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Identification of phenolic profiles, fatty acid compositions, antioxidant activities, and enzyme inhibition effects of seven wheat cultivars grown in Turkey: A phytochemical approach for their nutritional value

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ABSTRACT

In the present article, seven wheat cultivars (Ahmetaga, Bezostaya, Dagdas-94, Ekiz, Karahan-99, Konya-2002, and Tosunbey) grown in Turkey were compared for their phytochemical composition, antioxidant, and enzyme inhibitory activities. Antioxidant capacities and enzyme inhibitory effects were investigated with colorimetric methods. Total phenolic content ranged from 40.71 to 86.34 mg of gallic acid equivalent/100 g wheat grain. Tosunbey (92 mg Trolox equivalent/100 g wheat grain) and Ahmetaga (114.56 mg Trolox equivalent/100 g wheat grain) cultivars exhibited strong 2,2 azino-bis (3-ethylbenzothiazloine-6-sulfonic acid) and 1,1-diphenyl-2-picrylhydrazyl free radical scavenging activities. As compared to other wheat cultivars, Tosunbey cultivar had remarkable both antioxidant and enzyme inhibitory effects with the highest level of phenolics. Ferulic acid, chlorogenic acid, and apigenin were the major phenolics in extracts tested. This study suggested that an increased intake of wheat derived products could represent an effective strategy for the management of oxidative stress related chronic and degenerative diseases such as Alzheimers and diabetes mellitus.

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Introduction

In the last decade, numerous studies confirm that many natural compounds exert a protective action on human health and are key components of a healthy diet.[1] Epidemiological studies have correlated the intake of these compounds, especially phenolics, carotenoids, and tocopherols, with reduced incidence of chronic and degenerative diseases such as cardiovascular diseases, diabetes, cancer, and Alzheimers.[2] The involvement of free radicals (Reactive Oxygen Species (ROS) or Reactive Nitrogen Species (RNS)) in aetiology of the previously mentioned diseases has suggested that phytochemicals with antioxidant effect may contribute to prevention or protection.[3] In addition to the antioxidant role, several phytochemicals have many biological activities, such as enzyme inhibitor, antimicrobial, anti-inflammatory, and anticancer.[4] Therefore, phytochemicals as natural agents have received more attention recently and herbal medicine have been improved in many countries as an alternative remedy to health problems.[5,6]

Wheat is one of the major components of nutrients for the human diet. According to dietary guidelines, wheat and other cereal products are placed at the base of healthy diet pyramid.[7] Besides providing proportions of proteins and carbohydrates, recent studies on the health benefits of

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functional substances, such as phenolic compounds, carotenoids from wheat have become important.[7–9] Thus, the nutraceutical and functional properties of wheat varieties are raising interest among scientists and the food industries as consumers move toward functional foods with favorable health effects. Even though wheat is a staple cereal consumed in different regions of Turkey, there is no published data about biological activities or the chemical profile of Turkish wheat varieties. The present chemical study on Turkish seven wheat varieties is the first in scientific area. For this reason, the purpose of the current work was to determine the phytochemical profiles and evaluate the biological activities of seven varieties of wheat in order to bring together some of the nutritional profile of Turkish wheat varieties. The evaluation of the potential antioxidant capacities of the extracts from wheat samples were conducted using different chemical assays (1,1-diphenyl-2-picrylhydrazyl [DPPH], 2,2 azino-bis (3-ethylbenzothiazloine-6-sulfonic acid; ABTS], ferric ion reducing antioxidant power [FRAP], Cupric reducing power [CUPRAC], and phosphomolybdenum). The inhibitory activities on AChE, BChE, α-amylase, and α-glucosidase were also investigated. Again, the fatty acid and phenolic profiles were determined by gas chromatography-flame ionization detector (GC-FID) and high-performance liquid chromatography-diode array detector (HPLC-DAD) techniques, respectively. The results from the present work can provide highlights for future studies into the health benefits of seven wheat varieties and guide our breeding efforts for better wheat varieties.

