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Chemical, nutritional and bioactive properties of common buckwheat cultivars bred in Turkey

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RESEARCH ARTICLE

Abstract

The objective of this study was to determine some chemical, nutritional and bioactive properties, such as total phenolic compound, antioxidant activity, dietary fibre, enzyme resistant starch, and rutin and quercetin contents of common buckwheat cultivars (Güneş cv. and Aktaş cv.) bred in Turkey. They were prepared as wholegrain buckwheat and buckwheat groat flours. Protein contents were in the range of 14.4-15.4%. Average total dietary fibre, total starch and resistant starch contents of wholegrain buckwheat and buckwheat groat flours were 29.5 and 7.6%, 52.9 and 78.1%, 4.64 and 4.38%, respectively. Total phenolic compound contents and antioxidant activity were higher in wholegrain buckwheat flours than that of the buckwheat groat flours. Rutin flavonoid contents of the wholegrain buckwheat flours were higher than that of the buckwheat groat flours. An average quercetin flavonoid contents in wholegrain buckwheat flours and buckwheat groat flours were found as 10.8 and 11.23 mg/100 g of flour, respectively.

Keywords: wholegrain buckwheat flour, buckwheat groat flour, bioactive compound, nutritional property, flavonoids

1. Introduction

Buckwheat, which is a dicotyledonous plant of cool climates adapted to high altitude and has short growing period, belongs to the *Polygonaceae* family. Generally, there are many species of buckwheat in the world, and mainly 9 species have an agricultural meaning. Among these species, only common buckwheat (*Fagopyrum esculentum,* Möench) is frequently grown, while a small amount of *Fagopyrum tartaricum* is grown in some mountainous regions. Common buckwheat is also recognised as an important functional food in Eastern Europe and Asian countries (Li and Zhang, 2001; Min *et al.*, 2010; Qian *et al.*, 1998).

Buckwheat is a gluten-free product (3.8-5.2 mg prolamins/100 g seed) and has more lysine content than cereal grains (Min *et al.*, 2010; Qian *et al.*, 1998; Wijngaard and Arendt, 2006). Buckwheat has received much attention due to its excellent nutritional qualities for humans recently. Buckwheat, which is added to food as an ingredient, can provide beneficial health effects and also act as an antioxidant during processing. Buckwheat flour contains several functional substances with beneficial health effects, such as rutin and quercetin flavonoids. Rutin provides anti-inflammatory, anti-hypertensive, and antioxidant activities. Cereals and other pseudocereals do not contain rutin flavonoid. Traditionally, buckwheat flour has been simply incorporated into food formulations instead of wheat flour (Min *et al.*, 2010).

Buckwheat is a very new pseudocereal crop in Turkey. Because of an increasing demand to the gluten-free and functional plant products, buckwheat is attracted an attention by the plant breeders in Turkey. The aim of this study was to determine some nutritional and bioactive properties of two common buckwheat cultivars (Güneş cv. and Aktaş cv.), which were bred in the Bahri Dağdaş International Agricultural Research Institute in Turkey, and prepared as wholegrain buckwheat and buckwheat groat flours. Thus, the new buckwheat cultivars can be utilised in cereal products by food industry and the farming of buckwheat can be extended in different regions of Turkey.

2. Materials and methods

The Turkish buckwheat (*F. esculentum* Moench) cultivars (Güneş cv. and Aktaş cv.), which were bred in the Bahri Dağdaş International Agricultural Research Institute in Turkey, and certified by the Turkish Ministry of Food, Agriculture and Livestock in 2008. Güneş cv. and Aktaş cv. buckwheat cultivars harvested in the year of 2013 growing season were used and analysed in this study. Güneş cv. and Aktaş cv. buckwheat flours were prepared as wholegrain buckwheat flours (WGBF-Gunes and WGBF-Aktas, respectively) and buckwheat groat flours (BGF-Gunes and BGF-Aktas, respectively). Whole grain buckwheat flours were prepared with hull (husk) after dry-milling in hammer mill (BASTAK, Ankara, Turkey). Buckwheat groat flours were prepared after cracking the seed and removing the husk, and then buckwheat groats were hammer-milled to get fine flours from each cultivar.

