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Determination of Biochemical Composition and Pigment Content in Legume and Cereal Microgreens

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ABSTRACT

Background: Legumes and cereals microgreens are consumed both in healthy nutrition and as a natural food against many degenerative diseases due to their rich bioactive content. The research was carried out to determine the biochemical contents of 5 legumes and 7 cereals.

Methods: The research was conducted in Van Yuzuncu Yıl University Field Crops Department Laboratory in 2020, in a controlled growing environment, according to the completely randomized experimental design. Total antioxidant activity, total phenolic, total flavonoid and total ascorbic acid contents and total Chlorophyll, Chlorophyll a, Chlorophyll b and Carotenoid contents and correlation between them were determined.

Result: The differences between the means of all traits were found to be significant. The biochemical contents of cereals were 1.6-7 times higher than legumes. There was no big difference between the pigment values. In legumes, Bilensoy alfalfa had the highest total antioxidat activity and total flavonoid content, Uzbek lentil total phenolic content and Goynuk bean had the highest Total ascorbic acid. In cereals, Kirklar oat had the highest total antioxidat activity, total phenolic, total flavonoid and total ascorbic acid contents, while Larende barley had the lowest values (except total ascorbic acid content). While total Chlorophyll and Chlorophyll a amounts were highest in Kirklar barley and lowest in Uzbek lentils, the opposite situation occurred in Chlorophyll b and Carotenoid amounts. There was no significant correlation between biochemical parameters in legumes. There was a positive and significant correlation between total phenolic content with total antioxidant activity and between total ascorbic acid with total fenolic content in cereals. There were positive and significant correlations between all pigment parameters in both legumes and cereals.

Key words: Bioactive contents, Cereals, Correlation, Legumes, Pigment contents, Total antioxidant.

INTRODUCTION

Legumes occupy a very important place in human nutrition in many parts of the world due to their rich nutritional content (Fidan and Ekincialp, 2017; Chiriac *et al*. 2020). At the same time, legumes, which are the source of many bioactive compounds such as flavonoids, carotenes, chlorophyll and antioxidants (Klopsch *et al*. 2018), are natural food sources used to prevent many degenerative diseases such as cancer (Rafiñska *et al*. 2017; Colgecen *et al*. 2020). but legumes also contain biochemical substances that are difficult to digest, such as saponin (Tuncturk *et al*. 2016). The biochemical compositions of cereals such as corn, barley, wheat and oat have been extensively investigated (Niroula *et al*. 2019). Although they are widely used as food and feed sources, the bioactive structures of many legumes have not been sufficiently investigated yet (Kabtni *et al*. 2020).

Bioactive compounds also increase the resistance of plants to stress conditions (Yadav and Hemantaranjan, 2017; Yilmaz and Kulaz, 2019). The responses of plants to these conditions can be determined by their antioxidative enzyme activities (Kusvuran, 2015). However, the amounts of compounds such as Total Chlorophyll, Total Phenolic and Total Flavonoids vary in plants under stress conditions (Kusvuran and Dasgan, 2017).

Microgreens have recently become an important element of popular nutrition. Like cereal microgreens (Islam *et al*. 2020), legume microgreens are widely used for this purpose (Wojdyło *et al.* 2020).

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In this study, it was aimed to determine the antioxidant and some biochemical compositions of Bilensoy alfalfa (*Medicago sativa* L.), Arda chickpea (*Cicer arietinum* L.), Uzbek lentils (*Lens culinaris* L.), Amazon cowpea (*Vigna sinensis* L.), Goynuk bean (*Phaseolus vulgaris* L.) from the legumes and Kral 97 and Larende barley (*Hordeum vulgare* L.), Palandoken and Bezostaja 1 wheat (*Triticum aestivum* L.), Dirilis, Haskara and Kirklar oats (*Avena sativa* L.) from the cereals, which are widely used in Turkey, microgreens and grown in a controlled environment and to reveal the relationships between them by correlation

MATERIALS AND METHODS

This research was conducted in the controlled plant growing room of the Van Yuzuncu Yil University, Faculty of Agriculture, Field Crops Research Laboratory in 2020 (between October and December). In the study, total antioxidant activity (TAA), total phenolic (TPC), total flavonoid (TFC) and total ascorbic acid (TAC) contents and total chlorophyll (TCHL), chlorophyll a (CHLa), chlorophyll b (CHLb) and carotenoid (CAR) amounts of legumes and cereals were determined.

