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Comparative Evaluation of Chemical Compositions and Biological Activities of Wild and Cultivated *Froriepia subpinnata* L. Essential Oils

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ABSTRACT

***Froriepia* is one of the Apiaceae genera. Only one species of this genus (*Froriepia subpinnata* L.) has been reported in Iran. In most parts of the North of Iran, young and pristine leaves are applied as stuffing in the preparation of various local foods. Despite wide applications of this medicinal plant, previously little research has been done on it. In this investigation, chemical compositions and antimicrobial activity of wild and cultivated *Froriepia subpinnata* essential oils were evaluated and compared. Applying GC and GC-MS, 53 components were registered in cultivated plant essential oil with major components- myrcenone (27.40%), limonene (18.60%), terpinolene (14.70%), and totarolone (7.35%), while 72 constituents were identified for wild plant essential oil with myrcenone (36.95%), limonene (13.62%), terpinolene (11.04%), and *β*-pinene (7.69%) as the major constituents. The antibacterial and the antimycotic activities of these oils were tested against six bacterial and fungal strains. The Gram-positive bacteria, *Staphylococcus aureus,* was most susceptible with MIC values 1-2 µg mL^{-1}. The study results demonstrated that the main compounds were the same in the wild and cultivated plants essential oils. Also, it seems that cultivation only influences the essential oil yields, while the essential oil composition remains mostly constant.**

Keywords: Antimicrobial activity, Apiaceae, Gas Chromatography, Mass Spectrometry, Medicinal plant.

INTRODUCTION

Essential oils are complex mixtures containing many individual components. Each of these components contributes to the useful or harmful effects of these essential oils. So, intimate knowledge of oil component allows for a further and particularly directed usage (Shaaban *et al*., 2012; Moghadam *et al*., 2016). Essential oils have been extensively used for long times in the medical, agricultural, pharmaceutical, hygienic and cosmetic crafts and have been added to foods as stuffing or herbs (Behbahani *et al*., 2017; Abdossi and Kazemi, 2016). They are isolated from various parts of plant materials such as flowers, roots, bark, seeds, fruit peels, and wood (Elgendy *et al*., 2017).

The expansion of drug resistance, besides the advent of side effects of some antibiotics, has led to the investigation of novel antimicrobial agents, especially among plant extracts and essential oils, with the purpose of introducing new chemical structures that overcome such detriments (Nielsen *et al*., 2017; Houicher *et al*., 2016). The food industry at present uses synthetic preservatives to barricade the formation of food borne and devastative microbes and to

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increase the life time of foods. Generally, due to undesirable effects like toxicity and carcinogenic effects of synthetic additives, detection of natural antimicrobial agents is very pleasant for use in food industries. (Aloui and Khwaldia, 2016). Many essential oils have been recognised as antimicrobial agents (Ambrosio *et al*., 2017). Also, it is reported that harvesting of many medicinal plants species occurs basically during the flowering time, before granulation set, lowering regeneracy and causing piecemeal degradation of wild populations. One hopeful solution to make certain the protection and sustainable usage of valuable medicinal herbs is to subject it to domestication (Phondani *et al*., 2016). The investigation of the chemical constituents and biological properties of the wild and cultivated plant species can, hence, provide new vision that may lead to the presentation of novel populations with unique features for use in the food and pharmaceutical industries.

The Apiaceae is one of the biggest plant families on Earth. *Froriepia* is one of the Apiaceae genus that can be found in Iran. Only one species from the genus *Froriepia* has been detected in Iran (Mozaffarian, 2007). *Froriepia subpinnata* (Ledeb.) Baill. has been observed natively in Golestan, Gilan and Mazandaran provinces of Iran (Rechinger, 1987). In most parts of the North of Iran, pristine leaves of the plant are applied as a vegetable for cooking and flavouring several local foods. In traditional medicine, this plant has been used against liver disorders, as carminative, antispasmodic, diuretic, sedative agent and as tonic (Seyedabadi *et al*., 2016). In the past years, only antioxidant activity, mineral elements (Ebrahimzadeh *et al*., 2010; Nabavi *et al*., 2008) and essential oil composition (Morteza-Semnani *et al*., 2009; Rustaiyan *et al*., 2001) of this plant were investigated. Due to the high usages of this plant, further research was needed on this medicinal species.

