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Determination of the Polyphenolic Contents in Some Cereals and Legume Microgreens by Dualex Measurements

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Highlights:
- Dualex+ 4 Scientific
- Polyphenolics in cereal and legume microgreens
- Chlorophyll and flavonol contents

Keywords:
- Cereals
- Legumes
- Dualex
- Nitrogen balance index
- Anthocyanin

ABSTRACT:

This research aims to measure the nitrogen balance index (NBI) used in the evaluation of nitrogen (N) and chlorophyll (CHL), anthocyanin (ANTS), and flavonol (FLAV) contents of some cereal and legume microgreens. The experiment was established in the Fully Controlled Climate Room of Van Yuzuncu Yil University Faculty of Agriculture Department of Field Crops in October-November 2020. The plant materials used in the research were Bezostaja-1, Dogu-88, Palandoken and Ayyildiz wheat, Tarm-92, Cetin-2000, Larende and Kral-97 barley, Haskara, Dirilis, Kirklar, Kahraman and Faikbey oats, Arifiye maize, Uzbek and Sazak lentils. Arda chickpea, Goynuk bean, Mung bean, black chickpea, Amazon cowpea, Lutfibey sainfoin, Bilensoy-80 alfalfa, and Dadas red clover including 14 cereal and 10 legume varieties. The seeds planted in the planting medium consisting of the mixture prepared in plastic chalets with a 1331olüme of 500 cc were taken to a fully controlled climate room and microgreens were obtained by applying 50-60% humidity, 21 ± 2/17 ± 2 °C and 16/8 light/dark period, and microgreens were obtained in cereals and legumes. Polyphenolic measurements were taken when the microgreens were 7-9 days old and when sprouts of the forage legumes group were 20-21 days old. Measurements were performed in triplicate with the Dualex+ 4 Scientific (FORCE-A, Orsay, France) device. Statistical analysis of the measurements was carried out according to the Randomized Parcels Trial Design. According to the measurement results, the highest contents based on varieties were determined in Lutfibey sainfoin for NBI (106.533±10.68 mg/g), for CHL in Arda chickpea (41.3 ±2.63 µg/cm²), for ANTS in Dadas red clover (0.08 ±0.01 dualex index) and FLAV in Amazon cowpea (0.746 ±0.03 dualex index). According to group-based averages, the highest values were determined for NBI in forage legumes (86.844 mg/g), for CHL in barley (31.14 µg/cm²) and oats, edible cereal legumes and forage legumes in the same group, for ANTS in forage legumes (0.053 dualex index) and wheat and oats in the same group, for FLAV in edible cereal legumes (0.56 dualex index) and oat in the same group. The study concluded that cereal and legume microgreens have polyphenolic-rich contents. Similar research to be carried out under controlled and field conditions would be useful in evaluating bioactive ingredients and N.

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INTRODUCTION

Microgreens are a plant food whose green leaves are harvested just above the root collar shortly after the first true leaves emerge and are consumed in salads or single specialties (Kou et al., 2014). The preference for microgreens continues to increase with the functional food concept due to the high amounts of antioxidants, phenolics, vitamins, and minerals they contain compared to their mature counterparts (Xiao et al., 2015). Although it is produced in large quantities in many broad-leafed vegetables, microgreen cultivation, and research in cereals are limited (Altuner et. al., 2021).

Polyphenolics are secondary metabolites, most of which are found in plant leaves. So much so that it has been determined that 23% of a dry leaf consists of polyphenolics (Kandil et al., 2004). In addition, it has been determined that there is a linear relationship between nitrogen content in leaves and polyphenolics (Cartelat et al., 2005; Meyer et al., 2006; Tremblay et al., 2007). Chlorophyll is one of the most important pigments that can be used as a measure in determining the nitrogen status of plants and where photosynthesis occurs in plants (Wood et al., 1992). Flavonols are another indicator that can be used as an indicator of nitrogen sensitivity. There is an inverse relationship with increasing flavonol contents when nitrogen levels in plants decrease (Cartelat et. al., 2005). Similarly, polyphenolics can be used as an alternative to chlorophyll measurements to evaluate N levels of plants. Some devices have been developed to measure nitrogen levels in plants simply and quickly. SPAD meters and Dualex devices are some of these devices. These devices offer the opportunity to evaluate the nitrogen (N) level in plants by measuring the chlorophyll levels in the plant leaves without damaging them. Thus, they are also used to determine the additional nitrogen fertilization needs of plants (Tremblay et al., 2008). On the other hand, as the N level in plant leaves increases, the accuracy of SPAD meters in chlorophyll measurements decreases (Richardson et al., 2002). At the same time, SPAD meter measurements are also affected by the environment and measurement conditions (Cerovic et. al., 2012).

