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Full Length Research Paper

Free radical scavenging and antibacterial activity of essential oil and solvent extracts of *Iris planifolia* (Mill) from Algeria

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Free radical scavenging and antibacterial activity of essential oil and solvent extracts of *Iris planifolia* (Mill) was investigated. The essential oil was analyzed by Gas chromatography mass spectrometry (GC-MS) and a total of 38 types of volatile organics were identified. The essential oil consists chiefly of alkanes (36.5%), acids (19.1%), ketones (11.7%), alcohols (9.0%), arylpropanoids (6.8%) and aldehydes (4.1%) accompanied by relatively much smaller amounts of monoterpenes (1.0%). The antimicrobial activity of essential oil and ethanolic extract shows an important activity against *Salmonella typhimurium* and *Klebsiella pneumoniae* with minimum inhibitory concentration (MIC) of 3.12 mg/ml. Furthermore, the free radical scavenging assay of the essential oil and extracts were determined using a 2,2-diphenyl-1-picrylhydrazyl (DPPH) test system. The dichloromethane and water extract possessed strong radical scavenging activity with the lowest IC_{50} value of 0.1 mg/ml followed by the aqueous extract with an IC_{50} value of 0.12 mg/ml. Phytochemical analysis revealed the presence of flavonoids, terpenoids, saponins, alkalois and tannins which may be responsible for antimicrobial and antioxidant activities.

Key words: *Iris planifolia* (Mill), essential oil, GC, GC/MS, phytochemical prospecting, antimicrobial and free radical scavenging.

INTRODUCTION

Aromatic plants have long been part of Algerian cultures and their uses are wide spread in most of the rural people that rely on traditional therapies which involve the use of plant parts, their extracts, infusions and decoctions, especially in diabetes, high blood pressure, arthritis, fever and cancer (Quezel and Santa, 1963; Allali et al., 2008). That could be explained partially by the presence of wide variety of biologically active constituents. On the other hand, in modern medicine due to indiscriminate and irrational use of antimicrobial drugs the infectious microorganisms have developed resistance. Hence, new alternative are required to combat the existing diseases as infections and cancer. Plants produce a wide variety of secondary metabolites such as vitamins, terpenoids, tannins, flavonoids, alkaloids and other metabolites, which are rich in antimicrobial and antioxidant activities (Wong et al., 2006; Baker et al., 2010). A great number of different spices and aromatic herbs have been tested for their antioxidant and antimicrobial activities during the last decade; however, there are still many plants, which were not yet examined. The genus *Iris* belongs to family *Iridaceae*, consists of about 300 species and is distributed throughout the world except in the cold

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regions.

In Algeria, the genus *Iris* is mainly represented by three species (*Iris pseudo acorus*, *Iris unguicularis* and *Iris planifolia*) (Belouahem-Abed et al., 2009). Plants of the genus *Iris* have been previously recognized as rich sources of secondary metabolites and are used in the treatment of cancer, inflammation and bacterial and viral infections (Choudhary et al., 2001; Orhan et al., 2003; Atta-ur-Rahman et al., 2003). A local ethnobotanical survey carried out showed its possible anti-tumoral activity. Previous phytochemical investigations on *Iris plants* have resulted in the isolation of a variety of compounds, including flavonoids, isoflavonoids and their glycosides, benzoquinones, triterpenoids and stilbene glycosides (Atta-ur-Rahman et al., 2003; Choudhary et al., 2001). This genus is rich in isoflavonoids which have a wide range of biological activity including antiinflammatory, antioxidant and cancer chemopreventive properities (Rahman et al., 2003; Wollenweber et al., 2003). *Iris* rhizomes are also popular in cosmetic preparations, and *Iris* oil is regarded as one of the most precious ingredients in perfumery (Cornelia Schütz et al., 2011). *Iris planifolia* (Mill)., locally known as kessar el touadjine, nouar si Messaoud, bou chahla, is widely distributed in Algeria, Crete, Greece, Italy, Libya, Morocco, Portugal, Sardinia, Sicily and Spain. The plant grows to about 20 cm high. The stems are very short and subterranean, flowers are blue or violet, rarely white and seeds are ovoid or pyriform, rugose, dark reddish-brown. Flowering in winter (Quezel and Santa, 1963). No uses in the folk medicine are known for this species. To the best of our knowledge, there is no information on the essential oils of *I. planifolia* and no studies of antioxidant and antimicrobial activities was performed for this specie.

