Selcuk Journal of Agriculture and Food Sciences

https://dergipark.org.tr/tr/pub/selcukjafsci

Research Article

(2025) 39(1), 229-239 DOI:10.15316/SJAFS.2025.019 e-ISSN: 2458-8377 Selcuk J Agr Food Sci

Antioxidant Capacity and Quality Parameters of Early Maturing Soybean Genotypes Under Sivas Ecological Conditions

Yeter Çilesiz[1,*], İlker Yüce[1], Muhammed Tatar[1], Meliha Feryal Sarıkaya[1]
Kağan Kökten[1], Tolga Karaköy[2]

[1]Sivas University of Science and Technology, Faculty of Agricultural Sciences and Technology, Department of Field Crops, Sivas, Türkiye

[2]Sivas University of Science and Technology, Faculty of Agricultural Sciences and Technology, Department of Plant Protection, Sivas, Türkiye

HIGHLIGHTS

- Twenty-five soybean genotypes and five registered soybean varieties (Arısoy, Traksoy, Samsoy, Soyanam and Ataem-7) were used as materials.
- This study aimed to evaluate the antioxidant capacity, moisture, and ash content of early-maturing soybean genotypes cultivated under the Sivas ecological conditions.

Abstract

Soybean (*Glycine max* L.) is a versatile crop characterized by its cholesterol- and saturated fat-free composition and high-quality protein content. Evaluating parameters such as antioxidant capacity, moisture, and ash content is crucial for assessing the nutritional quality of soybeans, which are widely consumed both globally and in Türkiye. Antioxidants are compounds that mitigate or neutralize the harmful effects of free radicals in the body. Dietary natural antioxidants are among the most critical factors for enhancing the body's antioxidant defense system. This study aimed to evaluate the antioxidant capacity, moisture, and ash content of early-maturing soybean genotypes cultivated under the Sivas ecological conditions. The highest antioxidant activity using the ABTS method was observed in the ÜNV-2 genotype (11.82 µmol TE/g dw), while the DPPH method revealed the ÜNV-15 genotype as the highest (4.03 µmol TE/g dw). The moisture content of the soybean genotypes and varieties used in this study ranged from 8.75% to 12.34%, while the ash content varied between 2.86% and 4.05%. Differences in all investigated traits among the samples were statistically significant at the 1% level. As a result, the ÜNV-2 and ÜNV-15 genotypes were prioritized due to their relatively higher antioxidant activity, and the Ataem-7 variety was preferred for its lower moisture content.

Keywords: *Glycine max* L.; DPPH; ABTS; quality traits

Citation: Çilesiz Y, Yüce İ, Tatar M, Sarıkaya MF, Kökten K, Karaköy T (2025). Antioxidant capacity and quality parameters of early maturing soybean genotypes under Sivas ecological conditions. *Selcuk Journal of Agriculture and Food Sciences*, 39(1), 229-239. https://doi.org/10.15316/SJAFS.2025.019
***Correspondence:** ycilesiz@sivas.edu.tr

Received date: 08/12/2024
Accepted date: 19/03/2025

1. Introduction

Soybean (*Glycine max* L.) is a plant that stands out for its rich protein and oil content, yet its antioxidant potential remains an area ripe for exploration. Antioxidants are compounds that reduce or neutralize the harmful effects of free radicals in the body. Dietary natural antioxidants play a pivotal role in enhancing the body's antioxidant defense system (Seeram et al. 2006; Yu et al. 2006). Bioactive components in foods directly influence human health. Scientific studies have shown that polyphenolic antioxidant compounds derived from plants mitigate the effects of unstable and harmful substances known as free radicals. Free radicals can arise from enzymatic reactions and environmental factors such as cigarette smoke, air pollution, UV radiation, and radiation exposure (Young and Woodside 2001). These radicals interact with lipids, proteins, and DNA, disrupting their normal functions. Damage caused by free radicals is suggested to be at the root of various health conditions, including heart disease, diabetes, cancer, and aging (Akkuş 1995; Bayram et al. 2019). Antioxidants prevent cellular damage by scavenging existing radicals (Kahkönen et al. 1999).

Research indicates that increasing antioxidant intake through daily consumption of plant-based foods is essential (Prior and Cao 2000; Kılınç and Kılınç 2002; Arbos et al. 2008). Factors that determine the significance of antioxidants for human health include their chemical structures, solubility, structure-activity relationships, and natural availability (Kaur and Kapoor 2001). In addition to antioxidants, parameters like moisture and ash content are widely used as indicators of food quality. The ash content of a food item refers to the inorganic residue left after the combustion of organic matter, which results in the formation of water and carbon dioxide, leaving behind a mineral-rich inorganic fraction. Plants are the primary source of minerals for humans, who obtain them through plant-based foods, water, and animal-derived products. Most minerals in foods are bound to organic compounds such as proteins, fats, and carbohydrates. Ash determination is a crucial method for assessing the quality of food products. Moisture determination is among the most fundamental analyses in food processing and quality control. The water content of food significantly affects its shelf life, as dry matter and water content are inversely proportional. As water content increases, dry matter decreases, and vice versa (Karaköy et al. 2012, Soretire and Olayinka 2013; Güler and Emeksiz 2014, Çilesiz et al. 2023).

