Influence of Variety on Bioactive Compounds, Fatty Acid and Nutrients of Different Soybean Seeds

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ABSTRACT

Total phenolic and flavonoid quantities of the soybean seeds were specified to be between 18.05 (ANP 2018) and 29.21 mgGAE/100g (Göksoy-07) to 10.05 (ANP 2018) and 18.24 mg/100g (Kocatürk), respectively. Antioxidant capacities of the soybean seeds were defined to be between 1.23 (ANP 2018) and 1.37 mmolTE/kg (Göksoy-07). Syringic acid and rutin contents of the soybean seeds were defined to be between 1.39 (Batem Erensoy and Arısoy) and 3.51 mg/100g (Göksoy-07) to 0.33 (Nazlıcan) and 0.93 mg/100g (Kocatürk), respectively. In addition, the soybean variety containing the highest content of quercetin (41.66 mg/100g) was "Ataem-7". Kocatürk, Ataluri and Batem Erensoy soybean varieties were found to contain the lowest contents of quercetin. The highest fatty acids in soybean oils were linoleic and oleic acids. Linoleic and oleic acid values of the oils were depicted to be between 48.00 (Batem Erensoy) and 56.08 (CYD-3446) to 22.17 (CYD-3446) and 30.25% (Batem Erensoy), respectively. K and P contents of the soybean seeds were recorded to be between 14589.10 (ANP-2018) and 16959.50 mg/kg (Kocatürk) to 4401.98 (Batem Erensoy) and 6539.97 mg/kg (Göksoy-07), respectively. The microelement found in the highest contents in soybean varieties was Fe. The lowest total phenol, flavonoid amounts and antioxidant activities were detected in the ANP 2018 soybean variety. In addition, the "Kocatürk" soybean seed was the richest variety in terms of total phenol and total flavonoid. Although the amounts of phenolic compounds in seeds showed partial phenolics depending on the soybean varieties, the amounts of phenolic compounds in soybean seeds were generally found to be lower than other oilseeds.

Keywords: soybean, variety, oil content, bioactive compounds, fatty acids, polphenols.

INTRODUCTION

Soybean (*Glycine max* L.) is a vital legume plant from the Fabaceae family, containing approximately 40% protein, 20% fat, 33% carbohydrates and minerals such as calcium and iron (Bellaloui et al., 2011; Król-Grzymała and Amarowicz, 2020; Jiang et al., 2023; Khan et al., 2024). The feature that makes soybeans widespread as human food and animal feed is due to their high protein, fat, carbohydrates, vitamins, minerals, fiber and phytochemicals, and excellent functional properties (such as antioxidant and anticarcinogenic) (Özcan and AlJuhaimi, 2014; Canaan et al., 2022; Qin et al., 2022; Khan et al., 2024). The medical benefits of soybeans have been described in preventing chronic and cardiovascular diseases (Maria John et al., 2016; Jiang et al., 2023; Khan et al., 2024). Soybean flour, soy protein isolate, soy milk, soy milk powder are the main foods made from soybean seeds (Tyug et al., 2010; Yang et al., 2015). In addition to their high biological value protein content, legume seeds are used in various industrial applications and are also vital nutritional sources for both humans and animals (Grela and Günter, 1995; Deme et al., 2021). Legume seeds contain minerals, bioactive phytochemical compounds (flavonoids, phenolic acids, carotenoids, and phytohemagglutinins) with a broad spectrum of activity (Grela and Günter, 1995; Kwak et al., 2007; Özcan and AlJuhaimi, 2014). Soybean oil contains significant amounts of

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unsaturated acids such as alpha-linolenic, linoleic, gamma-linolenic, and oleic acids (Olguin et al., 2003; Nikolic et al., 2009; Özcan and Aljuhaimi, 2014). Soybean seed oils are reported to contain 10-12% palmitic acid, 2.2-7.2% stearic, 24% oleic, 54% linoleic and 8.0% linolenic acid (Hymowitz and Collins, 1974; Schnebly and Fehr, 1993). Naturally occurring plant phenolics with health-supporting and antioxidant properties have been reported to reduce the risk of atherosclerosis, cancer, and coronary heart disease that may result from the oxidation of low-density lipoproteins (Emmons and Peterson, 2001). Phenolic compounds may help support endogenous enzymatic antioxidant systems in cells and scavenge free radicals (Heim et al., 2002; Filip et al., 2003; Oh et al., 2009). Phenolic compounds, which constitute an important element of the plant's defense system, and their effects generally have different tolerance powers against plant species and adverse environmental factors (Boscaiu et al., 2010). Soybeans are rich in isoflavones, phenolic acids and anthocyanins, which show antioxidant and some other bioactive activities (Alu'datt et al., 2013; Król-Grzymała and Amarowicz, 2020). Isoflavones, which are present in high amounts (1,431-2,130 mg/100 g) formed during soybean growth, are distributed mainly in the hypocotyl and cotyledon of soybean seeds (Król-Grzymała and Amarowicz, 2020). There have been very few studies on bioactive properties, phenolic compounds in seeds of various soybean genotypes. Therefore, the aim of present research was to investigate the differences and concentrations of bioactive components, antioxidant activities, fatty acids and mineral contents important for nutritional or pharmaceutical purposes in seeds of different soybean genotypes.