Herbal materials

The varieties used in the research, Uzbek lentil, Goynuk bean, Arda chickpea and Amazon cowpea were obtained from GAP International Agricultural Research Institute, Bilensoy alfalfa and Palandoken 97 wheat from Erzurum Eastern Anatolia Agricultural Research Institute, Kral 97 barley, Larende barley and Dirilis oats from Konya Bahri Dagdas Agricultural Research Institute, Bezostaja 1 wheat from Sakarya Maize Research Institute, Haskara oats from Aegean Agricultural Research Institute and Kirklar oats from Thrace Agricultural Research Institute.

Establishment of the experiment and microgreens formation

Trial layout and methods were created by making use of Niroula *et al*. (2019). The growth place consisting of sterile peat, cocopite (coconut shell) and perlite mixture obtained from a certified commercial company was placed by light pressing to cover 2/3 of the 500 cc plastic chalets and the seeds were sown by sprinkling. The seeds are covered with the same mixture in 2 cm thickness and lightly pressed. The prepared material was placed in a fully controlled climate cabinet at 21 ± 2/17 ± 2°C temperature, 50-60% humidity and 16/8 light / dark periods. Fujika 60-watt spiral fluorescent lamp was used for lighting. The cultivated material was irrigated daily with sufficient amount of pure water by spraying. After the microgreens reached a sufficient maturity, Palandoken 97, Bezostaja 1 wheats and Kirklar oats were cut on the day 7, Kral 97 wheat and Larende barley on the day 9, Uzbek lentils, Goynuk bean, and Arda chickpea on the day 11, Dirilis and Haskara oats on the day 13 and Bilensoy alfalfa on the day 20 with a sterile scissors from the junction where the soil and stem part meet.

Total chlorophyll, chlorophyll a, chlorophyll b, carotenoid values were measured in fresh weight (FW) and total phenolic, flavonoid, ascorbic acid and antioxidant amounts were measured in dry matter (DM).

Determination of total antioxidant activity (mg TE g^{-1} DM) (Ferric reducing antioxidant power, FRAP)

The material, which was weighed 0.2 g from the leaves and passed through the homogenizer by adding 5 ml of methanol, was then centrifuged at 12000 rpm for 15 minutes, and the supernatant part was removed. Later, 300 mM acetate buffer (pH 3.6), 10 mmol L^{-1} 2,4,6-tripyridyl-s-triazine (TPTZ), prepared by dissolving in 40 mM HCl, 20 mmol L^{-1} $FeCl_3.6H_2O$ solutions were prepared, respectively, 10 FRAP reagent was prepared by mixing in a ratio of 1:1. The mixture prepared for analysis with 2850 µL of FRAP reagent was diluted 20 times with methanol, then 150 µL of sample was mixed and kept at room temperature for 1 hour. The resulting ferrus tripyridyltriazine complex was measured at 593 nm in the spectrophotometer and the results were reported as mg Trolox g^{-1} (Lutz *et al*. 2011). Trolox concentration range has been studied as 0-500 ppm.

Determination of total phenolic content (mg GAE 100 g^{-1} DM)

The method developed by modifying the Folin-Ciocalteu spectrophotometric method specified by Obanda and Owuor (1997) was used to determine the total phenolic compound content. The serial operations specified in the method were carried out. After the obtained mixture was kept in the dark for 60 minutes, the absorbance value of the blue color formed was read in the spectrometer at 725 nm wavelength. The calibration curve was obtained by plotting the absorbance values read against these different concentrations of gallic acid and calculated as mg GAE 100 g^{-1}.