Materials and methods

Wheat samples and preparation of the methanolic extracts

Seeds of seven wheat (*Triticum aestivum* L.) cultivars (Ahmetaga, Bezostaya, Dagdas-94, Ekiz, Karahan-99, Konya-2002, and Tosunbey) were provided from Bahri Dagdaş International Agricultural Research Institute, Konya, Turkey. Wheat grain samples (5 g) included were macerated with methanol (100 mL) at room temperature for 24 h. Extracts were filtered through a filter paper. Methanol in the extracts from samples was removed with a rotary evaporator to obtain the extracts in the yield of 4.89, 5.26, 4.33, 4.75, 4.92, 4.12, and 7.30% (w/w), respectively.

Phenolic compounds and fatty acid analysis

Total phenolic and total flavonoid contents were determined by employing the methods given in the literature.[10] Phenolic compounds were evaluated by reversed-phase (RP) HPLC (Shimadzu Scientific Instruments, Kyoto, Japan. Phenolic compositions of the extracts were determined by a modified method of Sarikurkcu et al.[11] Fatty acid analysis was determined by employing the methods given in the literature.[12]

Antioxidant capacity assays

Antioxidant capacity were evaluated by using different chemical tests including phosphomolybdenum, DPPH radical, ABTS radical cation, CUPRAC, and FRAP as previously reported by Zengin et al.[10]

Enzyme inhibitory activity

Enzyme inhibitory effect was tested against cholinesterase (acetylcholinesterase [AChE] and butyrl-cholinesterase [BChE]), tyrosinase, α-amylase, and α-glucosidase. The detailed methods are given in our previous study.[10]

Statistical analysis

All assays were carried out in triplicate for all of the experiments. The results are expressed as mean and standard deviation values (mean ± SD). Differences between means were determined by analysis of variance (ANOVA) with Tukey's honestly significant difference post hoc test with $\alpha = 0.05$, which were analyzed with SPSS v. 14.0. Correlation analyses were performed using a two-tailed Pearson's correlation test.

Results and discussion

Total phenolic contents (TPCs), expressed as milligrams of gallic acid equivalent (GAE)/100 g of wheat grains, were shown in Table 1. The TPC in the wheat cultivars varied in the ranges 40.71–86.34 mg GAE/100 g wheat grain. Significant differences ($p < 0.05$) in TPC values were observed among wheat varieties. Results for total phenolic acid contents in seven wheat cultivar samples were given in Table 2. Six phenolic acids were detected in the selected wheat samples including protocatechuic, chlorogenic, caffeic, ferulic, rutin, and apigenin. Grain samples of seven wheat cultivars were significantly differed in their phenolic acid composition (Table 3). Ferulic acid (2.68–8.76 μg/g) was the predominant phenolic acid followed by apigenin (0.79–9.09 μg/g), chlorogenic (2.06–5.84 μg/g), caffeic (0.98–2.20 μg/g), protocatechuic (0.25–2.20 μg/g), and rutin (0.41–2.17 μg/g) for the seven wheat cultivars tested in this study. Five compounds, catechin, *p*-hydroxybenzoic acid, epicatechin, benzoic acid, and rosmarinic acid, were not detected. Flavonoid contents of wheat cultivars tested were expressed as milligrams of rutin equivalent per 100 g of wheat grain (Table 1). Flavonoid content of wheat cultivars ranged from 2.16–12.61 mg rutin equivalent/100 g wheat grain.

FRAP and CUPRAC assays were used to reducing powers of tested wheat samples and the results were listed in Table 1. In these assays, antioxidant react by donating an electron, thus converting Fe^{3+} to Fe^{2+} in FRAP assay or Cu^{2+} to Cu^{+} in CUPRAC assay. The highest FRAP value was found in the Tosunbey (119.71 mg Trolox equivalent [TE]/100 g wheat grain), while the lowest values were found in the Konya-2002 (58.26 mg TE/100 g wheat grain). There was a significant difference between different wheat cultivar varieties in FRAP activity. As can be seen from the Table 3, FRAP was significantly correlated with TPC ($r = 0.973$), Total Antioxidant Activity (TAA) ($r = 0.869$), and ABTS ($r = 0.926$; $p < 0.01$).