MATERIAL AND METHODS

Material

Soybean seeds (Kocatürk, Atakişi, Batem Erensoy, Lider, ANP 2018, Göksoy-07, Nazlıcan, CYD-3446, Arısoy, Adasoy, Ataem 7) were grown in three replications in order to establish the most suitable variety in terms of yield and quality in irrigated conditions of Konya province. Seeds of each variety obtained from the plots harvested by hand in October 2023 were brought to the laboratory.

Methods

Moisture content

The KERN & SOHN GmbH infrared moisture analyser was used for analysis of the moisture contents of barley and malt types.

Total oil content

After cleaning and grinding the soybean seeds, 10 g of each sample was weighed into the cartridge and placed in the extractor. After the samples were subjected to extraction in the Soxhlet system in the presence of petroleum ether at 50^{o}C for 5 hours, the petroleum ether in the oil-solvent mixture was removed by evaporator. The remaining extract was calculated as crude oil and defined as % (AOAC, 1990).

Extraction procedure

The extraction process of soybean seeds was made according to the method suggested by Jakopic et al. (2011). After adding 15 ml of methanol to 5 g of ground samples, the mixture was shaken well and kept in an ultrasonic water bath for 30 min. After this process, the mixture was centrifuged at 6000 rpm for 10 min and then 15 ml of n-hexane was added to the mixture and mixed using vortex for 2 min. After the methanol phase obtained by a separating funnel was evaporated at 40^{o}C, the extract was dissolved in 10 ml of methanol.

Total phenolic content

Total phenolic quantities of soybean seed extracts were characterized using Folin-Ciocalteu based on the study proposed by Yoo et al. (2004).

Total flavonoid content

After mixing 1 ml of soybean extract with 0.3 ml of $NaNO_2$, 0.3 ml of $AlCl_3$ and 2 ml of NaOH, the mixture was kept in the dark for

15 min and then the absorbance of each sample was measured at 510 nm. The findings are stated as mgQE/100g (dw) (Hogan et al., 2009).

Antioxidant activity

The antioxidant capacities of soybean seed extracts were stated using 1,1-diphenyl-2-picrylhydrazyl (DPPH) according to Lee et al. (1998). After pretreatments, the absorbance was recorded at 517 nm by using a spectrophotometer. The findings were characterized as mmol TE/kg.

Determination of phenolic compounds

HPLC (Shimadzu) equipped with a PDA detector and an Inertsil ODS-3 (5µm; 4.6 x 250mm) column was used analysis and chromatographic separation of phenolic compounds of soybean seed extracts was determined by. The peaks were taken at 280 using a PDA detector.

Fatty acid composition

Fatty acid methyl esters (FAMEs) of soybean seed oils esterified according to Multari et al. (2019) method were analysed gas chromatography (Shimadzu GC-2010) equipped with flame-ionization detector (FID) and capillary column (Tecnocroma TR-CN100, 60 m x 0.25 mm, film thickness: 0.20 µm). Column temperature was programmed 120ºC for 5 minutes.

Determination of protein andash

Protein and ash quantities of soybean seeds were established using the AOAC method (1990).

Determination of mineral

After powdered soybean seeds were dried in an oven at 70ºC for 48 h, 0.5 g of ground soybean powders was incinerated in a closed microwave system (Cem-MARS Xpress) using 5 ml of 65% HNO_3 and 2 ml of 35% H_2O_2. The volume of the sample was then completed up with 20 ml of distilled water. The mineral values of the soybean seeds were established by ICP- OES (Tošic et al., 2015).

Statistical analysis

Analysis of variance (ANOVA) was determined by using JMP version 9.0. The results are mean±standard deviation (MSTAT C) of independent seed varieties.

