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ORIGINAL ARTICLE / ORIGINALBEITRAG

Effect of Drying On Antioxidant Activity, Phenolic Compounds and Mineral Contents of Hawthorn and Wild Pear Fruits

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Abstract

The study demonstrated that SD-4 (3193.894 mg GAE/100 g) followed by SD-8 (2262.763 mg GAE/100 g) and SD-7 (1473.956 mg GAE/100 g) had the maximum total phenolic contents. SD-1 possessed the highest antioxidant activity, which later decreased from 83.067% in fresh fruit to 52.130% following drying. Across all fruits, drying resulted in significant reductions in both total phenolic content and phenolic compounds. Generally, gallic acid and (+)-catechin were the major phenolics in all fruits. Rutin trihydrate content of SD-4 decreased from 764.980 mg/100 g (fresh) to 0.620 mg/100 g when the fruit was dried. P, K, Ca, Mg and S were the macro elements of all fruits. Across all fruits, drying resulted in significant reductions in both total phenolic content and phenolic compounds. It was observed that dried fruits had the highest mineral contents compared to fresh fruits.

Keywords Hawthorn · Wild pear · Drying · Antioxidant · Total phenol · Phenolic compounds · Minerals

Einfluss des Trocknens auf die antioxidative Aktivität, die Phenolverbindungen und den Mineralgehalt von Weißdorn- und Wildbirnenfrüchten

Schlüsselwörter Weißdorn · Wilde Birne · Trocknen · Antioxidans · Gesamtphenol · Phenolverbindungen · Mineralien

Introduction

Crataegus fruit is one of most important fruits in Turkey flora. Some fruits of this genus are edible. Research have shown that hawthorn fruit contains significantly high amounts of bioactive compounds such as epicatechin, hyperoside, and chlorogenic acid (Özcan et al. 2005; Barros et al. 2011; Nabavi et al. 2015), with a wide range of antioxidant and free radical scavenging activities. Hyperoside, isoquercetin and epicatechin are the prominent flavonoid compounds present in hawthorn phenolic extract from hawthorn fruits (Zuo et al. 2006). In addition, the medicinal use of fruits, flowers and leaves of *Crataegus* spp have been demonstrated and they are particularly useful against cardiovascular disease, especially against candiovascular disease and they have also been used as a cure for stress, nervousness, sleep disorders, stomach ache and sore throat (Chang et al. 2002). *Pyrus* L. belongs to the subtribe Pyrinae of Rosaceae (Ercişli 2004), which is grown almost in all parts of Turkey is the second most important fruit after apple in the country. *Pyrus communis* is the main edible pear specie in Turkey (Ercişli 2004), and research have shown that both *Pyrus* L. and *Pyrus communis* cultivars have lower antioxidant activity in comparison to other cultivars. The total phenolics content in pear cultivars have been reported to range from 326 to 473 mg/kg of fresh mass (Karadeniz et al. 2005). This present study was conducted to evaluate the impact of drying process on the phenolic

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Table 1 Plants used in experiment

Family	Species		Location	Altitude	Herbariumnumber
Rosaceae	**SD-1**	*Pyrus kotschyana* Boiss. exDecne	C4 Konya: Seydişehir, Küpe Mountain, slopes, 25.06.2015	1450 m	S. Doğu 2972
Rosaceae	**SD-2**	*Crataegus orientalis* Pall. exM.Bieb. var. *orientalis*	C4 Konya: Konya-Hadim road, Egiste river location, slopes, 19.09.2015	1000 m	S. Doğu 2995
Rosaceae	**SD-3**	*Pyrus syriaca* Boiss. var. *microphylla*	C4 Karaman: Ermenek, Ermenek dam round, slopes, 11.07.2015	1000 m	S. Doğu 2979
Grossulariaceae	**SD-4**	*Ribes rubrum* L	C4 Konya: Meram, Garden inside, 13.10.2015	1150 m	S. Doğu 3002
Rosaceae	**SD-5**	Pyrus *syriaca* Boiss. var. *syriaca* Zoharyex Browicz	C4 Antalya: Akseki, Süleymaniye Village, slopes, 14.08.2015	1350 m	S. Doğu 2983
Rosaceae	**SD-6**	*Crataegu smonogyna* Jacq. subsp. *monogyna*	C4 Konya:Seydişehir, slopes, 20.09.2015	1400 m	S. Doğu 2998
Rosaceae	**SD-7**	*Crataegu smonogyna* Jacq. subsp. *azarella* (Gris.) Franco	C4 Antalya: Aksu, Kuru river side, 27.09.2015	50 m	S. Doğu 3000
Rosaceae	**SD-8**	*Pyracantha coccinea* Roem	C4 Mersin: Tarsus, Ulaş village round, slopes 21.08.2015	450 m	S. Doğu 2987

compounds, antioxidant activity and mineral content of hawthorn and wild pear fruits.