The phosphomolybdenum method has been routinely used to evaluate the antioxidant capacity of extracts. In the presence of extracts, Mo(VI) is reduced to Mo(V) and forms a green-colored phosphomolybdenum V complex, which shows a maximum absorbance at 695 nm. The assay being simple and independent of other antioxidant measurements commonly employed, its application was extended to plant polyphenols. The reducing activities of seven wheat cultivars samples were presented in Table 1. Among all the samples, the highest activity was noted for Tosunbey (4.63 mmol Trolox/100 g wheat grain), followed by lower activity (2.30 mmol Trolox/100 g wheat grain). The DPPH free radical scavenging activity of seven wheat cultivars are ranged from 23.92–114.56 mg TE/100 g wheat grain (Table 1). The ABTS value of the evaluated wheat cultivar samples were between 51.13–92.30 mg TE/100 g wheat grains, respectively (Table 1).

Alzheimers disease is a common complication of oxidative damage. Control of the disease via modulation of cholinesterase (AChE or BChE) by dietary agents could be an important strategy to manage this risk factor. In this investigation, we evaluated the ability of different types of wheat cultivars to inhibit AChE and BChE (Table 4). The results indicated that all the samples had significant inhibitory activity. More specifically, the Tosunbey had the highest inhibitory activity in AChE and BChE. Both AChE and BChE were significantly correlated with TPC, TAA, and FRAP ($r > 0.880$, $p < 0.01$). The methanolic extract of seven wheat cultivars showed 0.42–1.46 mmol acarbose equivalent/100 g wheat grain α-amylase inhibition (Table 4) under *in vitro* assay conditions. A moderate level of α-glucosidase inhibition (0.23–1.78 mmol acarbose equivalent/100 g wheat grain) observed in methanolic extract of seven wheat cultivars (Table 4).

Table 1. Total antioxidant activity by phosphomolybdenum method (TAA), total phenolic (TPC), and flavonoid (TFC) contents, reducing power (CUPRAC and FRAP), and radical scavenging activity (DPPH and ABTS) of the methanol extracts from seven wheat cultivars grown in Turkey.[a]

Sample	CUPRAC[b]	FRAP[b]	DPPH[b]	ABTS[b]	TAA[c]	TPC[d]	TFC[e]
Ahmetaga	116.03 ± 6.52e	72.87 ± 3.20cd	114.56 ± 2.41a	56.59 ± 5.53de	3.53 ± 0.19b	57.25 ± 2.13c	2.85 ± 0.05de
Bezostaya	167.64 ± 4.85b	88.20 ± 3.71b	50.39 ± 3.16c	68.10 ± 4.72bc	3.21 ± 0.14cd	67.19 ± 2.47b	12.61 ± 1.51a
Dagdas-94	150.49 ± 7.57c	75.67 ± 0.71c	47.92 ± 0.40cd	73.31 ± 0.69b	2.78 ± 0.10f	49.89 ± 2.62d	5.74 ± 0.09bc
Ekiz	155.99 ± 4.10bc	73.01 ± 1.24cd	41.31 ± 3.40de	63.45 ± 2.49cd	2.91 ± 0.10ef	54.86 ± 3.12cd	5.00 ± 0.53bcd
Karahan-99	140.69 ± 4.45cd	66.03 ± 2.02d	36.64 ± 1.79e	51.13 ± 1.29e	3.30 ± 0.12bc	51.52 ± 3.22cd	4.58 ± 0.01cd
Konya-2002	132.62 ± 2.30d	58.26 ± 2.74e	23.92 ± 0.46f	53.18 ± 2.15e	2.30 ± 0.08g	40.71 ± 0.32f	2.16 ± 0.05e
Tosunbey	242.47 ± 8.54a	119.71 ± 2.67a	77.57 ± 1.41b	92.30 ± 2.13a	4.63 ± 0.16a	86.34 ± 3.21a	7.22 ± 0.01b

[a]Values expressed are means ± S.D. of three parallel measurements; in the same column, data marked with different letters indicate significant difference ($p < 0.05$).
[b]mg Trolox equivalents/100 g wheat grain.
[c]mmol Trolox equivalents/100 g wheat grain.
[d]mg gallic acid equivalents/100 g wheat grain.
[e]mg rutin equivalents/100 g wheat grain.

