e-ISSN: 2687-6698 **Research Article**

Turkish Journal of Analytical Chemistry
www.turkjac.org
2019
TurkJAC

Parentucellia viscosa (growing in Türkiye): Essential Oil, Phenolic Composition, Antimicrobial and Lipase Inhibition

Büşra Korkmaz[1,2*], Gözde Bozdal[1], Büşra Şahin[1], Sıla Özlem Sener[3], Elif Öztürk[4], Seda Fandakli[5], Şengül Alpay Karaoğlu[6], Nurettin Yaylı[1]

[1] Karadeniz Technical University, Faculty of Pharmacy, Department of Pharmacognosy, 61080, Trabzon, Türkiye.
[2] Karadeniz Technical University, Graduate School of Health Sciences, 61080, Trabzon, Türkiye.
[3] Health Sciences University, Faculty of Gülhane Pharmacy, Department of Pharmacognosy, 06010, Ankara, Türkiye.
[4] Karadeniz Technical University, Faculty of Health Sciences, Department of Nutrition and Dietetics, 61080, Trabzon, Türkiye.
[5] Artvin Çoruh University, Vocational School of Health Services, Medical Laboratory Techniques Program, 08000, Artvin, Türkiye.
[6] Recep Tayyip Erdoğan University, Faculty of Science, Department of Biology, 53100, Rize, Türkiye.

Abstract

The essential oil (EO) and phenolic constituents of *Parentucellia viscosa* L. were analyzed by GC-FID-MS and HPLC, respectively. A total of 20 volatile compounds were identified accounting for 99.97% in hydrodistillation. Monoterpenes (50.57%, 5 compounds) were the primary chemical class in the essential oil of *P. viscosa*. Limonene (44.02%) and 1-octen-3-ol (25.23%) were the major components in the essential oil of *P. viscosa*. The phenolic constituent analysis for the methanol extract of *P. viscosa* gave benzoic acid (0.97 mg/g) as the major compound. The antimicrobial activities of the EO and crude solvent (*n*-hexane, acetonitrile, methanol, and water) extracts of *P. viscosa* were screened *in vitro* against ten microorganisms. *n*-Hexane and the acetonitrile extracts of *P. viscosa* resulted in the best activity against *Mycobacterium smegmatis* with IC_{50} values of 19.2 µg/mL and 53.8 µg/mL, respectively. The highest lipase enzyme inhibition activity was detected in the *n*-hexane extract with 44.22±1.1628 µg/mL IC_{50} value.

Keywords: *Parentucellia viscosa*, essential oil, phenolic, antimicrobial, lipase

1. Introduction

Parentucellia viscosa (L.) Caruel is a genus of Orobanchaceae which mainly includes herbaceous parasitic plants and is the most significant parasitic angiosperm family [1]. Four species are distributed in central and southwestern Asia, western Europe, and the Mediterranean, such as *P. viscosa* (L.) Caruel [syn. *Bartsia viscosa* L., *Bellardia viscosa* (L.) Fisch. & C. A. Mey., *Eufragia viscosa* (L.) Benth., *Euphrasia viscosa* (L.) Benth., *Lasiopera viscosa* (L.) Hoffmanns. & Link, *Trixago viscosa* (L.) Rchb.], *Parentucellia latifolia* (L.) Caruel, *Parentucellia latifolia* subsp. *flaviflora* (Boiss.) Hand.-Mazz. and *Parentucellia floribunda* Viv. [2]. The plant is also known as Yellow Glandweed, characterized by the presence of glandular trichomes [3]. *P. viscosa* is endemic to Western Europe and often occurs in roadside vegetation, undeveloped pastures, and other weed species and introduced annual grass [4]. Many chronic metabolic diseases have resulted from obesity, a long-term man-kind problem that causes psychological and