This study aimed to evaluate the antioxidant capacity, moisture, and ash content of early-maturing soybean genotypes grown under the Sivas ecological conditions.

2. Materials and Methods

This study utilized 25 soybean genotypes and five registered soybean varieties (Arısoy, Traksoy, Samsoy, Soyanam, and Ataem-7) as plant material. Arısoy; Thanks to its high adaptability, it has a high yield potential in fields with different soil structures. In Arısoy soybean seeds, the average first pod height is 15 cm over the years, preventing harvest losses. It is suitable for both main and second crop cultivation in Çukurova, Aegean, and Southeastern Anatolia regions, as well as for main crop cultivation in the Black Sea and Central Anatolia regions. As Arısoy soybean belongs to the medium-early maturity group, it provides earliness. It has high tolerance to whitefly and high tolerance to pod blight disease. It also exhibits tolerance to charcoal rot disease. In the second crop, sowing should be performed at a rate of 8–10 kg of seeds per decare. Arısoy soybean is suitable for both main and second crop soybean farming under Çukurova conditions. It is also appropriate for main crop cultivation in Southeastern Anatolia and the Black Sea regions. Samsoy; Developed through the selection breeding method, this variety belongs to the medium-early maturity group (143 days) and has a determinate growth habit. The plant exhibits a semi-erect structure with an average height of 115 cm, a first pod height of 15 cm, and white flowers. The seeds are round-flat in shape and light brown in color. The plant produces an average of 90 pods, with a thousand-seed weight of 202 g and a yield of 435 kg/da. It has no lodging or seed shattering issues. The protein content is 42.83%, while the oil content is 21.7%. Recommended cultivation areas include the Black Sea, Marmara, and transitional regions as a main crop, and the Mediterranean and Southeastern Anatolia regions as a second crop. Traksoy; Developed through hybridization (NE 3399 × Iroquois S01-02-0S-6T-1T-2T-1T-0T) by the Trakya Agricultural Research Institute, this variety belongs to the second maturity group and has purple flowers. The pod color is dark gray (brownish), while the pubescence color is gray. The seed hilum is grayish-black. The plant height ranges from

100 to 110 cm and is resistant to lodging. It produces 60–80 pods per plant, with a first pod height of 12–14 cm. The thousand-seed weight is 180–190 g. The protein content is 39.3%, and the oil content is 22.0%. It can be cultivated as a main crop in all regions (Trakya-Marmara, Black Sea, Aegean, Mediterranean, and Southeastern Anatolia). Additionally, it is suitable for second-crop cultivation in the Çukurova and Trakya regions. Soyanam (Kristal22); Developed through hybridization by the Trakya Agricultural Research Institute, this variety belongs to the third maturity group and has purple flowers. The pod color is brown, while the pubescence color is light brown. The seed hilum is black. The plant height ranges from 100 to 120 cm and is resistant to lodging. It produces 80–90 pods per plant, with a first pod height of 13–15 cm. The thousand-seed weight is 140–160 g. In the main crop, it has a yield potential of approximately 500 kg per decare. It can be cultivated as a main crop in all regions (Trakya-Marmara, Black Sea, Aegean, Mediterranean, and Southeastern Anatolia). Additionally, it is suitable for second-crop cultivation in the Çukurova and Trakya regions. As a main crop, it should be sown between April 20 and May 10, while for the second crop, sowing should be done between June 20 and June 30, and in the Trakya region, until July 10–12. The recommended seed rate is 6–8 kg per decare. Ataem7; Developed by the Western Mediterranean Agricultural Research Institute, this variety belongs to the third maturity group and has white flowers. The pod color is brown, while the pubescence color is light brown. The plant height ranges from 100 to 120 cm and is resistant to lodging. It produces 70–80 pods per plant, with a first pod height of 15–18 cm. The thousand-seed weight is 140–160 g. In the main crop, it has a yield potential of approximately 480 kg per decare. It can be cultivated as a main crop in the Mediterranean, Aegean, Çukurova, and Southeastern Anatolia regions. Additionally, it is suitable for second-crop cultivation in the Çukurova and Mediterranean regions.