Material and Methods

Material

Fruit samples used in this study were provided from Antalya, Karaman, Konya and Mersin provinces in Turkey (Table 1). They were immediately transferred to laboratory in cool bags. The fruit samples were sliced approximately to the same thickness using a sharp stainless steel knife priorto drying process. Moisture contents were determined thereafter and the fruits were then washed with distilled water. The seeds of raw and ripened rose fruits were removed and collected in a separate bag. They were dried at 70 °C, and were kept in refrigerator. 1 kg fruit was used for each analyses. All reagents and solvents used were of analytical grade and purchased from Sigma-AldrichCo. (St. Louis, MO, USA).

Methods

Drying Process

Fruits were dried in an oven (Nüve FN055 Ankara, Turkey, 551 volume) at 70 °C to moisture content less than 20%. Both freshly prepared and dehydrated samples were analyzed. The initial moisture contents of the fruit samples were determined at 105 °C and constantly monitored till a constant weight was attained.

Sample Extraction

The extraction of phenolic compounds and antioxidants capacity of the fruit samples were done using the method described by Liu et al. (2011) with slight modification. 20 ml of methanol was added to four grams of each sample and this was followed by sonication for 15 min, after which the mixture was centrifuged for 10 min at 5000 rpm. This procedure was repeated twice and the supernatants were collected. Concentration of extract was done using rotary evaporator under vacuum at 37 °C and extracts volume adjusted to 25 ml by adding methanol. The sample extracts were filtered using 0.45 µm nylon filter before injection. All analyses were performed in triplicate.

Total Phenolic Content and Antioxidant Activity

The method described by Yoo et al. (2004) using Folin-Ciocalteu (FC) reagent was used to quantify the total phenol contents of the fruit extracts, while the method of Lee *et al.* (1998) using DPPH (1,1-diphenyl-2-picrylhydrazyl) was used to quantify the free radical scavenging activity of the fruit extracts.

Phenolic Compounds Determination

The phenolic compounds in the extracts were determined using HPLC (Shimadzu-HPLC equipped with PDA detector and Inertsil ODS-3 (5 µm; 4.6 × 250 mm) column). Mixture of 0.05% acetic acid in water and acetonitrile was used as mobile phase. Mobile phase flow rate of 1 ml/min at 30 °C and injection volume of 20 µl was used. Peak records were determined at 280 and 330 nm and total running time for each sample was 60 min.

Table 2 Total phenolic contents and antioxidant activities of fresh and dried (D) fruits

Samples	Moisture (%)		Antioxidant Activity (%)		Total Phenolic Content (mg/100 g)	
SD-1	76.822	±0.251 [a] c	83.067	±0.006a	772.173	±0.014f
SD-2	67.671	±0.782g [b]	81.363	±0.004b	1211.894	±0.002d
SD-3	68.257	±0.084 fg	76.837	±0.005c	1107.793	±0.019e
SD-4	86.707	±0.103a	64.856	±0.008e	3193.894	±0.007a
SD-5	74.856	±0.312d	73.216	±0.001d	567.397	±0.012 fg
SD-6	69.256	±0.071ef	76.731	±0.001c	1340.036	±0.006 cd
SD-7	70.930	±0.098e	73.589	±0.003d	1473.956	±0.008c
SD-8	84.833	±0.235b	53.301	±0.012f	2262.763	±0.042b
D-SD-1	19.256	±0.362b	52.130	±0.023c	79.932	±0.003f
D-SD-2	16.667	±0.116e	82.854	±0.001b	176.667	±0.004d
D-SD-3	17.327	±0.700d	85.410	±0.001a	105.366	±0.009de
D-SD-4	20.349	±0.219a	85.463	±0.001a	446.118	±0.020a
D-SD-5	18.451	±0.345c	35.037	±0.019d	64.507	±0.005 fg
D-SD-6	18.951	±0.638c	82.162	±0.003b	244.838	±0.038bc
D-SD-7	17.913	±0.829d	82.055	±0.001b	273.202	±0.009b
D-SD-8	19.531	±0.164b	82.322	±0.002b	115.804	±0.014d