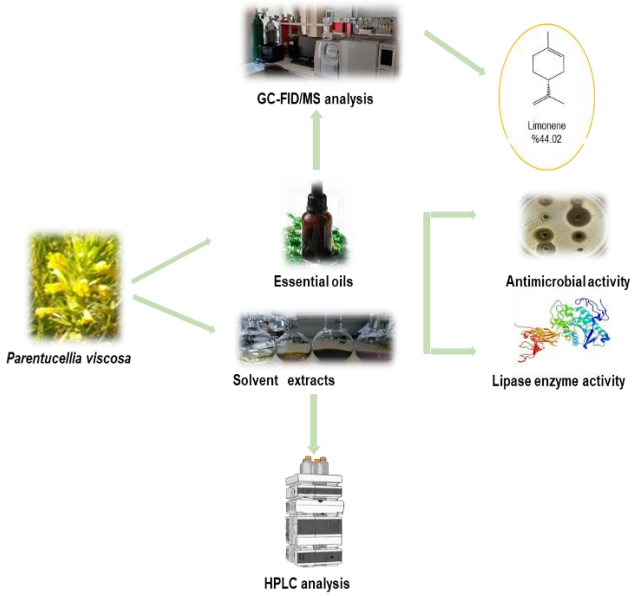

Figure 1. Graphical Illustration

Citation: B. Korkmaz, G. Bozdal, B. Şahin, S.Ö. Sener, E. Öztürk, S. Fandakli, Ş.A. Karaoğlu, N. Yaylı, *Parentucellia viscosa* (growing in Türkiye): Essential Oil, Phenolic Composition, Antimicrobial and Lipase Inhibition, Turk J Anal Chem, 6(2), 2024, 91–96.
https://doi.org/10.51435/turkjac.1513093

Author of correspondence: busra.yayli@ktu.edu.tr
Received: July 09, 2024 **Tel:** +90 (462) 325 6762
Accepted: September 09, 2024 **Fax:** +90 (462) 325 6717

physiological health problems. It is known that pancreatic lipase (PL) inhibitors are used to treat obesity. Research on this relationship has been increasing in recent years. Additionally, many studies have shown that natural products have strong to moderate PL inhibitory activity. These products are interesting for research due to their low toxicity. This low toxicity allows the development of new products in the pharmaceutical industry by utilizing natural resources. [5]. Previous phytochemical investigations of these species have led to the identification of several natural compounds such as iridoid glucosides, melampyroside, 8-epiloganin, gardoside methyl ester, shanzhiside methyl ester, aucubin, mannitol, benzoic acid, gallic acid, and diterpenes [3,6–10] have been reported. These compounds resulted in antibacterial activities [11]. The literature search revealed no research on the chemical composition of EO and phenolic compounds (HPLC). Therefore, in this study, we aimed to investigate the antimicrobial activities and lipase enzyme inhibition of EO and crude solvent (*n*-hexane, acetonitrile, methanol and water) extracts prepared from *P. viscosa.*

2. Material and Methods

2.1. Plant materials

The aerial part of *P. viscosa* (175 g, fresh) was harvested from the Karadeniz Technical University Campus at an altitude of 95 meters in May 2023. The plant was authenticated by Prof. Kamil Coşkunçelebi [1]. The voucher specimen (Coşkunçelebi 1250) has been deposited in the Herbarium of the Faculty of Biology, Karadeniz Technical University, Türkiye.

2.2. Chemicals and reagents

All solvents (*n*-hexane, acetonitrile, and methanol) and other chemicals (Tris-HCl and *p*-nitrophenyl butyrate) used were purchased from Sigma-Aldrich in analytical grade.

2.3. Isolation of essential oils

The aerial part of *P. viscosa* (115 g, fresh) was grounded with a plant mill into small pieces and then hydrodistillated (HD) with a modified Clevenger-type apparatus with a cooling bath (-10 °C, 3h), yield (*w*/*w*): 0.098%. After the HD, EO was extracted with HPLC grade *n*-hexane (0.5 mL) dried over anhydrous Na_2SO_4 and stored in a dark glass bottle in the refrigerator at -16 ℃ before the GC-FID-MS analysis [12–15].