The aim of this research was to provide new data helpful for identification of species with high bioactive compounds. Once selected and duly subjected to additional tests, the species with high quantities of the desired ingredients may be introduced as food additives. Essential oils offer an excellent potential for application as food preservatives to reduce the microbial pollutions during food handling, processing, and storage. It will be interesting to compare the wild and cultivated *Froriepia subpinnata* in an attempt to provide novel insights for extensive planting of this herb on farms, since it is possible to industrialize the production of essential oil and use it in the food industries.The present study was thus designed to evaluate chemical composition of essential oils and to distinguish *in vitro* antibacterial and antimycotic activities of the essential oils obtained from the aerial parts of the wild and cultivated *Froriepia subpinnata* (Ledeb.) Baill.

MATERIALS AND METHODS

Plant Materials

The aerial parts of *F. subpinnata* were collected in full flowering stage from natural sites in Babol, Mazandaran, Iran, on May 2015. Also, the seeds of this plant were cultivated in farm (Babol area) from April 2015 and harvested in full flowering period on May 2015. The plant material was identified by Dr. Ali Sonboli, and voucher specimen (MPH-2369) is deposited in the herbarium of the Medicinal Plants and Drugs Research Institute, Shahid Beheshti University, Tehran, Iran. Plant material was dried at ambient temperature and coarsely ground before extraction.

Extraction of Essential Oil

Air dried aerial portions of the plants (200 g) were subjected to hydrodistillation for 2.5 hours using a Clevenger-type apparatus system according to the procedure recommended in the European

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Pharmacopoeia (Anonymous, 1997). The acquired oils were dried over anhydrous sodium sulfate and stored in vials at 4°C in the dark until analysed and tested.

Gas Chromatography-Mass Spectrometry

GC analysis of the oil was done using a Thermoquest-Finnigan appliance armed with a DB-5 fused silica column (60 m×0.25 mm id, film thickness 0.25 µm). Nitrogen was used as the carrier gas at a constant current of 1.1 mL min^{-1}. The temperature of oven was held at 60ºC for 1 minute, then programmed to 250ºC at a rate of 4ºC min^{-1}, and then held for 10 minutes. The injector and detector (FID) temperatures were protected at 250 and 280ºC, respectively. GC-MS analysis was done on a Thermoquest-Finnigan Trace GC-MS system equipped with a DB-5 fused silica column (60 m×0.25 mm id, film thickness 0.25 µm). The oven temperature was raised from 60 to 250ºC at a speed of 5ºC min^{-1}, and then held at 250ºC for 10 minutes; transfer line temperature was 250ºC. The quadrupole mass spectrometer was scanned above 45-465 amu with an ionization voltage of 70eV and an ionization current of 150 ìA. The components of the essential oil were specified by computation of their retention indices under temperature programmed situations for *n*-alkanes (C_6-C_{24}) and the essential oil on DB-5 column. Identification of individual compounds was made by contrast of their mass spectra with those of the internal reference library or with reliable components and confirmed by comparison of their retention indices with those of offered data in the literature (Adams, 2007).

Antibacterial Activity

In vitro antibacterial activity of essential oils was assessed against *Staphylococcus aureus* ATCC 25923, *Enterococcus faecalis* ATCC 29212 as Gram positive bacteria and *Escherichia coli* ATCC 25922 and *Pseudomonas aeruginosa* PTCC1430 as Gram negative bacteria. Determination of *MIC* (Minimum Inhibitory Concentrations) was performed by broth micro-dilution method as recommended by CLSI (Clinical Laboratory and Standard Institute) with some modifications (Jorgensen and Turnidge, 2007). In brief, a serial dilution of each essential oil was made in a concentration range of 64 to 0.125 µg mL^{-1} in sterile 96 wells trays containing Mueller-Hinton broth medium supplemented by 0.5% Tween 80 as co-solvent. Normal saline was used for preparation of inoculants having turbidity equal to 0.5 McFarland standards. The inoculants of the microbial strains were prepared from freshly cultured bacteria that were adjusted to 0.5 McFarland standard turbidity and were further diluted (1:100) using MHB medium just before adding to the serial diluted samples. Trays incubated for 24 h at 37 °C. *MIC* values were recorded as the lowest concentrations which could inhibit visible growth of microorganisms (Jorgensen and Turnidge, 2007). Minimum Bactericidal Concentrations (MBCs) were determined by culturing 100 µL of each no-growth well onto nutrient agar plates and incubation at suitable temperature. *MBC* values were recorded as the lowest concentration which resulted in killing of 99.9% of the tested microorganism. Each experiment was done in triplicate and Cefixime was used as standard antibacterial agent.