D dried

[a] Mean ± standard deviation

[b] Values within each column followed by different letters are significantly different ($p < 0.05$)

Determination of Minerals Contents

Mineral contents of the fresh and dried fruit samples were determined using Inductively Coupled Plasma Atomic Emission Spectrometry as described in Varian-Vista, Australia (Skujins 1998). About 0.5 g of the samples were dried in an oven at 70 ± 5 °C for two days. The samples were then ground and digested using 5 ml of 65% HNO_3 and 2 ml of 35% H_2O_2 in a closed microwave system.

Statistical Analyses

Results obtained were subjected to Analysis of Variance (ANOVA) using JMP version 9.0 (SAS Inst. Inc., Cary, N.C.U.S.A). All results were expressed as mean and standard deviation of fruit samples (Püskülcü and İkiz 1989).

Results and Discussion

The mean values for antioxidant capacity using DPPH and total phenolic content using FC in fresh and dried 8 different fruit extracts are presented in Table 2. SD-1 demonstrated the highest antioxidant activity (83.067%), followed by SD-2 (81.363%) and SD-3 (76.837%). There was an increase in antioxidant activity of SD-3 (8.573%), SD-4 (20.607%), SD-6 (5.431%), SD-7 (8.466%) and SD-8 (29.021%) when fruits were dried at 70 °C, while the lowest antioxidant value was recorded in SD-8 (53.301%). However, antioxidant capacity of SD-1 decreased from 83.067 to 52.130% ($p < 0.05$). Additionally, drying process resulted in maximum reduction of antioxidant activity in SD-5 (38.179%). It can be observed from Table 2 that highest amount of total phenolic content in mg GAE/100 g fruit (dry basis) was found in SD-4 (3193.894), followed by SD-8 (2262.763) and SD-7 (1473.956). The results obtained in this present study showed that hawthorn and wild pear fruits are good sources of polyphenols. On the other hand, SD-5 (567.397 mg GAE/100 g) and SD-1 (772.173 mg GAE/100 g) had the lowest total phenolic content compared to other fruits. The results revealed that the total phenolic content of all fruits decreased after drying process. The highest reduction in total phenolic contents were observed in SD-4 and SD-8, with the proportion of 86.032% and 94.882%, respectively. The values of antioxidant and total phenol contents of fresh fruits (SD) and dried fruits (D-SD) (except D-SD-4 and SD-7) were significantly ($p < 0.05$) different. The antioxidant activity of phenolic compounds are attributed to their redox potentials, which allow them to act as reducing agents, hydrogen donors, and singlet oxygen quenchers (Mraihi et al. 2013). The high composition of antioxidant compounds and the higher antioxidant capacity activity of *Crataegus* can improve the use of these fruits in various field such as agroalimentary and pharmaceutical industry (Mraihi et al. 2013). Total phenolic contents of *C. monogyna* and *Crataegus arazolus* were found as 122.26 and 60.89 mg eq. GA/100 g, respectively (Mraihi et al. 2013). Related findings have been reported in literature for total phenolic content of fruit extract prepared using methanol. Kostic et al. (2013)