Determination of total flavonoid content (mg QE 100 g^{-1} DM)

Determination of total flavonoid content was determined according to the method developed by Quettier-Deleu *et al*. (2000). 2 ml of 2% $AlCl_3$ will be added onto 2 ml of extract and it will be kept at room temperature and in the dark for 1 hour. Total flavonoid contents of the extracts were measured with a spectrophotometer at 415 nm wavelength by performing 2 parallel runs in each sample and calculated in mg QE 100 g^{-1} by using the calibration curve prepared using standard quercetin.

Determination of ascorbic acid content (mg 100 g^{-1} DM)

2 g of fresh plant sample will be homogenized with Ultra-Turrax (WiseTis® homogenizer, HG 15A) with 20 ml of oxalic acid (0.4%) and kept at 5°C in a circular shaking oven (ACMI 006) for 24 hours. It was then centrifuged at 5000 rpm for 10 minutes. The supernatant taken was used in the ascorbic acid analysis. Ascorbic acid determination was determined spectrophotometrically (AOAC, 1990). Absorbance values were determined spectrophotometrically at 520 nm by adding 400 µL 0.4% oxalic acid and 4.5 ml (30 ppm) 2,6-dichlorophenolindophenol solution onto 100 µl supernatant. The amount of ascorbic acid in the samples was calculated in mg 100 g^{-1} with the help of the calibration curve drawn with pure ascorbic acid.

Pigment analysis

Determination of photosynthetic pigments performed according to Lichtenthaler (1985), formulas as below;

Total chlorophyll (µg g^{-1} FW) = (27.8 × A652),

Chlorophyll a (Chl a; µg g^{-1} FW) =

(11.75 × A662) - (2.350 × A645),

Chlorophyll b (Chl b; µg g^{-1} FW) =

(18.61 × A645) - (3.960 × A662),

Carotenoid (Car; µg g^{-1} FW) =

[(1000 × A470) - (2.270 × Chl a)] - (81.4 × Chl b 227^{-1}),

Where

FW: Fresh weight, A662: Absorbance reading at 662 nm wavelength, A652: absorbance reading at 652 nm wavelength, A645: absorbance reading at 645 nm wavelength, A470: absorbance reading at 470 nm wavelength.

Statiscal analysis

The data of the research were subjected to analysis of variance (ANOVA) according to the completely randomized experimental design. Statistical calculations were made using the program *COSTAT* (version 6.303). The differences between the means were determined according to the least significant differerence (LSD) comparison method and relationships among properties deetrmined with Pearson Correlation method.

RESULTS AND DISCUSSION

The amounts of TAA, TPC, TFC and TAC of the material examined in the study are given in Table 1 and the amounts of TCHL, CHLa, CHLb and CAR are given in Table 2. Accordingly, the differences between the averages of all the characteristics examined in both tables were found to be significant.

Total TAA Activities (mg TE g^{-1} "FRAP")

TAA measurement of plant extracts is still an unsolved problem and around 20 different indices are used to determine it (Sreeramulu *et al.*, 2009). FRAP is one of the most used methods (Marathe *et al.*, 2011).

TAA activities of legumes and cereals determined by FRAP method in our study ranged between 394.563±8.125 - 4989.375±25.000 mg TE g^{-1} DM. Kirklar oat variety was in the highest group, Arda chickpea and Amazon cowpea were in the lowest group. According to the group averages, the TAA level of cereals was around 7 times that of legumes. In the legume group, the highest TAA was in Bilensoy alfalfa (990.417±14.555 mg TE g^{-1} DM) and the lowest in grains in barley (1908.125±31.25 mg TE g^{-1} DM). In this case, the TAA level of the lowest cereal variety is 2 times higher than the highest legume variety.