Table 2. Phenolic components (μg/g wheat grain) in the methanol extracts from seven wheat cultivars grown in Turkey.[a]

Sample	Protocatechuic acid	Chlorogenic acid	Caffeic acid	Ferulic acid	Rutin	Apigenin
Ahmetaga	2.20 ± 0.07a	2.93 ± 0.20c	2.20 ± 0.02a	5.87 ± 0.07b	1.96 ± 0.12a	8.56 ± 0.05b
Bezostaya	1.84 ± 0.08b	2.63 ± 0.21cd	1.05 ± 0.05d	3.16 ± 0.08e	0.79 ± 0.13cd	0.79 ± 0.03g
Dagdas-94	0.43 ± 0.02e	4.76 ± 0.17b	2.17 ± 0.02a	3.68 ± 0.06d	2.17 ± 0.11a	9.09 ± 0.04a
Ekiz	1.66 ± 0.07bc	2.85 ± 0.19cd	1.90 ± 0.02b	3.80 ± 0.07d	Nd	1.19 ± 0.02f
Karahan-99	0.25 ± 0.02e	2.71 ± 0.20cd	0.98 ± 0.05d	5.17 ± 0.07c	1.23 ± 0.12bc	2.21 ± 0.02e
Konya-2002	1.44 ± 0.06c	2.06 ± 0.16d	1.44 ± 0.02c	2.68 ± 0.06f	0.41 ± 0.10d	4.33 ± 0.02d
Tosunbey	0.73 ± 0.04d	5.84 ± 0.29a	1.46 ± 0.07c	8.76 ± 0.11a	1.46 ± 0.18b	8.03 ± 0.04c

[a]Values expressed are means ± S.D. of three parallel measurements; in the same column, data marked with different letters indicate significant difference ($p < 0.05$).
Nd: not detected; (+)-Catechin, *p*-hydroxybenzoic acid, (-)-epicatechin, benzoic acid, and rosmarinic acid were not detected.

Table 3. Correlation coefficients between assays.[a]

	TPC	TFC	TAA	DPPH	ABTS	CUPRAC	FRAP	AChE	BChE	AAIA
TFC	0.58									
TAA	0.92**	0.30								
DPPH	0.48	–0.04	0.63							
ABTS	0.82*	0.49	0.68	0.26						
CUPRAC	0.88*	0.50	0.74	0.07	0.91**					
FRAP	0.97**	0.56	0.87*	0.41	0.93**	0.93**				
AChE	0.95**	0.40	0.94**	0.40	0.77*	0.89**	0.94**			
BChE	0.89**	0.30	0.96**	0.52	0.72	0.79*	0.88**	0.96**		
AAIA	0.59	0.60	0.43	–0.40	0.61	0.84*	0.64	0.65	0.51	
AGIA	0.92**	0.44	0.93**	0.71	0.73	0.67	0.87*	0.83*	0.84*	0.32

[a]Data represents Pearson Correlation Coefficient R.
*Indicates $p < 0.05$.
**Indicates $p < 0.01$.
TPC and TFC: total phenolic and flavonoid content, respectively; TAA: total antioxidant activity by phosphomolybdenum method; AChE: acetyl cholinesterase; BChE: butyryl cholinesterase; AAIA: α-amylase inhibition activity; AGIA: α-glycosidase inhibition activity.

Table 4. Enzyme inhibitory activity of the methanol extracts from seven wheat cultivars grown in Turkey.[a]

Sample	Acetyl cholinesterase[b]	Butyryl cholinesterase[b]	α-Amylase[c]	α-Glycosidase[c]
Ahmetaga	2.55 ± 0.09cd	0.51 ± 0.09b	0.42 ± 0.05d	1.29 ± 0.16ab
Bezostaya	2.77 ± 0.06b	0.46 ± 0.02bc	1.21 ± 0.06b	1.16 ± 0.18b
Dagdas-94	2.24 ± 0.02e	0.33 ± 0.01bc	0.94 ± 0.09c	0.91 ± 0.02b
Ekiz	2.41 ± 0.04d	0.20 ± 0.11c	1.01 ± 0.09bc	0.98 ± 0.14b
Karahan-99	2.60 ± 0.03c	0.50 ± 0.06b	1.14 ± 0.10bc	0.87 ± 0.08b
Konya-2002	2.18 ± 0.02e	0.21 ± 0.04c	0.89 ± 0.04c	0.23 ± 0.07c
Tosunbey	3.91 ± 0.05a	1.08 ± 0.09a	1.46 ± 0.16a	1.78 ± 0.19a

[a]Values expressed are means ± S.D. of three parallel measurements; in the same column, data marked with different letters indicate significant difference ($p < 0.05$).
[b]mg galanthamine equivalents/100 g wheat grain.
[c]mmol acarbose equivalents/100 g wheat grain.

