)	58.22±1.76a	49.27±2.20b	49.35±1.31b
FRAP reducing (mg TEs/g oil)	18.07±0.45a	16.93±1.00a	15.16±0.51b

¹⁾Different letters in the same row indicate significant difference ($p < 0.05$)

²⁾TEs, trolox equivalents

³⁾EDTAs, disodium edetate equivalents

ferric ions (58.22 and 18.07 mg TEs/g oil, respectively). The cupric ion reducing potential of this oil was found to be higher than that of the ferric ion reducing potential. In both systems, the *P. armeniaca* oil was followed by the *P. nissolii* and *P. pungens* var. *pungens* oils. As presented in the table, both of the oils showed an almost equal ion reducing potential in the both assays.

The scavenging potentials of the essential oils of *Phlomis* species on DPPH, ABTS, superoxide, and nitric oxide radicals are given in Table 4. Essential oils did not show scavenging effects on DPPH and superoxide radicals. However, the scavenging effect on nitric oxide radicals was found to be quite weak. Among the oils, only the *P. nissolii* oil showed a scavenging effect on this radical (2.05 mmol TEs/g oil). On the other hand, all the oils exhibited a moderate scavenging effect on the ABTS radical. In general, the scavenging potentials of the oils were found to be almost equal. According to data obtained from the ABTS system, the *P. armeniaca* oil was determined to be the strongest scavenger (0.53 mmol TEs/g oil), followed by the *P.*

pungens var. *pungens* and *P. nissolii* oils

As far as our literature survey could ascertain, the antioxidant capacities of *Phlomis* species evaluated here have not previously been reported. Therefore, the data presented here could be assumed as the first report. However, the antioxidant capacity of the herbal infusion of *P. armeniaca* has previously been reported by Dalar and Konczak (23). In this report, the antioxidant capacity was determined by FRAP and oxygen radical absorbance capacity assays. According to these researchers, herbal infusion, which is rich in polar phytochemicals, showed remarkable activity in both of the test systems. As well as *P. armeniaca*, the antioxidant capacity of the water and methanol extracts of another *P. pungens* variety (var. *hispida*) was also determined by Keser *et al.* (24). According to this report, *P. pungens* var. *hispida* flowers and leaves had effective ABTS, DPPH, and superoxide anion radical scavenging, reducing power, and metal chelating activities when compared with BHT, BHA, and α-tocopherol as reference antioxidants. As expected, the essential oils

Table 4. Radical scavenging activities of the essential oils of *Phlomis* species¹⁾

Assays	<i>P. armeniaca</i>	<i>P. nissolii</i>	<i>P. pungens</i> var. <i>pungens</i>
DPPH (mmol TE/g oil) ²⁾	na ³⁾	na	na
ABTS cation (mmol TE/g oil)	0.53±0.004a	0.42±0.006c	0.51±0.002b
Superoxide anion (mmol TE/g oil)	na	na	na
Nitric oxide (mmol TE/g oil)	na	2.05±0.136	na

¹⁾Different letters in the same row indicate significant difference ($p<0.05$)²⁾TE, trolox equivalents³⁾na, not active**Table 5.** Enzyme inhibitory activities of the essential oils of *Phlomis* species¹⁾

Assays	<i>P. armeniaca</i>	<i>P. nissolii</i>	<i>P. pungens</i> var. <i>pungens</i>
Acetylcholinesterase inhibition (mg GALAE/g oil) ²⁾	0.667±0.010c	1.090±0.007b	1.233±0.012a
Butyrylcholinesterase inhibition (mg GALAE/g oil)	1.881±0.023c	3.032±0.006a	2.521±0.018b
α -Amylase inhibition (mmol ACE/g oil) ³⁾	na ⁵⁾	0.029±0.016	na
α -Glucosidase inhibition (mmol ACE/g oil)	11.053±0.810a	0.576±0.028c	8.442±0.278b
Tyrosinase inhibition (mg KAE/g oil) ⁴⁾	66.723±0.269b	63.301±0.941b	86.303±1.075a

¹⁾Different letters in the same row indicate significant difference ($p<0.05$)²⁾GALAE, galanthamine equivalents³⁾ACE, acarbose equivalents⁴⁾KAE, kojic acid equivalents⁵⁾na, not active

evaluated here exhibited weak radical scavenging activities due to their high nonpolar chemical characteristics.