Determination of chemical properties

Moisture, ash, crude oil and protein contents were determined according to American Association of Cereal Chemists International (AACCI) approved methods for analysis (AACCI, 2010) Methods No. 44-15.02, 08-01.01, 30-25.01 and 46-12.01, respectively. The titration acidity was determined on the basis of sulphuric acid according to Wheat Flour Standard 4500/June 2010 Titration Acidity Method of Turkish Standard Institute (TSI, 2010).

Determination of total dietary fibre, total starch and enzyme resistant starch

Total dietary fibre, total starch and resistant starch contents of buckwheat flours were determined by using Megazyme Total Dietary Fiber, Total Starch and Resistant Starch Assay Kits (Megazyme International Irealand Ltd., Wicklow, Ireland). Wholegrain buckwheat flours were also sieved from 212 µm sieve (Retsch, Germany) and analysed.

Determination of water solubility and water binding capacity

Water solubility (WS, %) and water binding capacity (WBC, %) values of the buckwheat flours were determined based on the original method of Singh and Singh (2003) with slight modifications as described in detail in our previous study (Masatcioglu *et al.*, 2014).

Determination of total phenolic compound

Total phenolic compound (TPC) contents were determined colorimetrically using the Folin-Ciocalteu phenol reagent. The phenolic compound extractions were carried out using dimethyl sulfoxide (DMSO) solvent according to the methods of Gutfinger (1981) and Singleton *et al.* (1999), absolute ethyl alcohol and methyl alcohol solvents according to the methods of Ragaee *et al.* (2006) and Zielinski and Kozlowska (2000). Then, the absorbances were determined at 725 nm wavelength (Shimadzu 1700; Shimadzu, Kioto, Japan). The standard lines with each solvent were prepared using gallic acid. The mean values calculated from triplicate analysis were stated as mg gallic acid equivalent (GAE)/g on dry weight basis (dwb).

Determination of antioxidant activity

Antioxidant activity (AOA) was first determined with 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical scavenging activity (%) method (Yu *et al.*, 2002). The absorbance of the blank (absolute methylalcohol) was always higher than that of the sample absorbance in and UV-VIS spectrophotometer (Shimadzu, Kyoto, Japan) adjusted to 517 nm. After reading two sample absorbance values at the end of 30 min reaction period, one blank absorbance value was determined.

AOA was also calculated according to the reducing of DPPH radical by 6-hydroxy-2,5,7,8-tetramethylchromane-2-carboxylic acid (Trolox) as described by Masatcioglu *et al.* (2013). The standard line was prepared according to inhibition rate (%) against Trolox concentration. The mean values calculated from triplicate analysis were stated as mmol Trolox equivalent/kg on dwb.

AOA was further determined with Trolox equivalent antioxidant capacity (TEAC) assay based on the reducing of the 2,2'-azino-di-3-ethylbenzthiazoline sulphonate ($ABTS^+$) radical cation by antioxidants presented in buckwheat flour extracts (Masatcioglu *et al.*, 2013). The rate of inhibition (%) was determined after 6 min reaction of buckwheat flour extract/or Trolox with $ABTS^+$ radical cation. The standard line was drawn according to inhibition rate (%) against Trolox concentration. The scavenging activity of buckwheat flour extracts was expressed as mmole Trolox equivalent/kg on dwb.

Determination of rutin and quercetin flavonoids

The rutin and quercetin flavonoids contents of the buckwheat cultivars were determined in high performance liquid chromatography (HPLC, Shimadzu-Prominence 20A) according to Sedej *et al.* (2012) with slight modifications. HPLC equipment donations were as follow: Shimadzu LC 20AD pump, SPD-M20A model DAD Detector (280-350 nm), CTO-20AC model colon oven, C18 colon (250×4.60 mm, 5 µm; Browlee Analytical, Perkin Elmer, Waltham, MA, USA). Analysis conditions were as follow: mobile phase flow speed 0.8 ml/min, 30 °C colon temperature, 10 µl sample injection. Mobile phase linear gradient system was created by varying the proportion of methanol (solvent A) to 1.0% formic acid in ultra-pure water (v/v, solvent B) as follows: initial 10% A; 0-10 min: 10 to 90% B; 10-20 min: 25 to 75% B;