This study aimed to characterize the essential oil profile and to determine the free radical scavenging assay and antimicrobial activity of oil and of different extracts (aqueous, ethanolic and dichloromethane) of *I. planifolia*.

MATERIALS AND METHODS

Plant material

The whole of the plant were collected in January 2011 from a farm in Mansourah region, suburb west Tlemcen of Algeria. The plants collected were identified by Pr. Noury Benabadji, "Laboratory of Ecology and Ecosystem Management", University of Tlemcen (Algeria). A voucher specimen was deposited in this laboratory. Plant samples were dried in the share and conserved for future use.

Essential oil

Dried plant materials were powdered (400 g) and subjected to hydro-distillation (in 4000 mL distilled water) for 4 h, using a Clevenger-type apparatus according to the method recommended in the European Pharmacopoeia (Council of Europe, 1996). The essential oil yields were 0.05% (w/w). The oils were dried over anhydrous sodium sulfate and then stored in sealed glass vials at 4 to 5°C prior to analysis.

Soxhlet extraction

The extraction of soluble compounds from *I. planifolia* by the soxhlet method was performed using water, ethanol and dichloromethane as solvents. The total extracting time was 2 h and the total amount of solvent was 150 ml maintained continuously refluxing over the sample (5 g). All assays were performed with water, ethanol and dichloromethane extracts. For the antimicrobial tests, the extracts were re-dissolved in the appropriate culture medium.

Phytochemical prospecting of the plant extracts

A small portion of the dry extracts was used for the phytochemical tests for compounds which include tannins, flavonoids, alkaloids, saponins, triterpenoids and steroids in accordance with the methods of Harborne (1998); Gurinder and Daljit (2009).

Gas chromatography analysis (GC)

GC analyses were carried out using a Perkin–Elmer (Waltham, MA, USA) Autosystem XL GC apparatus equipped with a dual flame ionization detection system and a fused-silica capillary columns (60 m x 0.22 mm I.D., film thickness 0.25 µm), Rtx-1 (polydimethylsiloxane). The oven temperature was programmed from 60 to 230°C at 2°C/min and then held isothermally at 230°C for 35 min. Injector and detector temperatures were maintained at 280°C. Samples were injected in the split mode (1/50), using helium as the carrier gas (1 ml/min); the injection volume was 0.2 µL. Retention indices (I) of the compounds were determined relative to the retention times of the series of n-alkanes (C5 to 30) with linear interpolation, using the Van den Dool and Kratz (2003) equation and software from Perkin–Elmer. Component relative concentrations were calculated based on GC peak areas without using correction factors.

Gas chromatography-Mass spectrometry analysis (GC-MS)

Samples were analyzed with a Perkin–Elmer Turbo mass detector (quadrupole), coupled to a Perkin–Elmer Autosystem XL, equipped with the fused-silica capillary columns Rtx-1 (ion source temperature 150°C; energy ionization 70 eV). Electron-impact (EI) mass spectra were acquired over the mass range 35 to 350 Da (scan time: 1 s). Other GC conditions were the same as described under GC except split 1/80.

Component identification

Identification of individual components was based (i) on comparison of calculated RI, on polar and apolar columns, with those of authentic compounds or literature data (König et al., 2001; National Institute of Standards and Technology, 2008); and (ii) on computer matching with commercial mass spectral libraries (Adams, 2001; König et al., 2001; National Institute of Standards and Technology, 1999) and comparison of mass spectra with those of our own library of authentic compounds or literature data (Adams, 2001; König et al., 2001).

Evaluation of antibacterial activity

Tests were performed on four bacteria reference strains obtained

Table 1. Phytochemical prospection of aqueous, ethanolic and dichloromethane extract of *I. planifolia.*

Extract	Metabolites						
	1	2	3	4	5	6	7
Aqueous	+	+	-	+	-	+	-
Ethanol	+	+	-	-	-	+	-
Dichloromethane	-	-	-	+	+	-	-

1: tannins; 2: flavonoids; 3: saponins; 4: triterpenoids; 5: steroids; 6: alkaloids; 7: coumarines , +: presence; - : absence.

from (Laboratoire Antibiotic, Anti-fungal: physical chemistry, synthesis and biological activity, Department of Molecular and Cellular Biology, Faculty of Science, University of Tlemcen, 13000, Algeria), *Enterococcus faecalis* (ATCC 49452), *Staphylococcus aureus* (ATCC 25923), *K. pneumoniae* (ATCC 70063) and *S. typhimurium* (ATCC 13311). Two different techniques were used to test the antimicrobial activity: the paper disc diffusion and the dilution agar method. The MIC was determined by the later method.