Antifungal Activity

Two fungi, namely, *Aspergillus flavus* (Lab Isolate) and pathogenic yeast *Candida albicans* ATCC 10231, were assessed in this part of study. Determination of *MIC* was performed by broth micro-dilution method as recommended by CLSI with some modifications (Ana *et al.*, 2007). In brief, a serial dilution of each essential oil was made in a concentration range of 64 to 0.125 µg

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mL^{-1} in sterile 96 wells trays containing RPMI pH 7 supplemented by 2% (w/v) dextrose, MOPS (0.165 M) and 0.5% Tween 80 as co-solvent for oil. The inoculants of the yeast strain were prepared from freshly cultured yeast that were adjusted to 0.5 McFarland standard turbidity and were further diluted (1:1000) using mentioned medium just before adding to the serial diluted samples. For *A. flavus* tested strain, potato dextrose agar plates were used as medium for conidial growth. Plates were incubated at 35°C for 7 days. After that, a 1:50 diluted stock of conidia was used for inoculation of trays containing diluted oils. Trays incubated for 48 hours at 30°C. *MIC* values were recorded as the lowest concentrations, which could inhibit visible growth of microorganisms (Jorgensen and Turnidge, 2007). Minimum Fungicidal Concentrations (MFCs) were determined by culturing 100 µL of each no-growth well onto Sabouraud dextrose agar plates and incubation at suitable temperature. *MFC* values were recorded as the lowest concentration, which resulted in killing of 99.9% of tested microorganism. Each experiment was done in triplicate and Amphotericin B was used as standard antifungal agent.

RESULTS AND DISCUSSION

Chemical Composition of the Essential Oils

The essential oils were analysed by GC and GC-MS. Oil yields obtained by hydrodistillation from the aerial parts were 1.5% for the wild plants and 1.2% for the cultivated plants on a dry weight basis (w/w%). Chemical analyses of the volatile components of the essential oils (percentage content of each compound and retention index) are summarized in Table 1. Seventy-two compounds of the wild plant's oil, representing 98.06%, and fifty-three compounds of the cultivated plant's oil representing 97.91%, were identified. Myrcenone (27.40%), limonene (18.60%), terpinolene (14.70%), totarolone (7.35%), and sabinene (5.15%) were found to be the major constituents in the cultivated plant essential oil. The main components in the wild plant essential oil were myrcenone (36.95%), limonene (13.62%), terpinolene (11.04%), and *β*-pinene (7.69%). For easier comparison of the oils, the constituents were classified into five categories: monoterpene hydrocarbons, oxygenated monoterpenes, sesquiterpenes hydrocarbons, oxygenated sesquiterpenes and others (Table 1). As can be seen, oxygenated monoterpenes were the main class of components in the oil of wild plant (49.65%) sample. The oil of the wild plant contained mainly thirteen monoterpene hydrocarbons (39.22%), twenty-nine oxygenated monoterpenes (49.65%), six sesquiterpene hydrocarbons (2.61%), and sixteen oxygenated sesquiterpenes (4.37%) while the oil of the cultivated plant consisted principally of thirteen monoterpene hydrocarbons (41.72%), ten oxygenated monoterpenes (34.84%), four sesquiterpene hydrocarbons (1.08%), and nine oxygenated sesquiterpenes (2.19%). In both essential oils, the main constituents were myrcenone and limonene.