The fatty acid composition of the wheat cultivars was presented in Table 5. A total of 20 individual fatty acids were identified which ranged from C 10:0 to C 21:0. The dominant fatty acids in all tested samples were in this order: C 18:2 ω6 (linoleic), C 16:0 (palmitic), and C 18:1 ω9 (oleic). Oleic and stearic (C 18:0) fatty acids were presented in all wheat oils in relatively high amounts ranging from 15.13 to 19.62% and 1.64 to 5.16%, respectively. The other fatty acids including lauric (C 12:0), myristic (C 14:0), palmitoleic (C 16:1 ω7), and arachidic acid (C 20:0) were in minute quantities. This study also showed variation among the wheat cultivars for total content of saturated fatty acids (SFA; 37.76–45.20%), monounsaturated fatty acids (MUFA; 18.33–22.03%), and polyunsaturated fatty acids (PUFA; 32.77–43.41%). SFA content in oils from four wheat cultivars (Dagdas-94, Tosunbey, Ekiz, and Konya-2002) was higher than PUFA. Bezostaya

Table 5. Fatty acid composition of seven wheat cultivars grown in Turkey (%).[a]

Fatty acids	Wheat varieties						
	Ahmetaga	Bezostaya	Dagdas-94	Ekiz	Karahan-99	Konya-2002	Tosunbey
C 10:0	0.08 ± 0.01b	0.02 ± 0.01e	0.29 ± 0.01a	0.04 ± 0.01de	0.07 ± 0.01bc	0.05 ± 0.01cd	0.06 ± 0.01bcd
C 12:0	0.60 ± 0.05a	0.08 ± 0.01c	0.12 ± 0.01c	0.11 ± 0.01c	0.55 ± 0.01ab	0.07 ± 0.01c	0.50 ± 0.01b
C 13:0	0.43 ± 0.06b	0.03 ± 0.02d	0.09 ± 0.01cd	0.17 ± 0.01c	0.90 ± 0.01a	0.11 ± 0.01cd	0.82 ± 0.02a
C 14:0	1.42 ± 0.07a	0.32 ± 0.10b	0.44 ± 0.17b	0.45 ± 0.18b	1.43 ± 0.01a	0.48 ± 0.01b	1.16 ± 0.03a
C 15:0	1.84 ± 0.18a	0.36 ± 0.12b	0.41 ± 0.28b	0.58 ± 0.16b	1.40 ± 0.30a	0.35 ± 0.01b	0.29 ± 0.01b
C 16:0	26.94 ± 0.18e	30.78 ± 0.33c	33.68 ± 0.01b	30.02 ± 0.34c	24.10 ± 0.60f	35.83 ± 0.01a	28.49 ± 0.16d
C 17:0	3.49 ± 0.08a	0.83 ± 0.18c	1.23 ± 0.22c	1.71 ± 0.05b	3.13 ± 0.01a	1.13 ± 0.01c	3.31 ± 0.07a
C 18:0	1.64 ± 0.06f	3.28 ± 0.02e	3.57 ± 0.01d	4.48 ± 0.08b	5.16 ± 0.05a	4.21 ± 0.05c	4.50 ± 0.06b
C 20:0	0.38 ± 0.03b	0.50 ± 0.03ab	0.56 ± 0.04ab	0.53 ± 0.03ab	0.44 ± 0.13ab	0.66 ± 0.05a	0.42 ± 0.06ab