Table 3 Phenolic compounds of fresh and dried (D) fruits

Phenolic compounds (mg/100 g)																
	SD-1		**D_SD_1**		**SD_2**		**D_SD_2**		**SD_3**		**D_SD_3**		**SD_4**		**D_SD_4**	
Gallic Acid	2.529	±0.158 [a] g	2.255	±0.102g	36.137	±0.245c	23.803	±0.350e	40.010	±0.032b	29.388	±0.463d	69.810	±1.122a	22.021	±0.634f
3,4-Dihydroxybenzoic Acid	3.097	±0.607g [b]	4.356	±0.007f	15.440	±0.362d	17.108	±0.285c	20.797	±0.920b	10.990	±0.202e	83.346	±0.502a	21.353	±0.578b
(+)-Catechin	2.987	±0.260g	1.662	±0.075gh	28.665	±0.176c	6.658	±0.861f	20.930	±0.272d	13.209	±0.355e	60.523	±0.275a	40.314	±0.922b
1,2-Dihydroxybenzene	1.668	±0.211g	2.375	±0.390f	26.431	±0.087b	9.164	±0.061e	25.139	±0.122c	16.078	±0.361d	26.336	±0.756b	40.938	±0.508a
Syringic Acid	0.750	±0.144f	0.534	±0.038f	5.151	±0.988c	0.466	±0.047f	4.096	±0.045d	1.910	±0.112e	11.077	±0.415a	7.487	±0.410b
Caffeic Acid	1.345	±0.017c	0.436	±0.022d	6.565	±0.924b	0.446	±0.047d	1.541	±0.145c	0.695	±0.041d	10.828	±0.571a	5.412	±0.139b
Rutin trihydrate	0.761	±0.013f	2.079	±0.213d	2.960	±0.428d	1.269	±0.181e	3.039	±0.361c	0.585	±0.032f	764.980	±2.398a	0.620	±0.079b
p-Coumaric Acid	0.177	±0.035d	0.056	±0.004f	0.184	±0.009d	0.522	±0.092a	0.361	±0.069c	0.449	±0.057b	0.131	±0.012e	0.085	±0.008d
Trans-Ferulic Acid	1.689	±0.073c	0.727	±0.086d	1.183	±0.025c	0.194	±0.010e	9.962	±0.028b	0.784	±0.063d	20.344	±0.112a	0.170	±0.003e
Apigenin 7 glucoside	0.211	±0.008g	1.228	±0.147c	0.583	±0.029f	0.739	±0.100e	1.664	±0.080a	0.978	±0.118d	1.189	±0.056b	0.747	±0.044e
Resveratrol	0.292	±0.002d	0.116	±0.005e	0.539	±0.019c	0.105	±0.007	0.321	±0.010d	0.807	±0.099b	1.321	±0.122a	0.968	±0.128b
Quercetin	2.290	±0.177a	0.780	±0.090c	1.073	±0.039b	0.570	±0.021d	1.326	±0.074b	1.024	±0.092b	1.078	±0.040b	0.791	±0.083c
Trans-Cinnamic Acid	0.806	±0.053a	0.235	±0.045d	0.530	±0.055c	0.083	±0.008f	0.691	±0.035b	0.070	±0.002f	0.424	±0.017c	0.104	±0.013e
Naringenin	1.842	±0.164a	0.260	±0.025d	0.664	±0.055c	1.738	±0.365a	1.136	±0.128b	0.179	±0.017d	0.724	±0.092a	0.159	±0.014e
Kaempferol	– [c]	–	0.897	±0.096b	0.426	±0.039e	1.143	±0.056a	0.717	±0.085c	0.897	±0.082b	0.623	±0.058d	0.782	±0.100c