Similarly, with Dualex, polyphenolic contents in the leaf can be determined by measuring the UV rays at a wavelength of 375 nm absorbed by the leaf epidermis, based on the transmission of UV rays through the leaf epidermis (Goulas et al., 2004). This is because most of the polyphenolics in the leaf are actively used in absorbing UV rays. Using this, polyphenolic measurements are carried out in leaves. In some studies conducted on wheat and corn, it was determined that the polyphenolic and N contents in the leaves (Cartelat et al., 2005; Cerovic et al., 2005; Tremblay et al., 2007) could be used to estimate the protein ratio in the cereal (Cerovic et al., 2005). Flavonol and chlorophyll contents can be measured simultaneously with the Dualex sensor (Cerovic et al., 2012; Tremblay et al., 2012). The nitrogen balance index, which is formulated as the ratio of the amount of chlorophyll to the amount of flavonols and provides the opportunity to determine the nitrogen content and needs of plants, can be automatically calculated by Dulaex (Cartelat et al., 2005). Dualex-4 can make very good measurements with 3% error compared to other devices. The biggest advantage of Dualex-4 is that it can measure chlorophyll and flavonoid measurements from one point on the leaf and simultaneously. This allows the calculation of the nitrogen balance index. The nitrogen balance index can also be used as a reference in determining the N balance and nitrogen fertilization needs of plants (Cerovic et. al., 2012).

Research conducted with the Dualex device has mostly focused on the evaluation of the bioactive contents and nitrogen status of fruits and vegetables (Cerovic et al., 2012; Cerovic et al., 2015; Padilla et al., 2014, Padilla et al., 2018; Overbeck et al., 2018). Then, it began to be used in plants such as wheat (*Triticum aestivum* L.) and maize (*Zea mays* L.), which are considered basic food crops, and significant relationships were detected between nitrogen concentrations in leaves and plants and dualex measurements in these plants (Cartelat et al., 2005; Tremblay et al., 2007; Tremblay et al., 2020).

Dualex research has been carried out mostly based on measurements of vegetable and fruit leaves. Compared to these, it is noteworthy that the number of studies conducted on cereals and legumes is limited. It seems that these studies are limited in microgreens, which have increased in importance in recent years as a functional food. In this research, it was aimed to evaluate the polyphenolic contents such as chlorophyll, flavonols, and anthocyanins of cereal and legume microgreens, which have a limited number of dualex studies, and the nitrogen balance (NBI), which is considered an important reference for N evaluation and management in plants, by measuring them with a dualex device.

MATERIALS AND METHODS

Herbal Material

Information about the institute and organization from which the plant materials and seeds used in the research were obtained are given in Table 1. Accordingly, Dogu 88, Palandoken and Ayyildiz wheat Lutfibey sainfoin and Dadas red clover seeds were obtained from Eastern Anatolia Agricultural Research Institute, Bezostaja-1 and Arifiye maize seeds obtained from Corn Research Institute, Tarm-92, Cetin 2000 barley, Uzbek lentil and Bilensoy-80 alfa alfa seeds obtained from Field Crops Central Research Institute, Larende and Kral-97 barley and Dirilis oat seeds obtained from Bahri Dagdas International Agricultural Research Institute, Haskara oats obtained from Aegean Agricultural Research Institute, Kirklar, Kahraman and Faikbey oat seeds obtained from Trace Agricultural Research Institute, Sazak lentil and Goynuk bean seeds obtained from Gecit Kusagi Agricultural Research Institute, Arda chickpea obtained from GAP International Agricultural Research Institute, mung bean from Siirt rural (local), black chickpea from Iraq rural (local), and Amazon cowpea seeds from Ondokuz Mayis University Faculty of Agriculture.