Paper-disc diffusion method

Paper discs (6 mm in diameter) saturated with a 500 mg/ml solution of plant extract were applied to the surface of agar plates that were previously seeded by spreading of 0.1 ml overnight culture. The plates were incubated overnight at the appropriate temperature (see above) and the diameter of the resulting zone of inhibition was measured in millimeters. The results are indicated in Table 3 and the text represent the net zone of inhibition including the diameter (6 mm) of the paper disk. The scale of measurement was as follows (Barros et al., 2007) (disk diameter included): > 15 mm: very strong activity; < 15 to 12 mm: high activity; < 12 to 10 mm: average activity; 10 to 7 mm: low activity and < 7 mm: no activity. All the data collected for each assay are the averages of three determinations.

Dilution-agar method

A dilution agar method was used to determine the MIC. Stock solutions were obtained by dissolving extracts in dimethylsulfoxide (DMSO 1%). Serial dilutions were made to obtain concentrations ranging from 0 to 50 mg/ml of the extracts and essential oil. Each mixture was added to Mueller–Hinton agar (Cowan, 1999; Lennette and Balows, 1985).

The Petri dishes contained a sterile solution of DMSO and the culture medium, respectively, after incubation at 37°C for 24 h. The experiments were performed in triplicate.

2,2-diphenyl-2-picrylhydrazyl hydrate (DPPH) free radical scavenging activity

The hydrogen-donating abilities of the tested extracts were examined on the basis of the method described by Molyneux (2004) with some modifications. Used as reagent, DPPH obviously offers a convenient and accurate method for titrating the oxidizable groups of natural or synthetic antioxidants. About 1 ml of 90 µM DPPH solution of methanol was thoroughly mixed with an equal volume of test extracts at various concentrations (0.04 to 0.2 mg/ml) and kept in the dark for 60 min. Absorbance was read at 520 nm using methanol as blank. 1 ml of DPPH solution mixed with 1 ml of methanol was used as control. Inhibition of DPPH radical was calculated using the equation:

$$I\ (\%) = 100.\ (A0 - As)/A0$$

Where A_0 is the absorbance of the control (containing all reagents except the test compound) and A_s is the absorbance of the tested sample. The actual decrease in absorbance induced by the tested sample (change of colour from deep-violet to light yellow) was compared to that of the positive control trolox. The IC_{50} value represented the concentration of extract that causes 50% inhibition was determined. Experiments were carried out in triplicate and the mean value was recorded.

RESULTS

Phytochemical screening

From Table 1 it was observed that aqueous and ethanolic extract showed positive inference in the test for tannins, flavonoids and alkaloids. For saponins, the foam layer was showed only in aqueous extract. In triterpenoids test, dichloromethane extract showed positive result. It was also positive in steroids test. However coumarins test produced negative inference.

Essential oil composition

Table 2 shows the chemical composition of *I. planifolia* oil obtained by hydroditillation with a Clevenger-type apparatus. 47 components were detected and 21 of them were identified by comparison with pure standards (RI and mass spectra matching); 17 compounds were identified by comparing their RI and mass spectra with literature data and commercial mass spectra library. For the other 9 compounds (0.5 to 2.7% of the total oil components) not enough information was found, and no possible attribution was proposed (unknown compounds). Nonetheless, no study has been so far performed on the volatile constituents of the Algeria *Iris* species. In this study, our objective was to determine composition of volatiles compounds of the *I. planifolia*.

The essential oil consists chiefly of alkanes (36.5%), acids (19.1%), ketones (11.7%), alcohols (9.0%), arylpropanoids (6.8%) and aldehydes (4.1%) accompanied by relatively much smaller amounts of monoterpenes (1.0%). Alkanes are present in a

Table 2. Essential oil composition of *I. planifolia*.