20-30 min: 60 to 40% B; 30-40 min: 70 to 30% B; 40-45 min: 10 to 90% B. The run time and post-run time were 45 and 10 min, respectively. Elutes from the column were detected at 350 nm with the retention time being 20 min for rutin and at 330 nm with the retention time being 24 min for quercetin. The peak areas were used for the quantification of rutin and quercetin contents based on their standard calibration curves. For the standard calibration curves, rutin or quercetin standards (Sigma-Aldrich, St. Louis, MO, USA) were prepared at different concentrations (10-100 mg/l) and then the calibration curves and regression lines were drawn as a result of duplicate analysis and average values were used. The LC-Solution software was used for the quantifications.

Rutin and quercetin extractions for HPLC analysis were carried out according to a method of Jiang *et al.* (2006) after slight modifications. 0.2 g finely ground buckwheat flour sample was added to a 15 ml polypropylene tube, and 8 ml 80% methylalcohol was added, and then the sample was extracted at 70 °C for 50 min. After cooling to room temperature, the samples were centrifuged at 9,000×*g* for 10 min. Supernatant was collected in separate tube and the pellet was re-extracted by adding 1 ml 80% methylalcohol, then the tube was centrifuged again. The supernatants were combined, and total volume was completed to 9 ml. Prior to injection of the extracts into the colon, they were filtered through a PTFE filter (Merck Millipore, Carrigtwohill, Ireland) having a 0.45 µm pore size. The sample extraction was accomplished as triplicate and analysed separately. The rutin and quercetin contents (mg/100 g of flour) were given as an average of triplicate analysis on dwb.

Statistical analysis

The mean values calculated from triplicate analysis were given on dwb. Data were analysed using multiple-way analysis of variance (GLM) in IBM SPSS (Version 20.0 for Windows; Armonk, NY, USA) statistical programme. The Duncan multiple comparison test was applied to determine the differences among means according to 5% confidential level.

3. Results and discussion

Chemical and water solubility and water binding capacity properties

Some chemical properties of buckwheat flours are shown in Table 1. Moisture, crude protein, ash and crude oil contents were in the ranges of 11.6-12.6%, 14.4-15.4%, 1.78-3.02%, 3.0-3.8%, respectively. It was obvious that wholegrain buckwheat flours had higher ash contents than that of the buckwheat groat flours ($P<0.05$). The highest crude oil content (3.8%) was found in the sample of WGBF-Gunes ($P<0.05$). Titration acidity calculated on the basis of sulphuric acid was in the range of 0.13-0.22%. According to previous works, the moisture content of wholegrain buckwheat and buckwheat groat flours was similar with the findings of this study and ranged between 9.6-11.4% and 10.0-12.5%, respectively (Kreft *et al.*, 2006; Sedej *et al.*, 2012; Steadman *et al.*, 2001a). Protein contents of wholegrain and groat flours were reported as 14.3% and 12.3% (Bonafaccia *et al.*, 2003); 16.8% and 12.3% (Li and Zhang, 2001), respectively. The protein content of buckwheat groat flour was also determined as 11.9% by Ratan and Kothiyal (2011). Protein contents of wholegrain and groat flours were also found in the ranges of 8.3-14.2% (Sedej *et al.*, 2012) and 12.4-13.4% (Sedej *et al.*, 2010), respectively. The protein content findings in this study were similar to the values of previous works. The ash contents of wholegrain buckwheat flour and buckwheat groat flours were in the ranges of 1.93-2.90% and 0.98-2.40%, respectively, (Biacs *et al.*, 2002; Ratan and Kothiyal, 2011; Sedej *et al.*, 2012; Steadman *et al.*, 2001a). The ash contents in this study were similar to the values of previous works. The crude oil content in wholegrain buckwheat flour and buckwheat groat flour has been reported as 2.3 and 3.2% (Li and Zhang, 2001), and as 2.4 and 1.7% (Ratan and Kothiyal, 2011), respectively.

