



# Determination of phenolic compounds profiles and antioxidant properties of oleaster (*Elaeagnus angustifolia* L.) grown in Turkey

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## Abstract

The oleaster (*Elaeagnus angustifolia* L.) plant grown in three different locations in Nevşehir, Turkey was analyzed to determine its phenolic component profile, total phenolic compound, total carotenoid, total flavonoid, and antioxidant capacity values. Ultrasonic extraction of the oleaster's flour, shell, core, flower, and leaf parts was carried out under solvent and acidic hydrolysis conditions using eight different polarity solvents (water, methanol, ethanol, acetone, ethyl acetate, butanol, petroleum ether, and hexane). The phenolic component profiles were determined using high-performance liquid chromatography with diode array detector (HPLC–DAD), and the main phenolic components in the oleaster samples were gallic acid, catechin, and their derivatives. At the same time, antioxidant properties of oleaster samples were evaluated by Folin–Ciocalteu (FC), ABTS, FRAP, DPPH, and CHROMAC methods. Various parts of oleaster, whose phenolic component content was determined in this study, are thought to be a natural source that can be used against degenerative diseases in future studies.

**Keywords** Oleaster · *Elaeagnus angustifolia* L. · Phenolic compounds · Antioxidant capacity · HPLC–DAD

## Introduction

Foods are natural sources of various health-promoting substances with important biological activities. In recent years, the functional and nutritional properties of food components have gained importance with regards to improving human health. The relationship between different phenolic contents of fruits, vegetables, and plants and their antioxidant properties has been the focus of research for many years [1].

*Elaeagnus angustifolia* L., also called oleaster, Russian olive, wild olive or silver berry, belongs to the *Elaeagnus* genus of the *Elaeagnaceae* (*Araliaceae*) family. Oleaster, which has small reddish-brown elliptical fruits and has more than 90 species, is mostly grown in parts of Asia, Europe, and North America [2]. It is a plant with potential use in food, cosmetics, and pharmaceutical fields, especially when grown in the Southeast and Central Anatolia regions of Turkey [3]. Oleaster is a good source of essential fatty acids (especially palmitoleic, palmitic, and linoleic fatty acids), vitamins (especially A, C, and E), and minerals, as well as

being fruit rich in carotenoids, flavonoids, and other bioactive components (sitosterol, cardiac glycoside, terpene, alkaloid, polysaccharides, triterpenoids, coumarin, amino acids, saponins, phytoene, tannins, etc.) [3–7]. Various parts of the oleaster (such as the flower, fruit, leaf, shell, flour, oil, and gum) are also used as herbal medicine due to their therapeutic properties such as antioxidant, anti-inflammatory, antimutagenic, antitussive, antitumor, antiarthritic, antimicrobial, and hepatoprotective [3, 4, 7–9].

The increase in free radicals in the body due to external factors causes oxidative damage by attacking biomolecules such as proteins, lipids, enzymes, RNA, and DNA. These free radicals play a role in the formation and progression of many diseases such as cancer, cardiovascular diseases, atherosclerosis, Parkinson's, and Alzheimer's, after oxidative damage. Phenolic compounds, which are naturally found in herbal products and have different biological activities, are used to inhibit free radicals [10]. Phenolic compounds are known for their antioxidant and radical scavenging properties, as well as their antimicrobial, anti-fungal, anti-radiation, immunomodulatory, anti-inflammatory, and anti-cancer activities [11–13]. There are various methods that differ in terms of experimental principles and conditions for the investigation of phenolic compounds and the determination of antioxidant capacity [14]. Therefore, it is extremely

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important to use robust, sensitive, selective, and reliable analytical techniques [15].

In this study, it was aimed to characterize the phenolic compound profile of the oleaster samples collected from Nevşehir, Turkey. For this purpose, phenolic compound profiles of oleaster's various parts: flour, shell, core, flower, and leaf, which extracted under different conditions, were determined by HPLC–DAD. While antioxidant capacity and total phenolic content of oleaster samples were determined using the FC, ABTS, FRAP, and CHROMAC methods, at the same time, total carotenoid and total flavonoid contents were determined.

## Materials and methods

### Chemical and reagent

Ethanol, methanol, acetone, hexane, butanol, petroleum ether, ethyl acetate, sodium nitrate, aluminum chloride, potassium persulfate, sodium dihydrogen phosphate, iron (III) chloride, vanillic acid, formic acid, phosphoric acid, acetic acid, and hydrochloric acid were purchased from Merck (Darmstadt, Germany). Acetonitrile, 2,2-Diphenyl-1-picrylhydrazyl, 2,2-azino-bis(3-ethylbenzothiazoline-6-sulfonic acid) diammonium salt, 2,4,6-Tris(2-pyridyl)-s-triazine,  $\beta$ -carotene, potassium dichromate, sodium hydroxide, 1,5-diphenylcarbazine, Folin–Ciocalteu reagent, potassium sodium tartrate, copper(II) sulfate pentahydrate, sodium carbonate, sodium acetate trihydrate, 2-hydroxycinnamic acid, caffeic acid, *p*-coumaric acid, ferulic acid, resveratrol, gallic acid, trolox, gallic acid, quercetin, isoquercitrin, rutin, chlorogenic acid, rosmarinic acid, ellagic acid, myricetin, kaempferol, kaempferol glycoside, *p*-hydroxybenzoic acid, and protocatechuic acid in HPLC grade were purchased from Sigma-Aldrich (St. Louis, MO., USA). (–)-Epigallocatechin, (–)-epigallocatechin gallate, (+)-catechin, (–)-epicatechin, and (–)-epicatechin gallate in HPLC grade were purchased from Extrasynthese (Genay Cedex, France). Luteolin was purchased Applichem (Darmstadt, Germany). Water was purified with Purelab Option-Q from Elga Laboratory (UK).

### Oleaster (*Elaeagnus angustifolia* L.)

Oleaster (*Elaeagnus angustifolia* L.) samples were collected from three different locations in Nevşehir, Türkiye in 2019. The samples were divided into five parts as flour, shell, core, leaf, and flower and were dried under laboratory conditions (22–24 °C). The samples were divided into small pieces after drying and stored at 4 °C until the extraction processes.

### Preparation of phenolic fractions of oleaster samples

Ultrasonic extractions for both solvent extraction and acidic hydrolysis of the oleaster's flour, shell, core, flower, and leaf were performed using eight different solvents with water, methanol, ethanol, acetone, ethyl acetate, *n*-butanol, petroleum ether, and hexane. For solvent extraction, *x* g of oleaster sample was extracted with *y* mL of solvent for 60 min at 45 °C (*x*: 2 g, *y*: 20 mL for oleaster's flour; *x*: 2 g, *y*: 20 mL for oleaster's shell; *x*: 1 g, *y*: 20 mL for oleaster's core; *x*: 0.1 g, *y*: 10 mL for oleaster's flower; *x*: 1 g, *y*: 20 mL for oleaster's leaf). In acidic hydrolysis, *x* g of oleaster sample was extracted with *y* mL of solvent for 60 min at 45 °C (*x*: 1 g, *y*: 10 mL for oleaster's flour; *x*: 1 g, *y*: 10 mL for oleaster's shell; *x*: 1 g, *y*: 10 mL for oleaster's core; *x*: 0.1 g, *y*: 10 mL for oleaster's flower; *x*: 0.5 g, *y*: 10 mL for oleaster's leaf). Then, 0.02 M HCl was added (pH adjusted to 2) and was extracted for 60 min at 45 °C. After extraction, the samples were filtered with filter paper. The extracts of *n*-butanol, acetone, hexane, ethyl acetate, and petroleum ether were evaporated in the evaporator, and the remaining residues were dissolved in 5 mL of methanol. All extracts were kept at 4 °C until analysis.

### Determination of phenolic compounds in oleaster samples

The HPLC–DAD (high-performance liquid chromatography–diode array detector) system (Agilent 1200 Series) is equipped with an auto-sampler, vacuum degasser, and binary pump, and were used for the chromatographic analysis of phenolic compounds in the oleaster samples. Flow rate and injection volume were adjusted as 0.5 mL/min and 20  $\mu$ L, respectively. XBridge C18 (4.6  $\times$  250 mm, 3.5  $\mu$ m) column was used for the separation of phenolic components. During the analysis, a gradient solvent program consisting of 1% aqueous formic acid (phase A) and acetonitrile (phase B) was applied. The gradient elution program was arranged according to the percent of B as: 10% in 0–10 min, 13% in 10–20 min, 41% in 20–25 min, 70% in 25–35 min, and 10% in 35–36 min [16]. Limit of detection (LOD: 3 s/m, s: standard deviation, m: slope) and limit of quantitation (LOQ: 10 s/m) were determined.

### Spectroscopic analysis

#### Total phenolic content analysis

Total phenolic content of oleaster samples were determined by the Folin–Ciocalteu method [16, 17]. According to the

method, x mL extract of oleaster samples, (2-x) mL of distilled water, 2.5 mL of Lowry C solution, and 0.25 mL of Folin reagent (1:3 diluted with distilled water) were put into the test tube. The test tubes were mixed and kept in the dark for 30 min. And then UV–Vis absorption of the samples was analyzed at 750 nm. Total phenol contents of the samples were determined using the calibration curve prepared with gallic acid.

### The antioxidant capacity analysis

The antioxidant capacities of oleaster samples were determined by the ABTS [18, 19], FRAP [16, 20], DPPH [21, 22], and CHROMAC [16, 23] methods. The calibration curve obtained using trolox was used to determine antioxidant capacity values.

For the ABTS method, ABTS• radical solution was prepared as 2.45 mM  $K_2S_2O_8$  in 7 mM ABTS solution by distilled water. In test tubes, x mL oleaster extract, (4-x) mL ethanol, and 1 mL ABTS• radical solution (1:10 diluted with distilled water) were taken and mixed. 6 min later, absorptions of samples were measured at 734 nm by UV–Vis Spectrophotometer.

In the FRAP method, pH 3.6 acetate buffer and 20 mM  $FeCl_3$  by distilled water and 10 mM TPTZ solution by 40 mM HCl solution were prepared. FRAP reagent was prepared by mixing acetate buffer,  $FeCl_3$ , and TPTZ in a ratio of 10:1:1. The mixtures were kept for 30 min at 37 °C by adding x mL of oleaster extract and (3-x) mL of FRAP reagent, analyzed at 593 nm using the UV–Vis Spectrophotometer.

Free radical scavenging activity of oleaster samples was determined with a DPPH reagent. The extracts of oleaster (x mL) and 0.18 mL of 1 mM DPPH reagent (dissolved with methanol) were mixed, and the final volume in the test tubes was filled to 3 mL with methanol. The samples were kept in the dark for 30 min, and then, the absorbance values were recorded at 515 nm using the UV–Vis Spectrophotometer.

For the CHROMAC method, x mL of oleaster extract, (0.5-x) mL of distilled water, 3.5 mL of pH 2.8 phosphate buffer, and 0.5 mL of  $K_2Cr_2O_7$  (50 mg/L, dissolved in pH 2.8 phosphate buffer) were mixed. One minute later, 0.5 mL of 1,5-diphenylcarbazide ( $3.4 \times 10^{-4}$  mol/L, dissolved in pH 2.8 phosphate buffer) was added and the samples were kept in the dark for 50 min. Then, the samples were analyzed at 540 nm using the UV–Vis Spectrophotometer.

### Total flavonoid analysis

Total flavonoid content of oleaster samples was determined by a colorimetric method [24]. According to the method, x mL of oleaster extract, (2.7-x) mL of distilled water and 0.15 mL of 5%  $NaNO_3$  were mixed, and the mixture was kept in the dark for 6 min. Then, 0.15 mL of 10%  $AlCl_3$

was added to the mixture and was kept in the dark for 6 min again. Finally, 2 mL of 1 M NaOH was added to the mixture and kept in the dark for 15 min. The absorbance at the end of the reaction was read at 510 nm and results were given as a catechin equivalent (CAE).

### Total carotenoid analysis

The absorbance of oleaster extracts were measured at 450 nm by UV–Vis Spectrophotometer [25]. To calculate the average carotenoid concentrations (mol/L), the following equation was used:

$$C (M) = \frac{A_{450} \times F \times d}{\epsilon}$$

with  $A_{450}$ : absorbance of 450 nm, F: dilution factor, d: light path (1 cm), and  $\epsilon$ : molar absorptivity coefficient ( $\epsilon = 136,400$  for methanol,  $\epsilon = 135,800$  for ethanol). Using molecular weight of  $\beta$ -carotene, the results were expressed as  $\beta$ -carotene equivalent.

### Statistical analysis

The analysis data were statistically analyzed using the MINITAB 17.0 (Minitab Inc., Stage College, PA) statistical program with one-way ANOVA (solvent and acidic hydrolysis extracts separately for each method,  $p < 0.05$ ).

## Results and discussion

### Method validation of phenolic compounds

Validation parameters of standard phenolic compounds analyzed by HPLC–DAD for the qualitative and quantitative analysis of phenolic content in oleaster are shown in Table 1. A total of 24 phenolic compounds were detected in extracts of oleaster. Calibration curves of the standard phenolic compounds occurred in the range of 1–20 mg/L and the correlation coefficient of phenolic compounds with determined linearity was found to be higher than 0.9900. Recovery studies were done to the yield of extraction of phenolic compounds in different solvent environments. The results obtained showed that the recovery of phenolic compounds varies according to the solvent polarity and the acidity of the medium.

### Phenolic composition of oleaster

An HPLC phenolic profile of oleaster's flour is given in Table 2. Major differences have been identified between solvent media and extraction applications. A total of 15

**Table 1** Validation parameters of standard phenolic compounds

Phenolic compounds	Calibration equation	Regression coefficient (R <sup>2</sup> )	LOD (mg/L)	LOQ (mg/L)	Recovery (%)	Water extract		Methanol extract		Ethanol extract		Acetone extract		Ethyl acetate extract		n-butanol extract		Petroleum ether extract		Hexane extract	
						SE	AH	SE	AH	SE	AH	SE	AH	SE	AH	SE	AH	SE	AH	SE	AH
CAT	$y = 7.8378x + 1.4209$	0.9989	0.0499	0.1664	87	101	49	96	68	92	45	7	55	40	46	20	35	62	37	2	
ECAT	$y = 17.2960x - 0.5017$	0.9973	0.1187	0.3955	65	91	46	89	30	23	41	21	44	23	42	11	47	81	28	28	
ECATG	$y = 30.5643x + 6.1300$	0.9900	0.0843	0.2809	90	98	70	95	33	44	39	11	32	39	35	53	38	24	34	19	
EGCAT	$y = 5.9032x - 19.7339$	0.9962	0.2114	0.7046	79	117	89	119	99	102	84	70	92	83	93	79	80	73	109	64	
EGCATG	$y = 15.5587x + 0.0902$	0.9988	0.1694	0.5647	79	74	62	89	55	102	76	24	56	31	95	17	62	11	63	52	
2-HCA	$y = 135.9691x - 112.6913$	0.9971	0.0859	0.2862	106	109	104	107	106	108	103	98	100	98	98	100	99	94	97	99	
CHL	$y = 47.2881x - 3.3150$	0.9939	0.0767	0.2558	110	109	62	92	38	104	46	36	57	47	44	43	44	37	39	45	
CAF	$y = 111.0825x - 8.8965$	0.9982	0.0969	0.3230	82	83	75	86	75	80	68	46	78	41	72	57	69	57	68	54	
PCA	$y = 130.7578x + 11.8809$	0.9997	0.0475	0.1584	80	76	68	80	73	73	68	31	69	57	68	58	67	48	67	45	
FER	$y = 107.5075x - 2.3255$	0.9988	0.0344	0.1146	84	84	81	85	80	81	69	33	80	56	73	61	69	53	68	47	
ROS	$y = 50.4342x - 21.8842$	0.9982	0.0614	0.2048	85	87	84	88	83	84	69	39	71	42	75	53	71	53	70	51	
RES	$y = 135.3697x - 24.0625$	0.9992	0.0240	0.0800	85	86	80	89	86	86	79	37	77	28	79	31	79	28	78	35	
PRCA	$y = 65.8074x + 5.7423$	0.9997	0.1087	0.3623	86	87	72	91	59	86	66	64	71	63	66	67	62	65	66	67	
VAN	$y = 74.4184x + 5.6058$	0.9988	0.0029	0.0095	112	113	104	117	105	112	99	87	104	84	97	90	96	93	95	91	
PHBA	$y = 139.0133x - 97.2374$	0.9970	0.0340	0.1132	88	85	87	88	86	87	86	86	84	87	85	85	83	86	82	85	
GA	$y = 46.8968x + 10.7916$	0.9986	0.0207	0.0691	105	96	64	105	8	51	57	54	56	24	52	48	51	51	47	53	
EA	$y = 43.5766x - 15.7168$	0.9993	0.0558	0.1860	78	83	81	85	79	84	63	47	77	71	79	71	62	29	59	46	
QU	$y = 78.2328x - 32.5901$	0.9987	0.0481	0.1603	59	93	94	95	96	94	89	56	94	40	90	42	90	44	90	42	
MYR	$y = 64.3772x - 54.6879$	0.9991	0.0879	0.2931	76	100	120	116	127	105	111	76	128	73	84	71	121	71	112	72	
LU	$y = 63.2430x - 1.2038$	0.9997	0.0145	0.0482	98	99	108	109	104	108	105	83	98	16	101	97	93	92	93	95	
KAM	$y = 78.3573x - 16.9318$	0.9983	0.0224	0.0747	88	92	100	99	97	98	99	70	94	23	94	64	88	63	87	82	
KAMG	$y = 57.6594x + 3.9351$	0.9998	0.0087	0.0290	57	58	60	59	55	59	58	41	55	40	54	51	52	51	50	49	
IQU	$y = 45.4920x - 31.9872$	0.9970	0.0110	0.0368	111	115	122	126	118	115	115	82	112	68	119	106	108	98	121	102	
RU	$y = 37.5017x - 4.9297$	0.9976	0.0296	0.0987	85	87	80	91	86	87	81	53	82	37	80	71	76	68	80	66	

LOD limit of detection, LOQ limit of quantitation, SE solvent extraction, AH acidic hydrolysis, CAT catechin, ECAT epicatechin, ECATG epicatechin gallate, EGCG epigallocatechin gallate, EGCGG epigallocatechin gallate, 2-HCA 2-hydroxycinnamic acid, CHL chlorogenic acid, CAF caffeic acid, PCA p-coumaric acid, FER ferulic acid, ROS rosmarinic acid, RES resveratrol, PRCA protocatechuic acid, VAN vanillic acid, PHBA p-hydroxycinnamic acid, GA gallic acid, EA ellagic acid, QU quercetin, MYR myricetin, LU luteolin, KAM kaempferol, KAMG kaempferol-3-glycoside, IQU isoquercitrin, RU rutin

**Table 2** Phenolic compound contents of oleaster flour samples (mg/kg sample)

Solvent	Sample	EGCAT			EGCATG			EGCAT			CAF			PCA			FER		
		SE	AH	SE	SE	AH	SE	AH	SE	AH	SE	AH	SE	AH	SE	AH	SE	AH	
W	1	5970.11 ± 32.38 <sup>a</sup>	5441.64 ± 1.76 <sup>s</sup>	nd	1095.10 ± 1.06 <sup>f</sup>	nd	738.42 ± 1.21 <sup>p</sup>	5.85 ± 0.01 <sup>g</sup>	9.19 ± 0.16 <sup>b</sup>	5.19 ± 0.05 <sup>b</sup>	2.99 ± 0.20 <sup>gh</sup>	nd	8.41 ± 0.54 <sup>f</sup>						
	2	9445.34 ± 57.34 <sup>1</sup>	7128.57 ± 12.03 <sup>s</sup>	198.91 ± 3.17 <sup>b</sup>	210.90 ± 0.45 <sup>f</sup>	1288.60 ± 22.69 <sup>d</sup>	nd	772.66 ± 31.30 <sup>q</sup>	4.31 ± 0.09 <sup>i</sup>	7.50 ± 0.01 <sup>f</sup>	3.49 ± 0.03 <sup>e</sup>	1.21 ± 0.01 <sup>r</sup>	7.08 ± 0.03 <sup>h</sup>						
	3	10,068.96 ± 40.52 <sup>k</sup>	8224.29 ± 37.72 <sup>q</sup>	386.11 ± 2.38 <sup>q</sup>	348.05 ± 3.30 <sup>q</sup>	883.25 ± 61.01 <sup>b</sup>	nd	676.37 ± 5.59 <sup>q</sup>	nd	7.73 ± 0.03 <sup>e</sup>	1.92 ± 0.01 <sup>l</sup>	1.37 ± 0.01 <sup>op,q</sup>	nd	6.20 ± 0.05 <sup>k</sup>					
M	1	8963.95 ± 150.67 <sup>m</sup>	5584.42 ± 16.92 <sup>w</sup>	nd	147.86 ± 1.97 <sup>i</sup>	930.94 ± 10.11 <sup>s</sup>	nd	1048.80 ± 4.46 <sup>1</sup>	1026.40 ± 10.59 <sup>1</sup>	5.17 ± 0.04 <sup>r</sup>	4.68 ± 0.07 <sup>c</sup>	2.88 ± 0.03 <sup>hu</sup>	8.96 ± 0.10 <sup>e</sup>						
	2	13,024.51 ± 16.06 <sup>l</sup>	8379.49 ± 15.21 <sup>o</sup>	nd	153.99 ± 13.61 <sup>j</sup>	1009.84 ± 6.99 <sup>f</sup>	354.19 ± 5.23 <sup>3</sup>	1784.93 ± 5.35 <sup>3</sup>	1288.19 ± 15.50 <sup>8</sup>	nd	2.80 ± 0.02 <sup>t</sup>	1.53 ± 0.03 <sup>mn</sup>	8.98 ± 0.03 <sup>e</sup>						
	3	13,023.72 ± 50.50 <sup>l</sup>	8077.15 ± 36.16 <sup>q</sup>	nd	172.19 ± 2.03 <sup>3</sup>	1033.46 ± 2.41 <sup>c</sup>	366.91 ± 0.96 <sup>st</sup>	1555.59 ± 0.52 <sup>b</sup>	1307.52 ± 16.30 <sup>8</sup>	nd	2.94 ± 0.01 <sup>sh</sup>	2.82 ± 0.15 <sup>r</sup>	10.68 ± 0.22 <sup>d</sup>						
E	1	2834.54 ± 1.93 <sup>ab</sup>	5997.22 ± 33.42 <sup>r</sup>	nd	2201.00 ± 0.94 <sup>t</sup>	779.70 ± 0.82 <sup>2</sup>	nd	1086.43 ± 5.12 <sup>k</sup>	9.69 ± 0.08 <sup>s</sup>	2.57 ± 0.06 <sup>g</sup>	4.35 ± 0.06 <sup>d</sup>	10.78 ± 0.11 <sup>d</sup>							
	2	3375.15 ± 14.16 <sup>aa</sup>	8779.78 ± 2.17 <sup>m</sup>	nd	813.11 ± 3.98 <sup>8</sup>	2091.96 ± 13.99 <sup>8</sup>	961.61 ± 6.98 <sup>8</sup>	1554.32 ± 15.56 <sup>6</sup>	7.84 ± 0.03 <sup>e</sup>	1.31 ± 0.07 <sup>pr</sup>	2.59 ± 0.04 <sup>d</sup>	10.83 ± 0.17 <sup>d</sup>							
	3	3748.25 ± 61.60 <sup>q</sup>	8912.83 ± 20.63 <sup>m</sup>	nd	1091.87 ± 0.72 <sup>s</sup>	2153.19 ± 54.90 <sup>h</sup>	869.96 ± 2.60 <sup>h</sup>	1435.24 ± 4.47 <sup>e</sup>	8.63 ± 0.05 <sup>d</sup>	1.32 ± 0.21 <sup>o,q,r</sup>	3.01 ± 0.03 <sup>e</sup>	11.28 ± 0.28 <sup>e</sup>							
A	1	197.59 ± 0.83 <sup>ac</sup>	42,148.32 ± 5.83 <sup>f</sup>	20.98 ± 0.17 <sup>o</sup>	nd	390.34 ± 2.23 <sup>as</sup>	nd	1101.93 ± 5.02 <sup>ij</sup>	5.21 ± 0.03 <sup>3</sup>	0.64 ± 0.01 <sup>u</sup>	5.86 ± 0.03 <sup>a</sup>	13.47 ± 0.03 <sup>a</sup>							
	2	191.00 ± 0.65 <sup>ac</sup>	62,864.83 ± 92.79 <sup>d</sup>	nd	372.96 ± 1.32 <sup>st</sup>	nd	1508.45 ± 4.41 <sup>c</sup>	nd	nd	0.25 ± 0.01 <sup>v</sup>	3.41 ± 0.03 <sup>c</sup>	13.27 ± 0.01 <sup>a</sup>							
	3	236.24 ± 2.29 <sup>ae</sup>	59,455.18 ± 94.09 <sup>e</sup>	29.98 ± 0.57 <sup>n</sup>	nd	382.48 ± 2.36 <sup>st</sup>	nd	1293.46 ± 42.83 <sup>8</sup>	nd	0.35 ± 0.01 <sup>v</sup>	3.18 ± 0.02 <sup>f</sup>	12.59 ± 0.02 <sup>b</sup>							
EA	1	nd	6894.34 ± 20.13 <sup>3</sup>	10.58 ± 0.24 <sup>p</sup>	248.30 ± 1.99 <sup>q</sup>	454.23 ± 0.02 <sup>p</sup>	nd	1348.05 ± 37.16 <sup>1</sup>	5.46 ± 0.05 <sup>h</sup>	1.64 ± 0.03 <sup>m</sup>	1.95 ± 0.01 <sup>1</sup>	5.81 ± 0.02 <sup>1</sup>							
	2	nd	80.79 ± 18.33 <sup>q</sup>	nd	448.79 ± 3.43 <sup>q</sup>	nd	1029.40 ± 12.00 <sup>1</sup>	nd	nd	0.60 ± 0.01 <sup>uu</sup>	1.40 ± 0.01 <sup>op</sup>	7.56 ± 0.03 <sup>g</sup>							
	3	nd	7525.71 ± 11.30 <sup>q</sup>	8.51 ± 0.05 <sup>q</sup>	nd	509.96 ± 16.69 <sup>l,m,n</sup>	nd	1501.42 ± 11.53 <sup>cd</sup>	nd	0.61 ± 0.01 <sup>uu</sup>	1.37 ± 0.01 <sup>op,q</sup>	6.48 ± 0.01 <sup>1</sup>							
B	1	940.80 ± 41.35 <sup>ac,ad</sup>	14,532.79 ± 71.78 <sup>1</sup>	958.82 ± 10.09 <sup>b</sup>	470.14 ± 2.69 <sup>pp</sup>	nd	693.19 ± 1.81 <sup>q</sup>	nd	nd	1.30 ± 0.01 <sup>ps,r</sup>	3.36 ± 0.02 <sup>e</sup>	6.42 ± 0.01 <sup>1,k</sup>							
	2	871.68 ± 12.45 <sup>ad</sup>	19,095.32 ± 43.89 <sup>b</sup>	69.75 ± 0.26 <sup>m</sup>	nd	545.68 ± 5.07 <sup>k</sup>	nd	910.48 ± 4.90 <sup>m</sup>	nd	0.49 ± 0.01 <sup>1</sup>	1.26 ± 0.02 <sup>qr</sup>	4.80 ± 0.06 <sup>p</sup>							
	3	1002.22 ± 32.79 <sup>ac</sup>	20,724.20 ± 13.33 <sup>g</sup>	138.24 ± 0.77 <sup>k</sup>	nd	475.86 ± 0.05 <sup>o,p</sup>	nd	868.02 ± 4.68 <sup>m</sup>	nd	0.65 ± 0.02 <sup>1</sup>	1.44 ± 0.04 <sup>oo</sup>	5.30 ± 0.01 <sup>o</sup>							
PE	1	nd	4354.61 ± 3.34 <sup>q</sup>	nd	88.60 ± 0.74 <sup>1</sup>	418.52 ± 1.09 <sup>q</sup>	nd	1053.95 ± 32.68 <sup>kl</sup>	3.98 ± 0.04 <sup>k</sup>	nd	2.61 ± 0.01 <sup>1</sup>	6.61 ± 0.01 <sup>1</sup>							
	2	nd	5563.39 ± 1.56 <sup>w</sup>	nd	nd	501.77 ± 2.63 <sup>ma,o</sup>	nd	1467.08 ± 34.67 <sup>de</sup>	nd	nd	1.20 ± 0.01 <sup>r</sup>	6.17 ± 0.01 <sup>k</sup>							
	3	nd	6777.40 ± 0.36 <sup>n</sup>	nd	nd	520.02 ± 6.96 <sup>k,l,m</sup>	nd	1029.64 ± 3.90 <sup>1</sup>	nd	nd	1.41 ± 0.02 <sup>aa,p</sup>	5.73 ± 0.01 <sup>1,m</sup>							
H	1	nd	83,769.19 ± 63.36 <sup>6</sup>	nd	198.08 ± 3.89 <sup>h</sup>	545.05 ± 6.00 <sup>k</sup>	nd	814.65 ± 8.89 <sup>9</sup>	nd	3.81 ± 0.01 <sup>1</sup>	2.10 ± 0.04 <sup>k</sup>	5.42 ± 0.01 <sup>1,m,o</sup>							
	2	nd	12,784.19 ± 197.96 <sup>6</sup>	nd	77.45 ± 1.06 <sup>m</sup>	561.43 ± 7.34 <sup>h</sup>	nd	1218.79 ± 9.01 <sup>h</sup>	nd	nd	1.03 ± 0.02 <sup>s</sup>	5.67 ± 0.01 <sup>1,m,n</sup>							
	3	nd	123,136.23 ± 46.92 <sup>b</sup>	nd	nd	541.07 ± 9.69 <sup>kl</sup>	nd	1121.21 ± 5.79 <sup>9</sup>	nd	nd	0.96 ± 0.02 <sup>s</sup>	5.49 ± 0.01 <sup>1,m,n,o</sup>							
Solvent	Sam-ple	RES	PRCA	VAN	PHBA	GA	KAMG	RU											
	SE	AH	SE	AH	SE	AH	SE	AH	SE	AH	SE	AH	SE						
W	1	nd	3.68 ± 0.01 <sup>1</sup>	nd	24.69 ± 0.21 <sup>a</sup>	21.59 ± 2.69 <sup>b</sup>	5.52 ± 0.07 <sup>c</sup>	nd	14.18 ± 0.17 <sup>1</sup>	22.17 ± 0.62 <sup>k</sup>	nd	26.25 ± 0.21 <sup>c</sup>							
	2	nd	3.77 ± 0.06 <sup>k,l</sup>	nd	11.38 ± 0.05 <sup>g</sup>	10.83 ± 0.20 <sup>gh,i</sup>	nd	nd	nd	27.70 ± 0.22 <sup>j</sup>	nd	14.32 ± 0.23 <sup>o</sup>							
	3	8.33 ± 0.02 <sup>d</sup>	3.77 ± 0.02 <sup>k,l</sup>	nd	12.64 ± 0.07 <sup>f</sup>	10.16 ± 0.14 <sup>ba</sup>	nd	nd	nd	38.83 ± 0.15 <sup>b</sup>	nd	15.00 ± 0.21 <sup>n</sup>							
M	1	10.74 ± 0.23 <sup>a</sup>	4.15 ± 0.04 <sup>q</sup>	nd	24.42 ± 1.57 <sup>a</sup>	24.85 ± 0.29 <sup>a</sup>	nd	nd	nd	nd	nd	26.86 ± 0.52 <sup>b</sup>							
	2	8.84 ± 0.11 <sup>c</sup>	3.80 ± 0.04 <sup>k,l</sup>	nd	13.87 ± 0.12 <sup>e</sup>	12.61 ± 0.18 <sup>f</sup>	nd	nd	nd	nd	nd	16.31 ± 0.09 <sup>1</sup>							
	3	9.10 ± 0.18 <sup>b</sup>	3.86 ± 0.04 <sup>k</sup>	nd	10.51 ± 0.37 <sup>gh,i</sup>	11.18 ± 0.07 <sup>gh</sup>	nd	nd	nd	nd	nd	15.93 ± 0.13 <sup>m</sup>							
E	1	7.99 ± 0.13 <sup>c</sup>	3.28 ± 0.01 <sup>m</sup>	6.69 ± 0.04 <sup>8</sup>	17.66 ± 0.05 <sup>8</sup>	24.60 ± 0.40 <sup>a</sup>	1.00 ± 0.07 <sup>de</sup>	nd	314.26 ± 1.94 <sup>8</sup>	nd	nd	14.15 ± 0.27 <sup>o</sup>							
	2	7.86 ± 0.08 <sup>c</sup>	3.26 ± 0.02 <sup>m</sup>	6.18 ± 0.03 <sup>c</sup>	8.57 ± 0.19 <sup>l</sup>	12.93 ± 0.03 <sup>ef</sup>	0.56 ± 0.03 <sup>ef</sup>	nd	376.10 ± 1.64 <sup>8</sup>	nd	nd	8.76 ± 0.08 <sup>8</sup>							
	3	7.26 ± 0.03 <sup>l</sup>	3.21 ± 0.02 <sup>m</sup>	6.55 ± 0.01 <sup>b</sup>	1.84 ± 0.05 <sup>n</sup>	10.09 ± 0.08 <sup>1</sup>	0.74 ± 0.03 <sup>f</sup>	nd	317.89 ± 0.53 <sup>b</sup>	nd	nd	9.07 ± 0.06 <sup>av</sup>							
A	1	2.31 ± 0.02 <sup>l</sup>	4.57 ± 0.05 <sup>h</sup>	2.10 ± 0.01 <sup>n</sup>	18.83 ± 0.19 <sup>8</sup>	0.41 ± 0.01 <sup>gh,i</sup>	nd	nd	79.17 ± 0.05 <sup>e</sup>	nd	nd	1.69 ± 0.01 <sup>aa</sup>							
	2	nd	1.64 ± 0.03 <sup>q</sup>	10.87 ± 0.02 <sup>gh,i</sup>	1.64 ± 0.03 <sup>q</sup>	0.19 ± 0.01 <sup>1</sup>	nd	nd	47.46 ± 0.21 <sup>g</sup>	72.68 ± 0.32 <sup>f</sup>	nd	22.68 ± 0.21 <sup>f</sup>							
	3	nd	4.29 ± 0.03 <sup>l</sup>	1.63 ± 0.04 <sup>n</sup>	8.12 ± 0.14 <sup>kl</sup>	0.26 ± 0.02 <sup>ba</sup>	nd	nd	32.68 ± 0.50 <sup>9</sup>	96.69 ± 0.74 <sup>d</sup>	nd	16.71 ± 0.16 <sup>k</sup>							
	1	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	1.32 ± 0.02 <sup>ab</sup>							
	2	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	13.63 ± 0.07 <sup>b</sup>							
	3	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	23.65 ± 0.04 <sup>e</sup>							