The experiment was conducted during the 2023 soybean growing season at the Agricultural R&D Center trial fields of Sivas University of Science and Technology. The field experiment was arranged in a randomized block design with three replications. Each genotype was sown in 5-meter-long plots with four rows per plot. The row spacing was 70 cm, and the intra-row spacing was 10 cm.

At the time of sowing, 6 kg/da nitrogen (N) and 8 kg/da phosphorus (P_2O_5) were applied. Sowing was carried out on May 16, 2023, considering the climatic conditions of the region. During the growing season, all necessary agronomic practices, including weed control, irrigation, and other maintenance, were performed meticulously based on the needs of the plants and prevailing weather conditions. A drip irrigation system was used for watering. The soil properties of the trial field at the Agricultural R&D Center of Sivas University of Science and Technology are presented in Table 1.

Table 1. Soil properties of the Agricultural R&D Center of Sivas Science and Technology University, where the research was conducted.

Depth	Texture	pH	Lime (% $CaCO_3$)	Salt (%)	Phosphorus (P_2O_5 kg/da)	Potassium (K_2O kg/da)	Organic Matter Content (%)
0-30 cm	Silty clayey	7.28	19.6	0.33	3.40	93.59	1.7

The soil at the research location is classified as silty clay loam, with a pH value of 7.28. It is characterized by low organic matter content (1.7%), high potassium levels (93.59 kg/da), low phosphorus (3.40 kg/da), significant lime content (19.6%), and low salinity (0.33%) (Table 1). During the study, no issues with groundwater were encountered, and the field was adequately drained.

Climate data for the 2023 growing season and long-term averages for Sivas province are presented in Table 2. Sivas has a continental climate, characterized by hot and dry summers and cold, snowy winters. Key climatic values for the study period, such as total precipitation, average temperature, and average relative humidity, are summarized in Table 2. During the experimental period in 2023, the lowest total precipitation was recorded in July (3.0 mm), while the highest was observed in April (74.8 mm). The lowest average temperature was recorded in April (9.1 °C), whereas the highest average temperature occurred in August (23.4 °C). Regarding relative humidity, were the lowest average value was observed in September (72.3%), while the highest was recorded in June (95.3%).

Table 2. Climatic data for the 2023 growing season and long-term data of Sivas Province *

	Total Precipitation (mm)		Average Temperature (˚C)		Average Relative Humidity (%)	
Months	**2023**	**Long Term**	**2023**	**Long Term**	**2023**	**Long Term**
April	74.8	33.7	9.1	8.9	92.8	62.3
May	56.4	54.7	13.0	13.5	93.6	61.1
June	51.4	43.4	17.3	17.0	95.3	58.3
July	3.0	6.2	20.1	20.0	82.8	54.0
August	3.6	4.5	23.4	20.3	76.6	53.0
September	4.3	17.8	19.2	16.3	72.3	62.0
October	7.6	36.8	18.4	10.9	74.5	64.0
Total/Average	**201.1**	**197.1**	**17.21**	**15.27**	**83.99**	**59.24**

* Sivas Provincial Directorate of Meteorology.

2.1. Moisture

Moisture determination was performed according to the TS EN ISO 712 standard (TSE, 2012). Harvested seeds were first dried and then ground for analysis. A 3 g sample was weighed and placed into a moisture container. The samples were then transferred to a preheated oven at 130 °C and held for 2 hours. After drying, the samples were weighed. The moisture content was calculated using the following formula:

$$\text{Moisture (\%)} = [(m2-m1)(m2-m3)]\times 100 \tag{1}$$

m1: Weight of the dried, empty moisture container and lid (g)

m2: Weight of the analysis sample plus the moisture container and lid (g)

m3: Weight of the moisture container and lid with the analysis sample after drying (g).

2.2. Ash Analysis

Samples ground from each seed were weighed (2 g) and placed into pre-weighed porcelain crucibles. The samples were combusted in an ash furnace at 650 °C for 3.5 hours. After combustion, the crucibles with the ash were weighed again. The weight of the porcelain crucibles was subtracted to determine the ash content of the samples.

$$\text{Ash} = [(\text{amount of ash}) / (\text{amount of sample})] * 100 \ (\%) \tag{2}$$

2.3. Antioxidant Analysis

DPPH Assay: The DPPH radical (2,2-diphenyl-1-picrylhydrazyl) is an artificially stable radical widely used as a standard for determining antioxidant activity. The free radical scavenging activity of soybean samples was measured using the DPPH radical method as described by Blois (1958). For the assay, 0.1 mL of the sample was added to 2 mL of DPPH solution (0.025 g/L). The resulting mixture was incubated in the dark for 30 minutes. Absorbance was recorded at 517 nm. Results were expressed as µmol Trolox equivalents (TE) per gram of dry sample.