WS and WBC properties of buckwheat flours are shown in Table 1. WS values ranged from 6.3-8.7% in buckwheat flours. WS values of wholegrain buckwheat flours were higher than that of the buckwheat groat flours ($P<0.05$). Besides, WBC values ranged between 164.8-228.3%. WBC values of wholegrain buckwheat flours were higher than that

Table 1. Some chemical properties and water solubility (WS) and water binding capacity (WBC) properties of buckwheat flours.[1]

Buckwheat flours	Moisture (%)	Protein[2] (%)	Ash[2] (%)	Crude oil[2] (%)	Titration acidity[3] (%)	WS (%)	WBC (%)
WGBF-Gunes	11.7±0.00^{c}	15.4±0.06^{a}	3.02±0.107^{a}	3.8±0.09^{a}	0.17±0.000^{b}	8.7±0.06^{a}	223.4±6.19^{a}
BGF-Gunes	11.6±0.01^{c}	14.4±0.13^{b}	1.89±0.194^{b}	3.2±0.06^{b}	0.13±0.000^{c}	6.3±0.06^{b}	164.8±4.38^{b}
WGBF-Aktas	12.0±0.08^{b}	14.4±0.11^{b}	2.97±0.064^{a}	3.1±0.01^{b}	0.22±0.035^{a}	8.5±0.31^{a}	228.3±6.40^{a}
BGF-Aktas	12.6±0.13^{a}	15.4±0.08^{a}	1.78±0.000^{b}	3.0±0.03^{b}	0.16±0.006^{bc}	6.6±0.06^{b}	174.7±3.88^{b}

[1] Mean ± standard deviation (n=3); values followed by the same letter in the same column are not significantly different ($P>0.05$).
[2] Calculated on the basis of dry weight basis.
[3] Calculated on the basis of sulphuric acid.

of the buckwheat groat flours (P<0.05). It was reported that WBC values of two different buckwheat groat flours were 102 and 94% (Acquistucci and Fornal, 1997). WBC values of lyophilised and spray-dried buckwheat groat flours were informed as 171 and 250%, respectively (Zheng *et al.*, 1998).

Specific nutritional properties

From the nutritional point of view, total dietary fibre (TDF), total starch (TS) and resistant starch (RS) contents of buckwheat flours were investigated and are shown in Table 2. The determination of the moisture contents of buckwheat flours was repeated and they ranged between 10.6 and 12.0%. The highest TDF contents in WGBF-Gunes and WGBF-Aktas flours were 29.2 and 29.7%, respectively (P>0.05). The lowest TDF contents found in BGF-Gunes and BGF-Aktas were 7.5 and 7.7%, respectively (P>0.05). After sieving of wholegrain buckwheat flours from 212 µm sieves, TDF values in Güneş and Aktaş cultivars were 10.8 and 13.0%, respectively (P<0.05). Besides, the highest TS content was found in BGF-Aktas (79.6%), followed by BGF-Gunes with 76.6% (P<0.05). TS contents of WGBF-Gunes and WGBF-Aktas were 51.4 and 54.4%, respectively (P<0.05). Sieving of wholegrain buckwheat flours caused an increase on TS contents of Güneş and Aktaş cultivars, 69.0 and 72.7%, respectively (P<0.05). The highest RS content was obtained with the sample of WGBF-Aktas (4.93%), followed by its sieved form (4.87%, P>0.05), however, these results were statistically significant while considering the RS contents of the other buckwheat flour samples (P<0.05).

TDF contents of wholegrain common buckwheat and buckwheat groat flour were studied by Bonafaccia *et al.* (2003). They found a TDF of 27.38 and 6.77%, as well as 55.8 and 78.4% for TS content in wholegrain and groat flours, respectively. The RS content has been described in the ranges of 6.13-11.04% and 3.29-6.58% in dehulled buckwheat seeds and whole buckwheat seed flours, respectively (Dziadek *et al.*, 2016). According to their study, TS contents were in the ranges of 45.24-52.12% and 38.41-43.11% in dehulled seeds and whole seed flours, respectively. TDF contents were also reported as 1.16-6.69% and 20.32-25.45% in dehulled seeds and whole seed flours, respectively. The results of these studies were similar to that of this study.