Table 2 (continued)

Solvent	Sam- ple	ROS		RES		PRCA		VAN		PHBA		GA		KAMG		RU		
		SE	AH	SE	AH	SE	AH	SE	AH	SE	AH	SE	AH	SE	AH	SE	AH	
EA	1	3.02±0.01 <sup>b</sup>	nd	1.12±0.01 <sup>n</sup>	5.55±0.12 <sup>e</sup>	6.84±0.09 <sup>l</sup>	18.70±0.32 <sup>c</sup>	1.15±0.02 <sup>d</sup>	nd	3.09±0.01 <sup>a</sup>	nd	nd	nd	nd	nd	nd	nd	
	2	2.25±0.02 <sup>ik</sup>	nd	0.93±0.01 <sup>o</sup>	5.34±0.20 <sup>g</sup>	1.88±0.05 <sup>n</sup>	7.90±0.02 <sup>ka</sup>	0.46±0.01 <sup>g,h</sup>	nd	2.34±0.01 <sup>c</sup>	nd	nd	nd	0.80±0.13 <sup>b</sup>	nd	18.41±0.10 <sup>f</sup>	nd	
	3	2.39±0.02 <sup>j</sup>	nd	0.97±0.01 <sup>o</sup>	5.27±0.05 <sup>g</sup>	1.11±0.01 <sup>n</sup>	7.12±0.11 <sup>kl</sup>	0.43±0.01 <sup>g,hi</sup>	nd	2.67±0.02 <sup>b</sup>	nd	nd	nd	nd	nd	16.92±0.27 <sup>k</sup>	nd	
B	1	2.61±0.03 <sup>i</sup>	nd	1.01±0.01 <sup>n,o</sup>	nd	5.10±0.10 <sup>m</sup>	18.44±0.04 <sup>cd</sup>	1.09±0.03 <sup>d</sup>	7.30±0.09 <sup>b</sup>	nd	nd	nd	nd	1.39±0.04 <sup>a</sup>	3.64±0.04 <sup>f</sup>	16.69±0.04 <sup>k</sup>	nd	
	2	2.09±0.02 <sup>k</sup>	5.76±0.03 <sup>g</sup>	0.90±0.01 <sup>o</sup>	nd	1.46±0.01 <sup>n</sup>	8.38±0.01 <sup>j</sup>	nd	8.82±0.44 <sup>a</sup>	nd	nd	nd	0.84±0.01 <sup>b</sup>	1.76±0.01 <sup>z,aa</sup>	10.78±0.05 <sup>f</sup>	nd	7.04±0.01 <sup>s</sup>	
	3	2.25±0.03 <sup>ik</sup>	nd	0.94±0.01 <sup>o</sup>	nd	1.43±0.03 <sup>n</sup>	7.63±0.02 <sup>kl</sup>	0.76±0.02 <sup>ef</sup>	7.04±0.08 <sup>b</sup>	nd	nd	nd	nd	nd	2.03±0.03 <sup>c</sup>	10.36±0.01 <sup>s</sup>	12.72±0.10 <sup>q</sup>	9.18±0.05 <sup>u</sup>
PE	1	nd	nd	nd	5.72±0.07 <sup>d</sup>	nd	17.82±0.03 <sup>cd</sup>	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	9.19±0.03 <sup>u</sup>
	2	nd	nd	nd	5.37±0.09 <sup>f,g</sup>	nd	10.00±0.11 <sup>i</sup>	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	9.67±0.10 <sup>f</sup>
	3	nd	nd	nd	5.48±0.11 <sup>e,f</sup>	nd	7.98±0.30 <sup>ka</sup>	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	7.98±0.04 <sup>w</sup>
H	1	nd	nd	nd	4.08±0.04 <sup>j</sup>	nd	12.87±0.41 <sup>ef</sup>	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	7.04±0.01 <sup>s</sup>
	2	nd	nd	nd	4.04±0.06 <sup>j</sup>	nd	7.32±0.24 <sup>kl</sup>	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	7.04±0.01 <sup>s</sup>
	3	nd	nd	nd	nd	nd	5.26±0.02 <sup>m</sup>	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	

SE solvent extraction, AH acidic hydrolysis, CAT catechin, ECAT epicatechin, ECATG epicatechin gallate, EGCG epigallocatechin, CAF caffeic acid, PCA p-coumaric acid, FER ferulic acid, ROS rosmarinic acid, RES resveratrol, PRCA protocatechuic acid, VAN vanillic acid, PHBA p-hydroxycinnamic acid, GA gallic acid, KAMG kaempferol-3-glycoside, RU rutin, W water, M methanol, E ethanol, A acetone, EA ethyl acetate, B butanol, P petroleum ether, H hexane

\*Two replicates ± Standard deviation

<sup>a–w</sup>Different lowercase superscripts in the different extraction groups indicate significant differences between means of phenolic composition for oleaster samples ( $p < 0.05$ )

phenolic compounds (catechin, epicatechin, epicatechin gallate, epigallocatechin, caffeic acid, *p*-coumaric acid, ferulic acid, rosmarinic acid, resveratrol, protocatechuic acid, vanillic acid, gallic acid, kaempferol glycoside, and rutin) were identified in extracts of oleaster's flour. It has been established that the main components are catechin, and catechin derivatives (epicatechin, epicatechin gallate, and epigallocatechin). While the amount of catechin in water and methanol solvent media decreased with acidic hydrolysis compared to solvent extractions, it increased in other solvent media. At the same time, while no catechin was detected in ethyl acetate, petroleum ether, and hexane solvent extracts, it was detected in acidic hydrolysis. While epicatechin was not seen in methanol, ethanol, petroleum ether, and hexane solvent extracts, it was detected in acidic hydrolysis. In general, it was observed that the amount of epicatechin in the samples increased with acidic hydrolysis. While epicatechin gallate was detected in all solvent extracts, it was detected only in methanol and ethanol extracts when acidic hydrolysis was performed. The amount of epicatechin gallate in the samples decreased with acidic hydrolysis. Epigallocatechin gallate was detected only in the methanol extract, but the amount of epigallocatechin gallate increased with the application of acidic hydrolysis and was detected in all solvent extracts. Formation and an increase in the amount of gallic acid have been observed after acidic hydrolysis in water, ethanol, and acetone solvents.

The phenolic compounds of 19 (catechin, epicatechin, epicatechin gallate, epigallocatechin, epigallocatechin gallate, caffeic acid, *p*-coumaric acid, ferulic acid, rosmarinic acid, resveratrol, protocatechuic acid, vanillic acid, gallic acid, ellagic acid, myricetin, kaempferol, kaempferol glycoside, isoquercitrin, and rutin) were determined in the oleaster's shell (Table 3). Catechin, epicatechin gallate, and epigallocatechin (in acidic medium) were determined as main compounds. The catechin amount decreased as the solvent polarity decreased, and increased with acidic hydrolysis, except with water and methanol solvents. While epicatechin gallate was found at high amounts in solvent extractions, it could not be detected except in methanol and ethanol extracts after acidic hydrolysis, and the amounts were found to be low in these two-solvent media. While it was not observed in solvent extraction, it was observed that the amount of epicatechin–epigallocatechin gallate and epigallocatechin increased with acidic hydrolysis. At the same time, gallic acid was formed after acidic hydrolysis in ethanol and acetone solvents.

Twenty phenolic compounds: catechin, epicatechin, epicatechin gallate, epigallocatechin, epigallocatechin gallate, chlorogenic acid, caffeic acid, *p*-coumaric acid, ferulic acid, rosmarinic acid, resveratrol, protocatechuic acid, vanillic acid, gallic acid, ellagic acid, quercetin, myricetin, kaempferol, isoquercitrin, and rutin were detected in the oleaster's

core under different extraction conditions (Table 4). Generally, the amount of catechin and derivatives (epicatechin, epigallocatechin, and epigallocatechin gallate) have been seen to decrease as the solvent polarity decreased. Also, their amounts have been seen to increase by acidic hydrolysis except water and methanol solvents. While gallic acid could not be detected in solvent extractions, gallic acid was detected in all solution media except ethanol.

The phenolic compounds of 16 (catechin, epicatechin, epigallocatechin gallate, 2-hydroxycinnamic acid, caffeic acid, *p*-coumaric acid, ferulic acid, resveratrol, protocatechuic acid, vanillic acid, gallic acid, ellagic acid, myricetin, kaempferol, kaempferol glycoside, and isoquercitrin) have been determined in the oleaster's flower extracts (Table 5). The most abundant phenolic compound in the oleaster's flower extracts was determined as catechin. While catechin was found only in water, methanol, and ethanol extracts by solvent extraction, it was detected in high amounts in solvent environments other than petroleum ether, and hexane after acidic hydrolysis. Epicatechin and epigallocatechin gallate were seen in some solvents after acidic hydrolysis. Likewise, gallic acid was not observed in solvent extracts (except acetone), but was detected in most solvent media after acidic hydrolysis.

In the oleaster's leaf extracts, catechin, epicatechin, epicatechin gallate, epigallocatechin, epigallocatechin gallate, 2-hydroxycinnamic acid, *p*-coumaric acid, ferulic acid, resveratrol, protocatechuic acid, vanillic acid, gallic acid, ellagic acid, quercetin, myricetin, luteolin, kaempferol, kaempferol glycoside, and isoquercitrin were determined (Table 6). Catechin, epicatechin, and epigallocatechin gallate were determined as the main components. After acidic hydrolysis, catechin and epicatechin amounts decreased in water extract and increased in other solvent extracts. While epicatechin gallate, epigallocatechin, and epigallocatechin gallate were seen in some solvent extracts, they could not be detected after acidic hydrolysis.

As a result of epigallocatechin gallate and epicatechin gallate epimerization, there was an increase in the amounts of gallic acid, epigallocatechin, and epicatechin as degradation products. Likewise, as a result of epicatechin gallate and epicatechin epimerization, their amounts decreased, while catechin gallate and catechin amounts increased. When heat treatment was applied during extraction, epigallocatechin gallate and epicatechin gallate degrade and their amounts decreased. As a result of this decrease, an increase in the amount of gallic acid was observed. In addition, as the concentration of epigallocatechin gallate increased, its stability at low pH increases and its degradation decreased. Since epigallocatechin is dominant in epimerization, its amount appears to increase during heat treatment, but it starts to degrade when exposed to heat treatment for a long time [26]. In general, catechin is stable in an acidic environment, since