Comparisons could not be made due to different solvents used in the studies and different units used to express the values according to the method

In some studies conducted with the FRAP method, TAA values were determined between 04.109 ± 0.228-68.030 ± 2.358 FRAP µmol g^{-1} in 30 legumes (Marathe *et al.* 2011), the highest in Brown Cowpea and the lowest in white chickpea. TAA values of 10 plant microgreens (Ghoora *et al.*, 2020) used in salad were determined between 7.0±0.5 - 38.7±2.0 FRAP µmol $Fe2+$ g^{-1}. TAA values of 7 legume seeds (Amarowicz *et al.*, 2004) were determined between 0.30±0.02-1.76±0.13 µmol Trolox mg^{-1}, the highest Adzuki bean and the lowest pea. Dry grains extract of 4 legumes and 4 grains (Djordjevic *et al.*, 2011) TAA values 8.34±0.54-49.43±0.49 FRAP-nmol $Fe2+$ mg^{-1} d.e. The highest Buckwheat (*Fagopyrum esculentum*) and lowest Soybean (*Glycine hispide*) were also detected. Contrary to our findings in this study, TAA values of legumes (except *Buckwheat*) were generally higher than cereals. Studies have shown that legumes are the main source of antioxidant activity among foods (Zhao *et al.*, 2014).

Total TPC Contents (mg GAE 100^{-1} g DM)

TPC contents of legumes and cereals ranged between 219.550±7.780 - 641.778±0 mg GAE 100 g^{-1} DM. Haskara

Table 1: Contents of TAA, TPC, TFC and TAC in legumes and cereals.

Varieties	TAA (mg TE g^{-1} DM)	TPC (mg GAE 100^{-1} g DM)	TFC (mg QE 100^{-1} g DM)	TAC (mg 100^{-1} g DM)
Lentils (Uzbek)	468.145±4.653 i	385.440±3.908 f	277.227±7.752 h	12.169±0.338 h
Bean (Goynuk)	454.895±4.480 i	287.220±6.728 i	198.253±10.702 j	14.089±0.940 g
Alfalfa (Bilensoy)	990.417±14.555 h	327.885±0.555 h	366.273±11.07 f	9.775±1.056 i
Chickpea (Arda)	394.563±8.125 j	285.882±5.063 i	227.528±0.922 i	13.014±0.62 gh
Cowpea (Amazon)	410.813±7.5 j	219.550±7.78 j	113.137±5.904 k	12.451±0.479 h
Barley (Kral 97)	2826.875±43.75 f	475.667±8.333 e	413.506±0.830 e	18.288±1.027 d
Barley (Larnde)	1908.125±31.25 g	369.556±6.666 g	288.782±2.952 h	16.918±0.342 e
Wheat (Palandoken)	3930.000±9.375 e	520.111±11.667 d	478.819±6.457 c	17.945±0.370 de
Wheat (Bezostaja 1)	4461.250±34.375 b	556.778±2.778 c	309.815±7.011 g	15.411±0.329 f
Oat (Dirilis)	4267.500±34.376 d	608.444±10.000 b	461.107±7.269 d	20.616±0.342 c
Oat (Haskara)	4305.000±28.125 c	641.778±0 a	512.768±1.328 b	25.479±0.534 b
Oat (Kirklar)	4989.375±25.000 a	634.000±7.778 a	562.952±20.295 a	26.986±0.767 a
C.V. %	0.690	1.425	2.545	3.894
LSD	28.63	10.685	15.122	1.116
Group means				
Legume means	543.767	301.195	236.483	12.300
Cereal means	3812.589	543.762	432.536	20.235
Ratio	0.143	0.554	0.546	0.608

*TAA: Total antioxidant activity, TPC: Total phenolic content, TFC: Total flavonoid content, TAC: Total ascorbic acid content. There is no significant difference between values shown with the same letter in the same column. Values are given with standard deviation (n:3). In fractions after the dot, three numbers are used.

and Kirklar oat varieties were in the highest group, Amazon cowpea was in the lowest group. According to the group averages, the TPC level of cereals was around 1.8 times that of legumes. In the legume group, the highest TPC was in Uzbek lentils (385.440±3.908 mg GAE 100^{-1} g DM), while in cereals the lowest was in Larende barley (475,667±8.333 mg GAE 100^{-1} g DM). In this case, the TPC level of the lowest cereal variety is 1.23 times higher than the highest legume variety.

