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ANTIOXIDANT ACTIVITIES AND CHEMICAL COMPOSITON OF DIFFERENT EXTRACTS OF MOSSES GATHERED FROM TURKEY

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Abstract

Recent pharmacological investigations of bryophytes have proven that the active principles present in these plants are quite unique and having potential chemical application and antioxidant capacity. The mosses of Oxytegius tenuirostris, Eurhynchium striatum W. P. Schimper and Rhynchostegium murale (Hedw.) Schimp. were collected from different locations of Turkey, and dried and exracted with different solvents. Volatiles were isolated from the samples by solid phase microextraction. Gas Chromatography-Mass Spectrometry (GC-MS) was used to identify volatile compounds. Antioxidant activities of moss were tested by free radical scavenging activity (DPPH• assay), Trolox equivalent (TEAC) and Cupric Reducing Antioxidant Capacity (CUPRAC) methods. Antioxidant activities were found for mossesas 24.67-67.12 mg/g from chloroform extract, 18.83-35.83 mg/g from ethanol extract, 7.78-46.09 mg/g from methanol extract and 12.56-34.13 mg/g from water extract by DPPH• assay method. Antioxidan activities were found as 562.07-2060.52 mg/g from chloroform extract, 597.44-1765.77 mg/g from ethanol extract, 2506.23-7454.92 mg/g from methanol extract and 676.41-5631.23 mg/g from water extract by Trolox method. Antioxidant activities were found as 9.78-64.60 mg/g from chloroform extract, 5.62-28.37 mg/g from ethanol extract, 4.23-30.54 mg/g from methanol extract and 4.92-27.77 mg/g from water extract by Cuprac method. On the basis of the results it is suggested that the extract of mosses species determined here could be of use as an easily accessible source of natural antioxidant for the treatment.

Key words: *Oxytegus tenuirostris, Eurhynchium striatum, Rhynchostegium murale, mosses, antioxidant activity, DPPH; TEAC, CUPRAC methods.*

INTRODUCTION

Plant phenolics are commonly found in both edible and non-edible plants, and have been reported to have multiple biological effects, including antioxidant activity. The importance of the antioxidant constituents of plant materials in the maintenance of health and protection from coronary heart disease and cancer is also raising interest among scientists, food manufacturers, and consumers as the trend of the future is moving toward functional food with specific health effects (Löliger, 1991). Most phytochemicals in natural agricultural sources have been generally recognized as bioactive or health-promoting compounds, which play an important role in preventing cardiovascular diseases, cancers, obesity and diabetes, lowering blood cholesterol level, and reducing inflammatory action (Halliwell, 1996). *Bryophytes* belong to phylum bryophyte and include three classes *Hepaticopsida* (liverworts), *Bryopsida* (mosses), and *Anthocerotea* (hornworts). They are small, terrestrial photosynthetic, spore-bearing plants that require a humid environment and can be found all over the world. There are about 20,000 species of bryophytes worldwide, which is about five percent of the total of 400,000 plant species on the earth (Zinsmeister, 1991).

Until now, the chemistry of less than 10% of bryophytes has been studied and different types of terpenoids, bisbibenzyls, flavonoids, alkaloids, and other novel compounds have been isolated. Much of this has been documented in regular reviews (Asakawa, 2004). *Bryophytes* are considered as a **"remarkable reservoir"** of new, natural products or secondary compounds, many of which have shown interesting biologic activity. These activities can be presented as: antimicrobial, antifungal, cytotoxic, antitumor, vasopressin (VP) antagonist andcardiotonic. Some of the latest results also predicted the beneficial influence of bryophytes in AIDS therapy (some bibenzyles of liverworts) (Sabovljevic 2001, Pejin et al., 2012; Pejin et al., 2013). The biological characteristics of the terpenoids and aromatic compounds isolated from bryophytes show antibacterial and anti-fungal activity (Barros, 2007; Miller and Rice-Evans, 1999; Veljıć et al., 2010). Antioxidant capacity of the moss was found to be higher than certain common plants (Montenegro et al., 2009). (Singh et al., 2006), viral diseases (Frahm, 2004) etc. antioxidant capacity. Ethnomedicinal use of different bryophytes should be scientifically investigated for active principles in order to bridge between traditional knowledge and pharmacology (Yayintas et al., 2017).
Oxystegus tenuirostris (Hook. & Taylor) A.J.E. Sm; Zander (2007) outlines its area as extremely wide throughout the world, from Arctic to tropical areas on all continents. With about 1350 species the Pottiaceae comprise around 10% of moss diversity (Crosby et al., 1999) with many thriving in rather harsh environments (Zander, 1993). *O. tenuirostris* (Hook. & Taylor) A.J.E. Sm. exhibits a cosmopolitan distribution with a wide ecological and altitudinal amplitude occurs on damp to moist soil, soil over rock, peaty banks, humid cliffs, rarely on tree bases and logs that may be occasionally flooded. Brachytheciaceae is one of the largest families among pleurocarpous mosses, probably including 250 to 350 species and 41 genera (Ignatov&Huttunen, 2002), although the latest checklist of mosses contains a total of 570 accepted species (Crosby et al., 1999). Our species *R. murale* is nearly always found on rocks and stones. The other our species of *Eurhynchium striatum* grows on the ground and around stones in woodland, especially on base rich soils, but also on neutral to slightly acidic substrates.The GC-MS method is usually used to determine the chemical composition of the mosses(Yayintas et al., 2017). Generally, the antioxidant activities of mosses are using CERAC, CUPRAC, TEAC, DPPH*, TPC, and FRAP methods (Ertürk et al., 2015).