2.4. Solvent extractions (n-hexane, acetonitrile, methanol, and water)

The aerial parts of the plant (55 g, dry) were blended into small pieces. Blended material (~12 g, each) was extracted (25 mL × 3; 12 h each) using the maceration method at room temperature with analytical grade *n*-hexane, acetonitrile, methanol, and water solvents in flasks (50 mL) separately. After the suction filtration, the same extracts were combined and solvents were evaporated or lyophilized to yield crude *n*-hexane (0.0906 g), acetonitrile (0.0675 g), methanol (0.7820 g), and water extracts (0.0755 g) [15-16].

2.5. Gas chromatography-mass spectrometry (GC-FID-MS)

GC-FID-MS analysis of the EO was carried out by a Shimadzu QP2010 ultra, having Shimadzu 2010 plus FID, PAL AOC-5000 plus autosampler, and Shimadzu Class-5000 Chromatography Workstation software. Restek Rxi-5MS capillary column (30 mm x 0.25 mm × 0.25 µm) (USA) was used for the analysis. Sample (1 µL, in HPLC grade *n*-hexane) injection was performed in split mode (1:30) at 230ºC. The initial column temperature was 60 ºC for 2 min, then increased to 240 ºC with a 3ºC/min heating ramp. The final temperature for the oven was held at 250ºC for 4 minutes. Helium (99.999 %) was the carrier gas with a 1 mL/min flow rate. MS detection was implemented in electronic impact mode (EI, 70 eV, and scan mode 40-450 *m*/*z*). The sample was analyzed, and the mean was reported [12-20].

2.6. HPLC analyses

HPLC chromatographic analysis of phenolic compounds of *P. viscosa* carried out at Shimadzu Prominence series HPLC instrument using Zorbax Eclipse Plus-C18 (150 mm × 4.6 mm, 5 µm) analytical column. The mobile phase was formed from methanol (A), 2% acetic acid solution (A, pH: 2.65), and ultra-pure water (B). The gradient applied is as follows: 0 min, 80% B; 4 min, 70% B; 7 min, 60% B; 10 min, 55% B; 12 min, 50% B; 14 min, 40% B; 16 min, 20% B. The sample injection volume is 20 µL, and the flow rate is 1.5 mL/min. The column furnace temperature is set at 25 °C. The photodiode array was detected at a wavelength of 270 nm [21].

2.7. Antimicrobial activities

All test microorganisms: E. coli ATCC35218, Y. pseudotuberculosis ATCC911, P. aeruginosa ATCC43288, E. faecalis ATCC29212, S. aureus ATCC25923, B. cereus 709 Roma, L. monositogenez ATCC43251, M. smegmatis ATCC607, C. albicans ATCC60193, and S. cerevisiae RSKK 251 were obtained from the Hıfzısihha Institute of Refik Saydam (Ankara, Türkiye). The adapted antimicrobial screening test (agar-well diffusion method) was used earlier [22,23,25]. Each tested microorganism was suspended in Brain Heart Infusion (BHI) and diluted approximately 10^6 colony-forming units (per mL), which were "flood-inoculated" onto the surface of BHI agar and Sabouraud Dextrose Agar (SDA) and then dried. SDA was used for C. albicans. Wells (5 mm diameter) were cut from the agar, and the extracts (100 µL, each) were delivered into the wells. The plates were incubated (35 °C, 18h), and antimicrobial activity was evaluated by measuring the

inhibition zone against the test organism. The EO dissolved in n-hexane, and other solvent extracts (acetonitrile, methanol, and water solvents) were dissolved in dimethyl sulfoxide to prepare stock solutions (12.300-108.900 µg/mL). n-Hexane and dimethyl sulfoxide were used as solvent control with a dilution of 1:2. Ampicillin, streptomycin, and fluconazole were used as positive controls at 10 µg/mL, 10 µg/mL, and 5 µg/mL concentrations, respectively (Table 3). After the antimicrobial properties of the EO, n-hexane, acetonitrile, methanol, and water extracts of P. viscosa were investigated quantitatively, the minimal inhibition concentration (MIC) values (µg/mL) were calculated [23,25].