ABTS Assay: The ABTS assay was performed using the spectrophotometric method developed by Re et al. (1999). To prepare the stock solution, ABTS (7 mM) and potassium persulfate (2.45 mM) were each dissolved in 50 mL of distilled water. A mixture of 10 mL of the prepared ABTS solution and 10 mL of potassium persulfate solution was used to generate the ABTS radical solution. This mixture was allowed to stand in the dark at room temperature for 16 hours to form the ABTS radical solution. The working solution was prepared by diluting the stock solution to achieve an absorbance value of 0.700 ± 0.02 at 734 nm, establishing the initial absorbance value. For the assay, 100 µL of the extract was added to 3 mL of the working solution (ABTS + potassium persulfate), mixed thoroughly, and incubated at room temperature in the dark for 10 minutes.

Absorbance values were then recorded at 734 nm. Trolox was used as the standard, and results were expressed as Trolox equivalents (TE).

2.4. Statistical Analysis

The observed data were subjected to variance analysis using the MSTATC statistical software. Differences among the means were grouped using the Least Significant Difference (LSD) test at a significance level of p≤0.05.

3. Results and Discussion

The lower the absorbance of the mixture formed between antioxidants and the reagents (DPPH or ABTS), the higher the antioxidant's free radical scavenging activity. As the antioxidant concentration increases, the absorbance value decreases. The decrease in absorbance is due to the reaction between the radical and antioxidant molecules, resulting in the binding of hydrogen and the scavenging of the radical. The DPPH assay is commonly used to determine the degree to which a molecule acts as a free radical scavenger or hydrogen donor. The ABTS radical is soluble in both aqueous and organic solvents, making it suitable for measuring the antioxidant capacity of both lipophilic and hydrophilic compounds (Wong et al. 2006; Osman et al. 2006; Reis et al. 2011). The antioxidant capacity values determined by the DPPH method are presented in Table 3.

Table 3. Variance analysis results for the antioxidant capacity (DPPH method) values of the soybean genotypes

Genotypes	DPPH	Genotypes	DPPH
Arısoy	1,53±0,17	Ünv-3	3,25±0,12
Traksoy	3,94±0,04	Ünv-4	2,65±0,11
Samsoy	2,95±0,08	Ünv-5	1,37±0,24
Soyanam	2,32±0,17	Ünv-6	3,37±0,11
Ataem-7	2,51±0,11	Ünv-7	3,82±0,16
4	3,27±0,10	Ünv-8	2,93±0,08
5	2,63±0,17	Ünv-11	3,95±0,09
6	3,41±0,26	Ünv-12	3,51±0,11
7	2,34±0,22	Ünv-13	2,88±0,08
8	2,25±0,13	Ünv-15	4,03±0,18
9	3,49±0,31	Ünv-16	3,15±0,12
10	2,85±0,11	Ünv-17	1,88±0,13
11	3,05±0,10	Ünv-18	3,06±0,20
12	2,37±0,06	Ünv-19	3,32±0,19
Ünv-2	2,88±0,13	Ünv-20	3,36±0,10

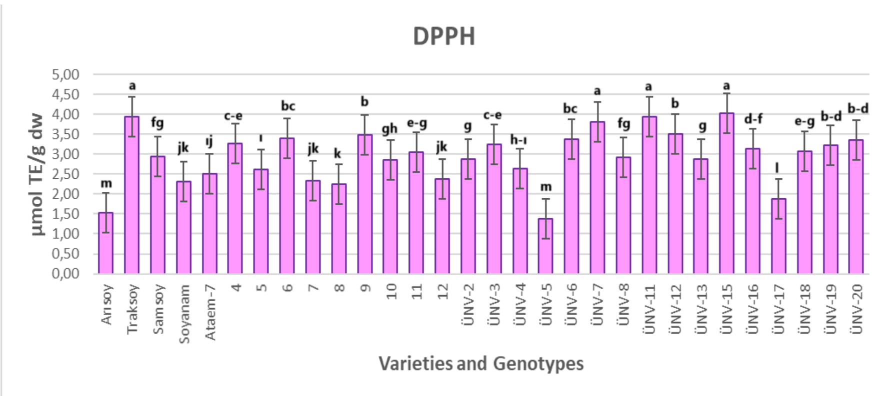

Figure 1. Different lowercase letters indicate significant differences between the samples (p < 0.01). LSD: 0.219. (dw: dry weight)