N[a]	Components	I_l [b]	I_a [c]	% [d]	Identification[e]
1	Heptanal	882	885	0.1	RI, MS, Ref_1
2	Octanal	981	973	0.3	RI, MS, Ref_1
3	Nonanal	1076	1088	0.1	RI, MS
4	Hexadecanal	1795	1789	0.6	RI, MS
5	Octadecanal	2017	2015	3.0	RI, MS
	Σ of aldehyde compound			4.1	
6	Limonene	1025	1028	0.2	RI, MS
7	Linalool	1086	1089	0.8	RI, MS
	Σ of monoterpene compound			1.0	
8	1,4-Dimethoxybenzene	1030	1130	0.5	RI, MS, Ref_2
9	Eugenol	1331	1331	0.1	RI, MS
10	Benzyl tiglate	1498	1502	5.8	RI, MS
11	Benzyl benzoate	1730	1727	0.4	RI, MS, Ref_2
	Σ of arylpropanoid compound			6.8	RI, MS, Ref_2
12	Dodecane	1200	1200	0.5	RI, MS
13	Tetradecane	1400	1400	0.6	RI, MS
14	Hexadecane	1600	1600	0.2	RI, MS
15	Heptadecane	1700	1700	0.2	RI, MS
16	Octadecane	1800	1800	0.3	RI, MS
17	Nonadecane	1900	1900	0.3	RI, MS
18	Eicosane	2000	2000	2.7	RI, MS
19	Heneicosane	2100	2100	3.2	RI, MS
20	Docosane	2200	2200	1.9	RI, MS
21	Tricosane	2300	2300	7.7	RI, MS
22	Tetracosane	2400	2400	0.8	RI, MS
23	Pentacosane	2500	2500	16.7	RI, MS
24	Hexacosane	2600	2600	0.2	RI, MS
25	Heptacosane	2700	2700	1.1	RI, MS
26	Octacosane	2800	2800	0.1	RI, MS
	Σ of alkane compound			36.5	
27	Tridecan-2-one	1477	1470	2.9	RI, MS
28	Phytone	1833	1828	8.1	RI, MS
29	Heptadecan-2-one	1892	1895	0.7	RI, MS
	Σ of ketone compound			11.7	
30	Tridecan-2-ol	1490	1490	0.6	RI, MS, Ref_1
31	Hexadecanol	1872	1869	1.4	RI, MS
32	Methyl heptadecanol	2030	2035	0.5	RI, MS
33	Octadecanol	2078	2075	2.6	RI, MS
34	(E)-Phytol	2114	2107	2.9	RI, MS
35	Eicosanol	2273	2272	0.2	RI, MS, Ref_2
36	Heneicosanol	2365	2372	0.8	RI, MS, Ref_2
	Σ of alcohol compound			9.0	
37	Dodecanoic acid	1554	1557	0.6	RI, MS, Ref_2
38	Hexadecanoic acid	1962	1953	18.5	RI, MS, Ref_2

Table 2. Contd.

	Σ of acid compound			19.1
39	Unknown	-	1432	2.7
40	Unknown	-	1584	0.8
41	Unknown	-	1626	1.5
42	Unknown	-	1990	1.4
43	Unknown	-	2009	1.1
44	Unknown	-	2052	1.5
45	Unknown	-	2055	0.5
46	Unknown	-	2062	1.7
47	Unknown	-	2084	0.6
	Σ of Unknown compound			11.8
	Total			100.00

[a] Order of elution is given on apolar column (Rtx-1), [b] Retention indices of literature on the apolar column (lRIa) reported from König et al., 2001.,[c] Retention indices on the apolar Rtx-1 column (RIa), [d] percentage, tr = trace (<0,05), e RI: Retention Indices; MS: Mass Spectrometry in electronic impact mode; Ref_1,: compounds identified from literature data König et al., 2001., Ref_2,: compounds identified from literature data NIST Chemistry WebBook.

significant amount (36.5%) with pentacosane as the major oil constituent (16.7%). It is accompanied by a noticeable amount of tricosane (7.7%), henicosane (3.2%), eicosane (2.7%) and a much smaller amount of docosane, (1.9%) and heptacosane (1.1%). The ketone compounds are distinctly dominated by phytone (8.1%) while tridecan-2-one and heptadecan-2-one are detected in much lower amounts (2.9 and 0.7%, respectively). On the other hand, (E)-phytol, octadecanol and hexadecanol were the major components of alcoholic fraction of the plant oil (2.9, 2.6 and 1.4%, respectively). However, hexadecanoic acid (18.5%), benzyl tiglate (5.8%) and octadecanal were the major compounds of faction of acids, arylpropanoids and aldehydes fraction, respectively.