2.8. Lipase Assay

Lipase inhibitory assay for the EO and solvent extracts (*n*-hexane, acetonitrile, methanol, and water) of *P. viscosa* were studied by the modified method using *p*-nitrophenyl butyrate (*p*-NPB) as substrate [26]. All extracts (25, 100, 200 and 400 µg/mL concentrations) were dissolved in buffer solution (0.1 M Tris-HCl, pH = 8.0) and 0.1% DMSO. Orlistat was used as positive control and prepared 6.25, 12.5, 25, 50, and 100 µg/mL concentration solutions. The experimental method was designed with A, B, C and D wells; A: 90 enzyme solution [(Crude porcine PL type II)-(200 units/mL)], 5 µL substrate solution (10 mM *p*-NPB in acetonitrile); 5 µL buffer solution (0.1 M Tris-HCl buffer, pH = 8.0); B: 90 µL enzyme solution, 10 µL buffer solution; C: 90 µL enzyme, 5 µL sample solution, 5 µL substrate solution; and D: 90 µL enzyme solution], 5 µL sample solution, 5 µL buffer solution. The plates were incubated at 37 °C (15 min) then substrate solution (10 mM *p*-NPB in acetonitrile) was added to each related well which was incubated again at 37 °C (15 min). The absorbance of the solutions was observed at 405 nm in a 96-well microplate using a SpetrostarNano-BMG LABTECH spectrophotometer. Experiments were carried out in triplicate. Results were stated (Table 4) as mean ± standard deviation (SD). The statistical significance level was considered as $p<0.05$. The percentage of PPL inhibition was calculated by the following equation: PPL inhibition (%) = [[(A-B)-(C-D)]/(A-B)]*100. Finally, IC_{50} values for the PPL were calculated graphically [26].

3. Results and Discussion

GC-MS analysis was performed on volatile components found in the *P. viscosa* EO using the Rxi-5MS capillary column. By comparing RI and MS data with libraries from NIST, Wiley7NL, FFNSC1.2, and W9N11, the chemical components in the EO were determined [12–20,24]. Table 1 shows the chemical compound structure, % concentration, and computed retention indices for the constituents of *P. viscosa*. GC-FID/MS analyses for the fresh aerial part of *P. viscosa* revealed 20 natural compounds within the ratio of 99.97%. Limonene (44.02%), 1-octen-3-ol (25.23%), (2*E*)-hexenal (4.05%), capronaldehyde (3.96%), and *γ*-terpinene (3.51%) were found to be major compounds in the EO of the *P. viscosa* (Table 1). The results revealed that the high terpene chemicals were monoterpenes, which are the primary components of EO derived from *P. viscosa*'s aerial parts. Alcohol (27.91%) and aldehyde (12.31%) were found to be the second main components in the EO of *P. viscosa*. In comparison to the previously published data, the EO of *Parentucellia latifolia* has been reported and 5 components were characterized, representing 99.5% of the oil.

Table 1. GC-FID-MS analysis of the EO obtained from *P. viscosa*

Compounds	RI*	RI[a]	(%)[b]
2-Ethylfuran	728	731	2.72
1,3,5-Cycloheptatriene	765	767	2.34
Capronaldehyde	803	801	3.96
2-(*E*)-hexenal	855	858	4.05
Hexanol	863	864	1.58
Benzaldehyde	960	965	2.61
1-Octen-3-ol	978	978	25.23
3-Octanone	979	982	2.19
Myrcene	988	987	0.91
α-Terpinene	1014	1015	0.46
o-Cymene	1022	1023	1.67
Limonene	1031	1030	44.02
Phenyl acetaldehyde	1044	1043	1.31
γ-Terpinene	1054	1058	3.51
Pelargonaldehyde	1100	1101	0.38
Terpinen-4-ol	1174	1179	1.10
β-Cyclocitral	1224	1224	0.47
Theaspirane	1298	1301	0.38
β-Damascenone	1386	1386	0.61
Valencene	1496	1495	0.47
Chemical classes		**NC[c]**	**%[b]**
Monoterpenes		5	50.57
Oxygenated monoterpene		1	0.48
Sesquiterpene		1	0.47
Terpene related		2	0.99
Aldehydes		5	12.31
Alcohols		3	27.91
Aliphatic hydrocarbon		1	2.34
Aromatic hydrocarbon		1	2.72
Ketone		1	2.19
Total		20	99.97