C 21:0	1.97 ± 0.14bc	1.59 ± 0.01bc	4.83 ± 0.65a	2.55 ± 0.02b	1.35 ± 0.08c	2.02 ± 0.09bc	1.47 ± 0.05c
ΣSFA	38.78 ± 0.09c	37.76 ± 0.04c	45.20 ± 0.08a	40.62 ± 0.65b	38.50 ± 0.18c	44.89 ± 0.06a	41.00 ± 0.12b
C 14:1 ω5	0.30 ± 0.06bc	0.03 ± 0.01d	0.39 ± 0.01b	0.05 ± 0.01cd	1.39 ± 0.16a	0.02 ± 0.01d	1.50 ± 0.01a
C 15:1 ω5	0.40 ± 0.12a	0.10 ± 0.04b	0.11 ± 0.04b	0.13 ± 0.04b	0.35 ± 0.04a	0.12 ± 0.01b	0.26 ± 0.01ab
C 16:1 ω7	0.58 ± 0.16a	0.12 ± 0.03b	0.27 ± 0.11b	0.15 ± 0.01b	0.30 ± 0.08ab	0.13 ± 0.02b	0.35 ± 0.01ab
C 17:1 ω7	0.34 ± 0.02a	0.09 ± 0.01b	0.11 ± 0.10ab	0.17 ± 0.02ab	0.25 ± 0.11ab	0.15 ± 0.03ab	0.30 ± 0.01ab
C 18:1 ω9	19.06 ± 0.97ab	17.45 ± 0.88b	19.62 ± 0.34a	17.70 ± 0.06ab	15.13 ± 0.06c	17.24 ± 0.04bc	16.99 ± 0.49bc
C 20:1 ω9	0.97 ± 0.02a	1.06 ± 0.04a	1.54 ± 0.06a	1.28 ± 0.33a	0.93 ± 0.12a	0.89 ± 0.04a	1.08 ± 0.42a
ΣMUFA	21.63 ± 0.95a	18.84 ± 0.91bc	22.03 ± 0.35a	19.47 ± 0.32bc	18.33 ± 0.18c	18.54 ± 0.01bc	20.48 ± 0.06ab
C 18:2 ω6	37.00 ± 0.71b	39.58 ± 0.86a	29.52 ± 0.34e	34.78 ± 0.25c	38.27 ± 0.05ab	33.06 ± 0.08cd	32.39 ± 0.08d
C 18:3 ω6	0.47 ± 0.02d	1.26 ± 0.16c	1.66 ± 0.04c	2.81 ± 0.17b	3.19 ± 0.34ab	1.25 ± 0.04c	3.79 ± 0.29a
C 18:3 ω3	1.89 ± 0.04ab	2.14 ± 0.04a	1.34 ± 0.02c	1.83 ± 0.08ab	1.40 ± 0.26c	1.63 ± 0.03bc	1.86 ± 0.01ab
C 20:2 ω6	0.24 ± 0.07d	0.44 ± 0.09bc	0.26 ± 0.01cd	0.49 ± 0.01ab	0.33 ± 0.04bcd	0.64 ± 0.04a	0.50 ± 0.01ab
ΣPUFA	39.59 ± 0.85b	43.41 ± 0.95a	32.77 ± 0.27d	39.91 ± 0.33b	43.18 ± 0.01a	36.58 ± 0.05c	38.53 ± 0.18bc
ΣUFA	61.22 ± 0.10ab	62.24 ± 0.04a	54.80 ± 0.08c	56.55 ± 3.34bc	61.50 ± 0.18ab	55.12 ± 0.06c	59.01 ± 0.12abc
EFA	38.89 ± 0.76ab	41.71 ± 0.89a	30.86 ± 0.32e	36.61 ± 0.18c	39.66 ± 0.31b	34.69 ± 0.05d	34.25 ± 0.10d
Σω3	1.89 ± 0.04ab	2.14 ± 0.04a	1.34 ± 0.02c	1.83 ± 0.08ab	1.40 ± 0.26c	1.63 ± 0.03bc	1.86 ± 0.01ab
Σω6	37.70 ± 0.81b	41.27 ± 0.92a	31.44 ± 0.29d	38.08 ± 0.41b	41.78 ± 0.25a	34.95 ± 0.08c	36.67 ± 0.20bc
AI	0.54 ± 0.01bc	0.52 ± 0.01bc	0.65 ± 0.01a	0.58 ± 0.04b	0.49 ± 0.01c	0.69 ± 0.01a	0.57 ± 0.01b
TI	0.85 ± 0.01a	0.94 ± 0.01a	1.22 ± 0.01a	1.27 ± 0.34a	0.90 ± 0.04a	1.28 ± 0.01a	1.00 ± 0.01a