Our TPC findings obtained from legumes are from the A-Low phenolic contents and B-Moderate phenolic contents groups of 20 legumes (0.325±0.002-1.878±0.062 mg GAE g^{-1}) and C-High phenolic contents group of a researcher (Marathe *et al.*, 2011). It is higher than red cowpea and soybean (respectively 2.086±0.058 - 2.170±0.062 mg GAE g^{-1}) and similar to the remaining 6 legumes in group C. TPC amounts of fenugreek and brown cowpea in group C of this study (4.298±0.072 - 6.378±0.054 mg GAE g^{-1}, respectively) were higher than the legume values in our study and similar to cereal values. While cowpea (brown cowpea) had the highest TPC value in the same study, it was the legume with the lowest value in our study. In another study in which the highest and lowest amounts were obtained from bean varieties (Sreeramulu *et al.*, 2009), TPC values (62.35 - 418.34 mg 100^{-1} g) in grains of 11 legume varieties were similar to the results of our study. In our study, the Goynuk bean variety was in the lowest group. The TPC value of Ragi Finger millet (373.15±70.07 mg 100^{-1} g), which has the highest amount in cereals in this study, is similar to the Larende barley variety of our study. Our results are lower than from Djordjevic *et al.* (2011) and Zhao *et al.* (2014) who the highest values were obtained from buckwheat and lentils (50.7±0.04 mg GAE g^{-1} d.e. and 47.6±5.3 mg g^{-1}, respectively).

Contrary to our findings, in a study conducted on dry grain extracts (Djordjevic *et al.*, 2011), TPC values of legumes were found to be higher than cereals, except for Buckwheat.

Total TFC contents (mg QE 100^{-1} g DM)

TFC contents of legumes and cereals ranged between 198.253±10,702-562.952±20.295 mg QE 100^{-1} g DM. Kirklar oats were in the highest group and Goynuk bean were in the lowest group. According to the group averages, the TFC level of cereals was 1.83 times higher than that of legumes. In the legume group, the highest TFC was in Bilensoy alfalfa (366.273±11.070 mg QE 100^{-1} g DM) and the lowest in cereals in barley (288.782±2.952 mg QE 100^{-1} g DM). In this case, the TFC level of the highest legume variety is 1.26 times higher than the lowest cereal variety.

The benefits of flavonoids, which have many varieties and plant-specific types, for human health (Ku *et al.*, 2020), protect humans against degenerative diseases such as cancer (Youdim *et al.*, 2004) and plants against environmental stress effects (Liu *et al.*, 2013) has been revealed by various studies. The TFC profile of plants is significantly affected by the plant developmental stages that make up the concentration and composition of secondary metabolites. Like other secondary metabolites, the amount of TFC increases with germination (Aisyah *et al.* 2016).

Table 2: TCHL, CHLa, CHLb and CAR contents in legumes and cereals.

Varieties	TCHL (µg g^{-1} TA FW)	CHLa (µg g^{-1} TA FW)	CHLb (µg g^{-1} TA FW)	CAR (µg g^{-1} TA FW)
Lentils (Uzbek)	35.076±0.119 b	24.526±0.295 b	10.550±0.141 a	7.234±0.130 a
Bean (Goynuk)	23.731±0.030 g	17.358±0.062 f	6.373±0.092 e	4.869±0.062 ef
Alfalfa (Bilensoy)	26.617±0.157 e	19.439±0.035 e	7.177±0.122 c	5.232±0.018 d
Chickpea (Arda)	19.568±0.123 j	14.451±0.044 h	5.117±0.167 i	4.523±0.078 g
Cowpea (Amazon)	21.094±0.131 i	15.396±0.091 g	5.698±0.041 g	4.041±0.007 i
Barley (Kral 97)	28.661±0.448 c	20.991±0.501 c	7.670±0.053 b	5.375±5.773 c
Barley (Larnde)	25.490±0.174 f	19.621±0.168 e	5.869±0.005 fg	4.750±0.034 f
Wheat (Palandoken)	22.719±0.004 h	17.363±0.006 f	5.356±0.002 h	4.080±0.001 i
Wheat (Bezostaja 1)	27.836±0.033 d	21.104±0.104 c	6.732±0.071 d	4.818±0.026 f
Oat (Dirilis)	27.366±0.379 d	20.342±0.035 d	7.025±0.344 c	4.943±0.021 e
Oat (Haskara)	23.720±0.345 g	17.785±0.291 f	5.935±0.053 f	4.396±0.033 h
Oat (Kirklar)	37.171±0.815 a	29.393±0.732 a	7.778±0.082 b	6.758±0.161 b
C.V. %	1.067	1.300	2.007	1.403
LSD	0.480	0.436	0.230	0.121
Group means				
Legume means	25.217	18.234	6.983	5.18
Cereal means	27.566	20.943	6.624	5.017
Ratio	0.91	0.87	1.05	1.03