Also, terpinolene was present in appreciable amounts in both essential oils, but its relative amount differed among the analysed oils (wild sample 11.04%, cultivated sample 14.07%). The fundamental composition of the essential oils from the wild plant was equivalent to those of the cultivated plant. However, the quantity of the main component myrcenone in *Froriepia subpinnata* (Ledeb.) Baill. oil was lower in the cultivated plant, but the quantity of some compounds such as limonene and terpinolene were higher. These differences may be a function of the ecological conditions as already observed for various plant species (Farsam *et al*., 2004; Esen *et al*., 2007; Baser *et al*., 2004; Nitta *et al*., 2006). Formerly, the composition of the essential oil of *F. subpinnata* growing wild in Masal-Shanderman (Rahst, Gillan, North of Iran) were investigated by Rustaiyan *et al*. (2001) and ten components were identified, with

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Table 1. The main constituents of the essential oil of the cultivated and wild *F. subpinnata* plants grown in Babol area, Mazandaran province, Iran.

No	Compound	*RI*[a]	*RI*[b]	From cultivated plant (%)	From wild plant (%)	No	Compound	*RI*[a]	*RI*[b]	From cultivated plant (%)	From wild plant (%)
1	(3*Z*)-Hexenal	792	797	0.61	0.15	54	*α*-Copaene	1370	1370	0.16	tr
2	3-methyl-Pentanol	834	833	tr[c]	0.02	55	*β*-Elemene	1391	1389	0.19	0.56
3	Heptanal	901	901	0.04	0.27	56	*trans*-Nerone	1439	1438	tr	0.07
4	*α*-Thujene	926	924	0.04	0.14	57	(*E*)-*β*-Farnesene	1454	1454	0.6	1.23
5	*α*-Pinene	934	932	0.77	1.44	58	*γ*-Decalactone	1468	1465	tr	0.16
6	Camphene	949	946	0.04	0.03	59	Geranyl propanoate	1480	1476	tr	0.05
7	Benzaldehyde	950	952	tr	0.01	60	2-Methyl-1-tetradecene	1485	1489	0.12	0.19
8	Sabinene	971	969	5.15	tr	61	*α*-Selinene	1495	1498	tr	0.11
9	*β*-Pinene	974	974	tr	7.69	62	Bicyclogermacrene	1497	1500	0.13	0.55
10	Myrcene	988	988	0.88	1.59	63	(*Z*,*E*)-1,5-Dimethyl-8-(prop-1-en-2-yl)-1,5-cyclodecadiene	1499	1502	tr	0.07
11	*α*-Phellandrene	1001	1002	0.08	1.15	64	*β*-Sesquiphellandrene	1522	1521	tr	0.34
12	Hexyl acetate	1005	1007	0.2	tr	65	*α*-Calacorene	1548	1544	tr	0.09
13	*δ*-3-Carene	1011	1008	0.08	0.22	66	Davanone B	1561	1564	tr	0.09
14	*α*-Terpinene	1017	1014	0.08	0.22	67	Caryophyllene oxide	1570	1577	0.92	tr
15	Limonene	1030	1024	18.6	13.62	68	Rosifoliol	1597	1600	tr	0.17
16	Sylvestrene	1033	1025	0.05	tr	69	(*Z*)-8-hydroxy-Linalool	1617	1619	tr	0.05
17	(*E*)-*β*-Ocimene	1046	1044	tr	0.02	70	10-*epi*-*γ*-Eudesmol	1625	1622	tr	0.06
18	*γ*-Terpinene	1058	1054	0.96	2	71	*α*-Bisabolol oxide B	1656	1656	tr	0.05
19	*cis*-Sabinene hydrate	1066	1065	0.06	0.11	72	(*Z*)-3-Tetradecen-1-ol	1660	1662	tr	0.07
20	Terpinolene	1090	1086	14.7	11.04	73	(6*Z*)-Pentadecen-2-one	1672	1667	0.49	tr
21	Linalool	1098	1095	1.3	1.59	74	Elemol acetate	1678	1680	tr	1.38
22	1,3,8-*p*-Menthatriene	1113	1108	tr	0.02	75	Guaiol acetate	1725	1725	tr	0.06
23	3,5,5-Trimethylcyclohexen-2-one	1119	1118	tr	0.01	76	*n*-Octadecane	1797	1800	0.34	tr
24	4-(1-Methylethyl)-1-methyl-2-cyclohexenol	1123	1121	tr	0.07	77	14-hydroxy-*δ*-Cadinene	1806	1803	0.13	tr
25	Geijerene	1139	1143	0.29	tr	78	(2*Z*,6*E*)-Farnesyl acetate	1838	1845	0.08	tr
26	Myrcenone	1141	1145	27.4	36.95	79	*α*-Vetivone	1838	1842	0.19	tr
27	*neo*-3-Thujanol	1146	1149	0.07	0.27	80	(2*E*,6*E*)-Farnesyl acetate	1845	1845	0.1	1.37