In the DPPH assay, the differences among the genotypes for this trait were statistically significant at the 1% level. The highest antioxidant activity was obtained from the ÜNV-15 genotype, with a value of 4.03 μmol TE/g dry weight (dw). This was followed by the ÜNV-11 genotype with 3.95 μmol TE/g dw and the Traksoy variety with 3.94 μmol TE/g dw. It was determined that the antioxidant activities of the Traksoy variety and ÜNV-11/15 genotypes were nearly identical. The lowest antioxidant activity was found in the ÜNV-5 genotype, with a value of 1.37 μmol TE/g dw. The differences among the genotypes for this trait were statistically significant at the 1% level (Table 3; Figure 1). Soedarjo et al. (2020), in their study using the DPPH method, reported that some developed soybean varieties, such as Detap 1 (29.66%), Anjasmoro (29.13%), and Dena 2 (28.35%), exhibited higher antioxidant activity compared to imported soybeans (27.75%). Zaini et al. (2024), in their study using the DPPH method, found that soybean samples showed a free radical scavenging activity of 38.92%, with an antioxidant activity of 3.47 mg AAE/100 g and a phenolic content of 14.75 mg GAE/100 g.

Table 4. Variance analysis results for the antioxidant capacity (ABTS method) values of the soybean genotypes

Genotypes	ABTS	Genotypes	ABTS
Arısoy	11,02±0,98	Ünv-3	8,83±0,27
Traksoy	8,65±0,36	Ünv-4	9,05±0,61
Samsoy	8,26±0,26	Ünv-5	8,26±0,43
Soyanam	6,98±0,57	Ünv-6	8,79±0,62
Ataem-7	7,65±0,60	Ünv-7	11,49±0,39
4	10,57±0,45	Ünv-8	10,22±0,42
5	8,95±0,55	Ünv-11	9,20±0,18
6	9,23±0,47	Ünv-12	10,54±0,70
7	7,74±0,57	Ünv-13	8,62±0,15
8	10,81±0,52	Ünv-15	9,44±0,07
9	9,25±0,51	Ünv-16	8,44±0,07
10	8,95±0,80	Ünv-17	10,34±0,23
11	9,45±0,42	Ünv-18	9,09±0,45
12	10,69±0,56	Ünv-19	8,11±0,13
Ünv-2	11,82±0,61	Ünv-20	8,25±0,11

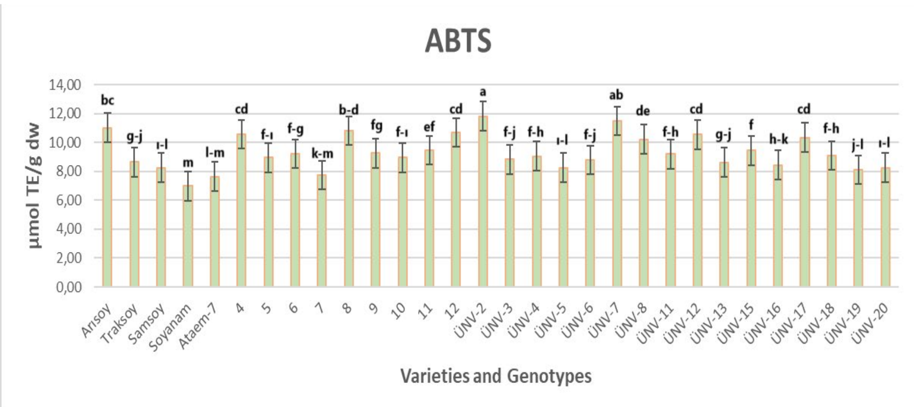

Figure 2. Different lowercase letters indicate significant differences between the samples (p < 0.01). LSD: 0.777. (dw: dry weight)

In the ABTS assay, the differences among the genotypes for this trait were statistically significant at the 1% level. The highest antioxidant activity was obtained from the ÜNV-2 genotype with a value of 11.82 μmol TE/g dry weight (dw). This was followed by the ÜNV-7 genotype with 11.49 μmol TE/g dw and the Arısoy variety with 11.02 μmol TE/g dw. The lowest antioxidant activity was found in the Soyanam variety, with a value of 6.98 μmol TE/g dw (Table 4). The differences among the genotypes for this trait were statistically significant at the 1% level (Table 4; Figure 2). In similar studies, Juliana et al. (2020) determined the IC50 value of the black soybean extract's ABTS scavenging activity as 77.39 μg/mL. Soedarjo et al. (2020), using the ABTS method, reported that the Demas sample exhibited 62.26% antioxidant activity, while Tanggamus soybean had 51.15% inhibitory activity. Zaini et al. (2024), in their study using the ABTS method, found that soybean samples exhibited an activity of 18.76 mg AAE/100 g.