**Table 3** Phenolic compound contents of oleaster shell samples (mg/kg sample)

Sol-vent	Sample	ECAT			ECCAT			ECCATG			CAF			PCA			FER			ROS		
		SE	AH	SE	AH	SE	AH	SE	AH	SE	AH	SE	AH	SE	AH	SE	AH	SE	AH	SE	AH	
W	1	5632.92±1.14 <sup>w</sup>	4996.63±87.33 <sup>y</sup>	nd	nd	1118.72±3.47 <sup>s</sup>	nd	nd	649.64±4.61 <sup>r</sup>	nd	nd	11.31±0.05 <sup>g</sup>	9.40±0.65 <sup>h</sup>	nd	12.45±0.46 <sup>i</sup>	nd	nd	nd	nd	nd	nd	15.72±0.06 <sup>j</sup>
	2	9666.71±28.25 <sup>v</sup>	9239.22±12.48 <sup>t</sup>	nd	nd	1447.43±47.74 <sup>r</sup>	nd	nd	873.87±18.11 <sup>q</sup>	nd	nd	4.79±0.03 <sup>oo</sup>	8.82±0.31 <sup>k</sup>	7.23±0.01 <sup>k</sup>	6.09±0.27 <sup>lm</sup>	nd	nd	nd	nd	nd	nd	13.01±0.18 <sup>l</sup>
	3	10,153.80±17.57 <sup>u</sup>	8912.81±97.39 <sup>s</sup>	nd	nd	1433.72±29.19 <sup>q</sup>	nd	nd	915.69±5.28 <sup>p</sup>	nd	nd	5.21±0.06 <sup>o</sup>	9.72±0.09 <sup>n</sup>	7.74±0.03 <sup>n</sup>	8.15±0.50 <sup>n</sup>	nd	nd	nd	nd	nd	nd	13.53±0.29 <sup>m</sup>
M	1	9839.82±51.65 <sup>t</sup>	5293.21±71.45 <sup>r</sup>	nd	nd	337.31±2.14 <sup>f</sup>	1651.89±5.54 <sup>d</sup>	nd	924.69±9.75 <sup>k</sup>	970.40±8.80 <sup>j</sup>	nd	nd	13.84±0.18 <sup>e</sup>	10.74±0.06 <sup>e</sup>	11.49±0.20 <sup>d</sup>	nd	nd	nd	nd	nd	nd	16.34±0.66 <sup>f</sup>
	2	15,253.32±18.96 <sup>s</sup>	9341.95±36.84 <sup>r</sup>	nd	nd	168.73±0.60 <sup>e</sup>	1661.80±0.60 <sup>d</sup>	418.18±21.04 <sup>d</sup>	1693.50±14.67 <sup>d</sup>	1567.80±17.59 <sup>d</sup>	nd	nd	12.09±0.24 <sup>d</sup>	8.73±0.11 <sup>ea</sup>	10.88±0.37 <sup>e</sup>	nd	nd	nd	nd	nd	nd	15.76±1.04 <sup>g</sup>
	3	16,220.05±49.25 <sup>r</sup>	9793.88±34.32 <sup>q</sup>	nd	nd	158.73±0.36 <sup>d</sup>	2015.50±16.75 <sup>d</sup>	455.47±3.29 <sup>d</sup>	1695.71±73.92 <sup>d</sup>	1723.17±0.78 <sup>d</sup>	304.11±2.07 <sup>c</sup>	6.94±0.03 <sup>m</sup>	10.72±0.38 <sup>h</sup>	9.25±0.09 <sup>f</sup>	8.41±0.04 <sup>ba</sup>	nd	nd	nd	nd	nd	nd	15.21±0.08 <sup>g</sup>
E	1	3888.54±35.90 <sup>aa</sup>	5256.55±19.03 <sup>s</sup>	nd	nd	3283.96±48.55 <sup>g</sup>	1038.65±4.68 <sup>h</sup>	nd	1071.63±13.16 <sup>e</sup>	1071.63±13.16 <sup>e</sup>	nd	nd	9.15±0.33 <sup>ka</sup>	3.91±0.19 <sup>g</sup>	9.36±0.90 <sup>f</sup>	nd	nd	nd	nd	nd	nd	8.04±0.05 <sup>m</sup>
	2	3666.30±14.90 <sup>ab</sup>	9840.57±42.03 <sup>p</sup>	nd	nd	3359.80±22.98 <sup>f</sup>	1064.78±7.42 <sup>h</sup>	nd	2097.95±5.52 <sup>e</sup>	2097.95±5.52 <sup>e</sup>	213.65±0.58 <sup>l</sup>	nd	2.82±0.01 <sup>kr</sup>	11.35±0.10 <sup>ld</sup>	12.69±0.21 <sup>le</sup>	nd	nd	nd	nd	nd	nd	16.42±0.19 <sup>f</sup>
	3	3085.44±19.60 <sup>ab</sup>	10,269.87±43.52 <sup>p</sup>	nd	nd	1039.40±6.49 <sup>f</sup>	3342.34±0.34 <sup>f</sup>	1302.52±11.73 <sup>f</sup>	1761.56±1.17 <sup>f</sup>	1761.56±1.17 <sup>f</sup>	324.17±3.99 <sup>l</sup>	nd	15.01±0.22 <sup>d</sup>	2.68±0.03 <sup>l</sup>	12.69±0.21 <sup>le</sup>	nd	nd	nd	nd	nd	nd	29.96±1.36 <sup>g</sup>
A	1	562.93±2.35 <sup>ee</sup>	41,635.83±102.82 <sup>l</sup>	nd	nd	637.60±0.32 <sup>m</sup>	637.60±0.32 <sup>m</sup>	nd	1363.99±18.26 <sup>e</sup>	1363.99±18.26 <sup>e</sup>	360.08±1.37 <sup>e</sup>	nd	1.96±0.16 <sup>sa</sup>	20.44±0.53 <sup>sa</sup>	nd	nd	nd	nd	nd	nd	nd	25.29±0.07 <sup>g</sup>
	2	721.53±2.42 <sup>ed</sup>	69,316.97±58.18 <sup>l</sup>	nd	nd	634.33±0.65 <sup>m</sup>	634.33±0.65 <sup>m</sup>	nd	1572.98±8.06 <sup>e</sup>	1572.98±8.06 <sup>e</sup>	551.33±0.63 <sup>b</sup>	nd	1.43±0.01 <sup>sv</sup>	14.99±0.02 <sup>sv</sup>	nd	nd	nd	nd	nd	nd	nd	nd
	3	837.04±5.83 <sup>ec</sup>	68,648.62±98.16 <sup>l</sup>	nd	nd	640.77±9.21 <sup>m</sup>	640.77±9.21 <sup>m</sup>	nd	1545.09±11.97 <sup>e</sup>	1545.09±11.97 <sup>e</sup>	564.90±3.33 <sup>a</sup>	nd	1.05±0.06 <sup>sv</sup>	14.99±0.02 <sup>sv</sup>	nd	nd	nd	nd	nd	nd	nd	23.92±0.25 <sup>g</sup>
EA	1	nd	8933.76±4.23 <sup>l</sup>	nd	nd	218.76±0.37 <sup>e</sup>	765.47±8.53 <sup>d</sup>	nd	nd	nd	nd	nd	23.59±0.05 <sup>e</sup>	2.84±0.02 <sup>sv</sup>	8.92±0.05 <sup>sa</sup>	nd	7.33±0.09 <sup>f</sup>	nd	18.24±0.22 <sup>g</sup>	nd	19.38±0.30 <sup>f</sup>	
	2	nd	11,838.37±4.55 <sup>m</sup>	nd	nd	144.13±0.61 <sup>k</sup>	803.58±2.79 <sup>d</sup>	nd	1615.39±1.94 <sup>e</sup>	1615.39±1.94 <sup>e</sup>	nd	nd	17.92±0.06 <sup>e</sup>	1.60±0.01 <sup>lm</sup>	6.19±0.04 <sup>l</sup>	nd	10.65±0.11 <sup>f</sup>	nd	10.65±0.11 <sup>f</sup>	nd	17.34±0.10 <sup>g</sup>	
	3	nd	12,541.33±18.89 <sup>l</sup>	nd	nd	154.44±0.69 <sup>j</sup>	591.32±0.19 <sup>d</sup>	nd	1818.80±13.30 <sup>d</sup>	1818.80±13.30 <sup>d</sup>	nd	nd	21.24±0.10 <sup>h</sup>	1.33±0.02 <sup>sv</sup>	6.94±0.06 <sup>k</sup>	nd	9.74±0.05 <sup>d</sup>	nd	9.74±0.05 <sup>d</sup>	nd	14.64±0.18 <sup>h</sup>	
B	1	621.11±8.22 <sup>aae</sup>	16,036.94±135.29 <sup>l</sup>	nd	nd	1024.63±7.34 <sup>b</sup>	722.09±3.07 <sup>k</sup>	nd	750.60±2.69 <sup>d</sup>	750.60±2.69 <sup>d</sup>	nd	nd	2.10±0.01 <sup>s</sup>	8.56±0.02 <sup>aba</sup>	2.61±0.01 <sup>s</sup>	nd	6.55±0.02 <sup>g</sup>	nd	6.55±0.02 <sup>g</sup>	nd	13.58±0.28 <sup>ba</sup>	
	2	906.36±9.76 <sup>ac</sup>	23,984.58±58.08 <sup>l</sup>	nd	nd	673.42±3.44 <sup>b</sup>	707.98±3.42 <sup>kl</sup>	nd	1075.97±1.13 <sup>d</sup>	1075.97±1.13 <sup>d</sup>	nd	nd	1.34±0.01 <sup>sv</sup>	4.45±0.02 <sup>sv</sup>	nd	nd	2.88±0.03 <sup>g</sup>	nd	2.88±0.03 <sup>g</sup>	nd	10.60±0.01 <sup>k</sup>	
	3	843.26±23.76 <sup>ac</sup>	23,530.70±61.57 <sup>l</sup>	nd	nd	675.79±7.23 <sup>l</sup>	675.79±7.23 <sup>l</sup>	nd	1081.07±2.12 <sup>d</sup>	1081.07±2.12 <sup>d</sup>	nd	nd	1.31±0.02 <sup>sv</sup>	5.38±0.13 <sup>sv</sup>	nd	nd	2.89±0.03 <sup>g</sup>	nd	2.89±0.03 <sup>g</sup>	nd	11.41±0.18 <sup>l</sup>	
PE	1	nd	3553.31±5.65 <sup>m</sup>	nd	nd	290.88±0.59 <sup>f</sup>	595.32±0.47 <sup>m</sup>	nd	586.35±2.52 <sup>d</sup>	586.35±2.52 <sup>d</sup>	nd	nd	5.07±0.03 <sup>sv</sup>	nd	5.89±0.02 <sup>lm</sup>	nd	3.55±0.09 <sup>h</sup>	nd	3.55±0.09 <sup>h</sup>	nd	8.22±0.14 <sup>m</sup>	
	2	nd	6085.79±11.03 <sup>l</sup>	nd	nd	43.40±0.38 <sup>m</sup>	552.54±0.10 <sup>m</sup>	nd	815.84±0.72 <sup>m</sup>	815.84±0.72 <sup>m</sup>	nd	nd	3.82±0.03 <sup>sv</sup>	nd	3.77±0.09 <sup>h</sup>	nd	5.96±0.03 <sup>h</sup>	nd	5.96±0.03 <sup>h</sup>	nd	7.85±0.00 <sup>nan</sup>	
	3	nd	6265.62±4.51 <sup>l</sup>	nd	nd	55.89±0.46 <sup>l</sup>	506.96±0.07 <sup>m</sup>	nd	829.12±1.88 <sup>m</sup>	829.12±1.88 <sup>m</sup>	nd	nd	3.22±0.03 <sup>sv</sup>	nd	3.22±0.04 <sup>kl</sup>	nd	5.18±0.10 <sup>h</sup>	nd	5.18±0.10 <sup>h</sup>	nd	7.93±0.01 <sup>nan</sup>	
H	1	nd	73,840.04±67.86 <sup>l</sup>	nd	nd	464.91±1.00 <sup>f</sup>	578.26±6.99 <sup>h</sup>	nd	712.26±3.49 <sup>m</sup>	712.26±3.49 <sup>m</sup>	nd	nd	4.35±0.03 <sup>sv</sup>	3.79±0.03 <sup>h</sup>	nd	3.26±0.06 <sup>f</sup>	nd	3.26±0.06 <sup>f</sup>	nd	7.22±0.11 <sup>n</sup>		
	2	nd	161,670.71±54.13 <sup>b</sup>	nd	nd	172.01±1.31 <sup>f</sup>	582.31±2.60 <sup>h</sup>	nd	1280.95±2.62 <sup>h</sup>	1280.95±2.62 <sup>h</sup>	nd	nd	3.86±0.04 <sup>kl</sup>	nd	4.57±0.07 <sup>m</sup>	nd	9.56±0.09 <sup>d</sup>	nd	9.56±0.09 <sup>d</sup>	nd	9.07±0.03 <sup>l</sup>	
	3	nd	174,482.19±59.73 <sup>a</sup>	nd	nd	191.96±0.95 <sup>h</sup>	597.64±0.19 <sup>h</sup>	nd	nd	nd	nd	nd	4.49±0.05 <sup>sv</sup>	nd	5.68±0.02 <sup>nan</sup>	nd	8.96±0.04 <sup>f</sup>	nd	8.96±0.04 <sup>f</sup>	nd	10.14±0.12 <sup>k</sup>	
W	1	nd	6.54±0.19 <sup>ee</sup>	30.35±0.31 <sup>d</sup>	23.88±0.12 <sup>ee</sup>	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	103.11±0.48 <sup>f</sup>	
	2	nd	7.12±0.05 <sup>ee</sup>	14.81±0.27 <sup>k</sup>	11.88±0.22 <sup>nd</sup>	nd	nd	nd	11.73±0.04 <sup>h</sup>	nd	nd	nd	15.76±0.58 <sup>h</sup>	32.05±1.49 <sup>h</sup>	nd	nd	nd	nd	nd	nd	109.13±2.78 <sup>i</sup>	
	3	nd	7.03±0.13 <sup>ed</sup>	14.54±0.11 <sup>k</sup>	9.59±0.17 <sup>nd</sup>	nd	nd	nd	11.02±0.12 <sup>nd</sup>	nd	nd	nd	23.18±2.61 <sup>m</sup>	25.91±0.21 <sup>l</sup>	nd	nd	nd	nd	nd	nd	110.97±2.14 <sup>h</sup>	
M	1	nd	6.85±0.01 <sup>f</sup>	31.66±0.20 <sup>h</sup>	27.99±0.16 <sup>nd</sup>	nd	nd	nd	23.27±0.23 <sup>h</sup>	7.77±0.03 <sup>cc</sup>	nd	6.10±0.01 <sup>cc</sup>	61.59±0.53 <sup>f</sup>	nd	nd	nd	nd	nd	nd	nd	183.96±1.15 <sup>i</sup>	
	2	nd	6.58±0.24 <sup>f</sup>	16.26±0.10 <sup>h</sup>	10.97±0.25 <sup>nd</sup>	nd	nd	nd	nd	nd	nd	3.77±0.25 <sup>h</sup>	27.65±3.20 <sup>l</sup>	75.71±0.49 <sup>h</sup>	6.98±0.55 <sup>d</sup>	nd	nd	nd	nd	nd	177.63±2.53 <sup>i</sup>	
	3	nd	6.91±0.02 <sup>de</sup>	16.10±0.22 <sup>h</sup>	11.72±0.15 <sup>nd</sup>	nd	nd	nd	nd	nd	nd	4.21±0.04 <sup>h</sup>	29.67±0.01 <sup>k</sup>	70.19±0.60 <sup>h</sup>	7.22±0.03 <sup>d</sup>	nd	nd	nd	nd	nd	188.19±2.16 <sup>h</sup>	
E	1	nd	7.13±0.08 <sup>de</sup>	6.56±0.23 <sup>h</sup>	31.03±0.35 <sup>e</sup>	2.39±0.33 <sup>h</sup>	nd	nd	nd	nd	nd	3.59±0.06 <sup>kl</sup>	6.46±0.04 <sup>d</sup>	nd	nd	nd	nd	nd	nd	nd	35.32±0.55 <sup>h</sup>	
	2	nd	7.22±0.02 <sup>d</sup>	4.97±0.05 <sup>h</sup>	17.14±0.21 <sup>nd</sup>	nd	nd	nd	nd	nd	nd	3.52±0.06 <sup>kl</sup>	5.76±0.05 <sup>l</sup>	82.83±1.88 <sup>h</sup>	4.27±0.07 <sup>h</sup>	nd	nd	nd	nd	nd	172.38±2.29 <sup>i</sup>	
	3	nd	7.66±0.07 <sup>d</sup>	4.04±0.16 <sup>h</sup>	12.24±0.10 <sup>nd</sup>	nd	nd	nd	nd	nd	nd	3.28±0.04 <sup>m</sup>	6.04±0.04 <sup>e</sup>	81.22±0.50 <sup>h</sup>	3.61±0.02 <sup>h</sup>	nd	nd	nd	nd	nd	182.85±0.56 <sup>i</sup>	
A	1	0.95±0.01 <sup>f</sup>	6.64±0.01 <sup>f</sup>	3.95±0.06 <sup>h</sup>	34.06±0.23 <sup>f</sup>	1.37±0.03 <sup>cd</sup>	nd	nd	10.56±0.05 <sup>h</sup>	1.14±0.01 <sup>na</sup>	3.45±0.21 <sup>lm</sup>	0.49±0.02 <sup>h</sup>	77.62±7.78 <sup>h</sup>	nd	nd	nd	nd	nd	nd	nd	202.41±0.61 <sup>f</sup>	
	2	1.05±0.01 <sup>f</sup>	5.77±0.11 <sup>ka</sup>	2.11±0.02 <sup>m</sup>	9.60±0.11 <sup>f</sup>	1.35±0.15 <sup>de</sup>	nd	nd	7.96±0.04 <sup>h</sup>	0.92±0.01 <sup>sa</sup>	3.77±0.04 <sup>h</sup>	0.99±0.06 <sup>f</sup>	72.43±0.71 <sup>h</sup>	nd	nd	nd	nd	nd	nd	nd	197.40±0.49 <sup>f</sup>	
	3	0.99±0.01 <sup>f</sup>	5.87±0.09 <sup>h</sup>	2.20±0.02 <sup>m</sup>	11.81±0.11 <sup>f</sup>	0.83±0.01 <sup>h</sup>	nd	nd	7.42±0.02 <sup>h</sup>	0.81±0.01 <sup>h</sup>	3.33±0.04 <sup>lm</sup>	0.51±0.01 <sup>h</sup>	67.24±1.09 <sup>h</sup>	nd	nd	nd	nd	nd	nd	nd	172.36±2.22 <sup>k</sup>	
EA	1	0.96±0.02 <sup>f</sup>	6.41±0.02 <sup>gh</sup>	5.30±0.04 <sup>s</sup>	26.04±0.19 <sup>f</sup>	1.75±0.03 <sup>b</sup>	nd	nd	1.40±0.03 <sup>o</sup>	0.81±0.01 <sup>f</sup>	20.21±0.16 <sup>h</sup>	0.81±0.01 <sup>f</sup>	60.07±0.74 <sup>h</sup>	nd	nd	nd	nd	nd	nd	nd	268.28±0.33 <sup>h</sup>	
	2	1.05±0.01 <sup>f</sup>	5.49±0.04 <sup>m</sup>	1.96±0.03 <sup>wx</sup>	10.78±0.22 <sup>o</sup>	1.13±0.02 <sup>de,f</sup>	nd	nd	1.01±0.01 <sup>qr</sup>	9.64±0.04 <sup>h</sup>	0.61±0.01 <sup>f</sup>	56.44±0.26 <sup>h</sup>	2.48±0.05 <sup>bb</sup>	nd	nd	nd	nd	nd	nd	nd	251.51±0.30 <sup>h</sup>	
	3	1.06±0.01 <sup>f</sup>	5.29±0.04 <sup>h</sup>	1.67±0.06 <sup>s</sup>	8.06±0.06 <sup>h</sup>	1.10±0.01 <sup>ef</sup>	nd	nd	0.95±0.01 <sup>rs</sup>	7.77±0.23 <sup>c</sup>	0.54±0.02 <sup>f</sup>	57.48±0.19 <sup>h</sup>	2.44±0.01 <sup>ab</sup>	nd	nd	nd	nd	nd	nd	nd	294.30±1.11 <sup>h</sup>	





Table 4 Phenolic compound contents of oleaster core samples (mg/kg sample)

Sol-vent	Sample	ECAT		EGCAT		EGCATG		CHL		CAF		PCA		FER		
		SE	AH	SE	AH	SE	AH	SE	AH	SE	AH	SE	AH	SE	AH	
W	1	2586.22 ±8.87 <sup>f</sup>	1095.89 ±1.40 <sup>f</sup>	390.42 ±1.91 <sup>f</sup>	132.03 ±0.45 <sup>w</sup>	nd	nd	3642.52 ± 10.01 <sup>c</sup>	502.92 ± 1.61 <sup>b</sup>	545.27 ± 2.17 <sup>f</sup>	nd	nd	7.06 ± 0.01 <sup>h</sup>	0.37 ± 0.03 <sup>uv</sup>	2.45 ± 0.06 <sup>z</sup>	1.43 ± 0.03 <sup>uv</sup>
	2	2972.26 ± 16.90 <sup>g</sup>	3457.77 ± 9.14 <sup>g</sup>	602.92 ± 2.03 <sup>m</sup>	588.79 ± 4.78 <sup>oa</sup>	nd	nd	3809.24 ± 3.64 <sup>b</sup>	1874.01 ± 4.36 <sup>b</sup>	786.20 ± 6.97 <sup>g</sup>	nd	nd	nd	5.96 ± 0.15 <sup>b</sup>	5.52 ± 0.13 <sup>f</sup>	10.53 ± 0.05 <sup>a</sup>
	3	3256.33 ± 10.90 <sup>p</sup>	2185.71 ± 0.18 <sup>h</sup>	778.64 ± 4.69 <sup>h</sup>	337.71 ± 1.27 <sup>u</sup>	nd	nd	4560.64 ± 2.42 <sup>a</sup>	1216.33 ± 2.83 <sup>n</sup>	963.04 ± 4.45 <sup>f</sup>	828.55 ± 0.36 <sup>i</sup>	nd	nd	nd	8.98 ± 0.20 <sup>a</sup>	6.45 ± 0.17 <sup>e</sup>
M	1	4231.63 ± 17.75 <sup>i</sup>	1345.80 ± 3.98 <sup>s</sup>	1292.07 ± 2.31 <sup>i</sup>	315.57 ± 1.04 <sup>i</sup>	nd	nd	1381.28 ± 5.80 <sup>j</sup>	702.04 ± 2.63 <sup>p</sup>	1174.51 ± 51.79 <sup>f</sup>	286.92 ± 1.85 <sup>f</sup>	nd	nd	5.75 ± 0.05 <sup>c</sup>	6.61 ± 0.02 <sup>d</sup>	1.63 ± 0.02 <sup>f</sup>
	2	4993.97 ± 6.66 <sup>j</sup>	1851.82 ± 2.63 <sup>w</sup>	1376.43 ± 0.54 <sup>b</sup>	508.52 ± 1.03 <sup>p</sup>	nd	nd	1737.70 ± 5.93 <sup>i</sup>	1081.36 ± 54.60 <sup>o</sup>	1484.76 ± 2.79 <sup>e</sup>	1011.03 ± 0.31 <sup>h</sup>	nd	nd	4.24 ± 0.02 <sup>f</sup>	5.53 ± 0.01 <sup>f</sup>	1.58 ± 0.03 <sup>est</sup>
	3	5482.23 ± 17.35 <sup>i</sup>	1769.78 ± 1.11 <sup>u</sup>	2088.55 ± 7.06 <sup>f</sup>	682.31 ± 1.02 <sup>l</sup>	nd	nd	2366.92 ± 13.72 <sup>d</sup>	1082.86 ± 2.18 <sup>o</sup>	2049.46 ± 7.46 <sup>c</sup>	650.84 ± 1.41 <sup>m</sup>	nd	nd	nd	1.29 ± 0.04 <sup>f</sup>	9.32 ± 0.10 <sup>b</sup>
E	1	774.09 ± 1.30 <sup>h</sup>	1422.18 ± 3.61 <sup>w,x</sup>	753.67 ± 4.86 <sup>k</sup>	1553.67 ± 1.05 <sup>z</sup>	nd	nd	1553.67 ± 1.05 <sup>z</sup>	1307.14 ± 4.10 <sup>m</sup>	368.06 ± 1.14 <sup>q</sup>	nd	nd	nd	0.54 ± 0.01 <sup>no</sup>	3.35 ± 0.02 <sup>k</sup>	1.85 ± 0.03 <sup>q</sup>
	2	1027.19 ± 14.12 <sup>z,aa</sup>	1010.89 ± 1.76 <sup>z,aa</sup>	959.79 ± 11.73 <sup>i</sup>	2389.44 ± 46.44 <sup>c</sup>	nd	nd	573.14 ± 3.24 <sup>f</sup>	2230.00 ± 9.84 <sup>f</sup>	649.46 ± 4.72 <sup>m</sup>	829.35 ± 3.99 <sup>j</sup>	nd	nd	nd	1.91 ± 0.02 <sup>baq</sup>	3.85 ± 0.02 <sup>l</sup>
	3	1224.12 ± 3.64 <sup>h</sup>	1461.72 ± 0.76 <sup>w</sup>	1371.50 ± 11.30 <sup>b</sup>	2377.65 ± 2.09 <sup>g</sup>	nd	nd	707.39 ± 0.72 <sup>p</sup>	1861.23 ± 3.85 <sup>b</sup>	809.05 ± 1.79 <sup>ka</sup>	600.58 ± 4.28 <sup>n</sup>	nd	nd	nd	nd	nd
A	1	255.99 ± 0.90 <sup>ec</sup>	2623.66 ± 110.96 <sup>c</sup>	331.08 ± 0.45 <sup>u</sup>	2689.22 ± 21.63 <sup>d</sup>	nd	nd	212.22 ± 0.43 <sup>w</sup>	1327.93 ± 14.02 <sup>m</sup>	80.37 ± 0.18 <sup>u</sup>	nd	nd	nd	0.82 ± 0.04 <sup>m</sup>	1.50 ± 0.01 <sup>aa</sup>	nd
	2	284.59 ± 1.49 <sup>ec</sup>	36780.71 ± 56.35 <sup>b</sup>	238.18 ± 0.25 <sup>q</sup>	3605.43 ± 5.56 <sup>f</sup>	nd	nd	224.36 ± 0.35 <sup>w</sup>	2274.69 ± 10.79 <sup>e</sup>	120.08 ± 0.44 <sup>f</sup>	4558.19 ± 10.64 <sup>a</sup>	nd	nd	0.27 ± 0.01 <sup>rs</sup>	0.71 ± 0.01 <sup>s</sup>	nd
	3	378.66 ± 7.35 <sup>ad</sup>	25994.22 ± 109.80 <sup>f</sup>	435.56 ± 0.60 <sup>h</sup>	3327.61 ± 50.32 <sup>b</sup>	nd	nd	368.99 ± 1.27 <sup>n</sup>	1619.37 ± 31.28 <sup>k</sup>	208.95 ± 0.18 <sup>e</sup>	nd	nd	nd	0.86 ± 0.01 <sup>m</sup>	1.14 ± 0.03 <sup>w</sup>	4.76 ± 0.07 <sup>z</sup>
EA	1	nd	2319.99 ± 13.59 <sup>z</sup>	nd	357.00 ± 0.70 <sup>h</sup>	nd	nd	nd	nd	nd	nd	nd	nd	0.13 ± 0.01 <sup>f</sup>	0.29 ± 0.01 <sup>aa</sup>	3.38 ± 0.02 <sup>k</sup>
	2	nd	4633.23 ± 3.91 <sup>k</sup>	nd	572.50 ± 8.65 <sup>eo</sup>	nd	nd	1720.63 ± 0.07 <sup>f</sup>	1226.99 ± 22.98 <sup>o</sup>	nd	957.10 ± 0.35 <sup>i</sup>	nd	nd	0.15 ± 0.01 <sup>u</sup>	0.35 ± 0.01 <sup>aa</sup>	nd
	3	nd	3551.16 ± 16.64 <sup>n</sup>	nd	585.48 ± 6.41 <sup>man</sup>	nd	nd	nd	1226.99 ± 22.98 <sup>o</sup>	nd	793.24 ± 2.86 <sup>kl</sup>	nd	nd	0.42 ± 0.01 <sup>spq</sup>	0.63 ± 0.01 <sup>xy</sup>	6.44 ± 0.03 <sup>c</sup>
B	1	127.13 ± 0.75 <sup>af</sup>	3981.51 ± 7.52 <sup>mn</sup>	nd	546.25 ± 1.22 <sup>o</sup>	nd	nd	448.65 ± 7.01 <sup>f</sup>	nd	408.10 ± 1.44 <sup>p</sup>	nd	nd	3.69 ± 0.01 <sup>b</sup>	0.37 ± 0.01 <sup>uv</sup>	0.46 ± 0.01 <sup>f</sup>	2.59 ± 0.02 <sup>m</sup>
	2	119.42 ± 0.10 <sup>af</sup>	9671.12 ± 31.97 <sup>z</sup>	26.85 ± 0.19 <sup>g</sup>	2727.38 ± 23.86 <sup>c</sup>	nd	nd	74.89 ± 1.52 <sup>a</sup>	1983.76 ± 8.02 <sup>s</sup>	nd	2224.76 ± 11.94 <sup>b</sup>	nd	nd	0.42 ± 0.02 <sup>spq</sup>	0.57 ± 0.01 <sup>f</sup>	7.16 ± 0.01 <sup>c</sup>
	3	99.72 ± 0.19 <sup>af</sup>	8106.74 ± 16.81 <sup>h</sup>	19.73 ± 0.05 <sup>g</sup>	2712.71 ± 5.15 <sup>d</sup>	nd	nd	69.10 ± 0.39 <sup>b</sup>	1661.92 ± 6.38 <sup>j</sup>	nd	1915.12 ± 2.52 <sup>d</sup>	nd	nd	0.23 ± 0.01 <sup>u</sup>	0.46 ± 0.01 <sup>f</sup>	6.52 ± 0.06 <sup>de</sup>
PE	1	nd	590.44 ± 6.07 <sup>ec</sup>	nd	84.62 ± 1.08 <sup>s</sup>	nd	nd	nd	nd	nd	nd	nd	nd	nd	3.61 ± 0.01 <sup>z</sup>	2.16 ± 0.01 <sup>o</sup>
	2	nd	1623.67 ± 0.70 <sup>g</sup>	nd	83.22 ± 0.02 <sup>s</sup>	nd	nd	nd	nd	nd	nd	nd	nd	nd	1.20 ± 0.02 <sup>f</sup>	1.97 ± 0.02 <sup>p</sup>
	3	nd	939.05 ± 4.29 <sup>aa</sup>	nd	151.86 ± 1.51 <sup>w</sup>	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
H	1	nd	29087.33 ± 5.53 <sup>z</sup>	nd	200.29 ± 1.37 <sup>y</sup>	nd	nd	nd	252.87 ± 6.83 <sup>y</sup>	nd	87.13 ± 1.47 <sup>m</sup>	nd	nd	nd	1.30 ± 0.02 <sup>f</sup>	1.53 ± 0.01 <sup>u</sup>
	2	nd	45294.19 ± 27.06 <sup>a</sup>	nd	208.97 ± 8.81 <sup>y</sup>	nd	nd	660.44 ± 7.32 <sup>z</sup>	nd	139.38 ± 0.46 <sup>i</sup>	nd	nd	nd	nd	1.61 ± 0.01 <sup>k</sup>	3.14 ± 0.01 <sup>l</sup>
	3	nd	35499.92 ± 223.00 <sup>c</sup>	nd	356.97 ± 0.56 <sup>g</sup>	nd	nd	489.73 ± 1.12 <sup>s</sup>	nd	137.68 ± 1.83 <sup>i</sup>	nd	nd	nd	nd	2.86 ± 0.02 <sup>f</sup>	4.26 ± 0.01 <sup>h</sup>

Table 4 (continued)

Solvent	Sam- ple	ROS		RES		PRCA		VAN		GA		EA		QU		MYR		KAM		IQU		RU	
		SE	AH	SE	AH	SE	AH	SE	AH	SE	AH	SE	AH	SE	AH	SE	AH	SE	AH	SE	AH	SE	AH
W	1	nd	nd	nd	63.79±0.20 <sup>b</sup>	14.90±0.12 <sup>c</sup>	nd	9.92±0.02 <sup>a</sup>	nd	92.44±0.19 <sup>c</sup>	12.22±0.17 <sup>b</sup>	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
	2	nd	nd	nd	32.48±0.05 <sup>c</sup>	44.53±0.46 <sup>c</sup>	nd	nd	nd	338.41±0.43 <sup>d</sup>	nd	11.33±0.01 <sup>f</sup>	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
	3	nd	nd	nd	27.41±0.07 <sup>f</sup>	14.22±0.20 <sup>b</sup>	nd	nd	nd	199.74±0.09 <sup>b</sup>	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
M	1	nd	nd	nd	67.54±1.17 <sup>a</sup>	14.98±0.02 <sup>c</sup>	nd	nd	nd	69.65±0.14 <sup>d</sup>	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
	2	nd	nd	nd	50.63±0.24 <sup>c</sup>	17.06±0.17 <sup>b</sup>	nd	nd	nd	136.32±0.06 <sup>k</sup>	15.21±0.08 <sup>k</sup>	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
	3	nd	nd	nd	45.61±0.74 <sup>d</sup>	8.19±0.05 <sup>m</sup>	nd	nd	nd	122.96±0.34 <sup>m</sup>	17.76±0.28 <sup>k</sup>	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
E	1	nd	nd	nd	nd	16.36±0.10 <sup>g</sup>	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
	2	nd	nd	nd	nd	22.63±0.35 <sup>mn</sup>	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
	3	nd	nd	nd	nd	6.92±0.07 <sup>n</sup>	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
A	1	nd	12.76±0.04 <sup>f</sup>	nd	8.24±0.12 <sup>n</sup>	32.28±0.34 <sup>n</sup>	nd	nd	nd	186.16±0.55 <sup>i</sup>	nd	29.36±0.05 <sup>h</sup>	nd	nd	nd	7.22±0.04 <sup>f</sup>	nd	2.35±0.01 <sup>f</sup>	nd	nd	nd	nd	nd
	2	nd	28.69±0.09 <sup>g</sup>	nd	5.63±0.04 <sup>w</sup>	38.31±0.35 <sup>g</sup>	nd	nd	nd	334.37±2.13 <sup>e</sup>	nd	nd	nd	nd	nd	7.48±0.01 <sup>e</sup>	nd	2.32±0.01 <sup>g</sup>	nd	9.79±0.06 <sup>g</sup>	nd	nd	
	3	nd	nd	nd	7.22±0.14 <sup>v</sup>	23.20±0.07 <sup>m</sup>	nd	nd	nd	224.34±3.68 <sup>g</sup>	4.33±0.05 <sup>l</sup>	28.00±0.05 <sup>b</sup>	nd	nd	nd	6.99±0.05 <sup>g</sup>	nd	nd	nd	7.54±0.02 <sup>b</sup>	nd	nd	
EA	1	nd	nd	nd	1.73±0.01 <sup>v</sup>	26.57±0.20 <sup>k</sup>	nd	nd	nd	nd	nd	5.44±0.01 <sup>k</sup>	nd	nd	nd	7.65±0.04 <sup>d</sup>	nd	6.71±0.01 <sup>a</sup>	nd	nd	nd	nd	nd
	2	nd	nd	nd	3.53±0.05 <sup>f</sup>	41.78±0.05 <sup>f</sup>	nd	nd	nd	629.00±3.81 <sup>f</sup>	nd	15.46±0.02 <sup>d</sup>	nd	nd	nd	7.98±0.02 <sup>b</sup>	nd	nd	nd	nd	nd	nd	nd
	3	nd	nd	nd	1.55±0.04 <sup>f</sup>	15.02±0.11 <sup>f</sup>	nd	nd	nd	446.16±0.94 <sup>f</sup>	nd	8.03±0.01 <sup>f</sup>	nd	nd	nd	7.22±0.02 <sup>f</sup>	nd	nd	nd	nd	nd	nd	nd
B	1	nd	7.69±0.04 <sup>f</sup>	nd	3.88±0.02 <sup>g</sup>	22.07±0.13 <sup>g</sup>	nd	nd	nd	94.94±0.07 <sup>g</sup>	nd	4.39±0.01 <sup>l</sup>	nd	nd	nd	nd	nd	2.31±0.01 <sup>g</sup>	nd	nd	nd	3.02±0.01 <sup>b</sup>	
	2	nd	13.38±0.09 <sup>b</sup>	nd	5.93±0.01 <sup>v</sup>	36.80±0.16 <sup>h</sup>	1.19±0.02 <sup>n</sup>	nd	nd	346.37±0.78 <sup>g</sup>	nd	14.78±0.02 <sup>d</sup>	nd	nd	nd	8.09±0.02 <sup>g</sup>	nd	2.59±0.01 <sup>b</sup>	nd	5.12±0.01 <sup>c</sup>	nd	nd	
	3	nd	12.46±0.10 <sup>d</sup>	nd	2.09±0.14 <sup>v</sup>	19.71±0.43 <sup>g</sup>	nd	nd	nd	282.40±1.07 <sup>g</sup>	nd	13.71±0.01 <sup>h</sup>	nd	nd	nd	7.87±0.02 <sup>g</sup>	nd	2.56±0.01 <sup>c</sup>	nd	nd	nd	7.54±0.01 <sup>a</sup>	
PE	1	nd	nd	nd	nd	8.94±0.05 <sup>f</sup>	nd	2.55±0.01 <sup>h</sup>	nd	nd	nd	nd	nd	nd	nd	nd	nd	2.49±0.01 <sup>c</sup>	nd	nd	nd	nd	
	2	nd	nd	nd	nd	22.45±0.55 <sup>h</sup>	nd	nd	nd	130.57±0.16 <sup>l</sup>	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	
	3	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	7.02±0.04 <sup>g</sup>	nd	2.53±0.02 <sup>d</sup>	nd	nd	nd	nd	
H	1	nd	nd	nd	nd	14.68±0.52 <sup>g</sup>	nd	nd	nd	58.52±0.01 <sup>o</sup>	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	
	2	nd	nd	nd	nd	24.15±0.07 <sup>l</sup>	nd	nd	nd	149.55±0.30 <sup>g</sup>	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	
	3	nd	nd	nd	nd	14.98±0.74 <sup>f</sup>	nd	nd	nd	111.65±1.46 <sup>g</sup>	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	