RESULTS AND DISCUSSION

The chemical and bioactive properties of different types of soybean seeds

The moisture, oil, bioactive properties of different varieties of soybean seeds are depicted in Table 1. The results showed changes based on the soybean varieties. In general, the moisture contents of soybean seeds were close to each other and the variety with the highest content of moisture was "Kocatürk" (6.34%) and the moisture contents of other soybean varieties varied between 5.23 (Batem Erensoy) and 5.73% (Ataem-7). Moisture contents of soybean seeds showed significant differences depending on the varieties, and oil quantities of soybean varieties were established between 15.60% (Kocatürk) and 23.60% (CYD-3446). Total phenolic and flavonoid quantities of the soybean seeds were specified to be between 18.05 (ANP 2018) and 29.21 mgGAE/100g (Göksoy-07) to 10.05 (ANP 2018) and 18.24 mg/100g (Kocatürk), respectively. Antioxidant activities of the soybean seeds were defined to be between 1.23 (ANP 2018) and 1.37 mmolTE/kg (Göksoy-07). There was no significant difference between the antioxidant activities of the seeds. The lowest total phenol, flavonoid contents and antioxidant activities were detected in the ANP 2018 soybean variety.

Table 1. Physico-chemical properties of soybeans seeds

Variety	Moisture content (%)	Total oil content (%)	Total phenolic content (mgGAE/100 g)	Total flavonoid content (mg/100 g)	Antioxidant activity (mmol/kg)
Kocatürk	6.34±0.28a*	15.60±0.00**	28.23±0.28A***	18.24±1.62A	1.35±0.01AB
Atakişi	5.61±0.03ab	16.70±0.42	24.05±0.65B	13.86±0.29CDE	1.29±0.01CD
Batem Erensoy	5.23±0.13b	17.80±0.28	23.12±0.02BC	15.10±0.16BC	1.34±0.01B
Lider	5.62±0.18ab	16.40±0.28	24.24±0.81B	14.14±1.48CDE	1.30±0.01C
ANP 2018	5.57±0.20ab	17.10±0.71	18.05±0.71D	10.05±0.59F	1.23±0.00H
Göksoy-07	5.63±0.02ab	16.80±0.28	29.21±0.96A	17.29±0.29AB	1.37±0.00A
Nazlıcan	5.65±0.45ab	17.30±0.71	21.22±0.74C	12.14±0.29DEF	1.27±0.01DEF
CYD-3446	5.50±0.12b	23.60±4.14	22.74±1.09BC	11.67±0.16EF	1.26±0.01FG
Arısoy	5.61±0.16ab	16.30±0.42	21.14±0.59C	12.52±0.66DEF	1.26±0.01EFG
Adasoy	5.35±0.06b	19.40±1.13	18.43±1.04D	12.33±0.16DEF	1.24±0.01GH
Ataem 7	5.73±0.12ab	18.90±0.71	23.71±0.61B	14.52±1.41CD	1.28±0.00CDE

*p<0.05, **p>0.05, ***P<0.01.

In addition, the "Kocatürk" soybean seed was the richest variety in terms of total phenol and total flavonoid. The antioxidant activity value of this variety was found to be close to the "Göksoy-07" soybean variety, which has the highest antioxidant activity. The moisture contents of soybean seeds were established between 6.0 to 7.3 g/100g (Vivar-Quintana et al., 2023). The oil quantities of roasted soybean and peanuts were established between 13.57 (10 min) and 17.68% (30 min) (Özcan and Uslu, 2024). The total phenolic contents of niger seed and linseeds were characterized to be between 22.4 (variety *Esete*) and 27.9 (variety *Ginchi*) to 20.5 (variety *Belay-96*) to 25.4mg GAE/g (variety *Ci-1525*), respectively (Deme et al., 2021). Total phenolic, flavonoid contents and antioxidant activities of soybean seed extracts were defined to be between 2.70 (Tara) and 4.66 g CE/kg (LN92-7369), 0.32 (Sava) and 0.61 g RE/kg (Alisa) to 22.87 (Sava) and 48.17% (LN92-7369), respectively (Malenčić et al., 2007). Total phenolic contents of oven-roasted soybean seeds were found to range from 9.74 (10 min) and 18.49 (30 min) (Özcan and Uslu, 2024). The total phenolic quantities of roasted soybean extracts were defined to be between 6.76 and 48.50 mg GAE/g (dw) (Thidarat et al., 2016). Lee et al. (2015) determined 3.63 (Neulchan) and 4.12 mg GAE/g (Daepung) (dw) total phenol in four soybean varieties. Bursac et al. (2017) determined the total phenolic and antioxidant activity values (DPPH analysis) of dried soybean seeds of different colors as between 1.91 and 2.28 mg GAE/g and 0.90 and 1.86 mg/ml, respectively. The total phenolics quantities and antioxidant activities of soybean seeds were defined to be between 10.3 (Isidor) and 13.7 Mazowia) mg/g extract to 44.1 (Isidor) and 50.6 µmolTrolox/g of Extract (Progres) (Król-Grzymała and Amarowicz, 2020). Antioxidant activities of oven- roasted soybean seeds were defined to be between 3.69 (10 mn) and 5.78% (30 min) (Özcan and Uslu, 2024). The antioxidant activity values (DPPH assay) of unroasted soybeans were characterized to be between 15.05% (Neulchan) and 38.55% (Daepung) (Lee et al., 2015). Differences were observed when the results related to total phenol, flavonoid contents and antioxidant activity values were compared with the results of Malenčić et al. (2007), Lee et al. (2015), Deme et al. (2021), and Özcan and Uslu (2024). The reason for these differences may be due to the analytical procedures applied, seed type, climatic factors and location differences.