Isorhamnetin	5.113	±0.407a	1.039	±0.101e	4.355	±0.061b	3.485	±0.853c	5.753	±0.302a	0.945	±0.059f	3.378	±0.077d	1.012	±0.045e
	SD-5		**D-SD-5**		**SD-6**		**D-SD-6**		**SD-7**		**D-SD-7**		**SD-8**		**D-SD-8**	
Gallic Acid	34.329	±0.383c	31.287	±0.161d	41.836	±1.584b	24.879	±0.844e	44.249	±0.124a	25.574	±0.502e	18.099	±0.883f	17.203	±0.982f
3,4-Dihydroxybenzoic Acid	33.422	±0.346c	24.020	±0.993d	64.103	±0.888a	6.531	±0.374f	37.810	±0.203b	16.677	±0.567e	8.594	±0.719f	5.411	±0.612g
(+)-Catechin	9.289	±0.402f	2.922	±0.296h	45.005	±0.421b	16.549	±0.626d	306.685	±1.672a	27.598	±1.654c	12.612	±0.199e	5.938	±0.511g
1,2-Dihydroxybenzene	1.875	±0.119f	2.518	±0.160e	169.055	±1.436a	5.629	±0.583d	73.691	±0.307b	17.067	±0.425c	18.382	±0.760c	1.961	±0.187f
Syringic Acid	0.185	±0.006d	0.173	±0.006d	29.115	±0.766a	0.831	±0.044d	20.586	±0.301b	0.613	±0.053d	4.518	±0.376c	0.487	±0.017d
Caffeic Acid	2.423	±0.310c	0.403	±0.061e	50.492	±1.589a	0.442	±0.024e	42.850	±0.503b	0.469	±0.047e	1.163	±0.095d	0.483	±0.034e
Rutin trihydrate	0.436	±0.056g	2.851	±0.359d	10.564	±0.498b	0.600	±0.015f	31.808	±0.160a	0.804	±0.091f	5.026	±0.335c	1.179	±0.024e
p-Coumaric Acid	0.037	±0.003d	0.139	±0.011c	1.281	±0.150b	0.087	±0.001d	1.529	±0.300a	0.040	±0.001d	0.116	±0.017c	0.090	±0.009d
Trans-Ferulic Acid	0.280	±0.013e	0.228	±0.026e	7.703	±0.686a	1.843	±0.226d	5.110	±0.911b	2.743	±0.517c	0.187	±0.004e	0.280	±0.030e
Apigenin 7 glucoside	0.278	±0.021g	2.182	±0.008c	0.470	±0.018f	1.565	±0.101d	4.790	±0.061b	18.682	±0.169a	0.381	±0.030f	0.677	±0.058e
Resveratrol	0.264	±0.003c	0.128	±0.014c	0.297	±0.031c	3.100	±0.836a	1.885	±0.441b	0.124	±0.006c	0.321	±0.002c	0.105	±0.004c
Quercetin	1.777	±0.129d	1.198	±0.031d	1.589	±0.036d	4.755	±0.381c	6.886	±0.087a	5.799	±0.799b	1.867	±0.231d	0.438	±0.015e
Trans-Cinnamic Acid	0.330	±0.016c	0.186	±0.015c	0.517	±0.026b	0.172	±0.017c	1.268	±0.146a	0.663	±0.055b	0.407	±0.009c	0.651	±0.083b
Naringenin	0.401	±0.036d	–	–	0.709	±0.012c	0.764	±0.070c	4.119	±0.625a	1.210	±0.142b	1.013	±0.030b	0.391	±0.037d
Kaempferol	–	–	0.444	±0.040b	0.498	±0.055b	0.415	±0.030b	4.297	±0.396a	0.259	±0.023c	–	–	0.292	±0.027c
Isorhamnetin	3.170	±0.258b	0.428	±0.021d	3.723	±0.141b	0.440	±0.046d	6.570	±0.724a	1.121	±0.100c	3.915	±0.085b	0.509	±0.039d