Total phenolic compound contents

TPC contents of buckwheat flours studied in different extraction solvents are presented in Table 3. In each extraction method, TPC contents of wholegrain buckwheat flours (WGBF-Gunes and WGBF-Aktas) were higher than that of buckwheat groat flours (BGF-Gunes and BGF-Aktas). By using DMSO solvent, the highest TPC was found with the sample of WGBF-Gunes (2.08 mg GAE/g, P<0.05). Total phenolic compound contents determined using DMSO solvent ranged in the range of 1.14-2.08 mg GAE/g. The highest TPC content determined using absolute ethylalcohol and methylalcohol were observed with a sample of WGBF-Gunes as 0.77 and 2.34 mg GAE/g, respectively. TPC contents determined by absolute methylalcohol ranged between 1.51-2.34 mg GAE/g. It was determined that absolute methyl alcohol was the most effective extraction solvent (P<0.05).

In previous works, using an ethylalcohol solvent, TPC contents of wholegrain buckwheat flours and buckwheat groat flours were in the range of 1.42-4.15 and 1.05-3.32 mg GAE/g, respectively (Inglett *et al.*, 2010; Sakac *et al.*, 2011; Sedej *et al.*, 2012). When using a methylalcohol solvent, TPC contents of wholegrain buckwheat flours were in the range of 0.91-10.47 mg GAE/g (Gorinstein *et al.*, 2007; Şensoy *et al.*, 2006), on the other hand, it was reported as 1.79 mg GAE/g for buckwheat groat flour (Şensoy *et al.*, 2006). The results achieved with absolute methylalcohol solvent in this study were similar to the findings in the literature.

Table 2. Moisture, total dietary fibre (TDF), total starch (TS) and resistant starch (RS) contents of buckwheat flours.[1]

Buckwheat flours	Moisture (%)	TDF[2] (%)	TS[2] (%)	RS[2] (%)
WGBF-Gunes	11.5±0.06^{b}	29.2±1.13^{a}	51.4±0.14^{f}	4.34±0.076^{b}
WGBF[3]-Gunes[212]	11.0±0.11^{c}	10.8±0.13^{c}	69.0±0.14^{d}	4.45±0.314^{b}
BGF-Gunes	10.6±0.20^{d}	7.5±0.16^{d}	76.6±1.27^{b}	4.35±0.062^{b}
WGBF-Aktas	11.7±0.20^{ab}	29.7±0.43^{a}	54.4±0.82^{e}	4.93±0.191^{a}
WGBF[3]-Aktas[212]	11.7±0.22^{ab}	13.0±1.12^{b}	72.7±0.78^{c}	4.87±0.234^{a}
BGF-Aktas	12.0±0.03^{a}	7.7±0.46^{d}	79.6±0.75^{a}	4.40±0.127^{b}

[1] Values are means ± standard deviation (n=3). Values followed by the same letter in the same column are not significantly different (P>0.05).
[2] Dry weight basis.
[3] Sieved through a 212 µm sieve.

Table 3. Total phenolic compound contents, antioxidant activity properties and rutin and quercetin contents of whole grain buckwheat (WGBF) and buckwheat groat flours (BGF).[1]

Buckwheat flours	DMSO extraction[2] (mg GAE/g)	EtOH extraction[2] (mg GAE/g)	MetOH extraction[2] (mg GAE/g)	DPPH scavenging activity[2] (%)	TEAC[2,3] (mmole Trolox/kg)	TEAC[2,4] (mmole Trolox/kg)	Rutin[2] (mg/100 g)	Quercetin[2] (mg/100 g)
WGBF-Gunes	2.08±0.041^{a,B}	0.77±0.034^{a,C}	2.34±0.088^{a,A}	55.8±1.75^{a}	0.59±0.020^{a}	0.19±0.023^{a}	75.72±0.813^{a}	10.46±0.319^{c}
BGF-Gunes	1.24±0.022^{c,B}	0.51±0.014^{c,C}	1.51±0.032^{d,A}	36.1±1,17^{c}	0.36±0.013^{b}	0.12±0.006^{b}	9.60±0.160^{b}	11.06±0.479^{b}
WGBF-Aktas	1.72±0.021^{b,B}	0.72±0.019^{b,C}	2.12±0.024^{b,A}	49.4±1.30^{b}	0.51±0.015^{a}	0.18±0.014^{a}	78.23±2.982^{a}	11.14±0.135^{b}
BGF-Aktas	1.14±0.126^{c,B}	0.56±0.031^{c,C}	1.64±0.043^{c,A}	34.5±0.21^{c}	0.34±0.003^{b}	0.11±0.033^{b}	9.42±0.140^{b}	11.39±0.199^{a}

[1] Values are mean ± standard deviation (n=3); values followed by a different letter in the same column are significantly different (P<0.05); values followed by a different capital letter in the same row are significantly different (P<0.05); GAE = gallic acid equivalent.
[2] Dry weight basis.
[3] Antioxidant activity determined with the DPPH radical by Trolox.
[4] Antioxidant activity determined with the ABTS radical by Trolox.