Table 1. Herbal material used in the research, procurement and registration information

Groups	Varieties	Supplier	Registration Date
Wheat	Wheat (Bezostaja 1)	Corn Research Institute	31.12.2013 (Registration extension date)
	Wheat (Dogu 88)	Eastern Anatolia Agricultural Research Institute	16.04.1990
	Wheat (Palandoken)	Eastern Anatolia Agricultural Research Institute	1997
	Wheat (Ayyildiz)	Eastern Anatolia Agricultural Research Institute	8.04.2011
Barley	Barley (Tarm 92)	Field Crops Central Research Institute	12.05.1992
	Barley (Cetin 2000)	Field Crops Central Research Institute	24.04.2000
	Barley (Larende)	Bahri Dagdas International Agricultural Research Institute	14.04.2006
	Barley (Kral 97)	Bahri Dagdas International Agricultural Research Institute	1997
Oat	Oat (Haskara)	Aegean Agricultural Research Institute.	26.03.2015
	Oat (Dirilis)	Bahri Dagdas International Agricultural Research Institute	2017
	Oat (Kirklar)	Trace Agricultural Research Institute	2014
	Oat (Kahraman)	Trace Agricultural Research Institute	11.04.2014
	Oat (Faikbey)	Trace Agricultural Research Institute	1.04.2004
Maize	Maize (Arifiye)	Corn Research Institute	31.12.2013 (Registration extension date)
Edible Cereal	Lentils (Uzbek)	Field Crops Central Research Institute.	27.04.2001

Table 1. Herbal material used in the research, procurement and registration information (continued)

	Lentils (Sazak)	Gecit Kusagi Agricultural Research Institute	31.12.2011 (Registration extension date)
	Chickpea (Arda)	GAP International Agricultural Research Institute	8.04.2013
	Bean (Goynuk)	Gecit Kuşagı Tarımsal Arşt.Enst.Mud.	31.12.2018 (Registration extension date)
	Mung bean	(Siirt-local)	
	Black chickpea	(Iraq-local)	
	Cowpea (Amazon)	Ondokuz Mayıs University Faculty of Agriculture	13.04.2010
Forage Legumes	Sainfoin (Lutfibey)	Eastern Anatolia Agricultural Research Institute	2005
	Alfalfa (Bilensoy-80)	Field Crops Central Research Institute	31.12.2014 (Registration extension date)
	Red clover (Dadas)	Ondokuz Mayıs University Faculty of Agriculture	2008

Setting Up the Experiment and Taking Measurements

The research was established in the Van Yuzuncu Yil University Faculty of Agriculture Field Crops fully controlled climate room with a setup similar to the method preferred by Niroula (2019). A planting environment was created by placing a mixture of peat, cocopit and perlite in 2/3 of the 500 cc plastic chalets with sufficiently drilled bottoms. Seeds of wheat, oats, edible cereal legumes and forage legumes group varieties were planted on 09.10.2020, and barley varieties were planted on 12.10.2020. After the seeds were sown, a 2 cm thick mixture was added and lightly pressed to increase contact. The cultivated chalets were placed in a fully controlled climate cabinet with 50-60% humidity, 21 ± 2/17 ± 2 °C temperature and a 16/8 light/dark period was applied. Fujika-60-watt spiral fluorescent bulb was used for lighting. Irrigation was done by spraying using pure water as needed.

Polyphenolic measurements of cereal and table legume group plants were made on 7-9 day-old microgreens after planting, and on 20-21-day-old sprouts of legume forage group plants.