*Literature RI values.
[a]Retention Index calculated from retention times relative to that of the *n*-alkane series (C_6-C_{30}).
[b]%: Percentages obtained by FID peak-area normalization.
[c]NC: Number of compounds.

Table 2. Phenolic constituent of the methanol extract obtained from *P. viscosa*

Extract	*p*-OH benzoic acid	Vanillic acid	Syringaldehyde	Coumaric acid	Sinapic acid	Benzoic acid	Quercetin
	mg/g						
Methanol	—	0.51	—	—	0.79	0.97	0.39

Table 3. Antimicrobial activity of the EO and solvent extracts obtained from *P. viscosa.*

Sample extracts	Const. (µg/mL)		Microorganisms, inhibition zone (mm), and MIC (µg/mL)									
			Gram (-)				Gram (+)		No Gr.		Fungi	
			Ec.	*Yp.*	*Pa.*	*Ef.*	*Sa.*	*Bc.*	*Li.*	*Ms.*	*Ca.*	*Sc.*
EO	86000	Zone	—	—	—	—	7	—	—	9	—	—
		MIC	—	—	—	—	4300	—	—	2150	—	—
n-Hexane	12300	Zone	—	—	—	—	—	8	—	15	—	—
		MIC	—	—	—	—	—	307.5	—	19.2	—	—
Acetonitrile	34400	Zone	—	—	—	—	—	—	6	16	—	—
		MIC	—	—	—	—	—	—	1720	53.8	—	—
Methanol	137000	Zone	—	—	—	—	—	7	—	10	—	—
		MIC	—	—	—	—	—	3424	—	1712	—	—
Water	108900	Zone	—	—	—	—	—	—	—	—	—	—
		MIC	—	—	—	—	—	—	—	—	—	—
Amp.	10	Zone	10	10	18	10	10	15				
		MIC	10	18	128	35	10	15				
Strep.	10	Zone							35			
		MIC							4			
Flu.	5	Zone								25	25	25
		MIC								<8	<8	<8

Ec: *Escherichia coli*, Yp: *Yersinia pseudotuberculosis*, Pa: *Pseudomonas aeruginosa*, Sa: *Staphylococcus aureus*, Ef: *Enterococcus faecalis*, Bc: *Bacillus cereus* 702 Roma, Li: *Listeria monositogenez*, Ms: *Mycobacterium smegmatis*, Ca: *Candida albicans*, Sc: *Saccharomyces cerevisiae*, Amp.: Ampicillin, Strep.: Streptomycin, Flu.: Fluconazole, (-): no activity of test concentrations

Germacrene D and germacrene B were the main compounds as sesquiterpene hydrocarbons accounting for 59.2% and 24.3% of the oil, respectively [2]. However, in this work, limonene and 1-octen-3-ol were the major constituents in the EO of the *P. viscosa* which could be used as a taxonomical marker. Volatile constituent variations in the EO of *P. viscosa* with another genus could be the environmental and analysis conditions.

HPLC was used to examine the phenolic profile of methanol extract from *P. viscosa*, using standards including *p*-hydroxybenzoic acid, benzoic acid, quercetin, vanillic acid, sinapic acid, syringaldehyde, and *p*-coumaric acid. Results indicated that benzoic acid (0.97 mg/g), sinapic acid (0.79 mg/g), and vanillic acid (0.51 mg/g) were major constituents of *P. viscosa*. Quercetin was also found in the amount of 0.39 mg/g in the methanol extract (Table 2).