*TCHL: Total chorophyll, CHLa: Chlorophyll a, CHLb: Chlorophyll b, CAR: Total carotenoid content. There is no significant difference between values shown with the same letter in the same column. Values are given with standard deviation (n:3). In fractions after the dot, three numbers are used.

According to the examined legumes, in some studies, the TFC contents of 10 salad plants (Ghoora *et al*., 2020) and *Cicer arietinum* microgreens (Kurian and Megha, 2020) were lower than our research (1.1±0.2-6.5±0.2 mg 100 g^{-1} FW and 1 mg QE g^{-1}, respectively). In germinated 7 commercial lentils (Bubelova *et al*., 2018), pea microsprouts (Klopsch *et al*., 2018) and *Vigna radiata* microgreens (Kurian and Megha, 2020) TFC contents were found similar to our study (34.8±1.65 - 55.2±2.74 mg RE kg^{-1} DM, 1.38 - 3.31 mg g^{-1} FW and 1.4 mg QE g^{-1}, respectively). Leaf and seed extracts of *Medicago minima* (Kabtni *et al.* 2020) were found to be higher (10.35 mg RE g^{-1} DM) than our research.

TFC amounts in the wheat microgreen (Islam *et al.* 2019) and whetgrass extracts (Islam *et al.* 2021) of the control groups (135.51±2.21 and 10.93±1.20ìg mL^{-1}, respectively) were lower than the cereal values of our study.

Total TAC (Vitamin C) contents (mg 100^{-1} g DM)

Regular consumption of vitamin C, which is required for collagen synthesis in humans, helps reduce oxidative stress and limit unwanted enzymatic oxidation reactions (Kyriacou *et al.* 2019).

In our study, TAC contents of legumes and cereals ranged between 9.775±1.057-26.986±0.767 mg 100^{-1} g DM. Kirklar oats were found in the highest group and Bilensoy alfalfa was found in the lowest group. According to the group averages, the TAC level of cereals was 1.64 times that of legumes. In the legume group, the highest TAC was in Goynuk bean (14.089±0.940 mg 100^{-1} g DM) and the lowest in cereals was Bezostaja 1 wheat (15.411±0.329 mg 100^{-1} g DM). In this case, the TAC level of the lowest cereal variety was close to the highest legume variety.

Our findings were low from L-ascorbic acid of lentil sprouts (Wojdyło *et al.* 2020) and TAC values of golden pea tendrils and pea tendrils (Xiao *et al.* 2012) (46.4±0.2, 25.1±0.7 and 50.5 ± 0.9 mg 100^{-1} g FW, respectively). Vitamin C values of the control group wheat microgreen (Islam *et al.* 2019) and whetgrass extracts (Islam *et al.* 2021) were similar to the TAC values of the cereals in our study (25.14±0.55 and 23.4±0.62 µg mL^{-1}, respectively). Our findings Wojdylo *et al.* (2020) black medick and mung bean sprouts and green peas microgreen values (6.2±0.0, 4.7±0.2 and 8.1±0.1 mg 100^{-1} g, respectively).

Studies show that TAC level is low in microgreens (Xiao *et al*., 2012). This situation is greatly influenced by genetics, environment, care and storage conditions (Kyriacou *et al.* 2019). However, in some plants, the vitamin C level peaked shortly after planting and then decreased to normal levels (Xu *et al.* 2005).

Pigment levels

The TCHL, CHLa, CHLb and CAR contents of the examined legumes and cereals are given in Table 2. The differences between the averages of all the analyzed features were found to be statistically significant.