Dualex 4 Scientfic Measurements

The Dualex® 4 Scientific (FORCE-A, Orsay, France) device measures polyphenolic contents in plant leaves via chlorophyll fluorescence (Figure 1). The optical sensor in the device measures anthocyanin, flavonol and chlorophyll in the leaves simply and quickly. The device uses the analysis of the light passing through the leaves to measure chlorophyll in μg/cm² units in the range of 0-150 μg/cm². The device measures flavonols and anthocyanins by taking advantage of the screening effect of polyphenolics on chlorophyll fluorescence. Flavonol and anthocyanin measurements are made with a relative absorbance value between 0-2.5. The area of the leaf material to be measured is 19.6 mm² and its thickness is 1.5 mm. The device performs measurements by giving its coordinates thanks to its built-in GPS (Anonymous, 2024a, 2024b). It has two output wavelengths: one is chlorophyll fluorescence excited by a light (UV) source at 375 nm wavelength, the other is a reference light source at 60 nm wavelength (red). These rays are activated sequentially. UV light is initially absorbed by polyphenolics, especially by flavonols. Red rays pass through the epidermis without being absorbed before reaching the chlorophyll in the mesophyll. The ratio between the two fluorescence responses of chlorophyll excited by UV and red light sources is measured by Dualex, using fluorescent light emitted at 695 nm (Muñoz-Huerta et al., 2013; Hamann, 2021).

The green leaves of the live plant material examined in the research were taken undamaged between the clips of the Dualex 4 Scientific device, and chlorophyll (μg/cm²), flavonol (dualex index), anthocyanin (dualex index) and nitrogen balance index (mg/g) were measured three times (Tremblay). et al., 2010; Dong et al., 2020).

Figure 1. Dualex+ 4 Scientific (FORCE-A, Orsay, France) cihazı (Cerovic et al., 2015)

Evaluation of Data and Statistical Analysis

Variance analysis of chlorophyll, flavonol, anthocyanin and nitrogen balance index values obtained from three repeated measurements with the Dualex device was performed according to the Randomized Parcel Trial Design. COSTAT (Version 6.303) computer analysis program was used in statistical analyses. The Least Significant Difference (LSD) Multiple Comparison Test was used to determine the significant differences between the obtained averages.

RESULTS AND DISCUSSION

Nitrogen Balance Index (NBI)

NBI values of the cereal and legume microgreen groups used in the research are given in Table 2. The differences between NBI values were found to be statistically significant ($P<0.05$). Accordingly, NBI values vary between 26.200±0.98-106.533±10.68 mg/g. The highest NBI values were detected in Lutfibey clover and the lowest in black chickpea.

The overall average NBI values of microfillets were determined as 60.88 mg/g in cereal groups and 62.36 mg/g in legume groups. The differences between the average NBI values based on variety of groups were also found to be statistically significant ($P<0.05$) and ranged between 51.87-86.84 mg/g. The highest NBI data was obtained from the forage legumes group, while the wheat, barley, and table legume groups were in the lowest group (Table 2). It is seen that NBI values in wheat, barley, and table legume groups are at close levels to each other, the highest level is taken from the feed cereal legume group, followed by the barley group among the cereals (Figure 2).