Antibacterial activity

The antibacterial activities of the different extracts of *I. planifolia* that is, aqueous, ethanolic, dichloromethane and the essential oil were determined against pathogenic strains of gram positive (*Staphylococcus aureus* and *Enterococcus faecalis*) and gram negative (*Salmonella typhimurium* and *Klebsiella pneumoniae*) bacteria. The inhibition zone, measured in millimeters, including the diameter of the paper disk, was used as the criterion for measuring the antibacterial activity of *I. planifolia* extracts and essential oil. Table 3 shows that the tested extracts could be classified according to their activity. The strongly active extract of this plant was essential oil with an antimicrobial inhibition zone of 14 mm against *S. typhimurium* and *K. pneumonia* and low activity against *S. aureus* and *E .faecalis* with an antimicrobial inhibition zone of 9 mm. The ethanolic extract had average activity against two food poisonous bacteria: *K. pneumoniae* and *S. aureus*, with inhibition zone of 12 mm. However, aqueous and dichloromethane extract exhibited no effect of antibacterial activity against the bacterial pathogens tested.

Minimum inhibitory concentrations (MIC)

The most promising results were obtained from the essential oil and ethanolic extract, which did not only had the lowest MIC value (3.12 mg/ml against *S. typhimurium* and *K. pneumoniae*), but also inhibited the growth of *S. aureus* and *E. faecalis* with MIC values of 6.25 and 25 mg/ml, respectively. However, the aqueous and dichloromethane extract showed no inhibition towards any of the microorganisms assayed up to the value of 50 mg/ml.

Radical scavenging activity

In order to assess the radical scavenging potential of the essential oil and solvent extracts, the reactivity towards the stable free radical DPPH was measured. DPPH is one of the chemical compounds that possess a proton free radical and it shows a maximum absorption at 520 nm because of its bright purple colour. When DPPH encounters proton radical, its purple colour fades rapidly and this scavenging action forms the basic mechanism for measuring antioxidant activity. Table 4 demonstrates DPPH scavenging activity, expressed in percentage, caused by different concentrations of essential oil and solvent extracts from *I. planifolia*. The weakest radical scavenging activity was exhibited by the essential oil and ethanolic extract (50.03 and 53.66%, respectively), whereas the strongest activity was exhibited by the

Table 3. Antimicrobial activity of essential oil and solvent extracts (water, ethanol and dichloromethane) from *I. planifolia*.

Species	Antimicrobial activity							
	Disc diffusion assay (mm)[a]				MIC (mg/ml)[b]			
	Gram-negative		Gram-positive		Gram-negative		Gram-positive	
	S. typhimurium	*k. pneumoniae*	*S. aureus*	*E. faecalis*	*S. typhimurium*	*k. pneumoniae*	*S. aureus*	*E .faecalis*
Aqueous extract	7	6	6	6	>50	>50	>50	>50
Dichloromethane extract	6	7	6	6	>50	>50	>50	>50
Ethanolic extract	12	12	9	9	3.12	3.12	6.25	25
Oil	14	14	10	10	3.12	3.12	6.25	25

Table 4. DPPH radical-scavenging of essential oil and solvent extracts (water, ethanol and dichloromethane) from *I. planifolia* measured at different concentrations.

Source	Concentrations (mg/ml)					
	0.04	0.05	0.06	0.08	0.2	IC_{50}
Aqueous extract	27.77	30.19	34.70	39.76	73.25	0.12
Dichloromethane extract	29.66	30.23	31.01	44.73	83.87	0.10
Ethanollc extract	11.96	12.39	13.03	16.52	53.66	0.19
Essential oil	6.81	7.34	8.91	10.78	50.03	0.20
Ascorbic acid	39.40	51.03	68,57	97.84	98.36	0.048

dichloromethane and aqueous extract (83.87 and 73.25%, respectively) at a concentration of 0.2 mg/mL.

Therefore, DPPH scavenging activity is usually presented by the IC_{50} value. Concentrations of the antioxidant providing 50% inhibition of DPPH in the test solution (IC_{50}) were calculated and presented in Table 4.