Phenolic compounds of different varieties of soybean seeds

Phenolic compounds of different varieties of soybean seeds are defined in Table 2. Although the amounts of phenolic constituents in seeds showed partial phenolics depending on the soybean varieties, the contents of phenolic constituents in soybean seeds were generally found to be lower than other oilseeds. Syringic acid and rutin contents of the soybean seeds were specified to be between 1.39 (Batem Erensoy and Arısoy) and 3.51 mg/100g (Göksoy-07) to 0.33 (Nazlıcan) and 0.93 mg/100g (Kocatürk), respectively. In addition, while p-coumaric acid quantities of the soybean seeds are stated between 0.01 (Adasoy and Ataem-7) and 1.80 mg/100g (Göksoy-07), kaempferol contents of the soybean varieties were characterized to be between 0.18 (Batem Erensoy) and 4.07 mg/100g (Göksoy-07). As seen in Table 2, Göksoy-07 soybean variety contained the highest contents of syringic acid, p-coumaric acid and kaempferol. This shows that "Atoem-7" and "Göksoy-07" varieties are rich in flavonoids. Also, quercetin quantities of the soybean seeds were displayed to be between 0.23 (Kocatürk) and 41.66 mg/100g (Ataem-7). In addition, the soybean variety containing the highest content of quercetin (41.66 mg/100g) was "Ataem-7". Kocatürk, Ataluri and Batem Erensoy soybean varieties were found to contain the lowest contents of quercetin. Also, cinnamic acid amounts of the soybean seeds were assessed to be between 0.14 (Kocatürk) and 0.91 mg/100g (Adasoy). The contents of other phenolic compounds in soybean varieties were found to be below 0.56 mg/100g. In a previous study, the highest amount of phenolic compound in unprocessed soybean seed was vanillin (144.3 μg/g), followed by catechin (53.0 μg/g) and naringin (38.6 μg/g) in decreasing order (Chung et al., 2017).

Table 2. Phenolic compounds of soybeans seeds (mg/100g)

Phenolic compounds (mg/100 g)	Kocatürk	Atakişi	Batem Erensoy	Lider	ANP 2018	Göksoy-07
Gallic acid	0.28±0.06ab*	0.27±0.34ab	0.33±0.18ab	0.52±0.32a	0.31±0.25ab	0.23±0.26ab
3,4-Dihydroxybenzoic acid	0.29±0.29**	0.33±0.36	0.35±0.34	0.27±0.13	0.25±0.40	0.07±0.02
Catechin	1.10±1.38AB***	2.03±0.62A	0.88±0.71BC	0.75±0.57BC	0.41±0.37BC	0.26±0.01BC
Caffeic acid	0.62±0.98	0.04±0.04	0.03±0.01	0.09±0.12	0.08±0.13	0.07±0.03
Syringic acid	1.53±0.17FG	2.13±0.12D	1.39±0.14G	1.89±0.12E	1.71±0.12EF	3.51±0.11A
Rutin	0.93±0.53a	0.44±0.12ab	0.60±0.46ab	0.38±0.36b	0.54±0.29ab	0.68±0.02ab
p-Coumaric acid	1.25±0.21AB	0.96±0.05ABC	0.48±0.05BCD	1.02±0.07ABC	0.40±0.56CD	1.80±0.09A
Ferulic acid	0.10±0.01b	0.06±0.03b	0.08±0.03b	0.05±0.04b	0.04±0.03b	0.16±0.07ab
Resveratrol	0.08±0.02E	0.38±0.03A	0.18±0.08BCD	0.16±0.08BCD	0.18±0.01BC	0.07±0.02E
Quercetin	0.23±0.19F	0.60±0.25F	1.93±0.32EF	2.61±0.92EF	5.85±1.38CD	3.41±1.62DE
Cinnamic acid	0.14±0.10D	0.20±0.11CD	0.29±0.17BCD	0.77±0.35ABC	0.51±0.22ABCD	0.89±0.24AB
Kaempferol	0.42±0.77C	0.28±0.02C	0.18±0.02C	3.86±0.53AB	1.49±1.58C	4.07±1.76A