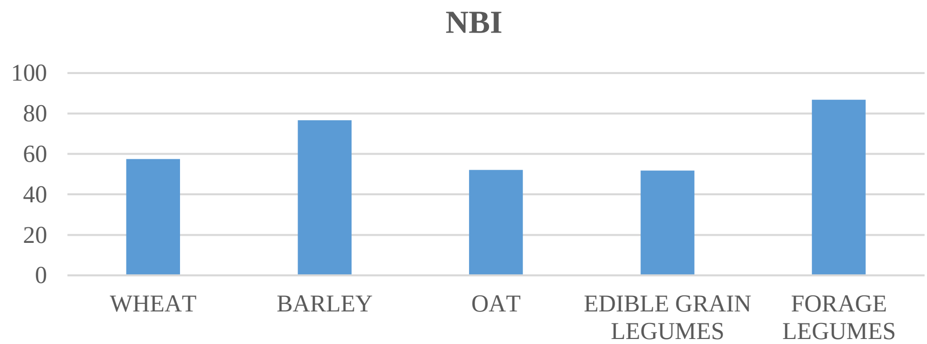

Figure 2. Graph of NBI values obtained in the microgreen groups examined

In a study (Espinoza S. et al., 2023), it was determined that as nitrogen doses increased, the NBI level in grasses increased, but remained constant in single and mixed planting forms of peas. The NBI level was detected at the highest level of 141.2 mg/g in fenugreek plants grown in a controlled environment under 50 mM salt stress and in 50% field soil + 30% vermicompost + 20% perlite (Tuncturk et al., 2023). In a study examining local wheat varieties and cereal microgreens (Altuner et al., 2021), the highest nitrogen balance index (100.767±10.276 mg/g) was determined in the Beysehir barley variety and the lowest in Seydisehir, Fetih oat varieties and Kirik local wheat variety. It was stated that the nitrogen balance index of the Beysehir barley variety was around 50% higher than some of the varieties examined. In a study conducted to examine the effect of planting frequency and nitrogen fertilization rates in corn on the chlorophyll and NBI values of the plant (Dong et al., 2021), according to Dualex 4 measurements, there was no difference between device NBI readings based on planting frequency, and the highest NBI value based on growth stages was 48.89. NBI_1-NBI_2 with dualex index and 59.4 based on nitrogen fertilization doses were obtained in the VT phase and NBI_1 with dualex index and 240 kg ha-1 dose. These values are similar to the wheat group average and the measurements obtained from corn in our research.

Chlorophyll (CHL) Contents

The values regarding the CHL content of the cereal and legume microgreens examined in the study are shown in Table 2. Accordingly, the differences between CHL values were found to be statistically significant ($P<0.05$). CHL values of the examined microgreens varied between 12.333±0.72-41.300±2.63 μg/cm². The highest CHL values were obtained from Arda chickpea and the lowest from the Ayyildiz wheat variety.

The general CHL average values of the examined microgreens on a group basis were determined as 26.96 μg/cm² in cereals and 27.006 μg/cm² in legumes. The differences between the CHL values of microgreens based on variety of groups were found to be statistically significant ($P<0.05$). CHL values of microgreen groups were determined between 18.32-26.86 μg/cm². In the CHL values data in this category, forage legumes, edible cereal legumes, and oat and barley groups were in the highest group, while the wheat group was found in the lowest level (Table 2). It is seen that the CHL values of the other groups except the wheat varieties group are close to each other. It is understood that wheat microgreens contain around 59-68% CHL of other variety groups (Figure 3).