MATERIALS AND METHODS

Collection and identification ofmosses

Moss samples were collected from different locations of the Turkey, and dried accordingly.
List of location sites:
Oxystegus tenuirostris (Hooker & Taylor) A. Smith (Figure 1a). **T. 1713:** Osmaniye: Yarpuz-Hasanbeyli (Turkey) 15 km, road side, 1500m, partial shade, on rock, 2002 (OT1). This abrrevation is indicated that *Oxystegus tenuirostris*. **T. 1715:** Osmaniye: Yarpuz, Fındıcak Tarla, (Turkey), 750 m, partial shade, on rock, 2002 (OT2). **T. 1718:** Osmaniye: Yukarı dereli village (Turkey), 350 m, on soil, slope, 2002 (OT3).OT1-OT3 are indicated that *Oxystegus tenuirostris*. T is indicated that Ozlem TONGUC YAYINTAS by collecting and defining moss species.

Eurhynchium striatum (Schreb. ex Hedw.) Schimp (Figure 1b).
Kor26: Fethiye: Ölüdeniz and environs, on soil, ca. 10m, 1994 (ES1). **Kor32:** Fethiye: Ölüdeniz and environs, under forest vegetation, on soil, 500 m, 1994 (ES2). **Kor38:** Fethiye: Ölüdeniz and environs, under forest vegetation, on soil, 500 m, 1994 (ES3). ES1-ES3 are indicated that *Eurhynchium striatum*. Kor is indicated that Koray ALTANby collecting and defining moss species.
Rhynchostegium murale (Hedw.) Schimp. (Figure 1c).

A. 3351, A. 3353, A. 3358: Kırklareli, Istranca, between İğneada-Demirköy (Turkey), 600 m, on soil; on old rock crevices, 1990 (RM1); (RM2); (RM3). RM1-RM3 are indicated that *Rhynchostegium murale*.

A is indicated that Ahmet Nuri YAYINTAS by collecting and defining moss species.Voucher specimens were identified according to below procedureby Dr. Ozlem TONGUC YAYINTAS and deposited in the Canakkale Onsekiz Mart

University, Applied Scienceof College, Fisheries Technology,Turkey. The status of these taxa wasevaluated by reviewing the related literature for Turkey (Uyar and Çetin 2004, Kürschner and Erdağ 2005; Kürschner and Frey 2011).We investigated the following species: *Oxystegus tenuirostris* (Hooker & Taylor) A. Smith, *Eurhynchium striatum* (Schreb. ex Hedw.) Schimp, *Rhynchostegium murale* (Hedw.) Schimp (Figures 1 a, b, c).