Phenolic compounds (mg/100 g)	Nazlıcan	CYD-3446	Arısoy	Adasoy	Ataem 7
Gallic acid	0.09±0.09b	0.16±0.26ab	0.24±0.17ab	0.40±0.28ab	0.18±0.19ab
3,4-Dihydroxybenzoic acid	0.12±0.26	0.04±0.03	0.12±0.10	0.13±0.04	0.08±0.08
Catechin	0.15±0.00BC	0.13±0.11C	0.47±0.23BC	0.56±0.40BC	0.24±0.25BC
Caffeic acid	0.22±0.44	0.06±0.08	0.13±0.03	0.07±0.09	0.12±0.03
Syringic acid	2.24±0.07D	2.63±0.06C	1.39±0.04G	2.31±0.13D	2.92±0.09B
Rutin	0.33±0.28b	0.37±0.19b	0.50±0.29ab	0.58±0.24ab	0.64±0.14ab
p-Coumaric acid	1.05±0.06ABC	0.93±1.32BC	0.24±0.66CD	0.01±0.01D	0.01±0.01D
Ferulic acid	0.12±0.07ab	0.49±0.65a	0.14±0.18ab	0.07±0.03b	0.11±0.11b
Resveratrol	0.20±0.04B	0.06±0.04E	0.17±0.05BCD	0.12±0.03CDE	0.10±0.03DE
Quercetin	2.67±1.23EF	20.98±1.66B	18.94±4.05B	7.59±2.60C	41.66±0.26A
Cinnamic acid	0.79±0.57ABC	0.58±0.23ABCD	0.55±0.26ABCD	0.91±0.74A	0.69±0.34ABCD
Kaempferol	1.70±1.67C	2.06±0.14BC	1.36±1.49C	1.98±1.02BC	3.97±1.39A

*$p<0.05$, **$p>0.05$, ***$P<0.01$.

In another study, syringic, ferulic, sinapic, *p*-coumaric, hydroxybenzoic, caffeic and chlorogenic acids, gentisic acid and salicylic acid constitute some of the phenolic compounds detected in soybeans (Chung et al., 2011; Król-Grzymała and Amarowicz, 2020; AbdElhamid et al., 2022). The value of phenolic compounds of soybean seed is 8.59 mgGAE/g extract, while the value of flavonoids was 0.82 mgQE/g extract

(Alsaloom, 2023). Soybean seed contained 0.91% syringic acid, 29.6 quercetin, 6.76 gallic acid, 3.47 benzoic acid, 27.8 genistein, 13.6% daidzein, 3.2 p-coumaric acid, 4.2% ferulic acid (Alsaloom, 2023). Whole soybean grains contained 5.9 gallic acid, 24 protocatechuic acid, 84.4 chlorogenic acid, 5,6 hydroxybenzoic acid, 16.1 vanillic acid, 5.0 caffeic acid, 9.8 coumaric acid, 9.9 g/100g sinapic acid (Khan et al., 2024). Daepung soybean extracts contained 41.2 µg/g gallic, 9.2 µg/g gentisic, 64.1 µg/g protocatechuic, 76.0 µg/g *t*-cinnamic, and 37.8 µg/g (unroasted) sinapic acids (Lee et al., 2015). Results showed some differences compared to the phenolic compound results of previous studies.

The fatty acid profiles of oils extracted from different varieties of soybean seeds

The fatty acid profiles of oils obtained from different varieties of soybean seeds are given in Table 3.