The dichloromethane extract of *I. planifolia* had the highest radical scavenging activity with the lowest IC_{50} value of 0.1 mg/ml followed by the aqueous extract with an IC_{50} value of 0.12 mg/ml. This was higher than the ethanol extract with an IC_{50} value of 0.19 mg/ml and essential oil with an IC_{50} value of 0.20 mg/ml.

DISCUSSION

Medicinal plants constitute an effective source of both traditional and modern medicines, herbal medicine has been shown to have genuine utility and about 80% of rural population depends on it as primary health care. The phytochemical analysis conducted on *I. planifolia* extracts revealed the presence of tannins, flavonoids, alkaloids, saponins and tannins which are known to have many biological activities such as antimicrobial (Djipa et al., 2000; Esquenazi et al., 2002) and antioxidant. The results of the study indicated that essential oil of *I. planifolia* exerted stronger antibacterial activity that solvent extracts.

Regarding to the composition of the essential oil of *I. planifolia*, various chemical compounds isolated by hydrodistillation have direct activity against many species of bacteria, such as terpenes and a variety of aliphatic hydrocarbons (alcohols, aldehydes and ketones). The lipophilic character of their hydrocarbon skeleton and the hydrophilic character of their functional groups are of main importance in the antimicrobial action of essential oils components. Therefore, a rank of activity has been proposed as follows: phenols>aldehydes>ketones>alcohols>esters>hydrocarbons (Kalemba and Kunicka, 2003). For example, some essential oils containing phenolic structures are highly active against a broad spectrum

of micro- organisms (Kalemba and Kunicka, 2003; Güllüce et al., 2003). The importance of the hydroxyl group has been confirmed (Dorman and Deans, 2000; Lawrence, 1993) and the relative position of the hydroxyl group on the phenolic ring does not appear to strongly influence the degree of antibacterial activity. Aldehydes are known to possess powerful antimicrobial activity. It has been proposed that an aldehyde group conjugated to a carbon to carbon double bond is a highly electronegative arrangement, which may explain their activity (Raja et al., 2011), suggesting an increase in electronegativity increases the antibacterial activity (Kurita et al., 1981). Terpenes have also shown antimicrobial properties that appear to have strong to moderate antibacterial activity against gram positive bacteria and against pathogenic fungi, but in general weaker activity was observed against gram-negative bacteria (Hada et al., 2003; Tepe et al., 2004).

Regarding free radical scavenging activity it was observed that the aqueous and dichloromethane extract of *I. planifolia* showed a significant dose dependent inhibition of DPPH radical scavenging activity compared to essential oil and ethanol extract. These extracts exhibited a noticeable antioxidant effect at low concentrations (Table 4). This suggests that extracts contain compounds that are capable of donating hydrogen to a free radical in order to remove odd electron which is responsible for radical's reactivity. According to these results, there is a relationship between chemical composition and antioxidant activity. Moreover, as reported in literature data, the antioxidant activity of essential oil could be attributed to phenolic compounds, flavonoids and saponins. The polyphenol compounds play a wide range of biological effects including antibacterial, anti-inflammatory, antiallergic, hepatoprotective, antithrombotic, antiviral, anticarcinogenic and cardioprotective and vasodilatory effects (Wong et al., 2006). These functions have been attributed to their antioxidant activity by several mechanisms such as free radical scavengers, reducing agents, complexers of pro-oxidant metals, quenchers of the formation of singlet oxygen and stimulating the antioxidative defence enzymes activities (Zhou and Yu, 2004).

These mechanisms will be led by two types of reactions: hydrogen atom transfer and single electron transfer (Huang et al., 2005). Flavonoids have been shown to exhibit their actions through effects on membrane permeability and by inhibition of membrane-bound enzymes such as the ATPase and phospholipase A2 (Surabhi and Leelavathi, 2010), and this property may explain the mechanisms of antioxidative action of *I. planifolia*. However, previous studies showed that the saponin fraction and single saponin such as 2- phenyl-benzopyrane have antioxidant activities (Rodrigues et al., 2005; Yalinkilic and Enginar, 2008).

In conclusion, essential oil and solvent extracts exhibited different range of free radical scavenging therefore, further tests should be conducted to confirm antioxidant activity. The obtained results may provide a support to utilize the plants as new potential sources of natural additives for the food and/or pharmaceutical industries.

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