Antioxidant activity properties

The AOA properties of whole grain buckwheat and buckwheat groat flours are presented in Table 3. The AOA values determined with the DPPH scavenging activity (%) method in wholegrain buckwheat flours were significantly higher than that of the buckwheat groat flours (P<0.05). The highest DPPH scavenging activity (55.8%) was found in the sample of WGBF-Gunes. AOA properties were also detected with the methods of reducing DPPH and ABTS radicals by Trolox and similar results were obtained with the buckwheat flours. For both methods, AOA properties of wholegrain buckwheat flours exhibited higher than that of the buckwheat groat flours (P<0.05). For instance, WGBF-Gunes had the highest AOA values among the samples.

The DPPH radical scavenging activities of wholegrain buckwheat flour and groat flour were reported as 60% (Sun and Ho, 2005) and 63.7% (Şensoy *et al.*, 2006), respectively. The AOA values were also described in wholegrain buckwheat flours as 2.13 mmol Trolox equivalent/kg (Inglett *et al.*, 2010) and 3.72 mmol Trolox equivalent/kg (Şensoy *et al.*, 2006), on the other hand, the value reported in buckwheat groat flour was 2.14 mmol Trolox equivalent/kg (Şensoy *et al.*, 2006). The AOA values determined by reducing ABTS radicals by Trolox were found in wholegrain buckwheat and groat flour as 28.60 mmol Trolox equivalent/kg (Zielinski *et al.*, 2009) and 14.35 mmol Trolox equivalent/kg (Gallardo *et al.*, 2006). Consequently, the AOA values determined in this study were lower than the values reported in other studies. This could be due to the different cultivars, growing conditions, and sample preparation methods used in this study.

Rutin and quercetin flavonoids contents

The rutin and quercetin contents of buckwheat flours are shown in Table 3. The rutin contents in WGBF-Gunes and WGBF-Aktas were 75.72 and 78.23 mg/100 g, respectively, whereas those in BGF-Gunes and BGF-Aktas were 9.60 and 9.42 mg/100 g, respectively. The rutin contents of whole grain buckwheat flours were significantly higher than that of the buckwheat groat flours (P<0.05). The rutin contents in common buckwheat groat flours were reported in the range of 18-19 mg/100 g (Steadman *et al.*, 2001b). The rutin content in buckwheat seed found by Oomah and Mazza (1996) was 47 mg/100 g. Besides, the average rutin content in *Fagopyrum homotropicum* was reported as 114.6 mg/100 g seed (Jiang *et al.*, 2006). The rutin contents in light buckwheat and wholegrain buckwheat flour were 8.24 mg/100 g and 17.92 mg/100 g, respectively, according to Sedej *et al.* (2010). The rutin contents in wholegrain and groat flours were also reported as 14.60 and 11.60 mg/100 g, respectively (Sedej *et al.*, 2012).

The quercetin contents in WGBF-Gunes and WGBF-Aktas were 10.46 and 11.14 mg/100 g, respectively, while that of BGF-Gunes and BGF-Aktas were 11.06 and 11.39 mg/100 g, respectively. The quercetin contents of WGBF-Aktas and BGF-Aktas were higher than that of the Güneş cultivar (Table 3). The quercetin contents in common and tartary buckwheats were found as 0.1 and 0.8 mg/100 g, respectively (Steadman *et al.*, 2001a). The quercetin contents in light buckwheat and wholegrain buckwheat flours were reported as 0.121 and 0.347 mg/100 g, respectively (Sedej *et al.*, 2010). The quercetin contents in wholegrain and groat flours were also determined as 0.304 and 0.248 mg/100 g, respectively (Sedej *et al.*, 2012).