(a) (b) (c)

Figure 1. Moss species of (a) *Oxystegus tenuirostris* (Hooker & Taylor) A. Smith, (b) *Eurhynchium striatum* (Schreb. ex Hedw.) Schimp, (c) *Rhynchostegium murale* (Hedw.) Schimp.in Turkey

Extraction of Moss Specimens

Milled moss specimens were weighed, extraction is carried out with chloroform, ethanol, methanol and water successively. 5 ml of chloroform was added to each sample and mixed with a vortex. It was waited for 30 min in ultrasonic bath and then mixed with vortex. Then, filtered and dried drogs. The same procedure was performed using ethanol, methanol and water

Gas chromatography-mass spectrometry (GC/MS)

Volatile compounds from moss samples were isolated by solid-phase microextraction (SPME) technique (Pawliszyn, 2012) and identified by Gas chromatography mass spectrometry. Volatiles were tentatively identified by GC–MS. A nonpolar HP5 column (30 m × 0.25 mm i.d. × 0.25-µm film thickness; J&W Scientific) was used for separation of volatiles. The GC–MS system consisted of an HP 6890 GC and 7895C mass-selective detector (MSD; Agilent Technologies, Wilmington, DE, USA).

Experimental Conditions for Methods

Free radical scavenging activity (DPPH• assay)

Antioxidant activities of these mosses were tested by free radical scavenging activity (DPPH• assay) of chloroform, ethanol, methanol and water extracts according to the procedures described by Srinivasan et al. Moss extract of 0.1 ml were mixed with 1.5 ml of DPPH• reagent and allowed to stand at room temperature for 30 minutes in the dark. The absorbance was taken at 517 nm. RSD is calculated by measuring the average and the third the preparation of each sample. Results are calculated as % reduction (Amarowicz, 2004) (Table 2). Trolox was used as a standard.

Trolox equivalent antioxidant capacity (TEAC) assay

Antioxidant activity was measured using the 2,2'-azino-bis(3-ethylbenzothiazoline-6-sulfonic acid) (ABTS) method as described before (Re et al., 1999). It is based on the Trolox equivalence of the samples. Mixed with 2.45 mM potassium persulfate was 7 mM ABTS, in order to produce an ABTS+ radical. Th is radical was left in a dark room at 30 °C for 2 days to reach stable absorbance at 734 nm. Extracts were diluted in ethanol to a final concentration of 0.1 mg/mL. Ethanol was used as the blank. The ABTS+ solution was diluted with 5 mM phosphate buffer until it had an absorbance of 0.70 ± 0.02 at 734 nm. Next, 1 mL of this stock solution was taken and mixed with 10 µL of a sample solution and measured at 734 nm for 1-6 min after the initial mixing. All measurements were carried out in triplicate. The inhibition percentages were calculated as follows: Inhibition % = $(A_{ABTS} + - A_{6.min}) \times 100/A_{ABTS}^{+}$, where $A_{ABTS.}^{+}$ is the absorbance of ABTS+ at 734 nm (0.700 ± 0.02) and A6.min is the 6-min absorbance aft er the addition of the sample to the ABTS+. The absorbances of the samples were compared to that of the stan-

dard curve and the antioxidant properties were expressed as mM Trolox equivalent/mg for extracts (Yayintas et al., 2017; Ertürk et al., 2015).

CUPRAC spectrophotometric assay of total antioxidant capacity

1 mL 10 mM cupric chloride, 1 mL 7.5 mM neucuproine, 1 mL 1M amonium acetatete buffer (pH:7) and 1 mL water were mixed. 0,1 mL bryophytes extracts were added in this mixture. The samples were incubated for half an hour at room temperature, absorbance against a reagent blank was measure at 450 nm. All procedures were repeated in triplicate. The results were expressed as means (±SD) mmol trolox per gram dry bryophytes (Apak et al., 2004).

RESULTS AND DISCUSSIONS

GC-MS identification of water extracts

The mosses were sampled from different locations of Turkey. They are abundant in nature. Data obtained from GC-MS from the sample of water extracts of *Oxystegus tenuirostris* (Hooker & Taylor) A. Smith, *Eurhynchium striatum* (Schreb. ex Hedw.) Schimp, *Rhynchostegium murale* (Hedw.) Schimp. were given respectively in Table 1.

A total of 89 compounds were determined from water extract of *Oxystegus tenuirostris* by GC-MS. Among these compounds with higher abundance were given in Table 1.

A total of 91 compounds were determined from water extract of *Eurhynchium striatum*by GC-MS. Among these compounds with higher abundance were given in Table 1.

A total of 92 compounds were determined from water extract of *Rhynchostegium murale* by GC-MS. Among these compounds with higher abundance were given in Table 1.Gas chromatogram with mass-spectrometric detection of the moss species are given in Figures 2-4.