Table 5. Variance analysis results of the moisture content of soybean genotypes

Genotypes	Moisture	Genotypes	Moisture
Arısoy	9,67±0,37	Ünv-3	11,13±0,11
Traksoy	10,14±0,12	Ünv-4	11,56±0,08
Samsoy	9,13±0,16	Ünv-5	10,73±0,44
Soyanam	10,72±0,18	Ünv-6	11,07±0,12
Ataem-7	8,75±0,20	Ünv-7	10,71±0,13
4	10,75±0,13	Ünv-8	11,43±0,21
5	10,40±0,05	Ünv-11	11,94±0,04
6	9,81±0,14	Ünv-12	11,57±0,09
7	9,66±0,08	Ünv-13	11,46±0,07
8	9,70±0,04	Ünv-15	10,88±0,12
9	10,69±0,40	Ünv-16	11,20±0,17
10	11,50±0,22	Ünv-17	11,39±0,14
11	11,21±0,15	Ünv-18	10,75±0,11
12	11,58±0,31	Ünv-19	10,59±0,24
Ünv-2	10,42±0,42	Ünv-20	12,27±0,22

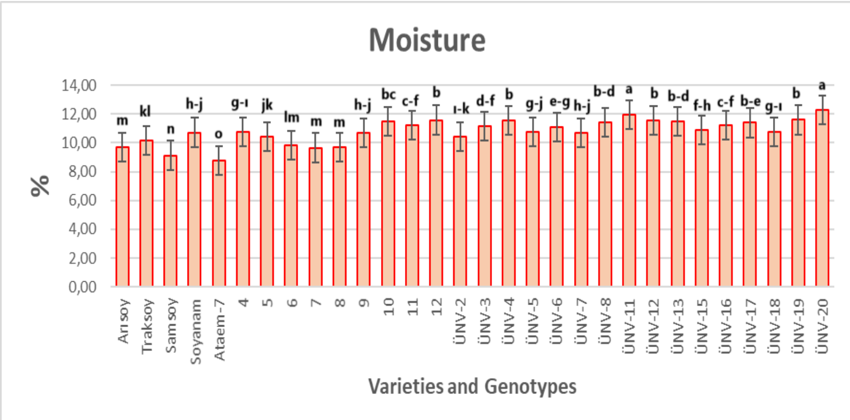

Figure 3. Different lowercase letters indicate significant differences between the samples (p < 0.01). LSD: 0.342.

The moisture content of the soybean genotypes and varieties used as material in this study ranged from 8.75 to 12.27%, and this difference was found to be statistically significant at the 1% level (Table 5; Figure 3). It was determined that the Soyanam variety had 10.72% moisture, while the Univ-19 and Univ-20 genotypes had 11.59% and 12.27% moisture, respectively. Ataem-7 and Samsoy varieties were found to have 8.75% and 9.13% moisture, respectively. Kolay (2007), in a study investigating the effects of different soil tillage methods on yield and some soil properties in second-crop soybean farming under Diyarbakır conditions, reported that the average moisture content of the seeds ranged between 7.06 and 7.13%. Furthermore, it was observed that the varieties had very similar values, and thus no statistical differences were found. The study also indicated that soil tillage methods did not significantly affect this trait (Kolay 2007).

Moisture content, one of the basic standard characteristics determined by TSE, is widely considered by all parties involved in buying and selling soybeans. However, industrial organizations involved in soybean imports mostly follow the official standards of the United States. In the TSE standard for soybeans, moisture is one of the key properties, and it has become an established rule in the market. Due to this characteristic, moisture content is one of the most important criteria for soybean marketing. The reason why moisture content is given considerable attention is that soybeans must contain low moisture to be harvested, stored, and processed properly (Güler and Emeksiz 2014).

Table 6. Variance analysis results of the ash content of soybean genotypes

Genotypes	Ash	Genotypes	Ash
Arısoy	2,91±0,06	Ünv-3	3,58±0,08
Traksoy	3,94±0,03	Ünv-4	3,24±0,11
Samsoy	3,76±0,05	Ünv-5	4,05±0,04
Soyanam	2,86±0,05	Ünv-6	3,71±0,05
Ataem-7	3,86±0,06	Ünv-7	3,51±0,15
4	2,98±0,08	Ünv-8	3,29±0,08
5	3,07±0,06	Ünv-11	3,65±0,21
6	3,17±0,16	Ünv-12	3,46±0,22
7	3,61±0,27	Ünv-13	3,55±0,12
8	3,96±0,06	Ünv-15	3,06±0,09
9	3,53±0,11	Ünv-16	3,40±0,23
10	3,13±0,12	Ünv-17	3,33±0,13
11	3,77±0,12	Ünv-18	3,36±0,23
12	3,88±0,08	Ünv-19	3,05±0,18
Ünv-2	3,22±0,11	Ünv-20	3,36±0,11