Table 3. Fatty acid compositions of the oils extracted from soybean seeds (%)

Fatty acids (%)	Kocatürk	Atakişi	Batem Erensoy	Lider	ANP 2018	Göksoy-07
Myristic	0.09±0.00AB*	0.10±0.00A	0.10±0.00A	0.08±0.00ABC	0.08±0.00ABC	0.08±0.00AB
Palmitic	11.90±0.20A	10.37±0.02BCD	11.80±0.10A	11.12±0.08AB	11.74±0.12A	11.01±0.23ABC
Stearic	4.33±0.01CD	4.13±0.02EF	5.23±0.03A	4.47±0.03BC	4.05±0.03F	5.13±0.05A
Oleic	24.01±0.02E	28.48±0.06C	30.25±0.07A	29.99±0.04AB	28.54±0.03C	22.43±0.06FG
Linoleic	53.25±0.13C	51.21±0.02D	48.00±0.02G	48.75±0.12F	49.86±0.10E	54.49±0.01B
Arachidic	0.36±0.00AB	0.33±0.00B	0.45±0.01A	0.39±0.05AB	0.33±0.03B	0.44±0.03A
Linolenic	5.72±0.05D	5.01±0.04E	3.76±0.00G	4.73±0.01F	5.05±0.07E	5.95±0.01C
Behenic	0.34±0.01B	0.35±0.03B	0.36±0.02B	0.43±0.08AB	0.30±0.01B	0.43±0.04AB
Arachidonic	ND**	0.04±0.00***	0.05±0.01	0.05±0.01	0.04±0.00	0.06±0.00

Fatty acids (%)	Nazlıcan	CYD-3446	Arısoy	Adasoy	Ataem 7
Myristic	0.07±0.00BC	0.06±0.00C	0.09±0.01AB	0.08±0.01ABC	0.06±0.00C
Palmitic	11.51±0.33A	9.77±0.13D	10.17±0.16BCD	10.03±0.66CD	9.73±0.27D
Stearic	4.08±0.04EF	4.12±0.01EF	4.24±0.00DE	4.08±0.09F	4.59±0.06B
Oleic	22.65±0.13F	22.17±0.05G	29.63±0.02B	26.70±0.26D	23.65±0.10E
Linoleic	54.76±0.13B	56.08±0.06A	50.31±0.19E	52.96±0.20C	54.87±0.04B
Arachidic	0.33±0.01B	0.37±0.00AB	0.36±0.03AB	0.45±0.05A	0.38±0.02AB
Linolenic	6.23±0.03B	7.06±0.00A	4.77±0.08F	5.11±0.01E	6.28±0.01B
Behenic	0.31±0.01B	0.34±0.00B	0.38±0.06B	0.55±0.07A	0.38±0.03AB
Arachidonic	0.04±0.00	0.04±0.00	0.05±0.01	0.05±0.01	0.05±0.01

*p<0.01, **ND: Not detected, ***p>0.05.

There were significant changes in the fatty acid compositions of the oils extracted depending on the soybean varieties. The highest fatty acid content in soybean oils was linoleic acid. Linoleic and oleic acid values of the oils extracted from the soybean seeds were depicted to be between 48.00 (Batem Erensoy) and 56.08 (CYD-3446) to 22.17 (CYD-3446) and 30.25% (Batem Erensoy), respectively. While palmitic acid contents of the oils obtained from several soybean seeds were assigned to be between 9.73 (Ataem-7) and 11.90% (Kocatürk), the stearic acid contents of the seed oils were determined to be between 4.05 (ANP 2018) and 5.23% (Batem Erensoy). Also, linolenic acid values of the oils extracted from several soybean varieties were established to be between 3.76 (Batem Erensoy) and 7.06% (CYD-3446). It has been determined that the oils of other oilseeds used for cooking contain more linolenic acid than linolenic fatty acid. This fatty acid is one of the characteristic fatty acids of soybean oil. The same fatty acid amounts showed differences among varieties and were established to be statistically significant. The amounts of other fatty acids in soybean oil were found to be at minor levels. Untreated soybean seed oil contained 16.75% palmitic, 6.81% stearic, 32.05% oleic, 78.27% linoleic, and 11.53% linolenic acids (Chung et al., 2017). Soybean oils contained 11.11 and 21.69 palmitic, 4.61 and 9.62 stearic, 24.81 and 33.65 oleic, 28.14 and

48.09 linoleic, 1.50 and 8.36 g/100g linolenic acids (Vivar-Quintana et al., 2023). The variations reported can be attributed to environmental factors and the cultivar (Kaur and Prasad, 2021). Soybean seed oils are reported to contain 10-12% palmitic acid, 2.2-7.2% stearic, 24% oleic, 54% linoleic and 8.0% linolenic acid (Hymowitz and Collins, 1974; Schnebly and Fehr, 1993). 3-6% palmitic, 0-3% stearic, 14-43% oleic, 44-75% linoleic, 0.6-4% arachidic acids in soybean seed oils were identified (Swern, 1979).