[a] Retention Index (*RI*) was calculated using n-alkane series from C_6 to C_{24} confirmed by comparison on DB-5MS; [b] Retention Index (*RI*) from literature data, [c] tr= Relative percentage less than 0.01%.

Table 1 contineud…

Continued of Table 1. The main constituents of the essential oil of the cultivated and wild *F. subpinnata* plants grown in Babol area, Mazandaran province, Iran.

No	Compound	*RI*[a]	*RI*[b]	From cultivated plant (%)	From wild plant (%)	No	Compound	*RI*[a]	*RI*[b]	From cultivated plant (%)	From wild plant (%)
28	Isoborneol	1153	1155	tr	0.07	81	8-hydroxy-Eremophilone	1844	1846	tr	0.21
29	(2*E*)-Nonen-1-al	1160	1157	tr	0.12	82	(*Z*)-Lanceol acetate	1860	1854	0.37	tr
30	Pinocarvone	1165	1160	tr	1.5	83	Cubitene	1873	1878	0.46	tr
31	Rosefuran epoxide	1171	1173	0.3	0.9	84	Laurenene	1874	1879	0.11	0.06
32	Terpinen-4-ol	1179	1174	0.45	0.67	85	Catalponone	1897	1894	0.09	0.09
33	*p*-Cymen-8-ol	1182	1179	2.16	0.93	86	*n*-Nonadecane	1898	1900	0.85	tr
34	*α*-Terpineol	1185	1186	tr	0.17	87	methyl Hexadecanoate	1926	1921	0.63	tr
35	*trans*-Dihydro carvone	1202	1200	tr	0.17	88	2-Methylnonadecane	1965	1966	0.97	tr
36	Verbenone	1203	1204	tr	0.06	89	(*Z,Z*)-Geranyl linalool	1966	1960	tr	0.09
37	*cis*-Carveol	1225	1225	1.46	tr	90	(*Z,E*)-Geranyl linalool	1998	1998	0.69	tr
38	(*Z*)-Ocimenone	1227	1226	1.34	tr	91	methyl Linoleate	2099	2095	0.45	tr
39	*trans*-Chrysanthenyl acetate	1240	1235	tr	0.23	92	Laurenean-2-one	2118	2115	tr	1.49
40	(*E*)-Ocimenone	1242	1239	tr	3.14	93	methyl Octadecanoate	2128	2124	0.49	tr
41	Carvone	1243	1239	tr	0.05	94	*cis*-Totarol methyl ether	2200	2208	0.54	tr
42	Neral	1245	1240	tr	0.45	95	4-*epi*-Abietal	2297	2298	0.41	tr
43	Linalool acetate	1254	1254	tr	0.03	96	Labd-13*E*-8,15-diol	2425	2422	1.44	tr
44	methyl Citronellate	1259	1257	tr	0.14	97	methyl Neoabietate	2444	2443	tr	0.12
45	*cis*-Chrysanthenyl acetate	1266	1261	tr	0.36	98	methyl-7,13,15-Abietatrienoate	2493	2501	2.2	tr
46	*γ*-Terpinen-7-al	1273	1278	0.3	tr	99	Totarolone	2538	2542	7.35	tr
47	Thymol	1291	1289	tr	0.42		Monoterpene Hydrocarbons			41.72	39.22
48	*iso*-Verbanolacetate	1306	1308	tr	0.12		Oxygenated Monoterpenes			34.84	49.65
49	*δ*-Terpinyl acetate	1313	1316	tr	0.06		Sesquiterpene Hydrocarbons			1.08	2.61
50	methyl Decanoate	1321	1323	tr	0.13		Oxygenated Sesquiterpenes			2.19	4.37
51	*p*-Mentha-1,4(8)-dien-3-one	1340	1342	tr	0.1		Others			18.04	2.21
52	Neryl acetate	1361	1359	tr	0.06		Total			97.91	98.06
53	2-Methylundecanal	1368	1366	tr	0.77						