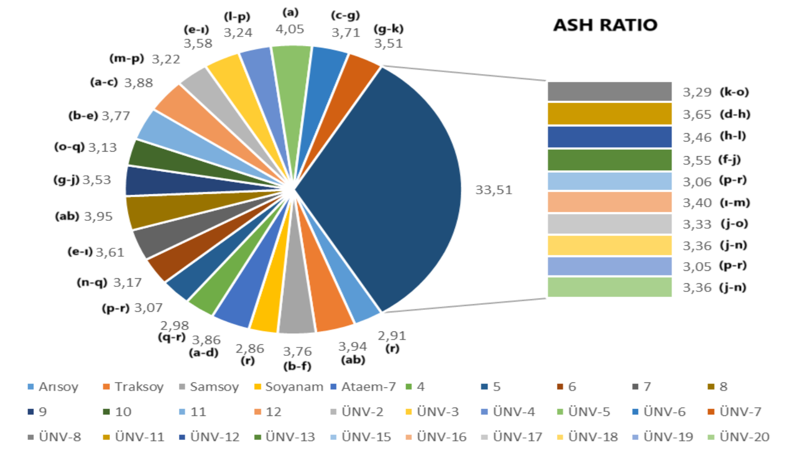

Figure 4. Different lowercase letters indicate significant differences between the samples. ($p < 0.01$). LSD: 0.219.

As seen in Table 6, the ash content in the genotypes ranged from 2.86 to 4.05%, with an average of 3.44%. The difference in the ash content values between the samples was found to be statistically significant at the 1% level (Table 6; Figure 4). Soyanam, Arısoy varieties and genotype number 4 had ash content of 2.86%, 2.91% and 2.98%, respectively. Öztürk et al. (2020) reported that the crude ash content in their study, which aimed to determine the silage quality of mixtures of hop with corn and feed soybean, ranged from 7.38 to 15%. Pejuhan (2018), in a study conducted over two years at different locations, determined the crude ash content of soybeans in the first year as 11.5% in Erzurum and 12.4% in Urumiye, and in the second year as 11.5% in Erzurum and 13.3% in Urumiye. Erekul (2020), in a study conducted in Aydın province, reported crude ash content values of 4.14 to 5.08% for soybeans in 2017-2018 field conditions. The values observed in these studies are higher than those found in the current study. This difference may be attributed to the genotypes used as material and the growing conditions.

4. Conclusions

Plants are powerful natural sources of antioxidants, exhibiting wide variability in chemical composition and biological properties. The antioxidant potential in some plants is based on the cumulative effects of various bioactive compounds. Therefore, it is essential to perform at least two different analytical methods simultaneously to obtain a reliable evaluation of antioxidant activity. In this regard, the DPPH analysis, which measures antioxidants with hydrogen-reducing capacity, and the ABTS analysis, which identifies both hydrophilic and hydrophobic antioxidants, were included in this study. The results revealed variability in antioxidant activity values among soybean seeds with different genetic backgrounds. Furthermore, since it is preferable for seeds to contain low moisture content for storage and processing, Ataem-7 was distinguished as the variety with the lowest moisture content. As a result, the ÜNV-2 and ÜNV-15 genotypes, with relatively higher antioxidant activity, and the Ataem-7 variety, with a low moisture content, were prioritized for selection based on these characteristics.

Author Contributions: Methodology, T.K. and Y.C.; planting process Y.C.; M.T.; İ.Y. and M.F.S.; formal analysis, T.K. and Y.C.; investigation, Y.C. and T.K.; resources, Y.C.; data curation, T.K. and Y.C.; writing—original draft preparation, T.K. and Y.C.; writing—review and editing, T.K.; K.K. and Y.C.; project administration, T.K. and Y.C.; All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by Sivas Science and Technology University Scientific Research Projects Coordination.

Acknowledgments: This study was produced from the project number 2023-GENL-TBT-0010, which was carried out with the support of Sivas Science and Technology University Scientific Research Projects Coordination.

Conflicts of Interest: The authors declare no conflict of interest.

References

Akkuş İ (1995). Free Radicals and Their Pathophysiological Effects. Mimoza Publications, Konya.

Arbos KA, Claro LM, Borges L, Santos C, Weffort-Santos AM (2008). Human erythrocytes as a system for evaluating the antioxidant capacity of vegetable extracts. *Nutrition Research*, 28(7): 457-463.

Bayram Y, Torlak Y, Sağdıç O (2019). Antioxidant activity of rowan fruit. *European Journal of Science and Technology*, (16): 933-939.

Blois MS (1958). Antioxidant determinations by the use of a stable free radical. *Nature*, 181(4617): 1199-1200.

Çilesiz Y, Nadeem MA, Gürsoy N, Kul R, Karaköy T (2023). Assessing the cooking and quality traits diversity in the seeds of faba bean germplasm. *Turkish Journal of Agriculture and Forestry*, 47(4): 448-466.

Erekul O (2020). International Innovation Cooperation Network for Increasing Soybean Production Due to Global Change (INNISOY), Aydın.