SE solvent extraction, AH acidic hydrolysis, CAT catechin, ECATG epicatechin, ECATG epigallocatechin gallate, EGCGATG epigallocatechin gallate, CHL chlorogenic acid, CAF caffeic acid, PCA p-coumaric acid, FER ferulic acid, ROS rosmarinic acid, RES resveratrol, PRCA protocatechuic acid, VAN vanillic acid, GA gallic acid, EA ellagic acid, QU quercetin, MYR myricetin, KAM kaempferol, IQU isoquercitrin, RU rutin, W water, M methanol, E ethanol, A acetone, EA ethyl acetate, B butanol, P petroleum ether, H hexane

\*Two replicates ± Standard deviation

<sup>a-z</sup>Different lowercase superscripts in the different extraction groups indicate significant differences between means of phenolic composition for oleaster samples (*p* < 0.05)

**Table 5** Phenolic compound contents of oleaster flower samples (mg/kg sample)

Sol-vent	Sam-ple	CAT			EGCATG			2-HCA			CAF			PCA			FBR			RES		
		SE	AH	SE	SE	AH	SE	AH	SE	AH	SE	AH	SE	AH	SE	AH	SE	AH	SE	AH		
W	1	4988.95±17.45 <sup>f</sup>	4839.67±4.97 <sup>g</sup>	nd	1085.14±3.40 <sup>f</sup>	nd	nd	nd	nd	105.02±0.42 <sup>d</sup>	457.91±0.40 <sup>g</sup>	39.18±1.44 <sup>f</sup>	309.41±1.19 <sup>g</sup>	87.50±0.29 <sup>g</sup>	83.27±0.05 <sup>h</sup>	nd	nd	nd	nd	nd		
	2	1746.07±18.92 <sup>w</sup>	2506.96±7.08 <sup>vv</sup>	nd	850.93±0.91 <sup>k</sup>	nd	nd	nd	nd	101.41±0.72 <sup>e</sup>	17.29±3.50 <sup>f</sup>	56.41±0.83 <sup>g</sup>	17.29±3.50 <sup>f</sup>	55.18±5.15 <sup>k</sup>	43.90±0.48 <sup>k,l</sup>	nd	nd	nd	nd	nd		
	3	2213.64±10.50 <sup>m</sup>	6820.12±8.66 <sup>g</sup>	nd	992.54±14.22 <sup>j</sup>	nd	nd	nd	nd	349.07±0.47 <sup>b</sup>	39.84±0.41 <sup>f</sup>	158.63±1.54 <sup>b</sup>	40.00±0.46 <sup>m</sup>	158.63±1.54 <sup>b</sup>	63.38±0.35 <sup>f</sup>	nd	nd	nd	nd	nd		
M	1	6280.59±53.44 <sup>m</sup>	32,093.69±80.91 <sup>c</sup>	nd	1931.86±0.15 <sup>d</sup>	1778.06±1.05 <sup>f</sup>	nd	1778.06±1.05 <sup>f</sup>	nd	61.74±0.85 <sup>e</sup>	95.93±0.14 <sup>e</sup>	71.88±0.13 <sup>m</sup>	96.77±0.90 <sup>f</sup>	74.79±3.79 <sup>h</sup>	131.31±0.61 <sup>d</sup>	147.06±0.35 <sup>e</sup>	nd	nd	nd	nd		
	2	1544.79±1.78 <sup>e</sup>	18,253.66±1.81 <sup>k</sup>	nd	815.46±3.75 <sup>e</sup>	981.12±0.09 <sup>f</sup>	32.85±0.06 <sup>f</sup>	32.85±0.06 <sup>f</sup>	nd	37.34±0.37 <sup>m</sup>	31.75±0.13 <sup>m</sup>	31.75±0.13 <sup>m</sup>	39.65±0.74 <sup>k</sup>	53.91±0.74 <sup>k</sup>	63.64±0.62 <sup>h</sup>	nd	nd	nd	nd	nd		
	3	2139.91±4.84 <sup>a</sup>	21,722.10±140.80 <sup>j</sup>	nd	1775.86±1.95 <sup>f</sup>	1962.02±1.03 <sup>f</sup>	46.08±0.22 <sup>h</sup>	46.08±0.22 <sup>h</sup>	nd	38.11±0.34 <sup>p</sup>	107.49±0.26 <sup>g</sup>	107.49±0.26 <sup>g</sup>	81.71±1.01 <sup>l</sup>	17.09±0.70 <sup>p</sup>	126.19±0.32 <sup>d</sup>	54.18±0.45 <sup>f</sup>	136.00±2.36 <sup>f</sup>	228.31±3.39 <sup>e</sup>	1536.00±2.36 <sup>f</sup>	nd		
E	1	1237.16±38.57 <sup>xx</sup>	37,219.13±139.71 <sup>d</sup>	nd	10,617.55±62.50 <sup>l</sup>	nd	nd	nd	137.32±1.22 <sup>a</sup>	17.09±0.10 <sup>l</sup>	81.71±1.01 <sup>l</sup>	17.09±0.10 <sup>l</sup>	17.09±0.10 <sup>l</sup>	126.19±0.32 <sup>d</sup>	54.18±0.45 <sup>f</sup>	136.00±2.36 <sup>f</sup>	228.31±3.39 <sup>e</sup>	1536.00±2.36 <sup>f</sup>	nd	nd		
	2	424.91±2.37 <sup>f</sup>	25,095.24±28.32 <sup>z</sup>	nd	204.38±0.23 <sup>s</sup>	1056.87±1.11 <sup>k</sup>	nd	1056.87±1.11 <sup>k</sup>	nd	110.75±0.45 <sup>e</sup>	11.59±0.28 <sup>h</sup>	39.12±0.14 <sup>nd</sup>	39.12±0.14 <sup>nd</sup>	63.85±0.79 <sup>j</sup>	32.50±0.05 <sup>oo</sup>	nd	nd	nd	nd	nd		
	3	1019.52±32.93 <sup>f</sup>	29,067.02±68.45 <sup>t</sup>	nd	13,227.77±7.19 <sup>p</sup>	2023.31±5.73 <sup>h</sup>	nd	2023.31±5.73 <sup>h</sup>	nd	121.53±0.47 <sup>b</sup>	13.50±0.05 <sup>vv</sup>	81.52±0.30 <sup>l</sup>	81.52±0.30 <sup>l</sup>	67.98±1.47 <sup>h</sup>	109.19±0.43 <sup>e</sup>	138.63±0.72 <sup>f</sup>	nd	nd	nd	nd		
A	1	168,285.03±788.55 <sup>h</sup>	12,070.67±57.91 <sup>b</sup>	nd	11,529.04±125.76 <sup>s</sup>	nd	nd	nd	nd	244.53±0.61 <sup>f</sup>	12.64±0.45 <sup>nn</sup>	244.53±0.61 <sup>f</sup>	12.64±0.45 <sup>nn</sup>	27.55±0.05 <sup>pp</sup>	nd	nd	nd	nd	nd			
	2	180,760.65±57.34 <sup>h</sup>	7719.60±27.14 <sup>h</sup>	nd	7539.64±65.24 <sup>h</sup>	nd	nd	nd	6.29±0.30 <sup>h</sup>	6.29±0.30 <sup>h</sup>	123.05±4.16 <sup>b</sup>	123.05±4.16 <sup>b</sup>	133.66±2.18 <sup>e</sup>	133.66±2.18 <sup>e</sup>	452.40±10.09 <sup>h</sup>	nd	nd	nd	nd			
	3	97,739.27±895.90 <sup>e</sup>	10,992.49±58.48 <sup>e</sup>	nd	7389.56±165.29 <sup>h</sup>	nd	nd	nd	7.22±0.32 <sup>aa</sup>	7.22±0.32 <sup>aa</sup>	191.29±6.41 <sup>d</sup>	9.53±0.17 <sup>h</sup>	9.53±0.17 <sup>h</sup>	24.94±0.31 <sup>p</sup>	24.94±0.31 <sup>p</sup>	nd	nd	nd	nd			
EA	1	8426.85±150.17 <sup>o</sup>	nd	nd	nd	nd	nd	nd	nd	119.82±0.31 <sup>l</sup>	123.78±1.27 <sup>d</sup>	123.78±1.27 <sup>d</sup>	nd	nd	nd	nd	nd	nd	nd			
	2	7831.20±76.69 <sup>p</sup>	nd	nd	nd	nd	nd	nd	nd	84.29±0.05 <sup>l</sup>	76.48±0.11 <sup>b</sup>	76.48±0.11 <sup>b</sup>	nd	nd	nd	nd	nd	nd	nd			
	3	9104.71±27.66 <sup>n</sup>	nd	nd	nd	nd	nd	nd	81.42±1.43 <sup>h</sup>	nd	99.68±2.76 <sup>k</sup>	99.68±2.76 <sup>k</sup>	nd	nd	nd	nd	nd	nd	nd			
B	1	17,365.89±56.93 <sup>l</sup>	7304.41±6.86 <sup>f</sup>	nd	7304.41±6.86 <sup>f</sup>	nd	nd	nd	nd	29.55±0.75 <sup>s</sup>	27.41±1.98 <sup>h</sup>	27.41±1.98 <sup>h</sup>	nd	nd	nd	nd	nd	nd	nd			
	2	31,234.05±136.24 <sup>f</sup>	6776.42±38.10 <sup>a</sup>	nd	6776.42±38.10 <sup>a</sup>	nd	nd	nd	45.77±1.70 <sup>h</sup>	nd	147.38±0.48 <sup>h</sup>	147.38±0.48 <sup>h</sup>	nd	nd	nd	nd	nd	nd	nd			
	3	28,050.12±252.57 <sup>h</sup>	nd	nd	nd	nd	nd	nd	nd	52.55±0.22 <sup>n</sup>	37.28±0.43 <sup>m</sup>	37.28±0.43 <sup>m</sup>	nd	nd	nd	nd	nd	nd	nd			
PE	1	nd	nd	nd	nd	nd	nd	nd	nd	nd	52.55±0.22 <sup>n</sup>	52.55±0.22 <sup>n</sup>	nd	nd	nd	nd	nd	nd	nd			
	2	nd	nd	nd	nd	nd	nd	nd	nd	nd	52.55±0.22 <sup>n</sup>	52.55±0.22 <sup>n</sup>	nd	nd	nd	nd	nd	nd	nd			
	3	nd	nd	nd	nd	nd	nd	nd	nd	nd	52.55±0.22 <sup>n</sup>	52.55±0.22 <sup>n</sup>	nd	nd	nd	nd	nd	nd	nd			
H	1	nd	nd	nd	nd	nd	nd	nd	nd	nd	52.55±0.22 <sup>n</sup>	52.55±0.22 <sup>n</sup>	nd	nd	nd	nd	nd	nd	nd			
	2	nd	nd	nd	nd	nd	nd	nd	nd	nd	52.55±0.22 <sup>n</sup>	52.55±0.22 <sup>n</sup>	nd	nd	nd	nd	nd	nd	nd			
	3	nd	nd	nd	nd	nd	nd	nd	nd	nd	52.55±0.22 <sup>n</sup>	52.55±0.22 <sup>n</sup>	nd	nd	nd	nd	nd	nd	nd			
Sol-vent	Sam-ple	PRCA			VAN			GA			MYR			KAM			KAMG			IQU		
		SE	AH	SE	SE	AH	SE	AH	SE	AH	SE	AH	SE	AH	SE	AH	SE	AH	SE	AH		
		SE	AH	SE	SE	AH	SE	AH	SE	AH	SE	AH	SE	AH	SE	AH	SE	AH	SE	AH		
W	1	194.02±2.93 <sup>b</sup>	178.85±1.85 <sup>d</sup>	nd	101.38±2.49 <sup>f</sup>	nd	nd	947.96±0.58 <sup>f</sup>	nd	325.72±0.73 <sup>f</sup>	235.65±1.88 <sup>h</sup>	147.83±3.12 <sup>f</sup>	nd	nd	nd	nd	nd	nd	nd	nd		
	2	119.27±3.06 <sup>e</sup>	82.23±1.20 <sup>h</sup>	49.80±0.83 <sup>j</sup>	nd	704.55±0.62 <sup>h</sup>	nd	704.55±0.62 <sup>h</sup>	nd	251.23±0.39 <sup>j</sup>	nd	135.79±0.20 <sup>h</sup>	nd	nd	nd	nd	nd	nd	nd	nd		
	3	300.32±6.46 <sup>g</sup>	339.52±6.45 <sup>g</sup>	237.98±0.16 <sup>e</sup>	nd	582.34±6.42 <sup>h</sup>	nd	582.34±6.42 <sup>h</sup>	nd	181.96±4.23 <sup>l</sup>	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd		
M	1	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd		
	2	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd		
	3	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd		
E	1	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd		
	2	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd		
	3	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd		
A	1	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd		
	2	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd		
	3	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd		
EA	1	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd		
	2	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd		
	3	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd		

**Table 5** (continued)

Sol-vent	Sample	PRCA		VAN		GA		EA		MYR		KAM		KAMG		IOU	
		SE	AH	SE	AH	SE	AH	SE	AH	SE	AH	SE	AH	SE	AH	SE	AH
B	1	nd	nd	nd	nd	2055.57 ± 31.18 <sup>a</sup>	228.37 ± 1.19 <sup>a</sup>	70.29 ± 0.15 <sup>f</sup>	nd	167.51 ± 0.40 <sup>f</sup>	211.68 ± 0.23 <sup>k,j</sup>	nd	117.11 ± 0.28 <sup>m</sup>				
	2	nd	nd	nd	nd	nd	250.54 ± 7.43 <sup>i</sup>	nd	nd	125.19 ± 1.07 <sup>h</sup>	168.34 ± 2.20 <sup>m</sup>	nd	106.71 ± 3.48 <sup>o</sup>				
	3	nd	nd	nd	nd	1921.65 ± 3.96 <sup>b</sup>	489.26 ± 1.94 <sup>d</sup>	101.39 ± 2.54 <sup>d</sup>	nd	349.56 ± 4.96 <sup>d</sup>	302.90 ± 2.29 <sup>b</sup>	nd	239.02 ± 2.75 <sup>s</sup>				
PE	1	nd	nd	nd	nd	nd	114.18 ± 3.70 <sup>m</sup>	nd	nd	39.46 ± 0.14 <sup>q,r,s</sup>	nd	nd	nd				
	2	nd	nd	nd	nd	nd	nd	nd	nd	49.09 ± 0.20 <sup>u,v,w</sup>	nd	nd	nd				
	3	nd	nd	nd	nd	nd	186.96 ± 0.56 <sup>l</sup>	nd	nd	52.39 ± 0.49 <sup>u,v</sup>	nd	nd	nd				
H	1	nd	nd	nd	nd	nd	92.57 ± 1.01 <sup>p</sup>	nd	nd	101.48 ± 0.78 <sup>t</sup>	nd	nd	70.65 ± 1.44 <sup>p</sup>				
	2	nd	nd	nd	nd	nd	65.05 ± 0.66 <sup>q</sup>	nd	nd	76.95 ± 1.27 <sup>k</sup>	12.37 ± 0.35 <sup>p</sup>	nd	63.53 ± 0.21 <sup>q</sup>				
	3	nd	nd	nd	nd	nd	94.44 ± 1.03 <sup>q</sup>	nd	nd	59.11 ± 2.47 <sup>l</sup>	nd	nd	58.85 ± 0.29 <sup>r</sup>				

SE solvent extraction, AH acidic hydrolysis, ECAT catechin, ECATG epigallocatechin gallate, 2-HCA 2-hydroxycinnamic acid, CAF caffeic acid, PCA p-coumaric acid, FER ferulic acid, RES resveratrol, PRCA protocatechuic acid, VAN vanillic acid, GA gallic acid, EA ellagic acid, MYR myricetin, KAM kaempferol, KAMG kaempferol-3-glycoside, IOU isoquercitrin, W water, M methanol, E ethanol, A acetone, EA ethyl acetate, B butanol, P petroleum ether, H hexane

\*Two replicates ± Standard deviation

<sup>a–y</sup>Different lowercase superscripts in the different extraction groups indicate significant differences between means of phenolic composition for oleaster samples ( $p < 0.05$ )

collected from different genotypes were determined [32]. According to the results, TP contents of the peel were in the range of 1179.04 and 262.36 mg GAE/100 g FW. Also, the highest and lowest TP contents of the pulp were 820.88 and 250.55 mg GAE/100 g FW, respectively. TP contents in different genotypes of *Elaeagnus umbellata* Thunb. fruit were in the range of 168.9 and 258.1 mg GAE/100 g FW [33]. Saboonchian et al. [34] determined TP contents using ethanoic and methanolic extract of leaf and flower of *Elaeagnus angustifolia* L. For both varieties, the phenolic content of the methanol extract is higher; at the same time, the leaf has a higher phenolic content than the flower. The leaf of *Elaeagnus oldhamii* Maxim. was extracted with methanol and the result of TP content was found as 106.09 ± 3.83 µg catechin/mg sample [9].

Antioxidant capacity values of oleaster extracts in different extraction conditions were determined using FRAP, ABTS, CHROMAC, and DPPH methods, and the results were expressed as mg TE/g sample. The FRAP method is based on the reduction of Fe<sup>3+</sup>-TPTZ (ferricripyridyl-triazine) complex to the ferrous form at low pH. For the FRAP method, the antioxidant capacity values ranged from 0.43 to 15.10 mg TE/g of oleaster flour for solvent extracts and from 2.68 to 46.66 mg TE/g of oleaster flour for acidic hydrolysis (Table 7), from 0.45 to 2.12 mg TE/g oleaster shell for solvent extracts and from 1.85 to 16.77 mg TE/g oleaster shell for acidic hydrolysis (Table 8), from 1.32 to 47.99 mg TE/g oleaster core for solvent extracts and from 7.64 to 336.12 mg TE/g oleaster core for acidic hydrolysis (Table 9), from 4.93 to 20.62 mg TE/g oleaster flower for solvent extracts and from 20.70 to 146.40 mg TE/g oleaster flower for acidic hydrolysis (Table 10), and from 1.08 to 21.68 mg TE/g oleaster leaf for solvent extracts and from 5.82 to 98.45 mg TE/g oleaster leaf for acidic hydrolysis (Table 11). In a study [32], the antioxidant capacities of the oleaster fruit's seed and pulp with different genotypes were examined. The results showed that the antioxidant capacity of peel was in the range of 57.00–131.33 mg Fe<sup>2+</sup>/100 g FW. The highest antioxidant capacity of pulp was found as 164.67 mg Fe<sup>2+</sup>/100 g FW and the lowest was found as 86.00 mg Fe<sup>2+</sup>/100 g FW. In the other study, according to Faramarz et al. [35], the antioxidant capacity of peel and pulp extracts of *Elaeagnus angustifolia* L. collected from different genotypes were determined as 0.246 and 548 mM Fe<sup>2+</sup>/mg, respectively [35].

The ABTS method is based on the reduction of ABTS• radical formation by phenolic compounds. For the ABTS method, the antioxidant capacity values ranged from 0.89 to 30.99 mg TE/g oleaster flour for solvent extracts and from 3.04 to 22.43 mg TE/g oleaster flour for acidic hydrolysis (Table 7), from 1.60 to 23.30 mg TE/g oleaster shell for solvent extracts and from 4.76 to 19.85 mg TE/g oleaster shell for acidic hydrolysis (Table 8), from 2.34 to