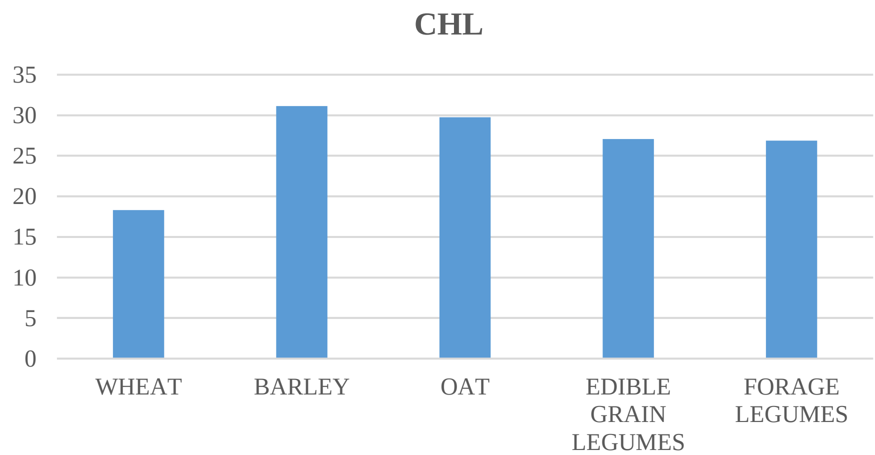

Figure 3. Graph of CHL values obtained in the microgreen groups examined

In a study (Espinoza S. et al., 2023), it was determined that as nitrogen doses increased, the amount of chlorophyll in grasses increased, but the increase in legumes was insignificant. In a study examining local wheat varieties and cereal microgreens (Altuner et al., 2021), the highest chlorophyll value (30.1004±0.435 µg/cm²) was determined in the Beysehir barley variety. According to the averages in our research, the highest chlorophyll value was determined in the barley group, in this respect the results are similar. Similarly, in another study (Cerovic et al., 2012), chlorophyll levels were determined to be between 21-32 µg/cm² dualex index in kiwi, grape, wheat, and corn leaves with a similar device (Dualex-4 Scientific). (Tremblay et. al., 2009), it was determined that the interaction between factors, planting times and nitrogen fertilization doses did not have a significant effect on the measurements made with the dualex device in both seasons. In this research, the amount of chlorophyll was determined between 30.8-44.6 dualex index and was similar to our research. In a study conducted to examine the effect of planting frequency and nitrogen fertilization rates on the plant's chlorophyll and NBI values in corn (Dong et al., 2021), according to Dualex 4 measurements, the highest chlorophyll value based on growth stages was in the Chl_2 and V8 stages with a dualex index of 44.36. Based on frequency, 44.5 dualex index was obtained at Chl_2 and 5.5 plants m^{-2} frequency, and on the basis of nitrogen fertilization doses, 49.66 dualex index was obtained at Chl_2 and 240 kg ha-1 dose. These results are higher than the measurements obtained in our research. Dualex measurements vary depending on factors such as research conditions, measurement phase, plant density, and nitrogen content (Dong et al., 2021).

Anthocyanin (ANTS) Values

Data regarding the ANTS values of the cereal and legume microgreens examined in the study are shown in Table 2. Accordingly, the differences between ANTS values were found to be statistically significant (P<0.05). ANTS values of the examined plants varied between 0.02±0.0-0.08±0.01 dualex index. The highest CHL values of microgreens were taken from Bilensoy-80 alfalfa and the lowest from Mung bean.

ANTS values of the examined microgreen groups, based on general averages, were determined as 0.049 dualex index in the cereals group and 0.038 dualex index in the legume groups. The differences between the average values of the microfillet groups were found to be statistically significant (P<0.05). It is seen that the edible legume group has ANTS content around 63%-74% of other groups (Figure 4).

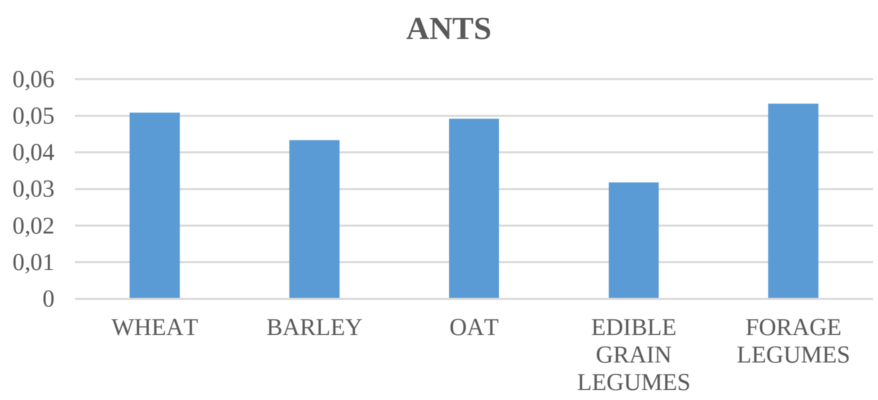

Figure 4. Graph of ANTS values obtained in the microgreen groups examined

In a study examining local wheat varieties and cereal microgreens (Altuner et al., 2021), the highest anthocyanin level (0.073±0.015 dualex index) was determined in the Seydisehir oat variety. These values are similar to the data obtained from Dadas red clover in our research. Tremblay et. get.

(2009) in a study conducted on wheat, it was determined that the interaction between factors, planting times, and nitrogen fertilization doses did not have a significant effect on the measurements made with the dualex device in both seasons. In this research, the amount of polyphenolics was determined between 2.1-2.6 dualex. In 30 repeated measurements on 80 leaves with the Dualex-4 device, the number of epidermal flavonoids was determined to be between 1.2-1.8 dualex (Cerovic et. al., 2012). It was determined that anthocyanin and flavonoids contents measured with the Dualex 4 device showed a negative correlation with N doses (Tripathi et al., 2023). In this study, the highest anthocyanin was determined as 0.06 dulaex value in the control plots during the Dualex 4 device measurements during the stemming period, and it was observed that the anthocyanin values varied between 0.04 and 0.11 dualex during the flowering period. The data obtained in both periods are similar to our research.