[a] Retention Index (*RI*) was calculated using n-alkane series from C_6 to C_{24} confirmed by comparison on DB-5MS; [b] Retention Index (*RI*) from literature data, [c] tr= Relative percentage less than 0.01%.

principal components: *β*-phellandrene (50.3%), sabinene (25.7%), and *β*-pinene (4.5%). However, the concentrations of some components were different from our report. Also, Morteza-Semnani *et al*. (2009) reported the main constituents of the essential oils of *F. subpinnata* growing wild in Behshahr (Mazandaran, North of Iran) as *p*-cymen-8-ol (34.7%), terpinolene (12.5%), limonene (10.5%), and neophytadiene. The results of this investigation were closer to our research findings. These differences in the essential oil compositions can be ascribed to several environmental factors such as climate and seasonal and geographical conditions variations. Essential oil composition may be affected by a variety of parameters including genetics, nutrition, temperature, humidity, solar radiation, location and harvesting time (Farhang *et al*., 2017; Kchaou *et al*., 2016). While both kinds of this plant grow in the same province and even at identical altitude, their growing conditions, including the composition of the soil, are not entirely the same. This might be the main cause of differences in the composition of oils of this plant, especially the main components content.

Antibacterial and Antifungal Activity

Antimicrobial activities of *Froriepia subpinnata* essential oils were determined by measuring the lowest concentration that could inhibit the growth (MIC) or kill the assessed microorganism (MBC or MFC). Results are shown in the Table 2. Both oils obtained from aerial parts of the wild and cultivated *F.subpinnata* species inhibited growth of the tested microorganisms. The Gram-positive bacteria, *Staphylococcus aureus* was most susceptible, with *MIC* values between 1 and 2 mg mL^{-1}. Gram-negative bacteria appeared more resistant to these oils with *MIC* values between 8 and > 64 mg mL^{-1}. This may be explained by differences in the bacterial coverage because the gram-negative bacteria are surrounded by a cell wall of peptidoglycan, which itself is surrounded by an outer membrane containing lipopolysaccharide that makes them resistant. The antimicrobial activity of the *Froriepia subpinnata* oils is presumably associated with compounds like limonene, terpinolene, sabinene, *β*-pinene, and *γ*-terpinene, which are known to possess antimicrobial potentials (Dorman and Deans, 2000).

An extensive diversity of essential oils is known to possess antimicrobial activities due to the presence of active monoterpene ingredients. Essential oils are complex mixtures of abundant molecules. Therefore, the antibacterial properties of the essential oil is not the result of the activity of the chief component, and its interaction with the minor ingredients. Antimicrobial properties are often determined by more than one component; each of them contributes to the useful or adverse

Table 2. Antimicrobial activities of wild and cultivated *F. subpinnata* (μg mL^{-1}).

		S. aureus	*E. faecalis*	*E. coli*	*P. aeruginosa*	*C. albicans*	*A. flavus*
Wild sample	*MIC*	1	8	16	>64	64	64
	MBC	16	32	32	>64	>64	64
Cultivated sample	*MIC*	2	8	8	>64	>64	64
	MBC	16	32	32	>64	>64	>64
Cefixim	*MIC*	1	4	4	64	-	-
	MBC	8	32	16	>64	-	-
Amphotericin B	*MIC* (μg ml^{-1})	-	-	-	-	0.5	4
	MBC (μg ml^{-1})	-	-	-	-	1	8

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influences. The main compound may not be the only one responsible for the antimicrobial properties but a synergistic effect may take place with the other oil ingredients.