**Table 6** Phenolic compound contents of oleaster leaf samples (mg/kg sample)

Solvent	Sample	CAT		ECAT		ECATG		EGCAT		EGCATG		2-HCA		PCA		FER		RES			
		SE	AH	SE	AH	SE	AH	SE	AH	SE	AH	SE	AH	SE	AH	SE	AH	SE	AH		
W	1	36.44±3.94	5.53 <sup>z</sup>	2607.88±37.69 <sup>ab</sup>	5760.42±5.33 <sup>z</sup>	3292.62±69.29 <sup>ab</sup>	nd	4336.57±181.37 <sup>nd</sup>	7128.61±81.38 <sup>nd</sup>	nd	nd	nd	nd	438.59±5.12 <sup>z</sup>	222.27±2.45 <sup>z</sup>	221.08±3.40 <sup>z</sup>	135.08±2.13 <sup>z</sup>	98.55±0.28 <sup>nd</sup>	nd		
	2	8508.06±22.39 <sup>z</sup>	4942.10±24.27 <sup>z</sup>	4942.10±24.27 <sup>z</sup>	nd	3317.74±15.34 <sup>z</sup>	nd	nd	5694.73±26.32 <sup>z</sup>	nd	nd	nd	nd	397.68±4.95 <sup>z</sup>	268.34±1.87 <sup>z</sup>	260.44±1.86 <sup>z</sup>	294.70±1.83 <sup>z</sup>	nd	nd		
	3	29.77±7.28	1.02 <sup>z</sup>	2490.41±4.24 <sup>ab</sup>	6979.60±144.13 <sup>b</sup>	2675.43±31.17 <sup>z</sup>	nd	nd	nd	nd	nd	nd	nd	461.97±5.83 <sup>z</sup>	279.18±0.34 <sup>z</sup>	256.19±0.34 <sup>z</sup>	225.39±3.31 <sup>d</sup>	771.18±1.00 <sup>b</sup>	nd		
	M	1	6853.91±71.82 <sup>z</sup>	86.39±5.58	131.38 <sup>z</sup>	86.39±5.58	3465.69±61.44 <sup>z</sup>	nd	nd	nd	nd	nd	nd	nd	1885.96±9.04 <sup>z</sup>	nd	nd	nd	nd	nd	
		2	6540.08±60.27 <sup>z</sup>	20.19±2.62	46.12 <sup>z</sup>	20.19±2.62	3100.77±27.02 <sup>z</sup>	nd	nd	nd	nd	nd	nd	nd	1018.34±1.08 <sup>z</sup>	nd	nd	nd	nd	nd	
		3	5333.56±22.94 <sup>z</sup>	84.63±4.63	301.29 <sup>d</sup>	84.63±4.63	3629.17±66.40 <sup>z</sup>	nd	nd	nd	nd	nd	nd	nd	1634.52±0.51 <sup>b</sup>	nd	nd	nd	nd	nd	
	E	1	1042.56±84.09 <sup>zw</sup>	46.91±5.86	111.70 <sup>f</sup>	46.91±5.86	32.83±3.96	206.83 <sup>b</sup>	nd	nd	nd	nd	nd	nd	1559.77±6.35 <sup>z</sup>	22.13±0.88 <sup>z</sup>	34.39±0.73 <sup>z</sup>	nd	nd	nd	
		2	1104.34±66.87 <sup>z</sup>	16.10±1.41	119.46 <sup>z</sup>	16.10±1.41	11.61±3.29	129.35 <sup>z</sup>	nd	nd	nd	nd	nd	nd	6081.81±61.64 <sup>b</sup>	18.84±0.13 <sup>z</sup>	nd	nd	nd	nd	
		3	611.98±2.83 <sup>z</sup>	50.85±0.62	349.08 <sup>z</sup>	50.85±0.62	41.24±6.46	231.33 <sup>z</sup>	nd	nd	nd	nd	nd	nd	2267.47±21.82 <sup>z</sup>	151.42±0.23 <sup>z</sup>	18.79±0.09 <sup>z</sup>	27.43±0.24 <sup>z</sup>	nd	nd	
	A	1	213.58±0.77 <sup>z</sup>	254.27±1.45	926.96 <sup>z</sup>	47.64±0.62 <sup>z</sup>	11.918.79±114.62 <sup>z</sup>	nd	nd	nd	nd	nd	nd	nd	32.88±0.16 <sup>z</sup>	4.06±0.05 <sup>z</sup>	9.24±0.02 <sup>z</sup>	nd	nd	nd	
2		320.59±5.82 <sup>z</sup>	31.74±4.81	127.75 <sup>b</sup>	31.74±4.81	nd	nd	nd	nd	nd	nd	nd	nd	673.20±4.46 <sup>z</sup>	2.63±0.01 <sup>z</sup>	10.02±0.04 <sup>z</sup>	nd	nd	nd		
3		150.74±0.48 <sup>z</sup>	2296.19±2.68 <sup>z</sup>	35.38±0.14 <sup>z</sup>	37.03±0.74 <sup>z</sup>	12.278.12±24.32 <sup>z</sup>	nd	nd	nd	nd	nd	nd	nd	1002.64±4.58 <sup>b</sup>	3.52±0.01 <sup>z</sup>	7.32±0.01 <sup>z</sup>	nd	nd	nd		
EA	1	nd	nd	2796.38±11.59 <sup>z</sup>	28.35±1.51 <sup>z</sup>	31.08±95±6.20 <sup>z</sup>	345.48±16.73 <sup>z</sup>	nd	nd	nd	nd	nd	nd	24.68±0.02 <sup>z</sup>	657.24±0.20 <sup>z</sup>	1.74±0.03 <sup>z</sup>	7.73±0.23 <sup>z</sup>	nd	nd		
	2	nd	nd	15.074.67±94.95 <sup>z</sup>	nd	4524.92±118.55 <sup>z</sup>	342.66±0.94 <sup>z</sup>	nd	nd	nd	nd	nd	nd	10.35±0.13 <sup>z</sup>	525.31±0.39 <sup>z</sup>	0.72±0.03 <sup>z</sup>	5.18±0.12 <sup>z</sup>	nd	nd		
	3	nd	nd	31.234.41±62.34 <sup>z</sup>	nd	11.929.70±67.38 <sup>d</sup>	nd	nd	nd	nd	nd	nd	nd	627.64±1.31 <sup>z</sup>	0.36±0.03 <sup>z</sup>	4.30±0.08 <sup>z</sup>	nd	nd			
B	1	75.75±2.06 <sup>z</sup>	9275.74±16.76 <sup>z</sup>	27.056.94±145.49 <sup>z</sup>	nd	10.161.27±41.27 <sup>z</sup>	nd	nd	nd	nd	nd	nd	nd	249.08±0.13 <sup>z</sup>	819.83±0.57 <sup>z</sup>	5.96±0.11 <sup>z</sup>	6.63±0.08 <sup>z</sup>	nd	nd		
	2	112.42±1.56 <sup>z</sup>	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	266.80±0.33 <sup>z</sup>	423.61±2.14 <sup>z</sup>	nd	nd	nd	nd		
	3	42.82±0.01 <sup>z</sup>	422.24±1.75 <sup>z</sup>	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	256.07±0.98 <sup>z</sup>	508.77±1.14 <sup>z</sup>	4.67±0.01 <sup>z</sup>	4.67±0.01 <sup>z</sup>	nd	nd		
PE	1	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	392.55±0.39 <sup>z</sup>	nd	0.34±0.02 <sup>z</sup>	nd	1.73±0.01 <sup>z</sup>	nd		
	2	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	360.91±3.20 <sup>z</sup>	nd	0.27±0.04 <sup>z</sup>	nd	nd	nd		
	3	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	371.45±1.71 <sup>z</sup>	nd	0.38±0.02 <sup>z</sup>	nd	1.61±0.01 <sup>z</sup>	nd		
H	1	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd		
	2	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd		
	3	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd		
Solvent	Sample	PRCA		VAN		GA		QU		MYR		LU		KAM		KAMG		IQU			
		SE	AH	SE	AH	SE	AH	SE	AH	SE	AH	SE	AH	SE	AH	SE	AH	SE	AH		
		nd	113.44±0.25 <sup>z</sup>	nd	64.43±0.97 <sup>z</sup>	68.81±15.30 <sup>z</sup>	1126.74±3.39 <sup>z</sup>	nd	nd	108.42±0.22 <sup>z</sup>	nd	nd	nd	nd	796.33±2.23 <sup>z</sup>	nd	293.76±0.49 <sup>z</sup>	nd	nd		
	nd	425.04±0.98 <sup>z</sup>	nd	nd	317.70±18.83 <sup>z</sup>	318.16±1.24 <sup>z</sup>	nd	nd	nd	nd	nd	nd	nd	nd	731.22±3.26 <sup>z</sup>	nd	324.04±0.16 <sup>z</sup>	nd	nd		
	nd	133.64±1.57 <sup>z</sup>	nd	378.40±2.93 <sup>z</sup>	664.77±0.85 <sup>z</sup>	2601.29±16.57 <sup>z</sup>	758.06±5.58 <sup>z</sup>	nd	118.16±0.65 <sup>z</sup>	nd	nd	nd	nd	nd	343.86±1.86 <sup>z</sup>	nd	641.91±10.19 <sup>z</sup>	nd	nd		
	nd	0.13±0.03 <sup>z</sup>	nd	nd	nd	97.90±3.49 <sup>z</sup>	nd	nd	nd	nd	nd	nd	nd	32.39±0.56 <sup>z</sup>	55.11±0.14 <sup>z</sup>	3.65.11±0.33 <sup>z</sup>	807.13±2.27 <sup>z</sup>	115.94±0.15 <sup>z</sup>	nd		
	nd	1.33±0.12 <sup>z</sup>	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	16.42±0.39 <sup>z</sup>	31.08±0.07 <sup>z</sup>	2.99.01±0.09 <sup>z</sup>	8.10.88±9.98 <sup>z</sup>	5.44±0.30 <sup>z</sup>	nd		
	nd	2.49±0.09 <sup>z</sup>	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	33.47±0.23 <sup>z</sup>	36.70±0.22 <sup>z</sup>	468.07±1.11 <sup>z</sup>	768.46±2.39 <sup>z</sup>	107.96±0.08 <sup>z</sup>	nd		
	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	42.17±0.80 <sup>z</sup>	nd	nd	617.74±6.25 <sup>z</sup>	465.82±5.86 <sup>z</sup>	nd		
	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	32.84±0.11 <sup>z</sup>	45.82±0.04 <sup>z</sup>	nd	828.74±4.58 <sup>z</sup>	433.92±0.59 <sup>z</sup>	nd		
	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	21.24±2.17 <sup>z</sup>	nd	nd	685.31±4.17 <sup>z</sup>	496.20±0.11 <sup>z</sup>	nd		
	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	32.83±6.61 <sup>z</sup>	50.37±0.55 <sup>z</sup>	nd	653.21±0.03 <sup>z</sup>	507.99±3.51 <sup>z</sup>	nd		
	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	5.38±0.09 <sup>z</sup>	39.93±0.03 <sup>z</sup>	nd	653.21±0.03 <sup>z</sup>	507.99±3.51 <sup>z</sup>	nd		
	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	30.87±0.28 <sup>z</sup>	30.87±0.28 <sup>z</sup>	nd	667.99±5.79 <sup>z</sup>	305.00±1.36 <sup>z</sup>	nd		
	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	5.76±0.03 <sup>z</sup>	79.63±0.49 <sup>z</sup>	nd	689.96±0.06 <sup>z</sup>	547.38±5.86 <sup>z</sup>	nd		
Sol-Sam-ventple	PRCA	VAN		GA		QU		MYR		LU		KAM		KAMG		IQU		SE		AH	
		SE	AH	SE	AH	SE	AH	SE	AH	SE	AH	SE	AH	SE	AH	SE	AH	SE	AH	SE	AH
		nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
EA	1	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	465.08±1.44 <sup>b</sup>	nd	519.47±2.06 <sup>z</sup>	nd	289.56±1.16 <sup>z</sup>	nd		
2	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	213.72±1.79 <sup>z</sup>	nd	345.50±0.48 <sup>z</sup>	nd	224.11±1.29 <sup>z</sup>	nd		
3	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	545.00±2.29 <sup>a</sup>	nd	325.32±4.95 <sup>z</sup>	nd	378.68±1.88 <sup>b</sup>	nd		

Table 6 (continued)

Sol-Sam-ventple	PRCA		VAN		GA		EA		QU		MYR		LU		KAM		KAMG		IQU	
	SE	AH	SE	AH	SE	AH	SE	AH	SE	AH	SE	AH	SE	AH	SE	AH	SE	AH	SE	AH
B	1	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	57.54 ± 1.53 <sup>f</sup>	nd	388.88 ± 4.23 <sup>l</sup>	nd	320.88 ± 2.72 <sup>j</sup>
	2	nd	nd	nd	nd	nd	3.99 ± 0.04 <sup>e</sup>	nd	nd	nd	nd	nd	nd	nd	nd	31.35 ± 0.57 <sup>l</sup>	6.04 ± 0.08 <sup>l</sup>	324.64 ± 1.75 <sup>o</sup>	nd	183.57 ± 3.03 <sup>o</sup>
	3	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	3.14 ± 0.32 <sup>n</sup>	149.38 ± 2.15 <sup>d</sup>	267.86 ± 0.87 <sup>p</sup>	nd	272.03 ± 0.28 <sup>m</sup>
PE	1	nd	nd	nd	nd	nd	nd	46.09 ± 0.17 <sup>d</sup>	nd	28.53 ± 0.08 <sup>e</sup>	nd	14.73 ± 0.06 <sup>c</sup>	nd	nd	nd	24.08 ± 0.09 <sup>m</sup>	nd	3.92 ± 0.02 <sup>l</sup>	nd	12.68 ± 0.02 <sup>l</sup>
	2	nd	nd	nd	nd	nd	nd	52.63 ± 0.17 <sup>c</sup>	nd	29.90 ± 0.12 <sup>e</sup>	nd	nd	nd	nd	nd	11.95 ± 0.04 <sup>o</sup>	nd	15.10 ± 0.07 <sup>s</sup>	nd	12.75 ± 0.03 <sup>t</sup>
	3	nd	nd	nd	nd	nd	nd	48.44 ± 0.23 <sup>c,d</sup>	nd	28.66 ± 0.12 <sup>e</sup>	nd	14.78 ± 0.09 <sup>c</sup>	nd	nd	nd	16.61 ± 0.10 <sup>n</sup>	nd	nd	nd	20.85 ± 0.08 <sup>s</sup>
H	1	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	10.64 ± 0.05 <sup>s,t</sup>	nd	15.65 ± 0.08 <sup>s,t</sup>
	2	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	41.82 ± 0.10 <sup>t</sup>	nd	20.45 ± 0.08 <sup>s</sup>
	3	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	7.94 ± 0.08 <sup>t</sup>	nd	16.45 ± 0.08 <sup>s,t</sup>

SE solvent extraction, AH acidic hydrolysis, CAT catechin, ECAT epicatechin, ECATG epicatechin gallate, EGCG epigallocatechin gallate, 2-HCA 2-hydroxycinnamic acid, PCA p-coumaric acid, FER ferulic acid, RES resveratrol, PRCA protocatechuic acid, VAN vanillic acid, GA gallic acid, EA ellagic acid, QU quercetin, MYR myricetin, LU luteolin, KAM kaempferol, KAMG kaempferol-3-glycoside, IQU isoquercitrin, W water, M methanol, E ethanol, A acetone, EA ethyl acetate, B butanol, P petroleum ether, H hexane

\*Two replicates ± Standard deviation

<sup>a–y</sup>Different lowercase superscripts in the different extraction groups indicate significant differences between means of phenolic composition for oleaster samples ( $p < 0.05$ )

51.20 mg TE/g oleaster core for solvent extracts and from 15.05 to 129.26 mg TE/g oleaster core for acidic hydrolysis (Table 9), from 13.67 to 49.68 mg TE/g oleaster flower for solvent extracts and from 37.98 to 200.30 mg TE/g oleaster flower for acidic hydrolysis (Table 10), and from 1.55 to 43.15 mg TE/g oleaster leaf for solvent extracts and from 7.66 to 119.73 mg TE/g oleaster leaf for acidic hydrolysis (Table 11). According to Incilay [8], the antioxidant capacities of methanol extracts of oleaster’s leaf were found to be in the range of  $0.385 \pm 0.027$  and  $1.955 \pm 0.000$   $\mu\text{g TE/g}$ , flowers were  $0.623 \pm 0.000$  and  $1.689 \pm 0.029$   $\mu\text{g TE/g}$ , fruits were  $0.031 \pm 0.003$  and  $4.642 \pm 0.133$   $\mu\text{g TE/g}$ , and fruit peels were  $0.434 \pm 0.027$  and  $1.651 \pm 0.027$   $\mu\text{g TE/g}$ . The antioxidant capacity value of *Elaeagnus latifolia* Linn. was measured as  $0.070 \pm 0.003$   $\mu\text{g trolox/mL}$  extract [31]. In Nazir et al.’s [10] study, IC<sub>50</sub> values of methanol, hexane, chloroform, ethyl acetate, n-butanol, and aqueous extracts of *Elaeagnus umbellata* Thunb. were found as 760, 135, 57, 70, 120, and 1175  $\mu\text{g trolox/mL}$  extract, respectively. In another study, the average antioxidant capacity values in different genotypes of *Elaeagnus umbellata* Thunb. fruit were in the range of 20.3 and 29.9  $\mu\text{mol TE/g}$  sample [33].

The CHROMAC method is based on the measurement of the remaining Cr (VI) as a result of the transformation of antioxidants reacting with excessive Cr (VI) in acidic environment into radical structures and reduction of Cr (VI) to Cr (III) form. With the CHROMAC method, the antioxidant capacity values ranged from 29.72 to 62.32 mg TE/g oleaster flour for solvent extracts and from 64.83 to 122.07 mg TE/g oleaster flour for acidic hydrolysis (Table 7), from 35.00 to 76.04 mg TE/g oleaster shell for solvent extracts and from 49.37 to 117.86 mg TE/g oleaster shell for acidic hydrolysis (Table 8), from 24.70 to 100.11 mg TE/g oleaster core for solvent extracts and from 93.02 to 336.94 mg TE/g oleaster core for acidic hydrolysis (Table 9), from 245.93 to 859.08 mg TE/g oleaster flower for solvent extracts and from 454.83 to 699.48 mg TE/g oleaster flower for acidic hydrolysis (Table 10), and from 74.84 to 196.96 mg TE/g oleaster leaf for solvent extracts and from 122.59 to 233.95 mg TE/g oleaster leaf for acidic hydrolysis (Table 11).

The DPPH method is based on the decrease in the amount of radicals as a result of the interaction between DPPH• radical and antioxidants. For the DPPH method, the antioxidant capacity IC<sub>50</sub> values ranged from 11.60 to 24.08 mg TE/g oleaster flour for solvent extracts and from 22.66 to 39.71 mg TE/g oleaster flour for acidic hydrolysis (Table 7), from 14.48 to 22.27 mg TE/g oleaster shell for solvent extracts and from 23.50 to 34.42 mg TE/g oleaster shell for acidic hydrolysis (Table 8), from 23.72 to 38.28 mg TE/g oleaster core for solvent extracts and from 47.25 to 67.55 mg TE/g oleaster core for acidic hydrolysis (Table 9), from 148.70 to 898.99 mg TE/g oleaster flower for solvent extracts and from 238.97 to 620.75 mg TE/g oleaster flower for acidic

**Table 7** Spectroscopic analysis results of oleaster flour samples

Sol-vent	Sam-ple	TPC		FRAP		ABTS		CHROMAC		DPPH		TFC		TCC	
		SE	AH	SE	AH	SE	AH	SE	AH	SE	AH	SE	AH	SE	AH
W	1	12.33±0.13 <sup>a</sup>	21.21±0.49 <sup>bu</sup>	2.50±0.08 <sup>a</sup>	5.03±0.24 <sup>ku</sup>	7.64±0.29 <sup>g</sup>	15.04±0.01 <sup>d</sup>	38.63±0.31 <sup>sl</sup>	69.88±1.46 <sup>e</sup>	13.55±0.09 <sup>w</sup>	28.77±0.15 <sup>cl</sup>	2.65±0.77 <sup>i</sup>	1.91±0.01 <sup>j</sup>	3.07±0.03 <sup>l</sup>	1.82±0.01 <sup>k</sup>
	2	20.1±0.97 <sup>jd</sup>	28.59±1.89 <sup>e</sup>	12.03±0.08 <sup>f</sup>	16.92±0.06 <sup>d</sup>	25.03±0.12 <sup>e</sup>	13.02±0.12 <sup>e</sup>	51.57±0.66 <sup>h</sup>	90.64±4.81 <sup>l</sup>	11.60±0.01 <sup>x</sup>	24.65±0.01 <sup>ij</sup>	6.45±0.03 <sup>g</sup>	5.06±0.09 <sup>f</sup>	6.61±0.05 <sup>f</sup>	6.21±0.01 <sup>k</sup>
	3	24.57±0.92 <sup>e</sup>	31.54±0.67 <sup>b</sup>	15.10±0.05 <sup>e</sup>	22.68±0.01 <sup>c</sup>	30.99±0.05 <sup>a</sup>	22.43±0.50 <sup>f</sup>	62.32±1.20 <sup>p</sup>	100.89±4.78 <sup>ghij</sup>	11.87±0.01 <sup>x</sup>	23.86±0.01 <sup>kl</sup>	4.47±1.61 <sup>g</sup>	6.48±0.05 <sup>ab</sup>	6.62±0.02 <sup>i</sup>	5.47±0.03 <sup>m</sup>
M	1	8.22±0.07 <sup>h</sup>	15.67±0.40 <sup>m</sup>	1.37±0.09 <sup>h</sup>	3.63±0.14 <sup>lman</sup>	5.31±0.14 <sup>d</sup>	5.71±0.13 <sup>b</sup>	45.38±2.06 <sup>f</sup>	75.43±1.57 <sup>m</sup>	16.49±0.14 <sup>wy</sup>	28.91±0.20 <sup>f</sup>	0.40±0.09 <sup>h</sup>	0.77±0.02 <sup>opqrst</sup>	5.57±0.15 <sup>lm</sup>	1.56±0.02 <sup>y</sup>
	2	8.45±0.22 <sup>g</sup>	21.97±0.14 <sup>ab</sup>	1.36±0.02 <sup>h</sup>	9.91±0.02 <sup>e</sup>	2.86±0.31 <sup>q</sup>	5.47±0.10 <sup>bu</sup>	45.52±3.15 <sup>f</sup>	64.83±3.42 <sup>n</sup>	15.90±0.11 <sup>v</sup>	24.59±0.03 <sup>ijk</sup>	0.47±0.05 <sup>uv</sup>	2.78±0.07 <sup>r</sup>	3.02±0.17 <sup>n</sup>	4.56±0.01 <sup>op</sup>
	3	8.16±0.62 <sup>g</sup>	26.71±0.24 <sup>d</sup>	1.15±0.09 <sup>psq</sup>	23.17±0.61 <sup>e</sup>	3.42±0.10 <sup>p</sup>	4.75±0.21 <sup>kl</sup>	45.90±2.24 <sup>f</sup>	94.00±0.89 <sup>kl</sup>	16.35±0.11 <sup>uv</sup>	23.17±0.11 <sup>uv</sup>	0.50±0.04 <sup>stuv</sup>	5.83±0.21 <sup>de</sup>	2.83±0.02 <sup>n</sup>	2.79±0.02 <sup>n</sup>
E	1	2.89±0.18 <sup>pq</sup>	19.24±0.60 <sup>kl</sup>	0.73±0.01 <sup>pq</sup>	14.41±0.26 <sup>e</sup>	2.09±0.24 <sup>rs</sup>	4.58±0.20 <sup>lmn</sup>	34.63±0.24 <sup>sluvwx</sup>	67.00±0.99 <sup>op</sup>	22.27±0.11 <sup>uv</sup>	25.23±0.06 <sup>f</sup>	0.55±0.01 <sup>pqrstuv</sup>	2.76±0.11 <sup>l</sup>	2.59±0.06 <sup>n</sup>	11.08±0.01 <sup>a</sup>
	2	3.09±0.07 <sup>pq</sup>	34.50±0.83 <sup>x</sup>	0.72±0.03 <sup>pq</sup>	32.61±1.79 <sup>b</sup>	1.91±0.02 <sup>st</sup>	3.04±0.06 <sup>g</sup>	35.99±0.71 <sup>sluv</sup>	107.02±0.61 <sup>de</sup>	19.37±0.33 <sup>p</sup>	22.66±0.01 <sup>mn</sup>	0.48±0.03 <sup>stuv</sup>	5.54±0.31 <sup>e</sup>	2.32±0.01 <sup>w</sup>	10.93±0.01 <sup>b</sup>
	3	3.49±0.18 <sup>q</sup>	34.89±0.14 <sup>a</sup>	0.72±0.02 <sup>pq</sup>	46.66±1.85 <sup>x</sup>	1.67±0.06 <sup>tuw</sup>	3.45±0.02 <sup>g</sup>	39.17±1.26 <sup>s</sup>	122.07±1.67 <sup>m</sup>	15.78±0.26 <sup>v</sup>	24.26±0.01 <sup>ik</sup>	0.59±0.05 <sup>pqrstuv</sup>	6.63±0.22 <sup>n</sup>	2.28±0.06 <sup>w</sup>	10.08±0.02 <sup>d</sup>
B	1	2.89±0.03 <sup>psq</sup>	21.67±0.10 <sup>ab</sup>	0.86±0.04 <sup>psq</sup>	3.77±0.11 <sup>lm</sup>	1.65±0.02 <sup>tuw</sup>	3.92±0.04 <sup>g</sup>	31.92±1.38 <sup>wx</sup>	96.34±2.24 <sup>kl</sup>	18.59±0.22 <sup>n</sup>	32.75±0.16 <sup>d</sup>	1.08±0.02 <sup>lm</sup>	1.08±0.02 <sup>lm</sup>	5.69±0.03 <sup>l</sup>	10.71±0.09 <sup>e</sup>
	2	2.19±0.23 <sup>qr</sup>	23.70±1.20 <sup>cf</sup>	0.89±0.04 <sup>psq</sup>	2.68±0.09 <sup>h</sup>	1.74±0.03 <sup>tuw</sup>	5.29±0.06 <sup>f</sup>	37.08±2.49 <sup>stuv</sup>	101.51±3.10 <sup>defgh</sup>	16.90±0.17 <sup>ia</sup>	32.51±0.86 <sup>d</sup>	1.47±0.03 <sup>k</sup>	0.81±0.05 <sup>manopq</sup>	5.47±0.09 <sup>m</sup>	7.73±0.08 <sup>g</sup>
	3	2.78±0.01 <sup>psq</sup>	21.60±0.32 <sup>ab</sup>	0.92±0.02 <sup>psq</sup>	3.11±0.13 <sup>man</sup>	1.73±0.03 <sup>tuw</sup>	4.84±0.11 <sup>kl</sup>	38.43±0.47 <sup>st</sup>	112.24±5.90 <sup>l</sup>	18.35±0.39 <sup>hr</sup>	32.76±0.27 <sup>d</sup>	1.18±0.05 <sup>kl</sup>	0.83±0.04 <sup>manop</sup>	5.48±0.07 <sup>m</sup>	6.89±0.28 <sup>i</sup>
A	1	1.05±0.33 <sup>r</sup>	21.65±0.37 <sup>ab</sup>	0.58±0.01 <sup>pq</sup>	3.89±0.26 <sup>lm</sup>	1.79±0.03 <sup>tu</sup>	5.40±0.19 <sup>jl</sup>	33.92±0.70 <sup>kluvwx</sup>	101.56±3.79 <sup>defgh</sup>	16.13±0.18 <sup>v</sup>	26.69±0.12 <sup>b</sup>	0.73±0.04 <sup>pqrstuv</sup>	0.63±0.01 <sup>pqrstuv</sup>	4.37±0.09 <sup>h</sup>	7.16±0.08 <sup>b</sup>
	2	0.66±0.02 <sup>r</sup>	26.58±0.68 <sup>d</sup>	0.56±0.02 <sup>h</sup>	5.95±0.18 <sup>x</sup>	2.28±0.03 <sup>t</sup>	8.82±0.09 <sup>f</sup>	32.64±0.65 <sup>vw</sup>	105.92±2.25 <sup>def</sup>	18.48±0.18 <sup>h</sup>	28.34±0.06 <sup>efg</sup>	0.50±0.03 <sup>stuv</sup>	1.08±0.05 <sup>lm</sup>	2.48±0.02 <sup>y</sup>	8.76±0.07 <sup>e</sup>
	3	0.79±0.05 <sup>r</sup>	28.96±0.09 <sup>e</sup>	0.76±0.04 <sup>psq</sup>	8.24±0.06 <sup>b</sup>	1.73±0.08 <sup>tuw</sup>	7.46±0.08 <sup>g</sup>	35.06±0.36 <sup>sluv</sup>	77.53±1.50 <sup>man</sup>	18.47±0.49 <sup>i</sup>	26.06±0.08 <sup>b</sup>	0.65±0.06 <sup>pqrstuv</sup>	3.28±0.16 <sup>h</sup>	4.62±0.06 <sup>n</sup>	5.58±0.28 <sup>lm</sup>
H	1	0.16±0.04 <sup>r</sup>	18.01±0.80 <sup>i</sup>	0.48±0.01 <sup>h</sup>	5.95±0.15 <sup>x</sup>	1.27±0.07 <sup>psq</sup>	4.33±0.07 <sup>n</sup>	29.88±0.51 <sup>wx</sup>	80.75±3.56 <sup>m</sup>	16.98±0.04 <sup>ia</sup>	27.68±0.28 <sup>g</sup>	0.61±0.05 <sup>pqrstuv</sup>	2.57±0.10 <sup>l</sup>	3.42±0.04 <sup>s</sup>	3.88±0.06 <sup>r</sup>
	2	0.41±0.01 <sup>r</sup>	20.93±0.89 <sup>bu</sup>	0.43±0.01 <sup>h</sup>	4.39±0.07 <sup>kl</sup>	1.81±0.01 <sup>sluv</sup>	5.26±0.25 <sup>j</sup>	31.52±0.33 <sup>vw</sup>	97.48±3.02 <sup>ijk</sup>	18.28±0.32 <sup>hr</sup>	34.74±0.10 <sup>f</sup>	0.51±0.06 <sup>pqrstuv</sup>	2.79±0.07 <sup>r</sup>	4.86±0.06 <sup>n</sup>	4.43±0.18 <sup>pq</sup>
	3	0.42±0.01 <sup>r</sup>	18.34±0.79 <sup>kl</sup>	0.47±0.01 <sup>h</sup>	2.87±0.08 <sup>ao</sup>	1.67±0.04 <sup>tuw</sup>	4.83±0.08 <sup>kl</sup>	32.57±0.69 <sup>psq</sup>	99.53±3.64 <sup>hij</sup>	20.68±0.86 <sup>o</sup>	32.93±0.06 <sup>d</sup>	0.45±0.01 <sup>tu</sup>	2.11±0.20 <sup>i</sup>	4.99±0.04 <sup>n</sup>	4.39±0.23 <sup>q</sup>
EA	1	0.54±0.02 <sup>r</sup>	24.12±1.06 <sup>e</sup>	0.71±0.03 <sup>psq</sup>	2.88±0.11 <sup>lno</sup>	1.49±0.06 <sup>vw</sup>	4.87±0.24 <sup>kl</sup>	31.53±0.86 <sup>wx</sup>	108.18±1.93 <sup>abcd</sup>	17.40±0.53 <sup>sl</sup>	37.28±1.56 <sup>f</sup>	0.74±0.02 <sup>pqrstuv</sup>	1.04±0.02 <sup>lmn</sup>	1.72±0.04 <sup>s</sup>	8.02±0.03 <sup>f</sup>
	2	0.59±0.01 <sup>r</sup>	21.17±1.01 <sup>bu</sup>	0.58±0.03 <sup>psq</sup>	2.85±0.04 <sup>ao</sup>	1.53±0.01 <sup>uvwx</sup>	4.36±0.03 <sup>mn</sup>	29.72±1.86 <sup>s</sup>	104.99±4.07 <sup>defg</sup>	17.72±0.14 <sup>rs</sup>	39.71±0.60 <sup>h</sup>	0.80±0.01 <sup>manopqr</sup>	0.83±0.02 <sup>manop</sup>	0.76±0.05 <sup>r</sup>	5.46±0.32 <sup>m</sup>
PE	1	0.63±0.01 <sup>r</sup>	21.42±0.50 <sup>h</sup>	0.58±0.01 <sup>pq</sup>	5.43±0.25 <sup>j</sup>	1.25±0.01 <sup>wx</sup>	4.92±0.10 <sup>k</sup>	32.45±1.53 <sup>vw</sup>	110.09±4.26 <sup>bc</sup>	21.00±0.10 <sup>p</sup>	28.10±0.08 <sup>fg</sup>	0.62±0.04 <sup>pqrstuv</sup>	1.02±0.01 <sup>lmno</sup>	0.85±0.01 <sup>r</sup>	6.95±0.11 <sup>i</sup>
	2	0.13±0.01 <sup>r</sup>	22.66±0.21 <sup>fg</sup>	0.77±0.06 <sup>psq</sup>	2.88±0.10 <sup>no</sup>	1.24±0.04 <sup>psq</sup>	4.62±0.02 <sup>lm</sup>	36.99±0.82 <sup>sluv</sup>	103.07±2.26 <sup>efgh</sup>	20.35±0.54 <sup>op</sup>	35.14±0.11 <sup>e</sup>	0.56±0.04 <sup>pqrstuv</sup>	6.32±0.09 <sup>bc</sup>	0.44±0.03 <sup>mn</sup>	5.47±0.02 <sup>m</sup>
	3	0.14±0.01 <sup>r</sup>	21.83±0.14 <sup>ab</sup>	0.45±0.01 <sup>h</sup>	5.22±0.02 <sup>j</sup>	1.16±0.07 <sup>psq</sup>	4.60±0.19 <sup>lmn</sup>	35.28±0.27 <sup>stuv</sup>	119.92±0.49 <sup>h</sup>	22.08±0.43 <sup>p</sup>	28.25±0.06 <sup>efg</sup>	0.40±0.02 <sup>h</sup>	6.05±0.07 <sup>cd</sup>	0.24±0.02 <sup>ab</sup>	5.51±0.16 <sup>m</sup>
	3	0.14±0.01 <sup>r</sup>	18.85±0.58 <sup>kl</sup>	0.51±0.09 <sup>h</sup>	3.29±0.03 <sup>man</sup>	0.89±0.01 <sup>y</sup>	5.61±0.14 <sup>bu</sup>	38.67±0.49 <sup>st</sup>	100.36±3.90 <sup>ghij</sup>	24.08±0.23 <sup>kl</sup>	33.18±0.13 <sup>d</sup>	0.44±0.02 <sup>uv</sup>	1.88±0.32 <sup>z</sup>	0.58±0.01 <sup>mn</sup>	4.85±0.35 <sup>n</sup>