The antimicrobial activities of *P. viscosa* EO and solvent extracts were tested against *Escherichia coli*, *Yersinia pseudotuberculosis*, *Pseudomonas aeruginosa*, *Staphylococcus aureus*, *Enterococcus faecalis*, *Bacillus cereus*, *Listeria monositogenez*, *M. smegmatis*, *Candida albicans*, and *Saccharomyces cerevisiae* using an in vitro agar diffusion method (Table 3). Inhibition zones were measured in mm and then MIC (µg/mL) values were calculated [22–23]. The crude n-hexane extract of *P. viscosa* had the highest activity against *M. smegmatis* with a 15 mm inhibition zone diameter (MIC, 19.2 µg/mL) and *B. cereus* with an 8 mm inhibition zone (MIC, 307.5 µg/mL). The EO was only active against *S. aureus* and *M. smegmatis* which was effective in anti-tuberculosis activity against *M. smegmatis* within 2150 µg/ml MIC values. The most active extract of *P. viscosa* against *M. smegmatis* (16 mm, 53.8 µg/mL) was found in acetonitrile. It was discovered that the EO and solvent extracts (without water) were more efficient in eliminating no-gram bacteria (*M. smegmatis*). No activity against gram-negative or fungi was detected in essential oils and extracts. Antimicrobial activity results indicate the presence of active compounds in *n*-hexane, acetonitrile, and EO extracts. The previous antimicrobial assessment of crude dichloromethane and methanol extracts obtained from *P. viscosa* showed the greatest inhibition zone diameter against *P. aeruginosa, Proteus vulgaris, Klebsiella pneumonia, Enterobacter, E. coli*, and *S. aureus*, respectively [11]. In our case, extracts (except water extract) were more active to *M. smegmatis*, which could be the fact of the location and time collection of the plant.

Table 4. Lipase inhibition of the EO and solvent extracts obtained from *P. viscosa*

Extracts	IC_{50} (µg/mL)*
Essential oil	49.50 ± 2.12
n-Hexane	44.22 ± 1.16
Acetonitrile	199.42 ± 4.88
Methanol	78.89 ± 3.42
Water	52.60 ± 1.88
Orlistat	13.52 ± 1.42

*Results were stated as mean ± standard deviation (SD). The statistical significance level was considered as $p<0.05$

Research has shown that terpenoids, polyphenols, flavonoids, and other naturally occurring chemicals can suppress the activity of lipase [5]. Terpenoids are often the main components of n-hexane extract and essential oil [13,14]. As a result, we evaluated the lipase activity of *P. viscosa* essential oil and solvent extracts. Lipase enzyme inhibition activities of solvent extracts and essential oil of *P. viscosa* were investigated against orlistat as a positive control (IC_{50}: 13.52±1.42 µg/mL) (Table 4). The *n*-hexane extract showed the highest

activity, with an IC_{50} of 44.22±1.16 µg/mL. Afterward, the best activity was found in essential oil (IC_{50}: 49.50±2.1220 µg/mL). Lipase inhibition activities of acetonitrile, methanol, and water extracts of *P. viscosa* were found with IC_{50} values of 199.42±4.88 µg/mL, 78.89±3.42 µg/mL, and 52.60±1.88 µg/mL, respectively. The lowest activity was observed at the highest polarity. A positive correlation was observed between polarity reduction and lipase activity.

4. Conclusions

The EO and phenolic composition for the aerial part of the *P. viscosa* were characterized by GC-FID-MS and HPLC, respectively. Monoterpenes (50.57%) were identified as the main chemical class in the EO of *P. viscosa*. The major components in the EO of *P. viscosa* were limonene and 1-octen-3-ol. The antimicrobial activities for the EO and crude solvent extracts of *P. viscosa* showed that *n*-hexane and acetonitrile extracts showed the best activity against *M. smegmatis* with IC_{50} values of 19.2 and 53.8 µg/mL, respectively. Resulted antimicrobial activities suggest the availability of active compounds in *n*-hexane, acetonitrile extracts, and the oil. The highest lipase enzyme inhibition activity was detected in the *n*-hexane extract with an IC_{50} value of 44.22 ± 1.16 µg/mL. A positive correlation was observed between polarity reduction and lipase activity. Thus, the reported lipase enzyme and antimicrobial assay results collectively imply that *P. viscosa* EO, *n*-hexane, and acetonitrile extracts may hold promise for use in medicinal applications. In a future investigation, bio-guided activity isolation and purification of *P. viscosa*, particularly the *n*-hexane extract, could be performed to improve bioavailability.