Enzyme inhibitory activity Cholinesterase inhibitory potentials of the essential oils of *Phlomis* species are presented in Table 5. The *P. pungens* var. *pungens* oil was determined to be the highest AChE inhibitor (1.233 mg GALAEs/g oil), while the *P. nissolii* oil showed the best inhibitory potential against BChE (3.032 mg GALAEs/g oil). In both cases, the *P. armeniaca* oil showed the weakest inhibitory effect. According to these results, essential oils of *P. nissolii* and *P. pungens* var. *pungens* can be considered as new and alternative cholinesterase inhibitors. As far as our literature survey could ascertain, this is the first report on the enzyme inhibitory potentials of *Phlomis* species.

α -Amylase and α -glucosidase inhibitory activities of the essential oils of *Phlomis* species are also presented in Table 5. The oils did not show α -amylase inhibitory activity, except the *P. nissolii* oil (0.029 mmol ACEs/g oil). However, the oils showed excellent α -glucosidase inhibitory potentials. Among the oils, *P. armeniaca* showed the best inhibitory activity (11.053 mmol ACEs/g oil), followed by *P. pungens* var. *pungens* (8.442 ACEs/g oil). According to the data presented here, the essential oils of *P. armeniaca* and *P. pungens* var. *pungens* can be considered as alternative inhibitors on α -glucosidase and can be further evaluated for their therapeutic values in the treatment of type 2 diabetes.

The inhibitory effects of the essential oils mentioned above on α -amylase and α -glucosidase have not previously been reported. However, herbal infusion of *P. armeniaca* was studied for its inhibitory effect on these enzymes (23). According to this report, *P. armeniaca* exhibited weak inhibitory activity against α -amylase and

pronounced activity against α -glucosidase, which suggests a potential antidiabetic property. The results presented here are in agreement with those reported by Dalar and Konczak (23).

Table 5 shows the tyrosinase inhibitory potentials of the essential oils of the *Phlomis* species. The *P. pungens* var. *pungens* oil was determined as the most effective tyrosinase inhibitor (86.303 mg KAEs/g oil), followed by the *P. armeniaca* and *P. nissolii* oils. According to these results, the oils studied here (especially *P. pungens* var. *pungens* oil) can be considered as an alternative tyrosinase inhibitory agent. Therefore, the cytotoxic and carcinogenic effects of these oils should be further evaluated.

According to our literature survey, the tyrosinase inhibitory potentials of the essential oils from *Phlomis* species given here have not previously been reported. Therefore, we believe that the data presented here can be assumed to be an original contribution.

In conclusion, the antioxidant and enzyme inhibitory potentials and fatty acid compositions of the essential oils from *Phlomis* species presented here were studied for the first time. According to our results, the *P. armeniaca* and the *P. pungens* var. *pungens* oils showed remarkable antioxidant and metal chelating activities as well as great reducing potentials. These oils also showed a moderate scavenging effect on ABTS radicals. However, all the oils exhibited various degrees of inhibitory activities on AChE, BChE, α -amylase, α -glucosidase, and tyrosinase. Additionally, the *P. armeniaca* and *P. pungens* var. *pungens* oils were found to be rich in polyunsaturated fatty acids. Due to their excellent antioxidant and enzyme inhibitory activities and fatty acid profiles, *Phlomis* species evaluated here can be considered as important sources for human diet and can also be considered as alternative sources for the treatment of enzyme-related diseases such as Alzheimer's disease, type 2 diabetes, and skin problems.

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