\*Two replicates ± Standard deviation

W water, M methanol, E ethanol, B butanol, A acetone, H hexane, EA ethyl acetate, PE petroleum ether, SE solvent extraction, AH acidic hydrolysis, TPC mg GAE/g sample, FRAP-ABTS-CHROMAC mg TE/g sample, DPPH IC<sub>50</sub> (mg TE/g sample), TFC mg QE/g sample, TCC mg BC/g sample

<sup>a-z</sup>Lowercase superscripts in the different extraction groups indicate significant differences between means of spectroscopic results for oleaster samples in a method ( $p < 0.05$ )



**Table 8** Spectroscopic analysis results of oleaster shell samples

Sol-vent	Sam-ple	TPC			FRAP			ABITS			CHROMAC			DPPH			TFC			TCC		
		SE	AH	SE	SE	AH	SE	AH	SE	AH	SE	AH	SE	AH	SE	AH	SE	AH	SE	AH		
W	1	12.85 ± 0.40 <sup>h</sup>	14.25 ± 0.62 <sup>op</sup>	1.91 ± 0.03 <sup>ma,op</sup>	1.85 ± 0.05 <sup>op,pq</sup>	3.49 ± 0.10 <sup>s</sup>	4.80 ± 0.04 <sup>tr</sup>	46.60 ± 1.76 <sup>s</sup>	72.02 ± 4.28 <sup>k</sup>	17.07 ± 0.15 <sup>wxx</sup>	34.42 ± 0.90 <sup>s</sup>	0.30 ± 0.01 <sup>x</sup>	0.12 ± 0.01 <sup>y</sup>	7.80 ± 0.03 <sup>z</sup>	5.43 ± 0.03 <sup>1</sup>							
	2	16.22 ± 0.19 <sup>h</sup>	18.41 ± 0.74 <sup>k,l</sup>	2.12 ± 0.10 <sup>mn</sup>	4.09 ± 0.20 <sup>z</sup>	7.03 ± 0.14 <sup>1</sup>	7.29 ± 0.04 <sup>kl</sup>	36.74 ± 0.88 <sup>wxx</sup>	65.18 ± 3.45 <sup>1</sup>	15.43 ± 0.03 <sup>yz</sup>	34.24 ± 0.91 <sup>s</sup>	0.32 ± 0.01 <sup>wxx</sup>	0.54 ± 0.01 <sup>qrst</sup>	3.71 ± 0.02 <sup>s</sup>	2.33 ± 0.02 <sup>s</sup>							
	3	16.99 ± 0.98 <sup>mn</sup>	17.72 ± 0.12 <sup>lm</sup>	1.71 ± 0.05 <sup>op,pq</sup>	3.38 ± 0.05 <sup>hi</sup>	9.51 ± 0.03 <sup>h</sup>	6.46 ± 0.16 <sup>m</sup>	47.38 ± 0.61 <sup>es</sup>	69.91 ± 1.12 <sup>k</sup>	17.43 ± 0.17 <sup>u,v,w</sup>	29.19 ± 0.09 <sup>h</sup>	0.16 ± 0.01 <sup>y</sup>	0.36 ± 0.01 <sup>wxx</sup>	2.06 ± 0.04 <sup>t</sup>	3.77 ± 0.07 <sup>q</sup>							
M	1	8.41 ± 0.06 <sup>s</sup>	14.89 ± 0.10 <sup>p</sup>	1.48 ± 0.07 <sup>q</sup>	3.15 ± 0.22 <sup>ijk</sup>	2.56 ± 0.10 <sup>h</sup>	5.05 ± 0.06 <sup>l</sup>	42.28 ± 0.28 <sup>w</sup>	81.49 ± 0.78 <sup>h</sup>	15.77 ± 0.08 <sup>y</sup>	31.63 ± 0.07 <sup>s</sup>	0.51 ± 0.01 <sup>rst</sup>	0.48 ± 0.01 <sup>uvwx</sup>	1.77 ± 0.03 <sup>uv</sup>	3.18 ± 0.02 <sup>r</sup>							
	2	9.26 ± 0.05 <sup>s</sup>	18.82 ± 0.49 <sup>k</sup>	1.56 ± 0.04 <sup>pq</sup>	5.09 ± 0.21 <sup>f</sup>	4.55 ± 0.20 <sup>f</sup>	5.82 ± 0.11 <sup>p</sup>	37.29 ± 0.76 <sup>wxx</sup>	54.78 ± 0.54 <sup>op</sup>	14.76 ± 0.03 <sup>am</sup>	24.86 ± 0.03 <sup>k</sup>	0.52 ± 0.02 <sup>qrst</sup>	1.54 ± 0.01 <sup>t</sup>	1.65 ± 0.01 <sup>vw</sup>	4.58 ± 0.01 <sup>o</sup>							
	3	10.45 ± 0.32 <sup>r</sup>	21.27 ± 0.18 <sup>l</sup>	2.04 ± 0.01 <sup>mn,oo</sup>	6.46 ± 0.44 <sup>e</sup>	14.17 ± 0.30 <sup>h</sup>	6.23 ± 0.06 <sup>mn</sup>	45.43 ± 2.70 <sup>st</sup>	82.74 ± 3.56 <sup>1</sup>	14.48 ± 0.08 <sup>am</sup>	25.99 ± 0.04 <sup>1</sup>	0.70 ± 0.02 <sup>op</sup>	1.87 ± 0.05 <sup>h</sup>	1.90 ± 0.01 <sup>tu</sup>	6.06 ± 0.01 <sup>1</sup>							
E	1	3.22 ± 0.10 <sup>p</sup>	13.78 ± 0.46 <sup>p</sup>	0.73 ± 0.02 <sup>rst</sup>	2.95 ± 0.14 <sup>kl</sup>	7.43 ± 0.21 <sup>jk</sup>	4.76 ± 0.11 <sup>qr</sup>	42.62 ± 2.01 <sup>tu</sup>	71.24 ± 1.73 <sup>k</sup>	18.02 ± 0.12 <sup>rst</sup>	31.88 ± 0.03 <sup>de</sup>	0.35 ± 0.01 <sup>wxx</sup>	0.54 ± 0.01 <sup>qrst</sup>	1.11 ± 0.02 <sup>y</sup>	4.82 ± 0.40 <sup>h</sup>							
	2	2.99 ± 0.12 <sup>nv</sup>	26.50 ± 0.15 <sup>g</sup>	0.80 ± 0.06 <sup>rst</sup>	15.11 ± 0.24 <sup>b</sup>	23.30 ± 0.14 <sup>d</sup>	16.94 ± 0.45 <sup>de</sup>	51.59 ± 1.34 <sup>opq</sup>	49.37 ± 3.51 <sup>ur</sup>	18.18 ± 0.02 <sup>rst</sup>	23.50 ± 0.04 <sup>1</sup>	0.33 ± 0.02 <sup>wxx</sup>	4.81 ± 0.17 <sup>b</sup>	0.85 ± 0.01 <sup>zmn</sup>	5.82 ± 0.03 <sup>k</sup>							
	3	2.77 ± 0.01 <sup>uv,w</sup>	26.30 ± 0.77 <sup>g</sup>	0.66 ± 0.01 <sup>rst</sup>	16.77 ± 0.68 <sup>h</sup>	22.91 ± 0.02 <sup>b</sup>	19.85 ± 0.52 <sup>f</sup>	57.90 ± 0.02 <sup>mn,oo</sup>	56.83 ± 2.51 <sup>no</sup>	18.61 ± 0.34 <sup>opqr</sup>	25.04 ± 0.03 <sup>kl</sup>	0.37 ± 0.01 <sup>uv,wxx</sup>	5.13 ± 0.14 <sup>s</sup>	0.88 ± 0.04 <sup>z</sup>	4.73 ± 0.01 <sup>no</sup>							
B	1	2.20 ± 0.03 <sup>w,x,y</sup>	29.34 ± 0.30 <sup>e</sup>	0.73 ± 0.04 <sup>rst</sup>	4.28 ± 0.31 <sup>e</sup>	1.60 ± 0.01 <sup>w</sup>	9.47 ± 0.15 <sup>h</sup>	36.00 ± 1.25 <sup>s</sup>	105.67 ± 2.07 <sup>bc</sup>	19.44 ± 0.42 <sup>o</sup>	31.89 ± 0.05 <sup>de</sup>	0.65 ± 0.02 <sup>opq</sup>	0.97 ± 0.06 <sup>k</sup>	1.60 ± 0.06 <sup>wxx</sup>	25.92 ± 0.08 <sup>c</sup>							
	2	2.15 ± 0.01 <sup>w,x,y</sup>	30.31 ± 0.90 <sup>d</sup>	0.66 ± 0.06 <sup>rst</sup>	5.11 ± 0.33 <sup>f</sup>	1.76 ± 0.06 <sup>w</sup>	7.03 ± 0.21 <sup>1</sup>	42.64 ± 0.88 <sup>tu</sup>	108.02 ± 2.32 <sup>b</sup>	18.69 ± 0.14 <sup>pqr</sup>	31.62 ± 0.01 <sup>e</sup>	0.61 ± 0.03 <sup>opqrs</sup>	1.36 ± 0.02 <sup>l</sup>	1.11 ± 0.08 <sup>y</sup>	32.09 ± 0.14 <sup>b</sup>							
	3	2.32 ± 0.07 <sup>wxx</sup>	29.53 ± 0.40 <sup>de</sup>	0.86 ± 0.05 <sup>es</sup>	5.04 ± 0.08 <sup>f</sup>	4.88 ± 0.07 <sup>hi</sup>	6.17 ± 0.32 <sup>mn</sup>	37.85 ± 1.48 <sup>wxx</sup>	100.03 ± 0.69 <sup>ef</sup>	18.26 ± 0.49 <sup>rst</sup>	31.60 ± 0.38 <sup>e</sup>	0.65 ± 0.03 <sup>opqrs</sup>	1.24 ± 0.03 <sup>l</sup>	1.12 ± 0.02 <sup>y</sup>	34.74 ± 0.06 <sup>s</sup>							
A	1	1.89 ± 0.04 <sup>yz</sup>	24.60 ± 0.96 <sup>h</sup>	0.78 ± 0.02 <sup>rst</sup>	4.21 ± 0.33 <sup>g</sup>	3.47 ± 0.04 <sup>s</sup>	7.48 ± 0.21 <sup>jk</sup>	36.51 ± 1.09 <sup>wxx</sup>	97.64 ± 2.60 <sup>fg</sup>	16.60 ± 0.01 <sup>x</sup>	29.07 ± 0.28 <sup>h</sup>	0.53 ± 0.02 <sup>qrst</sup>	0.92 ± 0.02 <sup>kl</sup>	0.56 ± 0.16 <sup>shae</sup>	16.25 ± 0.06 <sup>1</sup>							
	2	1.79 ± 0.03 <sup>yz,aaa</sup>	36.15 ± 0.93 <sup>a</sup>	0.98 ± 0.04 <sup>f</sup>	11.84 ± 0.43 <sup>e</sup>	2.60 ± 0.05 <sup>hi</sup>	15.21 ± 0.13 <sup>e</sup>	36.19 ± 0.17 <sup>s</sup>	58.50 ± 0.28 <sup>mn</sup>	16.77 ± 0.27 <sup>wxx</sup>	24.91 ± 0.09 <sup>k</sup>	0.47 ± 0.02 <sup>stuv</sup>	4.31 ± 0.26 <sup>e</sup>	1.47 ± 0.07 <sup>wxx</sup>	10.42 ± 0.36 <sup>e</sup>							
	3	1.49 ± 0.09 <sup>yz,aaab</sup>	36.16 ± 0.49 <sup>a</sup>	0.71 ± 0.03 <sup>rst</sup>	9.86 ± 0.08 <sup>d</sup>	1.88 ± 0.08 <sup>vw</sup>	10.76 ± 0.07 <sup>g</sup>	36.21 ± 1.43 <sup>s</sup>	59.11 ± 0.88 <sup>mn</sup>	17.80 ± 0.34 <sup>stuv</sup>	25.67 ± 0.02 <sup>ij</sup>	0.49 ± 0.02 <sup>stuv</sup>	3.87 ± 0.03 <sup>d</sup>	0.92 ± 0.05 <sup>yz</sup>	9.43 ± 0.23 <sup>f</sup>							
H	1	0.40 ± 0.01 <sup>ac</sup>	18.12 ± 0.47 <sup>kl</sup>	0.45 ± 0.03 <sup>1</sup>	2.25 ± 0.06 <sup>m</sup>	1.95 ± 0.03 <sup>s</sup>	5.79 ± 0.20 <sup>op</sup>	35.00 ± 1.20 <sup>s</sup>	94.57 ± 1.69 <sup>gh</sup>	18.70 ± 0.22 <sup>pqr</sup>	32.38 ± 0.30 <sup>cd</sup>	0.32 ± 0.02 <sup>wxx</sup>	3.55 ± 0.22 <sup>e</sup>	1.50 ± 0.16 <sup>wxx</sup>	5.16 ± 0.24 <sup>m</sup>							
	2	0.37 ± 0.06 <sup>ac</sup>	22.28 ± 0.32 <sup>e</sup>	0.64 ± 0.01 <sup>rst</sup>	2.87 ± 0.01 <sup>kl</sup>	3.09 ± 0.12 <sup>1</sup>	6.02 ± 0.08 <sup>no</sup>	40.16 ± 2.54 <sup>u,v,w</sup>	107.70 ± 2.63 <sup>b</sup>	22.27 ± 0.99 <sup>m</sup>	33.13 ± 0.35 <sup>b</sup>	0.43 ± 0.02 <sup>uv,wxx</sup>	2.16 ± 0.08 <sup>g</sup>	0.31 ± 0.02 <sup>shae</sup>	4.15 ± 0.42 <sup>p</sup>							
	3	0.37 ± 0.05 <sup>ac</sup>	28.28 ± 0.26 <sup>f</sup>	0.64 ± 0.05 <sup>rst</sup>	3.65 ± 0.08 <sup>h</sup>	1.60 ± 0.05 <sup>vw</sup>	6.19 ± 0.19 <sup>mn</sup>	41.81 ± 0.77 <sup>uv</sup>	99.41 ± 2.51 <sup>ef</sup>	20.81 ± 0.71 <sup>b</sup>	32.32 ± 0.08 <sup>cd</sup>	0.50 ± 0.01 <sup>stuv</sup>	2.34 ± 0.09 <sup>f</sup>	0.52 ± 0.02 <sup>shae</sup>	3.56 ± 0.10 <sup>1</sup>							
EA	1	1.14 ± 0.07 <sup>z,aaabac</sup>	29.57 ± 0.33 <sup>de</sup>	0.65 ± 0.04 <sup>rst</sup>	4.11 ± 0.37 <sup>g</sup>	1.72 ± 0.06 <sup>w</sup>	7.00 ± 0.15 <sup>1</sup>	37.06 ± 2.76 <sup>wxx</sup>	103.32 ± 1.38 <sup>cd</sup>	16.88 ± 0.45 <sup>wxx</sup>	31.22 ± 0.30 <sup>e</sup>	0.50 ± 0.03 <sup>st</sup>	0.82 ± 0.02 <sup>lmn</sup>	0.72 ± 0.02 <sup>z,aaabac</sup>	6.85 ± 0.08 <sup>h</sup>							
	2	0.96 ± 0.01 <sup>aaabac</sup>	32.28 ± 0.61 <sup>b</sup>	0.62 ± 0.04 <sup>rst</sup>	4.39 ± 0.34 <sup>g</sup>	1.71 ± 0.11 <sup>vw</sup>	7.62 ± 0.13 <sup>ij</sup>	38.37 ± 1.97 <sup>wxx</sup>	92.39 ± 0.03 <sup>h</sup>	18.07 ± 0.22 <sup>qrst</sup>	30.27 ± 0.27 <sup>f</sup>	0.62 ± 0.01 <sup>opqrs</sup>	0.82 ± 0.02 <sup>lmn</sup>	0.65 ± 0.01 <sup>aaabac</sup>	5.72 ± 0.22 <sup>k</sup>							
	3	0.76 ± 0.06 <sup>baac</sup>	31.18 ± 0.58 <sup>c</sup>	0.64 ± 0.02 <sup>rst</sup>	4.22 ± 0.12 <sup>g</sup>	1.79 ± 0.06 <sup>vw</sup>	7.94 ± 0.05 <sup>1</sup>	37.64 ± 0.29 <sup>wxx</sup>	102.82 ± 0.44 <sup>cd,ef</sup>	17.70 ± 0.13 <sup>stuv</sup>	29.96 ± 0.08 <sup>fg</sup>	0.55 ± 0.01 <sup>qrst</sup>	0.75 ± 0.03 <sup>mn,oo</sup>	0.29 ± 0.01 <sup>ae</sup>	9.34 ± 0.02 <sup>f</sup>							
PE	1	0.53 ± 0.04 <sup>ac</sup>	21.96 ± 0.40 <sup>ij</sup>	0.45 ± 0.01 <sup>1</sup>	2.68 ± 0.10 <sup>1</sup>	1.76 ± 0.04 <sup>w</sup>	7.00 ± 0.12 <sup>1</sup>	76.04 ± 0.74 <sup>j</sup>	94.86 ± 0.84 <sup>gh</sup>	18.10 ± 0.15 <sup>qrst</sup>	32.82 ± 0.45 <sup>bc</sup>	0.44 ± 0.01 <sup>uv,w</sup>	1.25 ± 0.11 <sup>1</sup>	1.50 ± 0.17 <sup>wxx</sup>	7.05 ± 0.70 <sup>h</sup>							
	2	0.40 ± 0.02 <sup>bc</sup>	26.38 ± 0.53 <sup>g</sup>	0.55 ± 0.01 <sup>st</sup>	3.20 ± 0.29 <sup>ijk</sup>	1.64 ± 0.03 <sup>w</sup>	6.30 ± 0.27 <sup>mn</sup>	61.20 ± 1.57 <sup>m</sup>	100.70 ± 3.00 <sup>cd,ef</sup>	18.99 ± 0.30 <sup>op</sup>	29.48 ± 0.17 <sup>gh</sup>	0.88 ± 0.03 <sup>kl,m</sup>	0.69 ± 0.04 <sup>no,op</sup>	0.76 ± 0.02 <sup>z,aaab</sup>	6.48 ± 0.23 <sup>1</sup>							
	3	0.46 ± 0.01 <sup>bc</sup>	26.86 ± 0.31 <sup>g</sup>	0.50 ± 0.04 <sup>st</sup>	3.31 ± 0.04 <sup>h,ij</sup>	1.73 ± 0.07 <sup>w</sup>	5.47 ± 0.04 <sup>p</sup>	73.08 ± 0.29 <sup>ik</sup>	117.86 ± 1.63 <sup>a</sup>	17.19 ± 0.03 <sup>uv,wxx</sup>	31.72 ± 0.34 <sup>de</sup>	0.69 ± 0.02 <sup>no,op</sup>	1.62 ± 0.09 <sup>1</sup>	1.36 ± 0.15 <sup>s</sup>	5.77 ± 0.17 <sup>k</sup>							

W water, M methanol, E ethanol, B butanol, A acetone, H hexane, EA ethyl acetate, PE petroleum ether, SE solvent extraction, AH acidic hydrolysis, TPC mg GAE/g sample, FRAP-ABTS-CHROMAC mg TE/g sample, DPPH IC<sub>50</sub> (mg TE/g sample), TFC mg QE/g sample, TCC mg BC/g sample

\*Two replicates ± Standard deviation

<sup>a-z</sup>Lowercase superscripts in the different extraction groups indicate significant differences between means of spectroscopic results for oleaster samples in a method (*p* < 0.05)