Table 1. GC-MS analysis of*moss species (*water extracts*)* component

Moss species	Compound number	Retention Time (min)	Identified Substance	Volatiles	Area %
***Oxystegus tenuirostris* (OT)**					
	1	1.91	Chloroform	plant volatile	2.04
	2	2.73	Dimethyl silanediol	organosilicon compound	5.88
	5	5.65	hexamethylcyclotrisiloxane	polymeric oil	7.30
	6	6.81	Formic acid	colourless corrosive liquid carboxylic acid	5.96
	7	7.91	Oxime-, methoxy-phenyl		2.22
	10	10.05	octamethylcyclotetrasiloxane	organosilicon	5.63
	11	10.51	1-Hexanol, 2-ethyl	light, sweet floral fragrance	4.13
	12	11.30	1-Octyl trifluoroacetate	fruit-like odor	2.49
	14	12.98	Octyl, cyclopropane,	anaesthetic	2.11
	17	15.01	Sulfurous acid, 2-pentyl ester	plant volatile (hsdb, 1995)	2.94
	19	15.67	Propanoic acid, 2-methyl-, 2,2-dimethyl-1-(2-hydroxy-1-methylethyl) propyl ester		6.02
	20	15.95	Butanoic acid, butyl ester	sweet fruity flavors	7.41
	22	16.93	5,9-Undecadien-2-one, 6,10-dimethy l-, (E)	flavor and fragrance agents	2.64
	24	18.73	Pentanoic acid, 2,2,4-trimethyl-3-carboxyisopropyl, isobutyl ester	flavor and fragrance	11.16
***Eurhynchium striatum* (ES)**					
	1	1.92	Chloroform	plant volatile	4.88
	2	2.73	Dimethyl,Silanediol	Organic compound	7.56
	5	5.66	Hexamethylcyclotrisiloxane	Organosilicon compound	7.46
	6	6.81	N-ethyl-1,3-dithioisoindoline	psychoactive drug	4.32
	7	7.90	Oxime-, methoxy-phenyl-1-Propanone, 2-chloro-1-(2,4-dimethylphenyl)-2-methylSilane, dodecyldiethoxymethyl	fungicides	3.84
	9	9.75	3-Octanone	flavor and fragrance	2.27
	10	10.06	Octamethylcyclotetrasiloxane	organosilicon compound	7.47
	11	10.52	2-ethyl-1-Hexanol	natural plant fragrance	5.85
	12	11.30	Formic acid, octyl ester	fruity odor	2.20
	14	12.79	3-Hydroxymandelic acid, ethyl ester, di-TMS		3.35

Moss species	Compound number	Retention Time (min)	Identified Substance	Volatiles	Area %
	18	15.31	(3-Methoxy-phenyl)-(6-methyl-4-phenyl-quinazolin-2-yl)-amine	stimulant drug	2.07
***Rhynchostegium murale* (RM)**					
	1	1.93	Chloroform	plant volatile	5.38
	2	2.53	Dimethyl Silanediol	Organic compound	7.53
	3	4.59	Hexanal	fruity flavors	6.35
	4	5.56	Hexamethylcyclotrisiloxane	polymeric oil	10.69
	5	6.84	N-ethyl-1,3-dithioisoindoline	psychoactive drug	2.22
	7	7.87	Oxime- methoxy-phenyl	fungicides	2.22
	10	10.04	Octamethyl, cyclotetrasiloxane	organosilicon compound	6.83
	11	10.52	2-tert-Butyl-3,4,5,6-tetrahydropyridine	heterocyclic compounds	4.88
	24	18.11	2-phenyl-5-propylresorcin	antiseptic and disinfectant	2.78