4. Conclusions

This is the first study describing some chemical, nutritional and bioactive compound compositions of buckwheat cultivars (Güneş and Aktaş) bred in Turkey. They provide good sources of proteins, total dietary fibre, enzyme resistant starch and flavonoids. It was shown that TPC, AOA and rutin flavonoid contents were higher in whole grain buckwheat flours than in buckwheat groat flours for both cultivars. Their nutritional and bioactive compounds can be improved by the future breeding programs. The food industry in Turkey is mainly interested in producing bulgur from buckwheat for a healthier diet. To conclude, the utilisation of buckwheat flour in food products is highly recommended to increase the contents of healthy phytochemicals.

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References

Acquistucci, R. and Fornal, J., 1997. Italian buckwheat (*Fagopyrum esculentum*) starch: physico-chemical and functional characterization and *in-vitro* digestibility. Food/Nahrung 41: 281-284.

American Association of Cereal Chemists International (AACCI), 2010. Approved methods of analysis, 11th edition. Methods No: 44-15.02, 46-12.01, 30-25.01 and 08-01.01. AACCI, St. Paul, MN, USA.

Biacs, P., Aubrecht, E., Leder, I. and Lajos, J., 2002. Buckwheat. In: Belton, P., Taylor, J. (eds.) Pseudocereals and less common cereals-grain properties and utilization potential. Springer-Verlag, Berlin, Germany, pp. 123-151.

Bonafaccia, G., Marocchini, M. and Kreft, I., 2003. Composition and technological properties of the flour and bran from common and tartary buckwheat. Food Chemistry 80: 9-15.

Dziadek, K., Kope, A., Pastucha, E., Piatkowska, E., Leszczynska, T., Pisulewska, E., Witkowicz, R. and Francik, R., 2016. Basic chemical composition and bioactive compounds content in selected cultivars of buckwheat whole seeds, dehulled seeds and hulls. Journal of Cereal Science 69: 1-8.

Gallardo, C., Jiménez, L. and García-Conesa, M.T., 2006. Hydroxycinnamic acid composition and *in-vitro* antioxidant activity of selected grain fractions. Food Chemistry 99: 455-463.

Gorinstein, S., Medina Vargas, O.J., Jaramillo, N.O., Salas, I.A., Martinez Ayala, A.L., Arancibia-Avila, P., Toledo, F., Katrich, E. and Trakhtenberg, S., 2007. The total polyphenols and the antioxidant potentials of some selected cereals and pseudocereals. European Food Research and Technology 225: 321-328.

Gutfinger, T., 1981. Polyphenols in olive oils. Journal of the American Oil Chemists Society 58: 966-968.

Inglett, G.E., Rose, D.J., Chen, D., Stevenson, D.G. and Biswas, A., 2010. Phenolic content and antioxidant activity of extracts from whole buckwheat (*Fagopyrum esculentum* Moench) with or without microwave irradiation. Food Chemistry 119: 1216-1219.

Jiang, P., Burczynski, F., Campbell, C.J. and Briggs, C.J., 2006. Development and validation of a HPLC assay for rutin in three buckwheat species: *F. esculentum*, *F. tataricum*, and *F. homotropicum.* Fagopyrum 23: 37-43.

Kreft, I., Fabjan, N. and Yasumoto, K., 2006. Rutin content in buckwheat (*Fagopyrum esculentum* Moench) food materials and products. Food Chemistry 98: 508-512.

Li, S. and Zhang, Q.H. 2001. Advances in the development of functional foods from buckwheat. Critical Review in Food Science and Nutrition 41: 451-464.

Masatcioglu, M.T., Yalçın, E., Hwan, P.J., Ryu, G.-H., Celik, S. and Köksel, H., 2014. Hull-less barley flour supplemented corn extrudates produced by conventional extrusion and CO_2 injection process. Innovative Food Science and Emerging Technologies 26: 302-309.

Masatcioglu, M.T., Yalcin, E., Kim, M., Ryu, G.-H., Celik, S. and Köksel, H., 2013. Physical and chemical properties of tomato, green tea and ginseng-supplemented corn extrudates produced by conventional extrusion and CO_2 injection process. European Food Research and Technology 237: 801-809.