**Table 9** Spectroscopic analysis results of oleaster core samples

Sol-vent	Sam-ple	FRAP			ABTS			CHROMAC			DPPII			TFC			TCC		
		AH	SE	AH	SE	AH	SE	AH	SE	AH	SE	AH	SE	AH	SE	AH	SE	AH	
W	1	21.52±0.21 <sup>1s</sup>	22.82±0.50 <sup>f</sup>	10.90±0.42 <sup>xy</sup>	7.64±0.38 <sup>8</sup>	16.61±0.15 <sup>z</sup>	15.05±0.35 <sup>7</sup>	77.14±0.47 <sup>1r</sup>	125.01±3.03 <sup>3</sup>	25.81±0.02 <sup>5</sup>	67.55±1.00 <sup>a</sup>	1.57±0.03 <sup>ad</sup>	2.01±0.09 <sup>ad</sup>	10.65±0.55 <sup>h</sup>	5.69±0.32 <sup>v</sup>				
	2	26.71±0.46 <sup>9a</sup>	36.88±0.75 <sup>9b</sup>	12.39±0.60 <sup>w</sup>	10.68±0.18 <sup>9</sup>	19.97±0.05 <sup>w</sup>	32.05±0.33 <sup>8</sup>	77.49±0.78 <sup>9a</sup>	111.95±0.18 <sup>k</sup>	25.15±0.03 <sup>3</sup>	53.55±0.33 <sup>b</sup>	3.14±0.02 <sup>ac</sup>	2.05±0.04 <sup>ad</sup>	6.89±0.04 <sup>ad</sup>	3.16±0.03 <sup>z</sup>				
	3	28.24±1.03 <sup>9a</sup>	36.70±0.92 <sup>b</sup>	14.18±0.17 <sup>w</sup>	15.36±0.23 <sup>9v</sup>	25.85±0.20 <sup>s</sup>	31.19±0.81 <sup>r</sup>	82.84±0.81 <sup>9p</sup>	127.22±3.86 <sup>6</sup>	24.98±0.04 <sup>4m</sup>	53.91±0.08 <sup>b</sup>	4.72±0.12 <sup>9a</sup>	3.66±0.16 <sup>ac</sup>	8.82±1.21 <sup>r</sup>	8.50±0.43 <sup>s</sup>				
M	1	32.97±0.42 <sup>o</sup>	51.24±0.89 <sup>1</sup>	26.34±1.01 <sup>r</sup>	36.29±0.39 <sup>9p</sup>	36.27±0.09 <sup>9</sup>	45.78±0.96 <sup>m</sup>	73.78±2.30 <sup>9s</sup>	164.80±3.04 <sup>h</sup>	23.90±0.02 <sup>4w</sup>	51.09±0.02 <sup>cd</sup>	12.07±0.33 <sup>9a</sup>	8.40±0.01 <sup>la</sup>	8.34±0.07 <sup>st</sup>	12.13±0.01 <sup>o</sup>				
	2	35.01±0.56 <sup>9no</sup>	71.53±0.32 <sup>h</sup>	47.99±1.21 <sup>lm</sup>	51.44±1.31 <sup>k</sup>	38.39±0.25 <sup>9</sup>	56.66±0.50 <sup>9</sup>	98.41±3.88 <sup>1m</sup>	185.51±2.89 <sup>f</sup>	24.27±0.02 <sup>4w</sup>	49.98±0.02 <sup>e</sup>	11.93±0.17 <sup>9a</sup>	14.18±0.25 <sup>m</sup>	8.07±0.01 <sup>t</sup>	11.22±0.01 <sup>9</sup>				
	3	44.93±1.34 <sup>m</sup>	69.13±1.60 <sup>9a</sup>	40.77±0.47 <sup>9</sup>	54.08±1.71 <sup>l</sup>	51.20±0.26 <sup>k</sup>	56.30±0.13 <sup>3</sup>	100.11±1.91 <sup>1</sup>	187.93±2.74 <sup>f</sup>	24.08±0.01 <sup>4w</sup>	49.37±0.01 <sup>f</sup>	14.82±0.11 <sup>klm</sup>	14.48±0.19 <sup>lm</sup>	10.69±0.01 <sup>9</sup>	14.59±0.01 <sup>m</sup>				
E	1	16.73±0.46 <sup>l</sup>	60.60±3.36 <sup>k</sup>	12.23±0.90 <sup>9x</sup>	47.16±0.98 <sup>m</sup>	18.43±0.12 <sup>x</sup>	54.82±0.28 <sup>l</sup>	33.62±1.52 <sup>7</sup>	163.15±1.88 <sup>h</sup>	24.91±0.02 <sup>4m</sup>	48.38±0.03 <sup>gh</sup>	9.22±0.11 <sup>st</sup>	10.31±0.05 <sup>r</sup>	3.07±0.06 <sup>9am</sup>	15.47±0.01 <sup>l</sup>				
	2	19.79±0.90 <sup>s</sup>	69.50±0.17 <sup>9a</sup>	14.76±1.03 <sup>9v</sup>	56.25±0.98 <sup>7</sup>	21.98±0.32 <sup>y</sup>	70.29±0.29 <sup>9</sup>	45.58±0.69 <sup>9</sup>	178.80±1.57 <sup>9</sup>	23.72±0.01 <sup>w</sup>	49.42±0.06 <sup>cd</sup>	9.54±0.59 <sup>9s</sup>	16.04±0.78 <sup>9j</sup>	4.16±0.01 <sup>9</sup>	13.75±0.02 <sup>n</sup>				
	3	23.30±0.13 <sup>t</sup>	58.83±1.77 <sup>k</sup>	19.00±0.26 <sup>l</sup>	51.99±0.20 <sup>k</sup>	25.00±0.01 <sup>l</sup>	58.76±0.92 <sup>h</sup>	66.68±0.56 <sup>l</sup>	168.39±5.68 <sup>h</sup>	24.03±0.01 <sup>4w</sup>	48.61±0.31 <sup>9</sup>	9.40±0.43 <sup>s</sup>	14.61±0.53 <sup>lm</sup>	4.67±0.01 <sup>9</sup>	21.41±0.01 <sup>9</sup>				
B	1	3.23±0.07 <sup>9vw</sup>	68.17±0.91 <sup>l</sup>	1.95±0.13 <sup>9a</sup>	45.03±0.37 <sup>9</sup>	4.25±0.14 <sup>9a</sup>	50.30±0.43 <sup>l</sup>	57.84±0.85 <sup>9</sup>	110.22±0.54 <sup>k</sup>	30.65±0.32 <sup>9r</sup>	48.37±0.01 <sup>gh</sup>	6.40±0.30 <sup>9v</sup>	15.60±0.54 <sup>kl</sup>	2.54±0.01 <sup>9a</sup>	16.52±0.16 <sup>l</sup>				
	2	3.86±0.07 <sup>9uv</sup>	131.55±2.88 <sup>9</sup>	2.67±0.20 <sup>9a</sup>	155.05±0.91 <sup>l</sup>	5.49±0.28 <sup>9a</sup>	125.98±0.42 <sup>9</sup>	60.01±1.59 <sup>9v</sup>	246.45±1.12 <sup>9d</sup>	30.17±0.10 <sup>9</sup>	47.74±0.01 <sup>9j</sup>	6.76±0.01 <sup>9</sup>	42.30±0.68 <sup>9a</sup>	2.19±0.06 <sup>9a</sup>	19.96±0.03 <sup>9</sup>				
	3	4.14±0.15 <sup>9v</sup>	125.51±0.04 <sup>9d</sup>	2.68±0.15 <sup>9a</sup>	161.11±0.25 <sup>9</sup>	4.81±0.09 <sup>9a</sup>	127.08±0.32 <sup>9b</sup>	66.97±1.22 <sup>l</sup>	251.15±3.93 <sup>9d</sup>	30.77±0.19 <sup>9a</sup>	47.29±0.08 <sup>9</sup>	6.15±0.32 <sup>9vw</sup>	36.74±0.97 <sup>9b</sup>	2.79±0.21 <sup>9a</sup>	33.46±0.05 <sup>9c</sup>				
A	1	26.20±0.20 <sup>9a</sup>	131.57±1.74 <sup>9</sup>	22.86±0.80 <sup>9</sup>	313.66±0.06 <sup>9</sup>	31.06±0.35 <sup>9</sup>	128.87±0.01 <sup>9</sup>	24.70±0.62 <sup>9a</sup>	311.30±2.97 <sup>9</sup>	24.24±0.01 <sup>4w</sup>	47.64±0.01 <sup>9j</sup>	13.23±0.82 <sup>9</sup>	12.35±0.55 <sup>9p</sup>	6.86±0.02 <sup>9</sup>	23.86±0.02 <sup>9d</sup>				
	2	21.21±0.83 <sup>9s</sup>	138.87±0.82 <sup>9b</sup>	16.17±1.08 <sup>9v</sup>	336.12±0.83 <sup>9</sup>	23.38±0.13 <sup>9</sup>	129.26±0.10 <sup>9</sup>	66.62±0.96 <sup>9</sup>	324.48±0.56 <sup>9</sup>	24.46±0.04 <sup>4v</sup>	47.81±0.01 <sup>9a</sup>	7.69±0.14 <sup>9</sup>	15.16±0.40 <sup>9l</sup>	5.09±0.35 <sup>9</sup>	20.83±0.01 <sup>9h</sup>				
	3	34.96±1.27 <sup>9o</sup>	158.73±1.27 <sup>9a</sup>	33.31±1.26 <sup>9v</sup>	271.01±0.62 <sup>9</sup>	33.13±0.26 <sup>9</sup>	129.09±0.01 <sup>9</sup>	82.54±2.29 <sup>9p</sup>	336.94±7.32 <sup>9</sup>	23.87±0.01 <sup>4w</sup>	47.69±0.01 <sup>9j</sup>	11.30±0.12 <sup>9</sup>	11.66±0.02 <sup>9a</sup>	8.51±0.01 <sup>9</sup>	23.41±0.04 <sup>9</sup>				
H	1	1.20±0.03 <sup>9w</sup>	47.35±1.46 <sup>9m</sup>	1.50±0.08 <sup>9a</sup>	26.32±0.98 <sup>9</sup>	3.74±0.13 <sup>9a</sup>	30.78±0.22 <sup>9</sup>	51.55±1.17 <sup>9x</sup>	93.02±3.59 <sup>9aa</sup>	31.66±0.69 <sup>9</sup>	50.65±0.33 <sup>9</sup>	5.05±0.32 <sup>9z</sup>	18.45±0.57 <sup>9</sup>	1.51±0.16 <sup>9ad</sup>	40.16±0.02 <sup>9b</sup>				
	2	1.59±0.07 <sup>9vw</sup>	78.14±3.06 <sup>9</sup>	1.48±0.05 <sup>9a</sup>	48.90±0.42 <sup>l</sup>	4.17±0.04 <sup>9a</sup>	51.41±0.22 <sup>9</sup>	70.08±1.12 <sup>9t</sup>	153.25±1.27 <sup>9</sup>	33.25±0.81 <sup>9</sup>	48.53±0.23 <sup>9</sup>	3.98±0.13 <sup>9a</sup>	17.28±0.76 <sup>9</sup>	1.25±0.30 <sup>9ad</sup>	11.03±0.06 <sup>9</sup>				
	3	1.94±0.01 <sup>9vw</sup>	60.32±1.28 <sup>9k</sup>	1.53±0.06 <sup>9a</sup>	44.54±1.60 <sup>9</sup>	3.28±0.11 <sup>9a</sup>	54.12±0.25 <sup>9</sup>	45.41±0.06 <sup>9</sup>	124.00±5.62 <sup>9</sup>	35.58±0.62 <sup>9</sup>	49.89±0.14 <sup>9f</sup>	5.50±0.03 <sup>9v</sup>	19.61±0.28 <sup>9</sup>	1.36±0.04 <sup>9ad</sup>	23.33±0.02 <sup>9</sup>				
EA	1	1.57±0.21 <sup>9vw</sup>	81.68±2.00 <sup>9</sup>	1.50±0.07 <sup>9a</sup>	73.28±0.38 <sup>9</sup>	4.65±0.09 <sup>9b</sup>	75.65±0.85 <sup>9</sup>	54.61±1.04 <sup>9w</sup>	200.52±8.66 <sup>9</sup>	31.26±0.60 <sup>9p</sup>	49.48±0.09 <sup>9f</sup>	5.08±0.04 <sup>9z</sup>	26.36±1.23 <sup>9d</sup>	2.75±0.10 <sup>9ab</sup>	22.14±0.03 <sup>9</sup>				
	2	2.24±0.34 <sup>9vw</sup>	114.78±1.99 <sup>9</sup>	1.80±0.06 <sup>9a</sup>	215.14±1.48 <sup>9</sup>	3.77±0.16 <sup>9a</sup>	118.08±0.86 <sup>9</sup>	59.60±1.38 <sup>9v</sup>	249.10±1.04 <sup>9d</sup>	33.59±0.46 <sup>9</sup>	47.25±0.03 <sup>9</sup>	5.85±0.62 <sup>9xy</sup>	31.97±0.17 <sup>9</sup>	2.06±0.15 <sup>9a</sup>	19.81±0.03 <sup>9</sup>				
	3	1.95±0.11 <sup>9vw</sup>	112.42±3.06 <sup>9</sup>	1.95±0.01 <sup>9a</sup>	129.15±0.47 <sup>9</sup>	3.29±0.05 <sup>9a</sup>	123.26±0.41 <sup>9d</sup>	48.11±0.72 <sup>9y</sup>	245.65±5.27 <sup>9d</sup>	34.23±0.13 <sup>9m</sup>	47.93±0.02 <sup>9a</sup>	5.64±0.23 <sup>9xy</sup>	21.91±0.43 <sup>9</sup>	4.96±0.02 <sup>9</sup>	20.62±0.02 <sup>9h</sup>				
PE	1	1.35±0.01 <sup>9vw</sup>	29.09±1.00 <sup>9</sup>	1.66±0.12 <sup>9a</sup>	15.71±0.45 <sup>9</sup>	2.80±0.05 <sup>9a</sup>	20.01±0.05 <sup>9</sup>	38.53±1.37 <sup>9</sup>	94.05±0.12 <sup>9m</sup>	36.16±0.33 <sup>9</sup>	51.46±0.20 <sup>9</sup>	5.07±0.33 <sup>9z</sup>	14.44±0.25 <sup>9m</sup>	2.07±0.02 <sup>9a</sup>	39.96±0.03 <sup>9b</sup>				
	2	1.14±0.08 <sup>9w</sup>	64.99±0.80 <sup>9</sup>	1.32±0.04 <sup>9a</sup>	46.79±1.01 <sup>9m</sup>	2.76±0.07 <sup>9a</sup>	56.28±0.50 <sup>9</sup>	87.67±0.03 <sup>9o</sup>	126.57±2.10 <sup>9</sup>	38.28±0.30 <sup>9k</sup>	48.37±0.17 <sup>9a</sup>	5.02±0.20 <sup>9z</sup>	16.78±0.08 <sup>9a</sup>	1.37±0.01 <sup>9ad</sup>	16.16±0.01 <sup>9k</sup>				
	3	1.12±0.01 <sup>9w</sup>	44.93±1.89 <sup>9m</sup>	1.49±0.04 <sup>9a</sup>	40.27±0.86 <sup>9</sup>	2.34±0.03 <sup>9f</sup>	36.24±0.51 <sup>9</sup>	64.51±0.83 <sup>9m</sup>	102.07±1.32 <sup>9</sup>	31.25±0.32 <sup>9p</sup>	50.95±0.29 <sup>9cd</sup>	4.91±0.05 <sup>9aa</sup>	13.17±0.57 <sup>9no</sup>	1.25±0.11 <sup>9ad</sup>	46.82±0.04 <sup>9a</sup>				

W water, M methanol, E ethanol, B butanol, A acetone, H hexane, EA ethyl acetate, PE petroleum ether, SE solvent extraction, AH acidic hydrolysis, TPC mg GAE/g sample, FRAP-ABTS-CHROMAC mg TE/g sample, DPPH IC<sub>50</sub> (mg TE/g sample), TFC mg QE/g sample, TCC mg BC/g sample

\*Two replicates ± Standard deviation

<sup>a-z</sup>Lowercase superscripts in the different extraction groups indicate significant differences between means of spectroscopic results for oleaster samples in a method ( $p < 0.05$ )

**Table 10** Spectroscopic analysis results of oleaster flower samples

Sol-vent	Sam-ple	FRAP			ABTS			CHROMAC			DPPH			TFC			TCC		
		SE	AH	SE	AH	SE	AH	SE	AH	SE	AH	SE	AH	SE	AH	SE	AH		
W	1	36.96 ± 1.94 <sup>p</sup>	36.79 ± 1.46 <sup>p</sup>	13.59 ± 0.94 <sup>o</sup>	22.32 ± 0.90 <sup>n</sup>	34.15 ± 0.47 <sup>t</sup>	47.69 ± 2.24 <sup>no</sup>	255.24 ± 1.72 <sup>y</sup>	598.72 ± 8.33 <sup>e</sup>	148.70 ± 6.73 <sup>r</sup>	375.82 ± 8.33 <sup>e</sup>	2.66 ± 0.04 <sup>lmanop</sup>	3.73 ± 0.22 <sup>pklman</sup>	82.83 ± 0.81 <sup>j</sup>	40.38 ± 1.31 <sup>r</sup>				
	2	31.22 ± 0.95 <sup>h</sup>	37.34 ± 1.39 <sup>q</sup>	11.76 ± 0.72 <sup>op</sup>	20.70 ± 1.22 <sup>n</sup>	28.43 ± 0.30 <sup>s</sup>	45.73 ± 0.75 <sup>r</sup>	265.38 ± 5.14 <sup>q</sup>	618.34 ± 1.87 <sup>de</sup>	165.54 ± 6.06 <sup>z</sup>	620.75 ± 6.86 <sup>b</sup>	1.96 ± 0.06 <sup>op</sup>	3.43 ± 0.41 <sup>lmanoo</sup>	45.57 ± 0.01 <sup>pq</sup>	132.74 ± 12.78 <sup>c</sup>				
	3	44.55 ± 1.34 <sup>no</sup>	38.00 ± 1.30 <sup>p</sup>	20.62 ± 1.19 <sup>q</sup>	21.87 ± 0.27 <sup>m</sup>	49.68 ± 0.51 <sup>n</sup>	56.02 ± 1.10 <sup>m</sup>	245.93 ± 4.88 <sup>r</sup>	603.98 ± 1.83 <sup>ef</sup>	151.73 ± 0.50 <sup>r</sup>	439.79 ± 3.69 <sup>r</sup>	2.98 ± 0.13 <sup>klmanop</sup>	2.13 ± 0.14 <sup>manop</sup>	113.61 ± 1.82 <sup>j</sup>	68.61 ± 14.37 <sup>l</sup>				
M	1	27.81 ± 1.39 <sup>r</sup>	74.35 ± 0.86 <sup>i</sup>	10.66 ± 0.27 <sup>pq</sup>	53.61 ± 1.76 <sup>i</sup>	27.74 ± 0.38 <sup>st</sup>	65.88 ± 0.66 <sup>i</sup>	397.27 ± 16.17 <sup>mp</sup>	571.77 ± 3.39 <sup>gh</sup>	172.17 ± 0.82 <sup>xy</sup>	300.52 ± 2.39 <sup>hij</sup>	3.88 ± 0.24 <sup>klm</sup>	3.91 ± 0.30 <sup>klm</sup>	56.25 ± 0.13 <sup>n</sup>	25.88 ± 0.09 <sup>p</sup>				
	2	17.99 ± 0.33 <sup>s</sup>	59.70 ± 0.81 <sup>l</sup>	9.05 ± 0.35 <sup>i</sup>	34.20 ± 0.50 <sup>t</sup>	85.10 ± 0.29 <sup>b</sup>	406.84 ± 13.19 <sup>o</sup>	544.75 ± 29.34 <sup>i</sup>	184.88 ± 1.45 <sup>wxy</sup>	184.88 ± 1.45 <sup>wxy</sup>	298.30 ± 2.88 <sup>hijkl</sup>	3.30 ± 0.22 <sup>klmanop</sup>	5.50 ± 0.06 <sup>l</sup>	36.53 ± 0.19 <sup>s</sup>	32.20 ± 0.08 <sup>t</sup>				
	3	26.30 ± 0.71 <sup>r</sup>	66.46 ± 2.03 <sup>k</sup>	9.73 ± 0.61 <sup>pqr</sup>	47.58 ± 0.01 <sup>j</sup>	25.45 ± 0.74 <sup>tu</sup>	57.14 ± 0.98 <sup>m</sup>	389.26 ± 7.59 <sup>opq</sup>	559.40 ± 16.92 <sup>hi</sup>	185.46 ± 1.17 <sup>wxy</sup>	301.13 ± 2.48 <sup>hij</sup>	3.97 ± 0.23 <sup>klm</sup>	3.38 ± 0.15 <sup>klmanop</sup>	57.20 ± 0.06 <sup>t</sup>	27.17 ± 0.01 <sup>u</sup>				
E	1	9.54 ± 0.30 <sup>tu</sup>	79.68 ± 0.65 <sup>hu</sup>	6.59 ± 0.02 <sup>stuv</sup>	61.65 ± 1.77 <sup>g</sup>	19.49 ± 0.63 <sup>wxy</sup>	86.53 ± 0.04 <sup>l</sup>	377.84 ± 5.88 <sup>pqrst</sup>	531.00 ± 12.24 <sup>l</sup>	241.10 ± 0.78 <sup>rs</sup>	280.87 ± 1.04 <sup>kl</sup>	2.51 ± 0.10 <sup>manop</sup>	4.53 ± 0.09 <sup>kl</sup>	36.44 ± 0.61 <sup>s</sup>	41.73 ± 0.08 <sup>t</sup>				
	2	5.99 ± 0.05 <sup>wxy</sup>	78.37 ± 1.31 <sup>i</sup>	5.42 ± 0.26 <sup>uv</sup>	55.42 ± 0.03 <sup>hu</sup>	17.38 ± 0.21 <sup>xyzam</sup>	113.22 ± 0.79 <sup>d</sup>	355.65 ± 22.98 <sup>st</sup>	523.86 ± 13.28 <sup>kl</sup>	161.17 ± 4.97 <sup>yz</sup>	275.80 ± 2.51 <sup>lmanoo</sup>	2.29 ± 0.11 <sup>manop</sup>	6.56 ± 0.02 <sup>hu</sup>	18.79 ± 0.53 <sup>r</sup>	42.20 ± 0.10 <sup>qr</sup>				
	3	9.70 ± 0.39 <sup>tu</sup>	82.19 ± 1.75 <sup>h</sup>	8.31 ± 0.68 <sup>stuv</sup>	55.63 ± 2.49 <sup>hu</sup>	19.39 ± 0.34 <sup>wxy</sup>	84.33 ± 1.65 <sup>b</sup>	327.76 ± 13.05 <sup>m</sup>	582.64 ± 5.32 <sup>efgh</sup>	216.99 ± 8.75 <sup>tu</sup>	295.12 ± 0.93 <sup>ijkl</sup>	3.23 ± 0.11 <sup>klmanop</sup>	4.70 ± 0.09 <sup>kl</sup>	42.26 ± 0.53 <sup>qr</sup>	39.04 ± 0.29 <sup>st</sup>				
B	1	3.43 ± 0.13 <sup>wxy</sup>	96.22 ± 1.74 <sup>f</sup>	5.41 ± 0.05 <sup>uv</sup>	62.15 ± 2.29 <sup>f</sup>	13.67 ± 0.11 <sup>ab</sup>	73.38 ± 1.46 <sup>k</sup>	436.94 ± 6.85 <sup>m</sup>	469.63 ± 8.90 <sup>m</sup>	186.96 ± 11.61 <sup>wxyz</sup>	271.31 ± 2.33 <sup>lmanoo</sup>	1.49 ± 0.01 <sup>p</sup>	8.20 ± 0.61 <sup>gh</sup>	74.65 ± 0.79 <sup>k</sup>	107.61 ± 0.26 <sup>g</sup>				
	2	4.22 ± 0.08 <sup>wxy</sup>	110.25 ± 3.19 <sup>e</sup>	5.68 ± 0.08 <sup>lxyz</sup>	79.44 ± 2.36 <sup>d</sup>	17.51 ± 0.72 <sup>xyzam</sup>	103.21 ± 4.69 <sup>e</sup>	442.91 ± 5.90 <sup>o</sup>	501.85 ± 27.86 <sup>kl</sup>	198.40 ± 3.50 <sup>w</sup>	260.56 ± 1.73 <sup>manoo</sup>	1.47 ± 0.03 <sup>p</sup>	12.25 ± 1.01 <sup>ef</sup>	51.52 ± 0.16 <sup>o</sup>	123.31 ± 1.11 <sup>de</sup>				
	3	4.70 ± 0.04 <sup>wxy</sup>	137.54 ± 3.08 <sup>e</sup>	5.81 ± 0.01 <sup>lxyz</sup>	87.89 ± 1.48 <sup>t</sup>	17.32 ± 0.70 <sup>xyzam</sup>	100.09 ± 1.52 <sup>f</sup>	371.32 ± 0.42 <sup>uz</sup>	467.90 ± 13.63 <sup>m</sup>	260.41 ± 48.81 <sup>manoo</sup>	248.56 ± 0.10 <sup>qr</sup>	2.18 ± 0.08 <sup>manop</sup>	14.63 ± 1.06 <sup>e</sup>	66.92 ± 0.19 <sup>l</sup>	110.10 ± 0.10 <sup>fg</sup>				
A	1	7.26 ± 0.15 <sup>stuv</sup>	187.75 ± 3.42 <sup>b</sup>	7.71 ± 0.59 <sup>stuv</sup>	129.91 ± 3.30 <sup>b</sup>	16.58 ± 0.89 <sup>yzam</sup>	177.82 ± 4.35 <sup>b</sup>	432.13 ± 1.22 <sup>n</sup>	591.56 ± 25.07 <sup>fg</sup>	277.59 ± 11.31 <sup>lm</sup>	253.06 ± 0.60 <sup>pqr</sup>	2.19 ± 0.10 <sup>manop</sup>	14.34 ± 3.54 <sup>cd</sup>	38.96 ± 1.79 <sup>st</sup>	120.00 ± 0.08 <sup>g</sup>				
	2	6.53 ± 0.06 <sup>stuv</sup>	204.39 ± 4.75 <sup>a</sup>	5.90 ± 0.31 <sup>lxyz</sup>	146.40 ± 1.17 <sup>m</sup>	21.15 ± 0.09 <sup>w</sup>	200.30 ± 2.43 <sup>n</sup>	433.99 ± 3.55 <sup>n</sup>	583.86 ± 7.77 <sup>efgh</sup>	313.75 ± 4.97 <sup>gh</sup>	238.97 ± 0.03 <sup>rs</sup>	2.14 ± 0.03 <sup>manop</sup>	21.79 ± 1.64 <sup>d</sup>	36.46 ± 0.47 <sup>s</sup>	193.60 ± 0.20 <sup>h</sup>				
	3	4.38 ± 0.28 <sup>wxy</sup>	205.26 ± 3.61 <sup>a</sup>	5.50 ± 0.41 <sup>lxyz</sup>	131.06 ± 4.00 <sup>b</sup>	16.82 ± 0.03 <sup>yzam</sup>	164.35 ± 0.04 <sup>e</sup>	386.98 ± 2.30 <sup>opq</sup>	546.09 ± 0.01 <sup>ij</sup>	287.27 ± 5.49 <sup>kl</sup>	252.24 ± 0.58 <sup>qr</sup>	1.92 ± 0.13 <sup>manop</sup>	13.55 ± 0.55 <sup>cd</sup>	16.26 ± 1.13 <sup>v</sup>	172.45 ± 0.52 <sup>h</sup>				
H	1	11.05 ± 0.56 <sup>i</sup>	60.62 ± 2.58 <sup>l</sup>	6.23 ± 0.52 <sup>lxyz</sup>	39.72 ± 1.09 <sup>k</sup>	15.70 ± 0.03 <sup>manab</sup>	56.07 ± 0.92 <sup>m</sup>	358.66 ± 14.92 <sup>st</sup>	588.48 ± 20.99 <sup>fg</sup>	248.89 ± 3.67 <sup>qr</sup>	311.03 ± 2.35 <sup>ghu</sup>	8.79 ± 0.70 <sup>g</sup>	12.02 ± 0.45 <sup>ef</sup>	7.37 ± 0.08 <sup>s</sup>	62.80 ± 0.10 <sup>m</sup>				
	2	7.12 ± 0.03 <sup>stuv</sup>	55.18 ± 2.53 <sup>m</sup>	5.48 ± 0.46 <sup>stuv</sup>	36.04 ± 0.24 <sup>l</sup>	21.06 ± 0.73 <sup>w</sup>	48.13 ± 0.93 <sup>no</sup>	345.00 ± 0.08 <sup>tu</sup>	599.86 ± 1.44 <sup>ef</sup>	203.66 ± 3.64 <sup>xyz</sup>	327.99 ± 3.89 <sup>g</sup>	11.13 ± 0.60 <sup>f</sup>	19.63 ± 1.60 <sup>h</sup>	3.03 ± 0.26 <sup>r</sup>	76.40 ± 1.08 <sup>k</sup>				
	3	7.11 ± 0.20 <sup>stuv</sup>	65.24 ± 0.98 <sup>k</sup>	6.06 ± 0.24 <sup>lxyz</sup>	40.53 ± 1.12 <sup>k</sup>	18.12 ± 0.46 <sup>xyzam</sup>	76.11 ± 1.93 <sup>j</sup>	390.83 ± 2.50 <sup>opq</sup>	563.60 ± 11.07 <sup>hu</sup>	355.48 ± 2.91 <sup>f</sup>	374.10 ± 8.25 <sup>c</sup>	12.51 ± 0.32 <sup>def</sup>	21.57 ± 3.21 <sup>f</sup>	11.50 ± 0.26 <sup>w</sup>	76.47 ± 0.23 <sup>k</sup>				
EA	1	2.36 ± 0.03 <sup>y</sup>	121.87 ± 1.87 <sup>d</sup>	5.28 ± 0.18 <sup>uv</sup>	74.32 ± 1.80 <sup>e</sup>	17.23 ± 0.30 <sup>xyzam</sup>	84.58 ± 0.07 <sup>b</sup>	434.47 ± 3.71 <sup>n</sup>	477.27 ± 3.25 <sup>lm</sup>	319.57 ± 5.21 <sup>g</sup>	258.88 ± 1.75 <sup>opq</sup>	1.58 ± 0.04 <sup>op</sup>	12.76 ± 1.53 <sup>cd</sup>	17.31 ± 0.11 <sup>v</sup>	92.01 ± 0.17 <sup>r</sup>				
	2	2.88 ± 0.08 <sup>stuv</sup>	92.31 ± 2.96 <sup>g</sup>	4.93 ± 0.10 <sup>uv</sup>	57.74 ± 1.76 <sup>h</sup>	18.45 ± 0.80 <sup>xyz</sup>	80.87 ± 1.94 <sup>i</sup>	361.32 ± 5.47 <sup>st</sup>	454.83 ± 23.69 <sup>man</sup>	898.99 ± 16.36 <sup>g</sup>	259.40 ± 0.85 <sup>opq</sup>	2.19 ± 0.06 <sup>manop</sup>	18.40 ± 0.02 <sup>h</sup>	16.18 ± 0.35 <sup>v</sup>	126.61 ± 0.28 <sup>d</sup>				
	3	3.09 ± 0.07 <sup>stuv</sup>	113.01 ± 2.57 <sup>e</sup>	5.04 ± 0.02 <sup>y</sup>	71.53 ± 2.06 <sup>f</sup>	19.41 ± 0.37 <sup>w</sup>	90.37 ± 0.97 <sup>g</sup>	383.47 ± 7.25 <sup>opqr</sup>	498.40 ± 2.80 <sup>l</sup>	225.46 ± 1.79 <sup>st</sup>	273.40 ± 0.47 <sup>lmanoo</sup>	2.71 ± 0.07 <sup>lmanop</sup>	12.12 ± 1.03 <sup>ef</sup>	46.80 ± 1.79 <sup>r</sup>	97.29 ± 0.16 <sup>h</sup>				
PE	1	4.29 ± 0.10 <sup>stuv</sup>	42.79 ± 0.87 <sup>m</sup>	5.48 ± 0.06 <sup>stuv</sup>	27.02 ± 1.23 <sup>m</sup>	23.50 ± 0.07 <sup>uv</sup>	37.98 ± 0.48 <sup>t</sup>	859.08 ± 9.35 <sup>t</sup>	699.48 ± 14.33 <sup>s</sup>	158.78 ± 0.72 <sup>yz</sup>	401.07 ± 4.29 <sup>d</sup>	12.01 ± 0.18 <sup>ef</sup>	11.75 ± 0.87 <sup>ef</sup>	2.27 ± 0.09 <sup>y</sup>	39.79 ± 0.14 <sup>st</sup>				
	2	7.28 ± 0.36 <sup>stuv</sup>	44.53 ± 1.49 <sup>no</sup>	5.50 ± 0.13 <sup>uv</sup>	26.78 ± 1.76 <sup>m</sup>	16.11 ± 0.27 <sup>manab</sup>	42.27 ± 0.45 <sup>p</sup>	835.40 ± 1.82 <sup>t</sup>	680.59 ± 2.61 <sup>c</sup>	199.59 ± 3.89 <sup>xyzw</sup>	270.41 ± 2.80 <sup>lmanoo</sup>	13.17 ± 0.24 <sup>de</sup>	8.62 ± 0.23 <sup>e</sup>	1.95 ± 0.26 <sup>r</sup>	46.91 ± 0.12 <sup>o</sup>				
	3	5.85 ± 0.43 <sup>wxy</sup>	47.07 ± 0.83 <sup>no</sup>	6.41 ± 0.21 <sup>stuv</sup>	34.21 ± 2.30 <sup>l</sup>	17.11 ± 0.60 <sup>xyzam</sup>	45.89 ± 0.33 <sup>r</sup>	745.83 ± 11.34 <sup>t</sup>	635.44 ± 25.28 <sup>d</sup>	276.40 ± 6.49 <sup>lmn</sup>	320.91 ± 8.07 <sup>g</sup>	8.67 ± 0.26 <sup>g</sup>	13.57 ± 1.59 <sup>de</sup>	1.12 ± 0.10 <sup>y</sup>	54.05 ± 0.35 <sup>no</sup>				