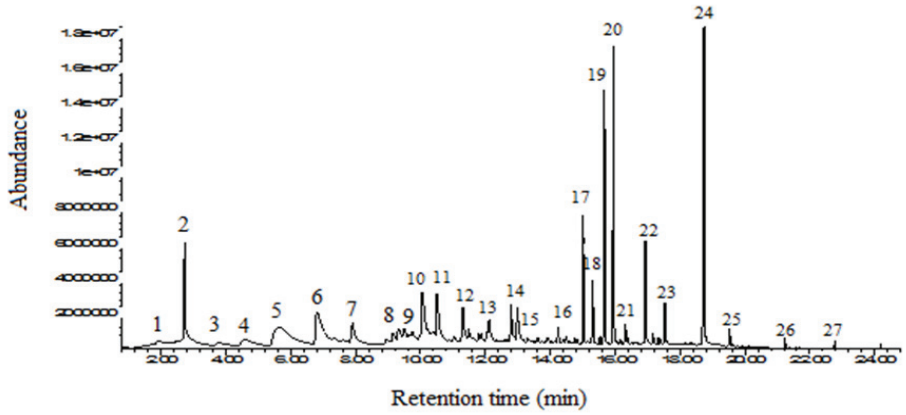

Figure 2. Gas chromatogram with mass-spectrometric detection of *Oxystegus tenuirostris;* numbers refer to the compounds listed in Table 1

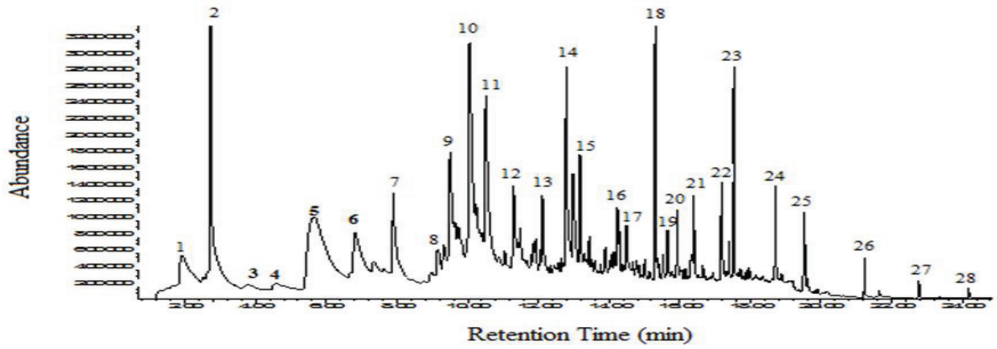

Figure 3. Gas chromatogram with mass-spectrometric detection of *Eurhynchium striatum*; numbers refer to the compounds listed in Table 1

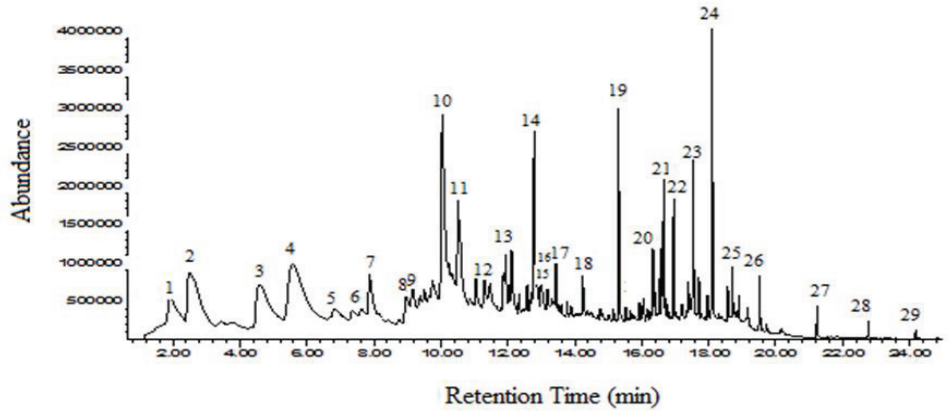

Figure 4. Gas chromatogram with mass-spectrometric detection of *Rhynchostegium murale;* numbers refer to the compounds listed in Table 1

Free radical scavenging activity (DPPH$^{\bullet}$ assay) of these mosses was given in Table 2.

Table 2. Free radical scavenging activity (DDPH asssay) of different solvent extracts of mosses (mg/g)