The different effects on *Escherichia coli* as Gram-negative bacteria may be ascribed to the different amounts of these components in the oils. Also, our results demonstrated that both essential oils possessed moderate antifungal activities against *Aspergillus flavus* and *Candida albicans*, a pathogenic yeast, with the *MIC* value of 64 mg mL^{-1} (Table 2). The oil extracted from cultivated sample exhibited the highest activity against *Escherichia coli* as a Gram-negative bacteria (MIC= 8 mg mL^{-1}) in contrast with the wild oils which showed a moderate activity with *MIC* value of 16 mg mL^{-1}. Based on our results, the essential oils of the wild and cultivated specimens could potentially be utilized as natural preservatives in foods against the famous causal agents of foodborne sickness such as *Escherichia coli*.

CONCLUSIONS

The study results demonstrated that main compounds were the same in the essential oils of wild and cultivated *Froriepia subpinnata***.** Also, it seems that cultivation of this plant only influences the essential oil yields, while the essential oil composition remains mostly constant. The data reported here contain new information in the field of chemical composition and antimicrobial activity of the *F. subpinnata* essential oil. The domestication of this plant did not substantially affect the chemical composition and biological properties of its essential oil. The biological evaluation in this research suggests that the essential oil exhibited a potent broad-spectrum antimicrobial activity, especially against Gram-positive bacteria. This study suggests that the *F. subpinnata* essential oil could be a natural alternative to synthetic and chemical preservatives to enhance food safety. The results of the present study also demonstrated that this plant has the potential to be cultivated in vast farms and its essential oil can be used in pharmaceutical and food industries. These aspects turn this medicinal plant into an interesting crop for cultivation and commercialization. The results obtained for oil production in connection with antimicrobial activity suggest that this medicinal plant may be a promising plant for agricultural and industrial use. Nevertheless, timely collection of the plant and optimization of growing conditions and also more biological investigations and other related researches are necessary in order to obtain a stable and useful crop.

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بررسی مقایسه‌ای ترکیبات شیمیایی و فعالیت بیولوژیک اسانس *Froriepia subpinnata* (اناریجه) در دو حالت وحشی و کاشته شده

ف. میرزانیا، ی. صرافی، و م. مرادی فریمانی

چکیده

فروریپیا یکی از جنس‌های خانواده‌ی چتریان است. تنها یک گونه از این جنس (اناریجه) در ایران گزارش شده است. در اکثر نقاط شمال ایران از برگ‌های تازه و جوان گیاه در تهیه‌ی بسیاری از غذاهای محلی استفاده می‌شود. علیرغم استفاده‌های گسترده‌ی این گیاه دارویی، تاکنون تحقیقات کمی بر روی آن صورت گرفته است. در این تحقیق ترکیبات شیمیایی و خاصیت ضدمیکروبی اسانس گونه‌ی وحشی و کاشته شده‌ی گیاه ارزیابی و مقایسه شدند. با استفاده از کروماتوگرافی گازی و کروماتوگرافی گازی طیف سنجی جرمی در اسانس گیاه کاشته شده تعداد ۵۳ ترکیب، که ترکیبات عمده مایرسنون (٪۲۷/۴۰)، لیمونن (٪۱۸/۶۰)، ترپینولن (٪۱۴/۷۰) و توتارولون (٪۷/۳۵) و در گیاه وحشی تعداد ۷۲ ترکیب شناسایی شدند که عمده‌ی ترکیبات مایرسنون (٪۳۶/۹۵)، لیمونن (٪۱۳/۶۲)، ترپینولن (٪۱۱/۰۴)، بتا-پینن (٪۷/۶۹) بودند. همچنین فعالیت ضدباکتریایی و ضدقارچی این اسانس‌ها بر روی شش عدد باکتری و قارچ اندازه‌گیری شدند. باکتری گرم مثبت استافیلوکوکوس اورئوس با MIC بین ۲-۱ میکروگرم بر میلی‌لیتر بیشترین اثر را نشان داد. نتایج این تحقیق نشان دادکه ترکیبات عمده‌ی اسانس در هر دو گونه‌ی وحشی و کاشته شده تقریبا یکسان بودند. همچنین اینطور به نظر می‌رسد که کاشتن تنها بر روی بازده‌ی اسانس تاثیر دارد و بر روی ترکیبات شیمیایی اسانس تاثیری نداشته و آن‌ها ثابت باقی می‌مانند.

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