Protein and element quantities of soybean seeds of different varieties

Protein and element amounts of soybean seeds of different varieties are defined in Table 4.

Table 4. Protein, ash and mineral contents of soybean seeds (mg/kg)

Variety	Protein %	Ash %	N	P	K	Ca
Kocatürk	14.91±0.282 **g***	96.45±0.886 **cd**	23860.18±451.73 **g**	6422.88±156.01 **a**	16959.50±274.42 **a**	3732.78±49.36 **c**
Atakişi	20.06±0.417 **e**	97.06±0.532 **bc**	32097.60±667.68 **e**	5495.71±36.78 **e**	15323.68±3.53 **c**	3825.08±24.72 **c**
Batem Erensoy	17.05±0.113 **f**	96.51±1.13 **cd**	27285.39±180.58 **f**	4401.98±25.23 **h**	16154.14±318.80 **b**	3503.73±55.97 **d**
Lider	20.28±0.253 **de**	95.71±1.01 **de**	32445.43±404.06 **de**	5460.37±9.19 **ef**	14835.41±27.47 **de**	4515.31±134.11 **a**
ANP 2018	17.66±0.912 **f**	94.85±0.010 **ef**	28248.15±1458.45 **f**	5655.07±12.47 **d**	14589.10±220.68 **e**	3999.98±104.52 **b**
Göksoy-07	30.15±0.398 **a**	94.44±0.168 **f**	48237.03±636.60 **a**	6539.97±75.29 **a**	16357.35±205.91 **b**	3130.59±35.99 **f**
Nazlıcan	22.27±0.690 **c**	96.26±1.52 **cd**	35639.39±1103.38 **c**	5851.23±65.56 **c**	16270.25±167.50 **b**	3496.12±49.06 **d**
CYD-3446	21.34±1.61 **cd**	98.40±0.204 **a**	34148.14±2578.79 **cd**	5113.03±30.55 **g**	14641.42±44.52 **e**	2179.20±34.80 **h**
Arısoy	24.95±0.127 **b**	98.06±0.085 **ab**	39926.90±203.92 **b**	6000.21±75.46 **b**	16190.43±170.41 **b**	3342.18±61.43 **e**
Adasoy	22.15±0.158 **c**	95.49±0.507 **def**	35442.77±252.92 **c**	5705.86±82.59 **d**	15163.04±427.11 **cd**	3131.30±58.37 **f**
Ataem 7	20.58±0.114 **de**	94.90±0.164 **ef**	32928.65±181.64 **de**	5339.93±89.85 **f**	16225.68±315.35 **b**	2450.76±9.30 **g**

*p<0.01

Variety	Mg	S	Fe	Zn	Cu	Mn	B
Kocatürk	2535.99±56.32 **de**	2916.38±28.75 **f**	79.69±1.41 **a***	44.57±0.819 **b**	21.66±0.669 **a**	30.57±0.371 **ef**	34.72±1.05 **b**
Atakişi	2851.48±2.91 **b**	2990.17±6.15 **de**	71.73±0.064 **bc**	32.66±0.225 **gh**	17.19±0.742 **d**	34.36±1.10 **bc**	30.09±1.07 **c**
Batem Erensoy	2040.86±44.56 **g**	2722.32±24.82 **h**	71.84±0.794 **bc**	41.06±0.036 **d**	18.00±0.873 **cd**	31.65±0.028 **de**	29.53±0.404 **c**
Lider	2694.50±24.22 **c**	2671.61±32.70 **h**	67.80±2.67 **cd**	32.07±0.758 **h**	17.84±0.951 **cd**	36.22±1.52 **a**	37.97±1.38 **a**
ANP 2018	2955.56±44.34 **a**	2945.50±28.06 **ef**	74.74±3.37 **b**	33.30±0.407 **g**	20.68±0.546 **b**	26.70±0.234 **g**	30.49±0.333 **c**
Göksoy-07	2569.55±17.08 **d**	3152.64±11.10 **c**	75.26±4.04 **b**	43.51±0.824 **c**	18.72±0.411 **c**	37.56±2.84 **a**	27.23±1.07 **d**
Nazlıcan	2706.65±13.52 **c**	2801.42±6.75 **g**	72.45±0.780 **b**	37.07±0.348 **e**	15.35±0.117 **e**	29.42±0.141 **f**	36.63±0.796 **a**
CYD-3446	2207.95±11.02 **f**	3207.49±51.28 **bc**	56.62±0.245 **f**	43.70±1.14 **bc**	15.56±0.301 **e**	36.13±0.180 **ab**	26.92±1.79 **d**
Arısoy	2940.55±23.26 **a**	3289.81±58.36 **a**	61.82±1.71 **e**	36.84±0.294 **ef**	14.65±0.019 **ef**	31.97±0.286 **de**	29.41±0.932 **c**
Adasoy	2487.78±64.43 **e**	3005.87±48.42 **d**	67.10±5.15 **d**	36.02±0.518 **f**	14.34±0.471 **f**	29.18±0.524 **f**	29.60±0.056 **c**
Ataem 7	2247.61±21.26 **f**	3258.01±30.50 **ab**	58.17±2.45 **ef**	48.12±0.526 **a**	15.29±0.043 **ef**	32.80±0.410 **cd**	24.91±0.671 **e**