W water, M methanol, E ethanol, B butanol, A acetone, H hexane, EA ethyl acetate, PE petroleum ether, SE solvent extraction, AH acidic hydrolysis, TPC mg GAE/g sample, FRAP-ABTS-CHROMAC mg TE/g sample, DPPH IC<sub>50</sub> (mg TE/g sample), TFC mg QE/g sample, TCC mg BC/g sample

\*Two replicates ± Standard deviation

<sup>a-z</sup>Lowercase superscripts in the different extraction groups indicate significant differences between means of spectroscopic results for oleaster samples in a method ( $p < 0.05$ )

Table 11 Spectroscopic analysis results of oleaster leaf samples

Sol-vent	Sam-ple	TPC		FRAP		ABTS		CHROMAC		DPPH		TFC		TCC	
		SE	AH	SE	AH	SE	AH	SE	AH	SE	AH	SE	AH	SE	AH
W	1	32.18±0.42 <sup>kl</sup>	34.69±0.72 <sup>i</sup>	14.67±0.06 <sup>vp</sup>	17.53±0.40 <sup>m</sup>	37.92±0.26 <sup>i</sup>	37.66±0.23 <sup>i</sup>	95.45±2.15 <sup>l,lm</sup>	159.06±3.26 <sup>jl</sup>	24.74±0.03 <sup>i</sup>	54.30±0.11 <sup>l,lmn</sup>	0.64±0.01 <sup>s,uv</sup>	0.29±0.01 <sup>xy</sup>	62.24±0.39 <sup>m</sup>	117.31±0.18 <sup>c</sup>
	2	22.28±0.28 <sup>m</sup>	27.95±0.91 <sup>l</sup>	15.77±0.14 <sup>wp</sup>	12.56±0.03 <sup>q</sup>	19.25±0.16 <sup>f</sup>	16.56±0.02 <sup>s</sup>	80.67±0.97 <sup>v</sup>	157.18±6.64 <sup>d</sup>	24.11±0.16 <sup>i</sup>	68.56±1.05 <sup>kl</sup>	0.42±0.01 <sup>w,xy</sup>	0.32±0.01 <sup>w,xy</sup>	58.76±0.14 <sup>d</sup>	66.64±0.56 <sup>f</sup>
	3	34.12±1.57 <sup>ij</sup>	31.05±1.07 <sup>k</sup>	21.68±0.66 <sup>k</sup>	16.69±0.55 <sup>m,nn</sup>	43.15±0.57 <sup>l</sup>	41.59±0.18 <sup>k</sup>	103.70±2.89 <sup>opq</sup>	195.85±1.18 <sup>h</sup>	195.85±1.18 <sup>h</sup>	24.00±0.01 <sup>i</sup>	53.22±0.30 <sup>l,lmn</sup>	0.58±0.01 <sup>t,uv</sup>	0.26±0.01 <sup>y</sup>	77.57±0.19 <sup>g</sup>
M	1	13.13±0.59 <sup>oo</sup>	58.36±2.34 <sup>b</sup>	4.34±0.17 <sup>tu</sup>	80.93±1.85 <sup>x</sup>	9.20±0.03 <sup>d</sup>	84.12±0.11 <sup>c</sup>	89.54±3.57 <sup>n</sup>	195.79±5.31 <sup>c</sup>	36.00±0.63 <sup>rs</sup>	47.54±0.01 <sup>n,op</sup>	0.99±0.03 <sup>p,q</sup>	0.71±0.06 <sup>f</sup>	69.43±0.79 <sup>e</sup>	32.87±0.14 <sup>nn</sup>
	2	8.92±0.35 <sup>o</sup>	35.71±1.61 <sup>bu</sup>	3.32±0.18 <sup>uv</sup>	25.59±0.80 <sup>aa</sup>	5.07±0.07 <sup>f</sup>	25.03±0.25 <sup>p</sup>	107.60±1.72 <sup>sp</sup>	158.13±1.44 <sup>d</sup>	38.48±0.16 <sup>q,rs</sup>	53.03±0.37 <sup>l,lmn</sup>	0.79±0.04 <sup>p,q,r</sup>	1.00±0.04 <sup>w</sup>	44.15±0.18 <sup>l</sup>	33.96±0.53 <sup>f</sup>
	3	12.49±0.70 <sup>op</sup>	59.20±1.76 <sup>b</sup>	4.23±0.05 <sup>v</sup>	71.04±2.31 <sup>r</sup>	6.96±0.13 <sup>e</sup>	75.48±0.08 <sup>d</sup>	94.98±4.23 <sup>l,lm</sup>	205.65±2.13 <sup>b</sup>	205.65±2.13 <sup>b</sup>	35.33±1.21 <sup>s</sup>	48.21±0.01 <sup>n,op</sup>	0.99±0.01 <sup>n,p</sup>	0.72±0.03 <sup>p</sup>	56.74±0.30 <sup>h</sup>
E	1	5.02±0.18 <sup>f</sup>	50.03±1.06 <sup>d</sup>	2.41±0.12 <sup>vw</sup>	55.52±0.17 <sup>ad</sup>	3.82±0.11 <sup>h</sup>	69.57±0.28 <sup>f</sup>	108.95±3.09 <sup>op</sup>	168.16±2.67 <sup>gh</sup>	52.95±3.88 <sup>l,lmn</sup>	47.98±0.01 <sup>n,op</sup>	0.59±0.01 <sup>t,uv</sup>	1.07±0.08 <sup>k,l</sup>	63.19±0.20 <sup>ij</sup>	52.94±0.84 <sup>f</sup>
	2	4.34±0.03 <sup>s,t</sup>	33.80±0.51 <sup>j</sup>	2.25±0.04 <sup>xw</sup>	25.86±1.03 <sup>ahac</sup>	4.35±0.17 <sup>g</sup>	27.40±0.15 <sup>o</sup>	108.96±6.57 <sup>op</sup>	147.67±4.77 <sup>k</sup>	82.18±1.62 <sup>g</sup>	52.94±0.47 <sup>l,lmn</sup>	0.62±0.01 <sup>t,uv</sup>	1.28±0.02 <sup>s</sup>	49.96±0.34 <sup>d</sup>	164.81±0.64 <sup>a</sup>
	3	4.67±0.16 <sup>s</sup>	53.23±1.50 <sup>e</sup>	2.20±0.03 <sup>xw</sup>	57.23±2.32 <sup>aaab</sup>	4.83±0.30 <sup>f</sup>	73.36±0.12 <sup>c</sup>	111.26±3.53 <sup>n</sup>	188.58±3.71 <sup>de</sup>	43.38±1.01 <sup>pq,r</sup>	48.61±0.07 <sup>op,q,r</sup>	0.88±0.02 <sup>p,q,r</sup>	0.94±0.01 <sup>h</sup>	70.48±0.27 <sup>b</sup>	47.11±0.44 <sup>b</sup>
B	1	2.43±0.01 <sup>tu,vw</sup>	55.05±2.80 <sup>e</sup>	1.50±0.02 <sup>x</sup>	43.41±1.79 <sup>g</sup>	3.69±0.01 <sup>ad,ae</sup>	56.00±0.32 <sup>g</sup>	100.20±1.20 <sup>q,rs</sup>	173.13±3.20 <sup>g</sup>	140.80±3.29 <sup>e</sup>	49.24±0.07 <sup>m,op</sup>	0.33±0.01 <sup>w,xy</sup>	1.70±0.03 <sup>m</sup>	58.96±0.13 <sup>n</sup>	62.85±0.14 <sup>lm</sup>
	2	3.60±0.27 <sup>s,t,uv</sup>	37.52±1.22 <sup>gh</sup>	1.64±0.02 <sup>w</sup>	19.97±1.51 <sup>i</sup>	3.98±0.14 <sup>ac,ad</sup>	20.74±0.40 <sup>l</sup>	102.79±1.84 <sup>op,q,r</sup>	165.72±7.14 <sup>h</sup>	45.06±3.82 <sup>op,q,r</sup>	57.89±1.25 <sup>k,l,m</sup>	0.34±0.01 <sup>w,xy</sup>	2.63±0.18 <sup>gh</sup>	40.81±0.13 <sup>z</sup>	47.99±0.62 <sup>i</sup>
	3	2.70±0.03 <sup>s,t,uv,w</sup>	49.90±1.95 <sup>d</sup>	1.71±0.04 <sup>w</sup>	42.37±1.30 <sup>g</sup>	3.30±0.08 <sup>ae,af</sup>	51.06±0.14 <sup>h</sup>	99.17±3.27 <sup>q,rs</sup>	165.11±0.94 <sup>hu</sup>	59.13±2.30 <sup>k,l,m</sup>	49.84±0.03 <sup>n,op</sup>	0.59±0.04 <sup>t,uv</sup>	3.20±0.09 <sup>e</sup>	31.11±0.40 <sup>ab</sup>	41.94±0.92 <sup>x</sup>
A	1	4.06±0.04 <sup>s,t,uv</sup>	77.49±0.35 <sup>h</sup>	2.16±0.13 <sup>xw</sup>	93.07±0.59 <sup>b</sup>	4.86±0.08 <sup>aa</sup>	113.54±0.08 <sup>b</sup>	92.15±3.73 <sup>lm</sup>	232.16±0.19 <sup>s</sup>	94.39±7.97 <sup>f</sup>	47.61±0.01 <sup>n,op</sup>	0.48±0.02 <sup>hi,uv</sup>	2.54±0.05 <sup>h,i,j</sup>	57.84±0.32 <sup>e</sup>	86.63±0.52 <sup>f</sup>
	2	3.90±0.16 <sup>s,t,uv,w</sup>	47.47±1.57 <sup>e</sup>	2.50±0.12 <sup>xw</sup>	30.04±1.35 <sup>f</sup>	4.99±0.13 <sup>aa</sup>	35.91±0.02 <sup>m</sup>	96.51±2.06 <sup>s,t</sup>	181.59±0.25 <sup>f</sup>	97.13±7.96 <sup>f</sup>	52.62±0.10 <sup>m,oo</sup>	0.54±0.01 <sup>hi,uv</sup>	4.52±0.32 <sup>c</sup>	44.88±0.39 <sup>e</sup>	104.74±0.87 <sup>g</sup>
	3	4.11±0.12 <sup>s,t,uv</sup>	76.99±1.39 <sup>a</sup>	2.09±0.07 <sup>xw</sup>	98.45±1.19 <sup>a</sup>	3.71±0.07 <sup>ad,ae</sup>	119.73±0.06 <sup>a</sup>	91.06±4.17 <sup>lm</sup>	233.95±1.18 <sup>s</sup>	130.54±9.29 <sup>df</sup>	47.77±0.01 <sup>n,op</sup>	0.59±0.02 <sup>t,uv</sup>	2.75±0.06 <sup>g</sup>	54.61±0.13 <sup>z</sup>	93.22±0.62 <sup>e</sup>
H	1	1.22±0.04 <sup>w</sup>	14.28±0.80 <sup>n</sup>	1.12±0.03 <sup>x</sup>	14.40±0.10 <sup>p</sup>	2.63±0.08 <sup>ag</sup>	14.81±0.48 <sup>l</sup>	95.81±2.09 <sup>s,t,uv</sup>	122.59±2.40 <sup>h</sup>	172.43±7.65 <sup>b</sup>	55.11±1.03 <sup>l,lmn</sup>	2.52±0.07 <sup>h,i,j</sup>	3.01±0.03 <sup>f</sup>	5.37±0.40 <sup>pl</sup>	25.97±0.77 <sup>ac</sup>
	2	1.08±0.03 <sup>w</sup>	14.10±0.51 <sup>n</sup>	1.15±0.01 <sup>w</sup>	10.10±0.30 <sup>f</sup>	3.18±0.07 <sup>af</sup>	8.89±0.34 <sup>s</sup>	105.36±0.83 <sup>op,q</sup>	165.67±4.20 <sup>h</sup>	49.08±0.86 <sup>op,q</sup>	57.51±0.78 <sup>l,m</sup>	2.61±0.17 <sup>gh,i</sup>	5.06±0.08 <sup>b</sup>	6.15±0.52 <sup>kl</sup>	14.12±0.58 <sup>mn</sup>
	3	1.56±0.17 <sup>w</sup>	13.19±0.23 <sup>oo</sup>	1.08±0.01 <sup>w</sup>	10.18±0.52 <sup>f</sup>	3.15±0.28 <sup>af</sup>	14.09±0.22 <sup>h</sup>	99.12±3.24 <sup>q,rs</sup>	131.85±4.77 <sup>m</sup>	94.48±7.31 <sup>f</sup>	60.39±1.45 <sup>k,l</sup>	2.29±0.11 <sup>kl</sup>	5.56±0.03 <sup>a</sup>	44.98±0.39 <sup>e</sup>	18.45±2.00 <sup>of</sup>
EA	1	2.79±0.23 <sup>s,t,uv,w</sup>	40.61±0.18 <sup>f</sup>	1.50±0.02 <sup>w</sup>	29.02±0.68 <sup>f</sup>	2.30±0.06 <sup>ag</sup>	30.43±0.77 <sup>n</sup>	89.78±2.27 <sup>n</sup>	123.56±2.26 <sup>h</sup>	69.67±6.78 <sup>h,i,j</sup>	51.98±0.21 <sup>m,oo</sup>	0.36±0.02 <sup>w,xy</sup>	2.33±0.17 <sup>k</sup>	30.58±0.46 <sup>ab</sup>	58.77±0.72 <sup>n</sup>
	2	2.22±0.04 <sup>x,w</sup>	37.99±1.91 <sup>g</sup>	1.56±0.01 <sup>w</sup>	16.01±0.44 <sup>m,oo</sup>	3.15±0.03 <sup>af</sup>	14.78±0.07 <sup>f</sup>	74.84±0.17 <sup>v</sup>	149.64±5.96 <sup>k</sup>	115.42±5.31 <sup>e</sup>	65.48±2.23 <sup>kl</sup>	0.58±0.01 <sup>t,uv</sup>	2.33±0.09 <sup>k</sup>	20.47±0.17 <sup>ac</sup>	63.68±0.68 <sup>k</sup>
PE	1	1.89±0.15 <sup>xw</sup>	53.93±1.99 <sup>f</sup>	1.81±0.11 <sup>xw</sup>	39.82±0.56 <sup>h</sup>	3.74±0.15 <sup>ad,ae</sup>	46.73±0.31 <sup>i</sup>	80.15±2.87 <sup>v</sup>	145.11±1.50 <sup>kl</sup>	77.21±1.03 <sup>ah</sup>	49.68±0.11 <sup>n,op</sup>	0.70±0.02 <sup>s,t</sup>	1.36±0.01 <sup>n</sup>	17.13±0.24 <sup>q,r</sup>	62.98±0.60 <sup>kl</sup>
	2	1.20±0.06 <sup>w</sup>	11.83±0.28 <sup>op</sup>	1.11±0.01 <sup>w</sup>	9.08±0.77 <sup>f</sup>	1.74±0.19 <sup>ah</sup>	12.07±0.28 <sup>h</sup>	193.34±1.88 <sup>cd</sup>	140.19±2.43 <sup>i</sup>	364.96±13.06 <sup>f</sup>	65.15±1.80 <sup>kl</sup>	2.43±0.10 <sup>kl</sup>	1.75±0.04 <sup>m</sup>	8.36±0.56 <sup>ij</sup>	16.73±0.53 <sup>q,r</sup>
	3	1.16±0.06 <sup>w</sup>	10.81±0.36 <sup>op</sup>	1.26±0.07 <sup>w</sup>	5.82±0.28 <sup>st</sup>	2.40±0.05 <sup>ag</sup>	7.66±0.08 <sup>h</sup>	196.96±1.03 <sup>t</sup>	168.27±2.49 <sup>gh</sup>	142.39±6.36 <sup>f</sup>	75.14±1.30 <sup>gh,i</sup>	2.45±0.03 <sup>kl</sup>	2.12±0.01 <sup>l</sup>	15.09±0.34 <sup>ab</sup>	14.65±0.59 <sup>gh,lm</sup>
	3	0.95±0.04 <sup>w</sup>	8.86±0.32 <sup>rs</sup>	1.09±0.03 <sup>w</sup>	7.24±0.17 <sup>s</sup>	1.55±0.06 <sup>ah</sup>	10.61±0.52 <sup>w</sup>	185.82±0.09 <sup>st</sup>	130.45±1.75 <sup>m</sup>	92.64±1.18 <sup>f</sup>	78.10±2.65 <sup>g</sup>	1.63±0.12 <sup>m</sup>	3.40±0.21 <sup>d</sup>	0.22±0.05 <sup>mm</sup>	16.87±0.87 <sup>q,r</sup>

W water, M methanol, E ethanol, B butanol, A acetone, H hexane, EA ethyl acetate, PE petroleum ether, SE solvent extraction, AH acidic hydrolysis, TPC mg GAE/g sample, FRAP-ABTS, CHROMAC mg TE/g sample, DPPH IC<sub>50</sub> (mg TE/g sample), TFC mg QE/g sample, TCC mg BC/g sample

\*Two replicates ± Standard deviation

<sup>a-z</sup>Lowercase superscripts in the different extraction groups indicate significant differences between means of spectroscopic results for oleaster samples in a method ( $p < 0.05$ )

hydrolysis (Table 10), and from 24.00 to 364.96 mg TE/g oleaster leaf for solvent extracts and from 47.54 to 78.10 mg TE/g oleaster leaf for acidic hydrolysis (Table 11). In a study done with extracts of the different parts of *Elaeagnus angustifolia* L., the highest antioxidant capacity was seen in fruit extract (from 1.109 to 4.450  $\mu\text{g TEAC/g DW}$ ) and the lowest antioxidant capacity was seen in leaf extract (from 0.713 to 1.620  $\mu\text{g TEAC/g DW}$ ). Also, the antioxidant capacity of the flower extract had ranges of 0.541 and 2.425  $\mu\text{g TEAC/g DW}$ , while the antioxidant capacity of the fruit peel extract had ranges of 0.756 and 2.063  $\mu\text{g TEAC/g DW}$  [8]. Antioxidant capacity ( $\text{IC}_{50}$ ) values of different solvents extracts of *Elaeagnus umbellata* Thunb. were found in the ranges of 40 and 1300  $\mu\text{g trolox/mL extract}$ , respectively. It was observed that the higher the polarity of the solvent, the higher the antioxidant capacity values [10]. According to Hassanzadeh and Hassanpour (2018), the mean antioxidant capacity of peel and pulp was found as 74.71% and 53.76%, respectively. Faramarz et al. [35] revealed that the mean antioxidant capacities ( $\text{IC}_{50}$ ) in different genotypes of *Elaeagnus angustifolia* L. peel, flesh, and seed were 86.95, 91.79, and 32.68 mg Trolox/mL, respectively.

Total flavonoid content (TFC) of oleaster's flour, shell, core, flower, and leaf were expressed mg catechin (CAE)/g sample. The TFC of oleaster's flour were found between 0.40 and 6.45 mg CAE/g sample for solvent extracts and ranged from 0.63 to 6.63 mg CAE/g sample for acidic hydrolysis (Table 7). The highest flavonoid contents showed in water extracts of solvent extraction and in water and ethanol extracts of acidic hydrolysis, while the lowest flavonoid contents were identified in methanol extracts of solvent extraction and in butanol and acetone extracts of acidic hydrolysis. The TFC of oleaster's shell range from 0.16 to 0.88 mg CAE/g sample for solvent extracts and 0.12 to 5.13 mg CAE/g sample for acidic hydrolysis (Table 8). The highest flavonoid contents were found in butanol extracts of solvent extraction and in ethanol extracts of acidic hydrolysis, while water extracts showed the least for both of them. The TFC of oleaster's core ranged between 1.57 and 14.82 mg CAE/g sample for solvent extracts and 2.01 and 42.30 mg CAE/g sample for acidic hydrolysis (Table 9). The highest flavonoid contents were shown by methanol extracts in solvent extraction and by butanol extracts in acidic hydrolysis, while the lowest flavonoid contents were identified in water extracts for both of them. The TFC of oleaster's flower were determined as ranging from 1.47 to 13.17 mg CAE/g sample for solvent extracts and 2.13 to 21.79 mg CAE/g sample for acidic hydrolysis (Table 10). Butanol extracts of solvent extraction and water extracts of acidic hydrolysis showed the lowest flavonoid contents, while the highest flavonoid contents were determined in hexane, and petroleum ether extracts of solvent extraction, and acetone, and hexane extracts of acidic hydrolysis. The TFC of oleaster's leaf ranged between 0.33

and 2.61 mg CAE/g sample for solvent extracts and 0.26 and 5.56 mg CAE/g sample for acidic hydrolysis (Table 11). Water extracts showed the lowest flavonoid contents, while the highest flavonoid contents were determined in hexane extracts for both of them. Ishaq et al. [3] reported flavonoid content of *Elaeagnus umbellata* ranged between  $1.5 \pm 0.15$  and  $3.8 \pm 0.3$  mg quercetin/g sample. The highest flavonoid content was seen in water, methanol, and hexane extracts, while acetone extracts showed the least. Earlier studies by Mercurieff et al. (2014) identified total flavonoid content of *Elaeagnus kologa* leaf's different solvent extracts ranged from  $5.20 \pm 0.06$  to  $21.19 \pm 0.45$  mg rutin/g sample. The results indicate that total flavonoid content was highest in petroleum ether extract, moderate in water and methanol extracts, and lower in chloroform extract. In another study, total flavonoid content of *Elaeagnus latifolia* Linn. fruit's 70% methanolic extract was found as  $5.44 \pm 0.16$  mg quercetin/100 g extract [31]. According to the results of Hassanzadeh and Hassanpour (2018), the highest TF content of peel was 489.58 mg catechin/100 g FW and the lowest TF content of peel was 23.50 mg catechin/100 g FW. The highest and the lowest TF contents of pulp were 318.75 and 17.00 mg catechin/100 g FW, respectively. In the present study, TF content of *Elaeagnus angustifolia* L. fruit was 1.35 mg catechin/g sample [36]. Also, Faramarz et al. [35] showed that the TF content of peel and pulp was reported as 121.55 and 148.52 mg catechin/100 g FW, respectively.

Total carotenoid contents (TCC) of oleaster's flour, shell, core, flower and leaf at different mediums were expressed by mg  $\beta$ -carotene (BC)/g sample. The TCC of oleaster's flour was determined as ranging from 0.24 to 6.62 mg BC/g sample for solvent extracts and from 1.56 to 11.08 mg BC/g sample for acidic hydrolysis (Table 7). The TCC of solvent extractions of oleaster's shell were found to range from 0.29 to 7.80 mg BC/g sample, while acidic hydrolysis of oleaster's shell varies in the range from 2.33 to 34.74 mg BC/g sample (Table 8). TCC of oleaster's core were found to range from 1.25 to 10.69 mg BC/g sample for solvent extractions and ranged from 3.16 to 46.82 mg BC/g sample for acidic hydrolysis (Table 9). The TCC of solvent extractions of oleaster's flower were determined to range from 1.12 to 113.61 mg BC/g sample and in the ranged between 25.88 and 193.60 mg BC/g sample for acidic hydrolysis (Table 10). TCC of oleaster's leaf ranged from 0.22 to 77.57 mg BC/g sample for solvent extractions, while acidic hydrolysis values ranged from 14.12 to 164.81 mg BC/g sample (Table 11). According to Carradori et al. (2020), total carotenoid contents of *Elaeagnus angustifolia* fruits and leaves were found as  $3.2 \pm 0.6$  and  $18.3 \pm 2.5$   $\mu\text{g BC/g dry extract}$ , respectively [37]. In the present study, total carotenoid contents in different genotypes of *Elaeagnus umbellata* Thunb. fruit ranged from 43.4 to 59.3 mg BC/100 g fresh mass.

## Conclusions

Oleaster is a functional food product that has a high phenolic component content. It is known to have therapeutic properties such as antioxidant, anti-inflammatory, antimutagenic, antitussive, antitumor, antiarthritic, antimicrobial, and hepatoprotective due to its wide phenolic component content. In this study, it was aimed to determine the phenolic component profiles in different extraction environments of the oleaster samples. In general, the antioxidant properties of the oleaster differ according to the geographical region where the plant grows, the parts of the plant, and the extraction conditions. Acidic hydrolysis using water or methanol solvents should be given preference to ensure maximum recovery.

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## Declarations

**Conflict of interest** The authors declare that they have no conflict of interest.

**Compliance with ethics requirements** This study does not contain any studies with human participants or animals performed by any of the authors.

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