Flavonol (FLAV) Contents

FLAV contents obtained from cereal and legume microgreens used in the research are shown in Table 2. The differences between FLAV contents were found to be statistically significant ($P<0.05$). Accordingly, FLAV contents were determined between 0.246 ±0.03- 0.746 ±0.03 dualex index. The highest FLAV contents were obtained from Amazon cowpea and the lowest from Bezostaja-1 wheat varieties, which are in the same group as Dadas red clover.

The overall average FLAV contents were 0.469 dualex in cereals and 0.482 dualex in legumes. The differences between the variety groups were found to be statistically significant ($P<0.05$). Accordingly, FLAV contents varied between 0.31-0.56 dualex index. Accordingly, the highest FLAV values were detected in the oat groups, which are statistically in the same group with the edible cereal legume varieties, and the lowest were detected in the forage legumes group.

It is understood that wheat and barley variety groups have similar levels of FLAV content, oats, and table legume groups have similar levels of FLAV content, and the legume forage crops group has lower levels of FLAV content. In this case, it is seen that the forage legumes group contains FLAV around 76% of the wheat and barley group and 56% of the oats and table legumes group. (Figure 5).

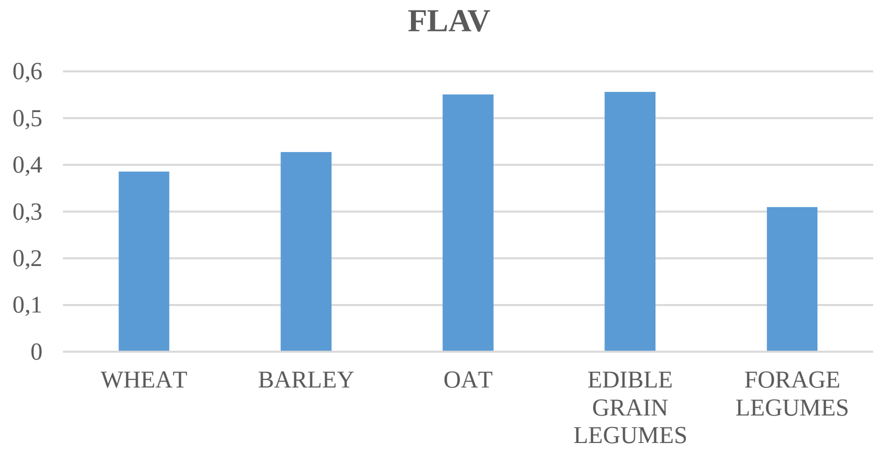

Figure 5. Graph of FLAV values obtained in the microgreen groups examined

The flavonol level in fenugreek plants grown under 50 mM salt stress and in 30% field soil + 50% vermicompost + 20% perlite environment was determined at the highest level as 0.52 dulaex value (Tuncturk et al., 2023). In a study examining local wheat varieties and cereal microfillets (Altuner et al., 2021), the highest flavonol value (0.607±0.04 dualex) was determined in Seydisehir oat variety. In a study conducted on wheat, the number of polyphenolics was determined to be between 2.1-2.6 dualex

(Tremblay et. al., 2009). In a study conducted to examine the effect of planting frequency and nitrogen fertilization rates in corn on the chlorophyll and NBI values of the plant (Dong et al., 2021), the relationship between chlorophyll, flavonol and NBI values obtained based on the 1st and 2nd trial areas according to Dualex 4 measurements (Using Cartelat et al., 2005), it was determined that flavonol contents varied between 0.92-0.93 dualex index. These values are higher than the measurements obtained in our research. Dualex measurements vary due to factors such as research conditions, measurement phase, plant density, and nitrogen content (Dong et al., 2021).