Güler D, Emeksiz F (2014). Soybean production, consumption and marketing in Türkiye. Master Thesis, Çukurova University(Unpublished), Türkiye.

Juliana C, Lister INE, Girsang E, Nasution AN, Widowati W (2020). Antioxidant and elastase inhibitor from black soybean (*Glycine max* L.) and its compound (daidzein). *Journal of Biomedicine and Translational Research*, 6(1): 11-14.

Kahkönen MP, Hopia AI, Vuorela HJ, Rauha JP, Pihlaja K, Kujala TS, Heinonen M (1999). Antioxidant activity of plant extracts containing phenolic compounds. *Journal of Agricultural and Food Chemistry*, 47(10): 3954-3962.

Karaköy T, Erdem H, Baloch FS, Toklu F, Eker S, Kilian B, Özkan H (2012). Diversity of macro-and micronutrients in the seeds of lentil landraces. *The Scientific World Journal*, (1): 710412.

Kaur C, Kapoor HC (2001). Antioxidants in fruits and vegetables–the millennium's health. *International Journal of Food Science and Technology*, 36(7): 703-725.

Kılınç K, Kılınç A (2002). Oxygen radicals as mediators of oxygen toxicity. *Hacettepe Medical Journal*, 33(2): 110-118.

Kolay B (2007). Effects of different tillage methods on yield and some soil properties in second crop soybean cultivation in Diyarbakır conditions. PhD Thesis, Harran University (Unpublished), Türkiye.

Osman AM, Wong KK, Hill SJ, Fernyhough A (2006). Isolation and the characterization of the degradation products of the mediator ABTS derived radicals formed upon reaction with polyphenols. *Biochemical and Biophysical Research Communications*, 340(2): 597-603.

Öztürk YE, Gülümser E, Mut H, Başaran U, Doğrusöz MÇ (2020). Determination of silage quality of hop mixtures with corn and feed soybean. *Harran Journal of Agricultural and Food Sciences*, 24(4): 440-446.

Pejuhan J (2018). Effects of foliar iron and zinc application with biological fertilizers on hay yield and yield components in forage soybean. PhD Thesis, Atatürk University, University of Science, Erzurum.

Prior RL, Cao G (2000). Analysis of botanicals and dietary supplements for antioxidant capacity. *Journal of AOAC International*, 83(4): 950-956.

Re R, Pellegrini N, Proteggente A, Pannala A, Yang M, Rice-Evans C (1999). Antioxidant activity applying an improved ABTS radical cation decolorization assay. *Free Radical Biology and Medicine*, 26(9-10): 1231-1237.

Reis FS, Heleno SA, Barros L, Sousa MJ, Martins A, Santos-buelga C, Ferreira I (2011). Toward the antioxidant and chemical characterization of mycorrhizal mushrooms from northeastern Portugal. *Journal of Food Science*, 76(6): 824–830.

Seeram NP, Zhang Y, Henning SM, Lee R, Niu Y, Lin G, Heber D (2006). Pistachio skin phenolics are destroyed by bleaching resulting in reduced antioxidative capacities. *Journal of Agricultural and Food Chemistry*, 54: 7036-7040.

Soedarjo M, Suhartina S, Nugrahaeni N, Wijanarko A, Putri DA, Fatmawati S (2020). The antioxidant activities and phenolic content of improved soybean seeds varieties of different grain sizes. *IPTEK The Journal for Technology and Science*, 31(1): 83-90.

Soretire AA, Olayinka A (2013). Response of soybean (*Glycine max* L.) to cow dung and wood ash application in tropical acid soils of South-Western Nigeria. *Nigerian Journal of Soil Science*, 23(2): 103-113.

TSE (2012). TS EN ISO 712, Grain and grain products - Determination of moisture content. Turkish Standard, Turkish Standards Institute, Ankara.

Wong SP, Leong LP, Koh JHW (2006). Antioxidant activities of aqueous extracts of selected plants. *Food Chemistry*, 99(4): 775-783.

Young IS, Woodside JV (2001). Antioxidants in health and disease. *Journal of Clinical Pathology*, 54(3): 176-186.

Yu J, Ahmedna M, Goktepe I, Dai J (2006). Peanut skin procyanidins: composition and antioxidant activities as affected by processing. *Journal of Food Composition and Analysis*, 19: 364-371.

Zaini NS, Karim R, Razis AFA, Zunairah W, Ibadullah W, Zawawi N (2024). Comparative analysis of ultra-high performance liquid chromatography-mass spectrometry and antioxidant properties between kenaf (*Hibiscus cannabinus* L.) seed and soybean (*Glycine max*) milk substitutes. In The 7th International Conference for Women in Science Without Borders, 2 April, Malaysia, p. 61.