*p<0.01

Statistically significant differences were observed in the protein content of soybean seeds, except for the Lider and Ataem-7 varieties. The protein content ranged from 14.91% in the Kocatürk variety to 30.15% in Göksoy-07 variety. Potassium (K) was the most abundant macroelement in soybean seeds, followed by phosphorus (P), calcium (Ca), sulfur (S), and magnesium (Mg) in decreasing order. The potassium content of the soybean seeds ranged from 14,589.10 mg/kg in the ANP-2018 variety to 16,959.50 mg/kg in the Kocatürk variety, while phosphorus levels varied between 4,401.98 mg/kg in Batem Erensoy and 6,539.97 mg/kg in Göksoy-07. In addition, Ca and Mg contents of the soybean seeds were established to be between 2179.20 (CYD-3446) and 4515.31 mg/kg (Lider) to 2040.86 (Batem Erensoy) and 2955.56 mg/kg (ANP 2018), respectively. The highest S (3289.81 mg/kg) was established in “Arısoy” soybean variety. In addition, the microelement found in the highest amounts in soybean varieties was Fe. Iron and zinc quantities of the soybean varieties were assigned to be between 56.62 (CYD-3446) and 79.69 mg/kg (Kocatürk) to 32.07 (Lider) and 48.12 mg/kg (Ataem-7), respectively. While Cu quantities of the soybean seeds vary between 4.34 (Adasoy) and 21.66 mg/kg (Kocatürk), Mn values of the soybean seeds were characterized to be between 29.18 (Adasoy) and 37.56 mg/kg (Göksoy-07). The highest B was detected in the soybean variety "Lider" (37.97 mg/kg). Soybean varieties have a significant effect on the protein, macro and microelement amounts of soybean seeds. In addition, factors affecting the protein and mineral contents of soybean seeds include growing conditions, environmental factors, soil plant nutrient element content, harvest time and some analytical procedures. Soybean seeds contained 987.7 and 1009.9 mg/kg Na, 2144.2 and 2390.9 Mg, 4147.8 and 5347.0 P, 17,595.8 and 18,850.9 K, 1609.2 and 2097.3 Ca, 5.379 and 8.436 Ni, 8.7 and 14.1 Cu, 25.9 and 33.6 Zn, 25 and 27.2 Mn, 59.3 and 103.6 Fe, 0.034 and 0.040 Cd, 0.492 and 0.602 Pb (Vivar-Quintana et al., 2023). In some legumes belonging to the Fabaceae family, macroelements were detected between 426-16.558 K, 269.75-445.81 Na, 2719-5556 P, 1309-2781 Ca and 2083-2900 Mg (Cabrera et al., 2003; Özcan et al., 2013).

CONCLUSIONS

The results showed differences among soybean varieties. The lowest total phenol content, flavonoid contents and antioxidant activity were detected in the ANP 2018 soybean variety. In addition, the "Kocatürk" variety was the richest in terms of total phenol and total flavonoid. Although the amounts of phenolic compounds in seeds showed partial phenolics depending on the soybean varieties, the amounts of phenolic compounds in soybean seeds were generally found to be lower than other oilseeds. The highest fatty acid content in soybean oils was linoleic acid. Linoleic acid was identified as the predominant fatty acid in soybean oils. Compared to soybean oil, the oils of other oilseeds commonly used for cooking contained higher levels of linolenic acid. Statistically significant differences were observed in the protein contents of soybean seeds, except for the Lider and Ataem-7 varieties. Regarding mineral composition, potassium (K) was the most abundant macroelement in soybean seeds, followed by phosphorus (P), calcium (Ca), sulfur (S), and magnesium (Mg) in decreasing order. Among the microelements, iron (Fe) was present at the highest concentration across all soybean varieties.

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