Min, B., Lee, S.M., Yoo, S.H., Inglett, G.E. and Lee, S., 2010. Functional characterization of steam jet-cooked buckwheat flour as a fat replacer in cake-baking. Journal of the Science of Food and Agriculture 90: 2208-2213.

Oomah, B.D. and Mazza, G., 1996. Flavonoids and antioxidative activities in buckwheat. Journal of Agricultural and Food Chemistry 44: 1746-1750.

Qian, J., Rayas-Duarte, P. and Grant, L., 1998. Partial characterization of buckwheat (*Fagopyrum esculentum*) starch. Cereal Chemistry 75: 365-373.

Ragaee, S., Abdel-Aal, E.S.M. and Noaman, M., 2006. Antioxidant activity and nutrient composition of selected cereals for food use. Food Chemistry 98: 32-38.

Ratan, P. and Kothiyal, P., 2011. *Fagopyrum esculentum* Moench (common buckwheat) edible plant of Himalayas: a review. Asian Journal of Pharmacy and Life Science 1: 426-442.

Sakac, M., Torbica, A., Sedej, I. and Hadnadev, M., 2011. Influence of breadmaking on antioxidant capacity of gluten-free breads based on rice and buckwheat flours. Food Research International 44: 2806-2813.

Sedej, I., Mandić, A., Sakač, M., Mišan, A. and Tumbas, V., 2010. Comparison of antioxidant components and activity of buckwheat and wheat flours. Cereal Chemistry 87: 387-392.

Sedej, I., Sakač, M., Mandić, A., Mišan, A., Tumbas, V. and Čanadanović-Brunet, J., 2012. Buckwheat (*Fagopyrum esculentum* Moench) grain and fractions: antioxidant compounds and activities. Journal of Food Science 77: C954-C959.

Şensoy, İ., Rosen, R.T., Ho, C.T. and Karwe, M.V., 2006. Effect of processing on buckwheat phenolics and antioxidant activity. Food Chemistry 99: 388-393.

Singh, J. and Singh, N., 2003. Studies on the morphological and rheological properties of granular cold water soluble corn and potato starches. Food Hydrocolloids 17: 63-72.

Singleton, V.L., Orthofer, R. and Lamuela-Raventos, R.M., 1999. Analysis of total phenols and other oxidation substrates and antioxidants by means of Folin-Ciocalteu reagent. Methods in Enzymology 299: 152-178.

Steadman, K.J., Burgoon, M.S., Lewis, B.A., Edwardson, S.E. and Obendorf, R.L., 2001a. Buckwheat seed milling fractions: description, macronutrient composition and dietary fibre. Journal of Cereal Science 33: 271-278.

Steadman, K.J., Burgoon, M.S., Lewis, B.A., Edwardson, S.E. and Obendorf, R.L., 2001b. Minerals, phytic acid, tannin and rutin in buckwheat seed milling fractions. Journal of the Science of Food and Agriculture 81: 1094-1100.

Sun, T. and Ho, C.-T., 2005. Antioxidant activities of buckwheat extracts. Food Chemistry 90: 743-749.

Turkish Standards Institution (TSI), 2010. Turkish wheat flour standard, 4500/June 2010 Acidity Method. TSI, Ankara, Turkey.

Wijngaard, H.H. and Arendt, E.K., 2006. Buckwheat. Cereal Chemistry 83: 391-401.

Yu, L., Haley, S., Perret, J., Haris, M., Wilson, J. and Qian, M., 2002. Free radical scavenging properties of wheat extracts. Journal of Agricultural and Food Chemistry 50: 1619-1624.

Zheng, G.H., Sosulski, F.W. and Tyler, R.T., 1998. Wet-milling, composition and functional properties of starch and protein isolated from buckwheat groats. Food Research International 30: 493-502.

Zielinski, H. and Kozlowska, H., 2000. Antioxidant activity and total phenolics in selected cereal grains and their different morphological fractions. Journal of Agricultural and Food Chemistry 48: 2008-2016.

Zielinski, H., Michalska, A., Amigo-Benavent, M., Dolores del Castillo, M. and Piskula, M.K., 2009. Changes in protein quality and antioxidant properties of buckwheat seeds and groats induced by roasting. Journal of Agricultural and Food Chemistry 57: 4771-4776.