[a]Values expressed are means ± SD of three parallel measurements; in the same row, data marked different letters indicate significant difference ($p < 0.05$).
[b]SFA: saturated fatty acids; MUFA: monounsaturated fatty acids; PUFA: polyunsaturated fatty acids; UFA: unsaturated fatty acids; EFA: essential fatty acids; AI: atherogenic index; TI: thrombogenic index.

gave the highest levels of PUFA (43.41%) and the lowest levels of SFA (37.76%). SFA content was higher in Dagdas-94 and Konya-2002 (45.20 and 44.89%, respectively), due to palmitic acid. Again, *trans* isomers of unsaturated fatty acids were not detected in studied wheat oils.

The ranges of TPC from the present study were greater than those of 113–371 μg of GAE/g in three winter wheat flours reported by Yu et al.[13] The high TPC of whole grain and bran are due to the presence of pericarp and aleurone layers which are rich in antioxidant compounds.[14] Our present findings are contrary to Junli et al.[15] which reported that greatest TPC value of 2.00 mg of GAE/g wheat flour was detected in the flour extract from SSMPV57 wheat, while flour extract from SS5205 variety had the lowest TPC value of 1.66 mg of GAE/g. As can be seen from the Table 2, TPC was significantly ($p < 0.01$) correlated with TAA ($r = 0.918$), FRAP ($r = 0.973$), AChE ($r = 0.933$), BChE ($r = 0.981$), and AGIA ($r = 0.918$), as well as ABTS ($r = 0.821$) and CUPRAC ($r = 0.863$; $p < 0.05$). HPLC is a traditional technique for the analysis of phenolic compounds, such as phenolic acids and polyphenols, such as flavonoids.[16] Thus, the wheat phenolics are more likely to exert health benefits in the colon where they are released. This may partly explain the reduced incidence of colon cancers and other chronic diseases associated with the consumption of wheat grain products.[17] The accumulation of the ferulic acid was due to the phenolic biosynthesis and hydrolysis of polyphenolic compounds bound to cell walls, as reported by Yang et al.[18] The increase in the free ferulic acid content found in sprouted wheat suggests an improved bioavailability and a higher antioxidant potential. Many studies have focused on flavonoid content in grains due to the potential contribution of flavonoids to human health. Our present findings are similar to Chlopicka et al.[19] who reported that the total flavonoid content in wheat flour is 70 μg/g dry weight (DW). On the other hand, our present findings are contrary to Lazarova et al.,[20] who reported that the flavonoid content in the wheat varieties ranged from 14.7 to 39.7 mg/100 g, with a mean value of 25.2 mg/100 g. Flavonoids have been shown to exhibit potent antioxidant and anticancer activities,[21] and, thus, may contribute to the health benefit of whole grains. Moreover, the differences observed for both total bioactive components and biological activities may be explained with different extraction techniques used. Similar findings were detected for several cereals. For example, Gangopadhyay et al. [22] were reported for oat and barley; Barros et al. [23] and Menga et al [24] were reported for sorghum bran and triticale. In this sense, the selection of extraction techniques is a very important point for bioactive components in the cereals.

Different free radicals should be used and antioxidant score calculated as done by Cao et al.[25] or should be preferably used the FRAP assay, which is the only assay that the CUPRAC value of the seven wheat cultivars was ranged from 116.03–242.47 mg TE/100 g wheat grain (Table 1). There was a significant and strong correlation between CUPRAC and ABTS ($r = 0.905$, $p < 0.01$) directly measures antioxidants or reductants in a sample as done by Halvorsen et al.[26] Since different methods were used to determine and report DPPH scavenging capacity, it was difficult to quantitatively compare the results from the present study with that from the previous studies. This trend is confirmed by literature data on the antioxidant properties of different cereal grains,[27,28] but it is difficult to make a precise comparison between reports due to the different units of measurement used to express the AA (i.e., TEs, mmol of vitamin C equivalent, mg extracts/mL, etc.). Our present study is similar to Dordevic et al.,[29] it showed that no correlation existed between TPC and DPPH radical scavenging activity in cereals. The cereals with higher TPC values were not necessarily better in DPPH inhibition. According to Brandwilliams et al.,[30] ferulic acid, the main phenolic acid in cereal grains, showed a weak antiradical effect in experiments with the DPPH radical, which may explain the discrepancies. In examining the results, significant differences ($p < 0.05$) in ABTS value were observed among the wheat cultivars. This was contradicted with the previous observation that no ABTS scavenging capacity was determined in any flour samples from Colorado grown hard wheat varieties under the experimental conditions.[13] These differences may be explained by different varieties and fraction of wheat. Taken together, the results in this study indicated that wheat variety and growing location had a significant influence on its antioxidant activities.