TCHL amounts of cultivars ranged from 19.568±0.123 to 37.171±0.815 µg g^{-1} TA FW. Kirklar oats were in the highest group and Arda chickpeas were in the lowest group. CHLa contents ranged from 14.451±0.044 to 29.393±0.732 µg g^{-1} TA FW. Kirklar oats were in the highest group and Arda chickpeas were in the lowest group. CHLb contents ranged from 5.117±0.167 to 10.550±0.141 µg g^{-1} TA FW. Uzbek lentils were in the highest group and Arda chickpeas were in the lowest group. CAR contents ranged from 4.041±0.007 to 7.234±0.130 µg g^{-1} TA FW. Uzbek lentils were the highest, Amazonian boron and Palandoken wheat were the lowest.

In the study, all pigment averages of legumes and cereals ("legumes-cereals", TCHL: 25.217-27.566 µg g^{-1} TA FW, CHLa: 18.234-20.943 µg g^{-1} TA FW, CHLb: 6.983-6.624 µg g^{-1} TA FW, CAR : 5.18-5.017 µg g^{-1} TA FW) were close to each other.

Color has serious effects on quality and consumer preference. Generally, the CHL and CAR contents of microgreens are higher than sprouts (Wojdylo *et al.* 2020).

Our TCHL findings, according to the results in a study (Wojdylo *et al.* 2020), are higher than mung beans sprout (6.0 µg/g fw), similar to the black medick sprout (14.3 µg g^{-1}FW) and lower than the lentils sprout and green peas microgreen (108.5 and 522.7 µg g^{-1} FW, respectively). Our CHLa values are higher than mung beans and black medick sprouts (3.9±0.1 and 10.5±0.7 µg g^{-1} fw, respectively) and lower than lentils sprouts and green peas microgreen (77.6±1.5 - 288.3±3.6 µg/g fw) of the same study. Our CHLb values were higher than black medick and mung beans sprouts (1.6±0.1, 1.0±0.2 µg g^{-1} fw, respectively) and lower than lentils sprouts and green peas microgreen (16.1±0.6 and 157.8±2.4 µg g^{-1} fw, respectively). Our CAR values are lower than the parameters of this study.

According to another study (Klopsch *et al.* 2018), our CAR values were lower than those obtained from pea microgreens in the first (135 µg g^{-1} FW) and the second (264 µg g^{-1} FW) studies.

Relationships between properties (Pearson correlation)

The relations between TAA, TPC, TFC and TAC contents of legumes and cereals calculated by Pearson correlation method are given in Table 3 and the relations between TCHL, CHLa, CHLb and CAR contents are given in Table 5.

A positive and insignificant correlation was determined between TPC and TAA (r=0.324) and between TFC and TAA (r=0.805) and TPC (0.769) in legumes analyzed according to Table 4. A negative and insignificant correlation was found between TAC and TAA (r= -0.876), TPC (r= -0.326) and TFC (r= -0.714).

In cereals, there is a positive and very significant correlation between TPC with TAA (r=0.935***), a positive and insignificant correlation between TFC with TAA and TPC, a positive and insignificant correlation between TAC with TAA and TPC and a positive and insignificant with TFC (0.857*). While no significant correlation was observed between TAA with TPC and TFC in legumes, the correlation with TAC was found to be negative. But, a negative correlation was not observed in cereals.

Table 3: Correlation (Pearson) among TAA, TPC, TFC and TAC.

	Legumes		
	TPC	TFC	TAC
TAA	0.324	0.805	-0.876
TPC		0.769	-0.326
TFC			-0.714
		Cereals	
TAA	0.935**	0.648	0.549
TPC		0.752	0.713
TFC			0.857*

Table 4: Correlation (Pearson) among TCHL, CHLa, CHLb ve CAR.

	Legumes		
	CHLa	CHLb	CAR
TCHL	0.998***	0.996***	0.968**
CHLa		0.991**	0.963**
CHLb			0.972**
		Cereals	
TCHL	0.992***	0.843*	0.988***
CHLa		0.768*	0.976***
CHLb			0.85*

According to Table 5, positive and very significant correlation was determined between CHLa with TCHL (r=0.998***) positive and very significant between CHLb with TCHL (r=0.996***) and with CHLa (r=0.991***) and a positive and very significant correlation between CAR with TCHL (r=0.968**), CHLa (r=0.963) and CHLb (R=0.972**) in legumes.