D dried

[a] mean ± standard deviation

[b] Values within each rows followed by different letters are significantly different ($p < 0.05$)

[c] nondetected

reported an average of 1831 mg GAE/100 g total phenolic content in fresh fruit of *Crataegus oxyacantha* grown in Serbia and prepared using methanol. Bahri-Sahloul et al. (2009) also reported varied concentration of phenolic compounds within the range of 499–1477 mg/100 g fresh fruit for 14 genotypes of hawthorn belonging to *C. azarolus* and *C. Oxyacantha.* Additionally, Ruiz-Rodriguez et al. (2014) reported that total phenolic compounds of *Prunus spinosa* (wild blackthorn) fruit and *Crataegus* ranged from 1851 to 3825 mg/g fresh weight and 449 to 1438 mg/g, respectively.

Phenolic compounds identified in fresh and dried fruits are given in Table 3. Gallic acid (2.529), 3,4-dihydroxybenzoic acid (3.097), (+)-catechin (2.987) and isorhamnetin (5.113) in mg/100 g fruit were the major phenolics in fresh SD-1 ($p < 0.05$). The contents of gallic acid (36.137 mg/100 g, 40.010 mg/100 g), (+)-catechin (28.665 mg/100 g, 20.930 mg/100 g), 1,2-dihydroxybenzene (26.431 mg/100 g, 25.139 mg/100 g) and 3,4-dihydroxybenzoic acid (15.440 mg/100 g, 20.797 mg/100 g) were the highest for fresh SD-2 and fresh SD-3, respectively. Rutin trihydrate was found as the dominant phenolic in fresh SD-4 (764.980 mg/100 g), followed by 3,4-dihydroxybenzoic acid and gallic acid. Moreover, Gallic acid, 3,4-dihydroxybenzoic acid and (+)-catechin were the pre-dominant phenolic acids in fresh SD-5. Fresh SD-6 contained the highest concentration of 1,2-dihydroxybenzene (169.055 mg/100 g), 3,4-dihydroxybenzoic acid (64.103 mg/100 g) and caffeic acid (50.492 mg/100 g). (+)-Catechin was the main flavonoid detected in fresh SD-7 (306.685 mg/100 g). There was not important difference in amount of gallic acid (18.099 mg/100 g) and 1,2-dihydroxybenzene (18.382 mg/100 g) ($p < 0.05$), which were the major phenolic compounds of the fresh SD-8. Additionally, all fruit contained minor amounts of the naringenin, *trans*-cinnamic acid, quercetin, resveratrol, apigenin 7 glucoside, *trans*-ferulic acid, *p*-coumaric acid, syringic acid. Generally, oven drying of the fruit slices resulted in significant decrease in phenolic compounds. It was noted that (+)-catechin content of SD-7 decreased from 306.685 mg/100 g to 27.598 mg/100 g when drying process was applied. Drying process also resulted in maximum reduction in rutin trihydrate content of SD-4 (from 764.980 mg/100 g to 0.620 mg/100 g) was observed. 1,2-dihydroxybenzene content of SD-6 decreased from 169.055 mg/100 g to 5.629 mg/100 g. In previous study, Ganhao et al. (2010) and Egea et al. (2010) reported 450 and 216.61 mg GA Eq./100 g total phenol in fruits. In previous study, 1–7 mg/g epicatechin, 2–4 mg/g procyanidin 0.5–1.0 hyperoside and 0.5–0.5 mg/g quercetin. Pontoside were found in hawthorn (*Crataegus grayana*) fruits (2011). Qaradax and Hawranan hawthorn fruits contained 11.99% and 15.52% quercetin, 13.72 and 18.10% nonacosan-10.01 18.25% and 10.82% apigenin, 11.80 and 16.59% kaempferol (Hamahameen and Jamal 2013). The genotypic variation on physico-chemical characteristics of wild grown plums (*Prunus spinosa* L.) was investigated. The total phenolic contents were in a range of 117 to 407 mg GAE/100 g FW (Ertürk et al. 2009). Antioxidant activity of dark purple, red and yellow skin colored plum fruits were found between 71.15–78.99% which lowers than standard BHA (82.07%) (Ertürk et al. 2009).

Tables 4 and 5 show micro and macro elements of fresh and dehydrated fruit samples. İt can be observed from the result that hawthorn and wild pear are rich sources of

Table 4 Mineral contents of fresh and dried hawthorn

Samples		Macro Elements (mg kg^{-1})								
		P		K		Ca		Mg		S
SD_1	100.860	±0.960 [a]	1405.980	±1.560ı	233.890	±0.360ı	65.170	±1.000ı	60,804.150	±0.320g
SD_3	57.920	±0.690g [b]	1667.950	±1.540h	226.110	±0.330ı	98.750	±1.000ı	48,486.790	±0.010ı
SD_4	146.350	±0.450f	1564.190	±1.880hı	0.980	±1.020i	134.130	±1.000hı	62,653.000	±0.040g
SD_5	61.810	±0.850g	1429.980	±1.240h	472.360	±1.000g	154.320	±1.000h	58,033.660	±0.080h
SD_6	245.650	±0.210e	3756.010	±2.250 fg	1832.810	±1.000d	372.140	±1.000ef	57,385.580	±0.100h
SD_7	319.420	±0.320d	2731.420	±2.360g	1841.400	±0.870d	322.680	±1.000f	68,896.430	±0.470g
SD_8	229.880	±1.000e	1821.040	±1.000ı	1192.560	±0.980h	301.520	±1.000f	100,479.180	±1.500f
D-SD_1	367.200	±1.000d	4719.510	±2.300f	605.380	±1.000f	205.510	±1.000g	113,454.710	±0.210e
D-SD_3	167.950	±1.000f	5545.280	±2.020e	839.720	±1.000f	302.800	±1.000f	129,191.330	±0.320d
D-SD_4	904.650	±1.000a	9280.900	±2.000c	1532.690	±2.000e	852.870	±1.000d	144,449.020	±0.140c
D-SD_5	297.370	±1.000e	6552.420	±1.000d	1500.640	±2.000e	497.830	±1.000e	160,945.350	±0.020a
D-SD_6	523.850	±1.000c	11,195.160	±1.000a	3111.560	±2.010c	1295.710	±1.020b	153,190.290	±0.140b
D-SD_7	711.380	±1.360b	10,497.730	±1.000b	5474.340	±2.600a	1011.650	±1.000c	154,066.630	±0.010b
D-SD_8	709.790	±1.960b	10,540.130	±1.690b	4139.820	±0.000b	1501.520	±1.000a	148,390.520	±0.010c