The amylase inhibition abilities is lower than cereal grains such as wheat, buckwheat, corn, and oats (38–55%),[31] Foxtail millet (32%), Proso millet (55%), and finger millet (55%).[32] Low level of α-amylase

inhibitors from natural fruits, vegetables, and legume grains offers the control of postprandial hyperglycemia[33] as high amylase inhibition resulted harmful side effects to human beings. The glucosidase inhibition abilities is higher than reported results in wheat, buckwheat, corn, and oats (18–31%),[31] and comparable to Proso millet (77%), finger millet (78%),[32] and *M. pruriens* seeds (79%).[34] α-glucosidase was significantly correlated with TPC ($r = 0.918$, $p < 0.01$), TAA ($r = 0.932$, $p < 0.01$), FRAP ($r = 0.872$, $p < 0.05$), AChE ($r = 0.834$, $p < 0.05$), and BChE ($r = 0.835$, $p < 0.05$). However, it should be noted that these results are based on *in vitro* biochemical tests as an indicator of anti-glycaemic effects in the prevention/management of type II diabetes and have limited implications to what happens *in vivo*.

These results for fatty acid composition were within ranges reported in some wheat cultivars[35,36] and cereals like *Sorghum bicolor*[35,36] and *Eleusine coracana*.[37] The content of linoleic acid in the tested oils range from 29.52 to 39.58% and was followed by palmitic acid which was also present in high amounts varying from 24.10% up to 35.83%. From a nutritional and biochemical point-of-view, linoleic, and α-linoleic acid (C 18:3 ω3) are considered as essential fatty acids (EFAs), and thus, must be obtained from the diet. Also, a deficient intake of EFAs can be responsible for many diseases including dermatitis and cardiac disfunctions. In all studied wheat species, levels of EFAs were determined as approximately 30–42% in percentage of all fatty acids. The highest EFAs content was determined in Bezostaya with 41.71%, while Dagdas-94 revealed the lowest levels with 30.86%. Regarding the thrombogenic (TI) and atherogenic potential (AI) of wheat oils, Ahmetaga, Bezostaya, and Karahan-99 cultivars have a nutritional values with low values of AI and TI. From this point, the high content of unsaturated and EFAs, and lack of *trans* fatty acids in wheat oils (especially, Bezostaya and Karahan-99 cultivars) could be making the oils important for a variety of health applications.

Conclusions

Based on the results of this study, a wide variation was observed in the antioxidant activity, enzyme inhibitory capacity and phytochemical composition of seven wheat cultivars from Turkey. As far as we know, this is the first report on the antioxidant, enzyme inhibitory properties, and phytochemical composition of these wheat varieties. The present study revealed that wheat extracts demonstrated high phenolic content and strong antioxidant and enzyme inhibitory properties. Tosunbey cultivar had the highest antioxidant and enzyme inhibitory activities with the highest level of phenolics and flavonoids. Six phenolic compounds (protocatechuic acid, cholorogenic acid, caffeic acid, ferulic acid, rutin, and apigenin) were detected in the studied extracts and generally, ferulic acid had the highest level followed by chlorogenic acid. Again, 20 fatty acids in wheat oils were detected by GC-FID technique and linoleic, palmitic, and oleic acid were identified as the most abundant fatty acids. It can be concluded that the wheat varieties appear to be good sources of natural agents, and, therefore, could be of significance for use in several industries, such as the food and drug industries. The results may also provide as a scientific basis for wheat breeding efforts to increase quality of wheat flours for human health.

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