Acknowledgments

We are thankful to Karadeniz Technical University for the financial support and to Prof. Dr. Kamil Coşkunçelebi for identifying the plant.

References

[1] A. Güner, S. Aslan, T. Ekim, M. Vural, M. T. Babaç, Türkiye Plants List; Vascular Plants, Nezahat Gökyiğit Botanical Garden and Flora Research Association Publication, 2012, 657.

[2] N. Badalamenti, M. Bruno, C. Formisano, and D. Rigano, Effect of Germacrene-Rich Essential Oil of *Parentucellia latifolia* (L.) Caruel Collected in Central Sicily on the Growth of Microorganisms Inhabiting Historical Textiles, Nat Prod Comm, 17(4), 2022, 1934578X221096963.

[3] A. Venditti, M. Ballero, M. Serafini, A. Bianco, Polar compounds from *Parentucellia viscosa* (L.) Caruel from Sardinia, Nat Prod Res, 29(7), 2015, 602-606.

[4] J. Pate, T. Bell, Host associations of the introduced annual root hemiparasite *Parentucellia viscosa* in agricultural and bushland settings in Western Australia, Ann Bot, 85(2), 2000, 203-213.

[5] T.T. Liu, X.T. Liu, Q.X. Chen, Y. Shi, Lipase inhibitors for obesity: A review, Biomed Pharmacother, 128, 2020, 110314.

[6] A. Bianco, P. Passacantilli, G. Righi, M. Nicoletti, Iridoid glucosides from *Parentucellia viscosa*, Phytochemistry, 24(8), 1985, 1843-1845.

[7] M. Grande, A. Fernández-Mateos, J.J. Blanco, M.M. Herrador, J.F.Q. del Moral, P. Arteaga, J.F. Arteaga, A.F. Barrero, Diversity on Diterpene Composition in Two Populations of *Parentucellia viscosa*: Labdane and Clerodane Chemotypes, Nat Prod Commun, 2(6), 2007, 621-624.

[8] E.J. Llorent-Martínez, M.L. Fernández-de Córdova, G. Zengin, M.B. Bahadori, M.Z. Aumeeruddy, K.R. Rengasamy, M.F. Mahomoodally, *Parentucellia latifolia* subsp. *latifolia*: A potential source for loganin iridoids by HPLC-ESI-MSn technique, J Pharm Biomed, 165, 2019, 374-380.

[9] J. Urones, I. Marcos, I.Cubillo, N.M. Garrido, P. Basabe, Terpenoid compounds from *Parentucellia latifolia*, Phytochemistry, 29(7), 1990, 2223-2228.

[10] J. Urones, I. Marcos, L. Cubillo, V. Monje, J. Hernández, P. Basabe, Derivatives of malonic acid in *Parentucellia latifolia*, Phytochemistry, 28(2), 1989, 651-653.

[11] Z. Amar, S.N. Labib, G. Noureddine, R. Salah, Phytochemical screening of five Algerian plants and the assessment of the antibacterial activity of two *Euphorbia guyoniana* extracts, Pharmacia Lettre, 4(5), 2012, 1438-1444.

[12] R.P. Adams, Identification of essential oil components by gas chromatography/mass spectrometry: Allured publishing corporation Carol Stream, IL, 2007.

[13] G. Kılıç, B. Korkmaz, İ. Erik, S. Fandaklı, S.S. Yaylı, Ö. Faiz, Ş. Alpay Karaoğlu, N. Yaylı, Antimicrobial, antioxidant, tyrosinase activities and volatile compounds of the essential oil and solvent extract of Epilobium hirsutum L. growing in Turkey, Turk J Chem, 2(2), 2020, 87-94.