In cereals, there is a positive and very significant correlation between CHLa with TCHL (r=0.992***) and CAR and TCHL (r=0.988***) and CHLa (r=0.976***), whereas there is a positive and very significant between CHLb with TCHL (0.843*) and CHLa (r=0.768*) and between CAR with CHLb, a positive and significant correlations were observed. It has been observed that there is a positive and significant correlation between pigment properties in legumes and cereals as well.

In contrast to our research, in a study conducted on raw, cooked and sprouted lentils samples (Bubelova *et al.* 2018), a positive and very significant correlation was determined between TFC with TPC in raw samples, and between TAA with TFC and TPC, but these correlations were relatively decreased in samples that were germinated. In some studies (Oomah *et al.* 2011; Guo *et al.* 2012), it was determined that legumes with the highest TPC content, likewise had the highest TAA levels.

In another study conducted on barley and wheat microgreens (Niroula *et al.* 2021), there was a positive and insignificant (r=0.443) relationship between TPC with TAC (Vitamin C) similar to our study and in contrast to our study, a positive and significant correlation (r=0.6139) was determined between Equivalent Antioxidant Capacities (EAC "FRAP") with Vitamin C and a positive and very significant correlation (r=0.918) with TPC. Similar to our study, in another study (Sreeramulu *et al.* 2009), a positive and insignificant correlation was found between TPC with TAA (r=0.44) in legumes and a positive and very significant correlation between TPC with TAA (r=0.91) in cereals and millets. On the other hand, similar to our research, there is a positive and very significant (r=0.99) correlation has been detected between CAR with TCHL, between CHLa with TCHL and CAR and between CHLb with TCHL, CAR and CHLa in the sprouts and grasses of selected cereals (Niroula *et al.* 2019). In contrast, a moderate correlation was found between CHLb with CHLa at doses of blue light (Samuoliene *et al.* 2017).

CONCLUSION

In terms of biochemical contents examined, cereals had 1.6 to 7.0 times higher amounts compared to legumes. Kirklar oats had the highest values in terms of total antioxidant activity, total phenolic, total flavonoid and total ascorbic acid contents. Among the cereals, Larende barley (except for total ascorbic acid content) had the lowest values.

Among the legumes, Bilensoy alfalfa had high values in terms of total antioxidant activity and total flavonoid content and Uzbek lentils had high values in terms of total phenolic and Goynuk beans had high values in terms of total ascorbic acid contents.

The highest difference between the groups occurred in the average total antioxidant activity. In this parameter, very large differences occurred between legumes and cereals, about 7 times. Thus, the total antioxidant activity of the lowest grain Larende barley is two times higher than the highest legume Bilensoy alfalfa (1908.125±31.25 and 990.417±14.555 mg TE g^{-1} DM, respectively).

The highest total chlorophyll and chlorophyll a values were determined in Kirklar oat (37.171±0.815 and 29.393±0.732 µg g^{-1} TA FW, respectively), it followed by Uzbek lentils. Chlorophyll b and carotenoid amounts were highest in Uzbek lentils (10.550±0.141 and 7.234±0.130 µg g^{-1} TA FW, respectively) this time, it followed by Kirklar oats. It is also understood from the group averages that there is not much difference between the varieties in terms of pigment amounts.

A very significant and positive correlation was found between total antioxidant activity with total phenolic content and a positive and significant correlation was found between total phenolic with total ascorbic acid contents, in cereals. A positive and insignificant correlation was found between pigment properties of cereals. A negative and insignificant correlation was found between total ascorbic acid with total antioxidant activity, total phenolic with total flavonoid contents, while a positive and insignificant correlation was found between other properties, in legumes. It was determined that there was a positive and significant correlation between total chlorophyll, chlorophyll a, chlorophyll b with carotenoid contents in legumes and cereals.

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