Sample and (location)*	Chloroform		Ethanol		Methanol		Water	
	Mean	RSD	Mean	RSD	Mean	RSD	Mean	RSD
OT1	29.03	4.69	35.83	5.21	15.48	3.71	24.98	4.64
OT2	25.45	4.25	18.83	0.69	16.81	1.26	27.64	1.69
OT3	24.85	2.34	21.17	10.58	7.78	2.55	34.13	2.88
Average	**26.44**	**3.79**	**25.27**	**5.49**	**13.35**	**2.50**	**28.91**	**3.07**
ES1	33.94	5.21	23.92	4.86	24.23	0.54	26.04	1.61
ES2	31.83	3.82	26.06	2.74	25.50	14.83	25.28	6.72
ES3	24.67	3.13	25.83	4.14	23.20	8.58	22.54	4.04
Average	**30.14**	**4.05**	**25.27**	**3.91**	**24.31**	**7.98**	**24.62**	**4.12**
RM1	67.12	2.20	22.74	2.25	20.91	8.60	12.56	13.53
RM2	28.32	1.59	22.59	7.92	19.45	7.10	21.92	2.94
RM3	25.11	1.38	22.65	1.82	20.01	4.88	25.67	9.24
Average	**40.18**	**3.44**	**22.66**	**3,99**	**20.12**	**6.86**	**20.05**	**8.57**

In general, when Table 2 is evaluated the chloroform extract of RM1 has been shown higher value than the other RM species. This value should be taken the evaluation of the results by the Q test (90 confident level). There is no difference between the moss species and the extraction solvents according to the free radical scavenging method (DDPH) ($p>0.05$). TEAC spectrophotometric assay of total antioxidant capacity of mosses is given in Table 3. In Table 3, the results of antioxidant capacity of the mosses determined by TEAC method is given.As it can be seen in Table 3 the methanol extracts of all kinds of mosses showed higher antioxidant capacity by TEAC method. Different results were teken from thesame group of mosses in the same solvent.

Table 3. Antioxidant activities of these mosses were tested by TEAC spectrophotometric method of chloroform, ethanol, methanol and water extracts (mg/g)

Sample and (location)*	Chloroform		Ethanol		Methanol		Water	
	Mean	RSD	Mean	RSD	Mean	RSD	Mean	RSD
OT1	840.66	1.43	597.44	3.17	6586.52	2.13	1373.09	3.72
OT2	687.57	4.46	1280.14	1.36	7454.92	3.18	1459.30	2.23
OT3	994.40	3.22	957.28	1.45	5046.73	5.43	1073.76	1.75
Average	**840.87**	**3.03**	**944.95**	**1.99**	**6362.72**	**3.58**	**1302.05**	**2.56**
ES1	688.52	2.91	1264.49	1.03	6490.16	3.71	1854.40	1.62
ES2	1822.30	4.25	1561.95	2.62	2506.23	1.63	4642.42	1.20
ES3	2060.52	0.88	1608.21	5.47	3498.50	0.26	5631.23	3.23
Average	**1523.78**	**2.68**	**1478.21**	**3.04**	**4164.96**	**1.86**	**4042.68**	**2.01**
RM1	958.07	0.85	1088.29	3.00	6891.34	1.04	819.91	4.13
RM2	562.07	0.99	1765.77	4.24	6710.46	2.19	676.41	0.46
RM3	1021.64	0.70	1315.97	5.58	4624.78	2.34	721.76	2.36
Average	**847.26**	**0.84**	**1390.01**	**4.27**	**6075.52**	**1.85**	**739.36**	**2.31**

When the result were compared statistically, the different values couldn't be eliminated (the Q test 90 confident level) and there were no difference between the extraction solvents, $p>0.05$). The third method was CUPRAC for the determination of antioxidant capacity of the mosses. The results were given in Table 4.

Table 4. Antioxidant activities of these mosses were tested by CUPRAC spectrophotometric method of chloroform, ethanol, methanol and water extracts (mg/g)

Sample and (location)*	Chloroform		Ethanol		Methanol		Water	
	Mean	RSD	Mean	RSD	Mean	RSD	Mean	RSD
OT1	12.08	1.90	7.74	4.38	4.23	2.00	6.03	4.26
OT2	11.23	3.50	10.42	8.34	9.64	7.49	4.92	2.50
OT3	13.57	4.13	12.57	9.76	4.27	3.88	7.10	5.69
Average	**12.29**	**3.17**	**10.24**	**7.49**	**6.04**	**4.45**	**6.01**	**4.15**
ES1	9.78	5.32	5.88	16.31	5.21	5.73	6.36	5.35
ES2	47.93	0.53	20.64	3.52	29.71	5.73	20.74	1.28
ES3	64.60	2.28	28.37	1.99	30.54	6.83	27.77	2.19
Average	**40.77**	**2.71**	**18.29**	**7.27**	**21.82**	**6.09**	**18.29**	**2.94**
RM1	11.66	3.62	5.62	5.62	5.16	5.54	6.53	6.97
RM2	22.78	4.08	6.11	6.94	8.15	6.97	5.77	5.83
RM3	18.95	4.43	5.84	6.53	8.52	5.18	10.84	3.12
Average	**17.79**	**4.04**	**5.85**	**6.36**	**7.27**	**5.89**	**7.71**	**5.30**