D dried

[a] Mean ± standard deviation

[b] Values within each rows followed by different letters are significantly different ($p < 0.05$)

Table 5 Microelement contents of fresh and dried hawthorn fruits

Samples		Micro Elements (mg kg^{-1})										
		Fe		Zn		Mn		B		Cu		Mo
SD_1	4.940	±1.000hı	1.520	±2.010e	–	–[c]	4.470	±1.000h	0.980	±0.200ef	–	–
SD_3	3.990	±1.000ı	0.440	±1.600f	–	–	3.190	±1.000ı	0.160	±1.000ı	–	–
SD_4	5.280	±1.000h	0.640	±0.650f	–	–	2.370	±1.000i	0.410	±1.000h	0.020	±1.000f
SD_5	4.990	±1.000hı	1.490	±0.980e	1.070	±1.000f	5.420	±1.000h	2.170	±1.000d	0.020	±1.000f
SD_6	8.090	±1.000g	3.350	±1.000c	6.630	±2.010c	6.080	±1.360g	1.890	±1.000e	–	–
SD_7	11.900	±1.000f	5.120	±1.000b	3.940	±1.000d	5.210	±1.250h	2.900	±1.000d	0.040	±1.650e
SD_8	20.530	±1.000d	3.000	±1.000c	1.030	±1.000f	9.890	±0.120f	0.470	±1.000h	0.120	±1.560c
D-SD_1	27.260	±1.000c	1.140	±1.000e	0.400	±1.000g	11.090	±1.000e	2.920	±1.000d	0.020	±1.000f
D-SD_3	9.070	±1.600g	0.200	±1.000g	–	–	9.290	±1.000f	0.610	±2.000g	–	–
D-SD_4	33.710	±0.660b	3.220	±1.000c	0.310	±1.000g	11.540	±1.000e	4.220	±1.000b	0.080	±1.000d
D-SD_5	15.570	±0.980e	2.710	±1.000d	2.280	±1.000e	16.620	±1.000d	5.810	±1.000a	–	–
D-SD_6	12.050	±0.240f	3.710	±1.000c	23.120	±2.030a	17.770	±1.000c	3.860	±1.000c	0.200	±1.000b
D-SD_7	19.010	±1.000d	8.100	±1.000a	13.870	±1.000b	24.130	±1.000b	4.710	±1.000b	0.250	±1.000a
D-SD_8	34.100	±1.000a	5.330	±1.000b	6.010	±1.000c	42.270	±1.000a	1.200	±1.000e	0.120	±1.200c

D dried

[a] Mean ± standard deviation

[b] Values within each column followed by different letters are significantly different ($p < 0.05$)

[c] Nondetected

important macro minerals such as potassium (K), calcium (Ca), sulfur (S), magnesium (Mg) and phosphorus (P). In addition, micro minerals including Fe, Zn, Mn, B, Cu and Mo were also present at a lower levels In addition, the maximum potassium content was observed in fresh SD-6 (3756.010 mg/kg), followed by SD-7 (2731.420 mg/kg) and SD-8 (1821.040 mg/kg). The highest *P* (319.420 mg/kg) and Ca (1841.400 mg/kg) content was obtained from SD-7, while SD-6 had the maximum K (3756.010 mg/kg) and Mg (372.140 mg/kg) content ($p < 0.05$). Moreover, drying process increased the mineral contents of all fruits. There was significant increase in the amount of sulfur after drying process. Variations in total phenolic contents of the fruits as observed in this present study may be linked to factors such as maturity level at harvest, climate, postharvest storage, genotype and geographical location where the fruits were grown (Kostic et al. 2013). Also, the information supplied on the chemical properties of the hawthorn and wild pear fruits can be used in human nutrition.

Conclusion

This present study was conducted to evaluate the effect of drying on the total phenolic compounds and antioxidant activity of hawthorn and wild pear fruits. The result revealed that drying caused a significant reduction in antioxidant activity of the fruits and maximum reduction was observed in sample SD-5. Also, the total phenolic content of all fruits samples decreased after drying. Across all fruits, drying resulted in significant reductions in both total phenolic content and phenolic compounds. Conventional oven drying generally result in significant reduction in phenolic compounds. However, it was observed that dried fruits had the highest mineral contents compared to fresh fruits.

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Conflict of interest M.O. Aladag, S. Doğu, N. Uslu, M.M. Özcan, S. Gezgin and N. Dursun declare that they have no competing interests.

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