[14] İ. Erik, G. Kılıç, E. Öztürk, Ş.A. Karaoğlu, N. Yaylı, Chemical composition, antimicrobial, and lipase enzyme activity of essential oil and solvent extracts from *Serapias orientalis* subsp. *orientalis*, Turk J Chem, 44(6), 2020, 1655-1662.

[15] N. Yayli, A. Yaşar, C. Güleç, A. Usta, S. Kolaylı, K. Coşkunçelebi, S.A. Karaoğlu, Composition and antimicrobial activity of essential oils from *Centaurea sessilis* and *Centaurea armena*, Phytochemistry, 66(14), 2005, 1741-1745.

[16] N. Yayli, E. Oksuz, B. Korkmaz, İ. Erik, S. Fandakli, Ö. Faiz Ö, K. Coşkunçelebi, Volatile and Phenolic Contents, Antimicrobial and Tyrosinase activities of Two Endemic Species *Scorzonera pisidica* and *Scorzonera sandrasica* L. Grown in Turkey, Rec Nat Prod, 16(1), 2022, 46-57.

[17] I. Erik, G. Kılıç, B. Korkmaz, S. Fandaklı, Ş.A. Karaoğlu, N. Yaylı, Volatile constituents and antimicrobial activity of *Vinca major* L. subsp. *hirsuta* (Boiss) stearn grown in Turkey, J Res Pharm, 25(5), 2021, 581-588.

[18] N. Yayli, C. Gülec, O. Üçüncü, A. Yaşar, S. Ülker, K. Coşkunçelebi, S. Terzioğlu, Composition and antimicrobial activities of volatile components of *Minuartia meyeri*, Turk J Chem, 30(1), 2006, 71-76.

[19] T.B. Cansu, B. Yayli, T. Özdemir, N. Batan, Ş.A. Karaoğlu, N. Yaylı, Antimicrobial activity and chemical composition of the essential oils of mosses (*Hylocomium splendens* (Hedw.) Schimp. and *Leucodon sciuroides* (Hedw.) Schwägr.) growing in Turkey, Turk J.Chem, 37(2), 2013, 213-219.

[20] O.D. Sparkman, Identification of essential oil components by gas chromatography/quadrupole mass spectroscopy, J Am Soc Mass Spectrom, 16(11), 2005, 1902.

[21] N. Korkmaz, S.O. Sener, N. Balturk, S. Kanbolat, M. Badem, R. Aliyazicioglu, U. Ozgen, A. Kandemir, S. Alpay Karaoglu, Determination of Phenolic Contents by HPLC, and Antioxidant,

Antimicrobial, Antityrosinase,and Anticholinesterase Activitiesof Psephellus huber-morathii, J Pharm Res Int, 26(1), 2019, 1-10.

[22] A.L. Barry, Methods for determining bactericidal activity of antimicrobial agents: approved guideline, National Committee for Clinical Laboratory Standards: National Committee for Clinical Laboratory Standards Wayne, PA, 1999.

[23] G.L. Woods, Susceptibility testing of mycobacteria, nocardiae, and other aerobic actinomycetes, *A*pproved Standard M24-A2, 31(5), 2011.

[24] N. Andriamaharavo, Retention Data NIST Mass Spectrometry Data Center, NIST Mass Spectrometry Data Center, 2014.

[25] G.L. Woods, B.A. Brown-Elliott, E.P. Desmond, G.S. Hall, L. Heifets, G.E. Pfyffer, Susceptibility testing of mycobacteria, nocardiae, and other aerobic actinomycetes. pproved standard, NCCLS document M24-A, 23(18), 2003.

[26] S.O. Sener, U. Ozgen, S. Kanbolat, N. Korkmaz, M. Badem, H. Hanci, T. Dirmenci, T. Arabaci, R. Aliyazicioglu, E. Yenilmez, G. Saltan Işcan, Investigation of therapeutic potential of three endemic Cirsium species for global health problem obesity, S Afr J Bot, 141, 2021, 243-254.