In CUPRAC method, chloroform is the best solvent for the extraction. Chloroform extracts of all the species of mosses had higher antioxiant capactity than the other solvent extracts. Q test were done for the evaluate the values.When we look at the

Table 4, the extraction values of *E. striatum* collected with Kor26 code in chloroform, ethanol, methanol and water were found to be quite low compared to other samples (Kor32 and Kor38). The reason for this may be attributed to the fact that the cormorant species of Kor 26 has been collected from a semi-shaded area, over rock and near the roadside.As shown in Table 3, the amounts of antioxidants in the same species of *Oxytegus tenuirostris* vary. The difference between the antioxidant values of the *O. tenuirostris* species can be attributed to the collection of the same species from different heights. The same situation is seen in *Eurhynchium striatum* and *Rhynchostegium murale* species.As seen from Tables 2-4, climate is the most important ecological factor that determines the bryophyte types and the basic characters and the distribution areas of the bryophytes associations. The common effects of the climate factors such as heat, humidity, rain, and light have important role in formation of the bryophyte vegetation of a place. Depending on these factors, antioxidant amounts in our species vary both within themselves and between species. Bryophytes possess strong antioxidative enzymatic machinery which helps them to cope up with extreme climates and stresses (Glime, 2007). Mosses holds good antioxidant capacity and has high phenolic content however; significant difference was also observed in the solvent system used along with the difference in the antioxidant capacity in the plant sample collected from different locations. The maximum antioxidant capacity was observed by DPPH forthe chloroform extract of *Rhynchostegium murale* collected from Kırklareli, Istranca (Turkey) than other area, extracts and moss speciemens.

The maximum antioxidant capacity was observed by TEAC for the methanol extract of *Oxytegus tenuirostris* collected from Osmaniye (Turkey) than other area, extracts and moss speciemens. The maximum antioxidant capacity was observed by CUPRAC for the chlorofom extract of *Eurhynchium striatum* collected from Fethiye (Turkey) than other area, extracts and moss speciemens. Erturk and his colleagues (2015) was found the phenolic content of *Hypnum lutescens* was considerably higher than *H. sericeum*. Among the moss samples, *H. sericeum* and *E. sriatulum* showed nearly the same CUPRAC, FRAP activity, and resulted highest antioxidant activity, 142.91±0.23 µmol Trolox/100 g sample and 118.12±0.42 µmol Trolox/100 g sample respectively.

CONCLUSIONS

This study presents the results of moss extracts of *Oxytegus tenuirostris*, *Eurhynchium striatum* W. P. Schimper and *Rhynchostegium murale* (Hedw.) Schimp were collected from different locations of Turkey by chemical composition antioxidant activities. To the best of our knowledge, these properties of mosses extracts have not been previously reported; thus, the results reported here are preliminary reports on the properties 3 different extracts of the mentioned mosses. Most of the extracts presented significant antioxidant activity in DPPH*, TEAC and CUPRAC tests. Significant changes were observed in the antioxidant quantities of the applied methods, the solvents used and the species studied according to the area of collection of the moss samples. Climate is the most important ecological factor that determines the bryophyte types and the basic characters and the distribution areas of the bryophytes associations. The common effects of the climate factors such as heat, humidity, rain, and light have important role in formation of the bryophyte vegetation of a place. Depending on these factors, antioxidant amounts in our species vary both within themselves and between species.

Naturally occurring antioxidant compounds are detected and can be obtained purely by working on the mosses. These compounds can be used in the pharmaceutical, cosmetic and food industries. Thus, we can obtain new and more effective compounds that enhance cellular defense. Many future studies with mosses may be promising in the formation, progression and treatment of many diseases. Oxidative stress, which is the aging effect, can be suppressed and the aging process can be slowed down and a longer and healthier life can be possible. On the basis of the results, it is suggested that the extract of three moss species determined here could be of use as an easily accessible source of natural antioxidant for the treatment.

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