Table 2. Dualex values for CHL, ANTS, FLAV and NBI contents of cereals and legumes*

	Varieties	**NBI** (mg/g)			**CHL** (μg/cm²)			**ANTS** (dualex index)			**FLAV** (dualex index)		
CEREALS	Wheat (Bezostaja 1)	86.133	±1.33	bc	20.266	±0.47	l	0.043	±0.006	ef	0.27	±0.01	l
	Wheat (Dogu 88)	55.866	±1.59	hi	20.833	±2.0	kl	0.06	±0.01	bc	0.443	±0.04	fgh
	Wheat (Palandoken)	54.9	±2.33	hi	19.833	±1.50	l	0.05	±0.0	de	0.43	±0.01	gh
	Wheat (Ayyildiz)	33.233	±0.50	n	12.333	±0.72	m	0.05	±0.0	de	0.4	±0.02	hi
	Wheat Means	57.533	**C**		18.32	**B**		0.051	**A**		0.39	**B**	
	Barley (Tarm 92)	84.5	±4.85	c	32.8	±2.79	bc	0.04	±0.0	fg	0.4	±0.02	hi
	Barley (Cetin 2000)	82.166	±0.95	c	28.866	±0.59	def	0.053	±0.006	cd	0.35	±0.01	ij
	Barley (Larende)	71.033	±1.75	d	31.666	±1.62	bcd	0.037	±0.006	fgh	0.47	±0.03	efg
	Barley (Kral 97)	68.766	±1.12	de	31.233	±1.96	bcde	0.043	±0.006	ef	0.49	±0.03	ef
	Barley Means	76.62	**B**		31.14	**A**		0.043	**B**		0.43	**B**	
	Oat (Haskara)	64.966	±1.90	ef	33.433	±0.74	b	0.043	±0.006	ef	0.51	±0.02	de
	Oat (Dirilis)	57.6	±0.95	gh	27.366	±3.79	fgh	0.04	±0.0	fg	0.49	±0.01	ef
	Oat (Kirklar)	51.1	±0.44	ij	28.4	±0.69	efg	0.043	±0.006	ef	0.503	±0.03	e
	Oat (Kahraman)	46.733	±1.68	jk	29.666	±1.3	def	0.053	±0.006	cd	0.676	±0.02	b
	Oat (Faikbey)	40.4	±2.25	lm	29.866	±4.19	cdef	0.066	±0.006	b	0.576	±0.01	c
	Oat Means	52.16	**C**		29.75	**A**		0.049	**A**		0.55	**A**	
	Maize (Arifiye)	54.866	±1.42	hi	30.9	±1.08	bcde	0.057	±0.006	cd	0.556	±0.05	cd
LEGUMES	Lentils (Uzbek)	70.766	±0.51	d	24.5	±1.04	hij	0.057	±0.006	cd	0.433	±0.04	gh
	Lentils (Sazak)	62.566	±2.74	f	29.4	±1.91	def	0.03	±0.0	hij	0.473	±0.03	efg
	Chickpea (Arda)	62.366	±3.51	fg	41.3	±2.63	a	0.027	±0.006	ijk	0.67	±0.07	b
	Bean (Goynuk)	62.166	±2.06	fg	27	±0.46	fgh	0.023	±0.006	jk	0.493	±0.02	ef
	Mung bean (Siirt-Local)	42.933	±2.65	kl	21.566	±0.35	jkl	0.02	±0.0	k	0.476	±0.02	efg
	Black chickpea (Iraq-Local)	26.2	±0.98	o	20.066	±0.93	l	0.033	±0.006	ghi	0.603	±0.03	c
	Cowpea (Amazon)	36.066	±0.46	mn	25.666	±0.64	ghi	0.033	±0.006	ghi	0.746	±0.03	a
	Edible Cereal Legumes Means	51.87	**C**		27.07	**A**		0.032	**C**		0.56	**A**	
	Sainfoin (Lutfibey)	106.533	±10.68	a	33.733	±3.95	b	0.023	±0.006	jk	0.316	±0.03	jk
	Alfalfa (Bilensoy-80)	63.733	±3.25	f	23.433	±2.47	ijk	0.057	±0.006	cd	0.366	±0.006	ij
	Red clover (Dadas)	90.266	±3.27	b	23.4	±1.49	jkl	0.08	±0.01	a	0.246	±0.03	l
	Forage Legumes Means	86.844	**A**		26.86	**A**		0.053	**A**		0.31	**C**	
	C.V. %	4.93			6.78			13.2			6.37		
	LSD(0.05)	4.89			2.97			0.01			0.05		
	Grup Means												
	Cereals	60.876			26.962			0.049			0.469		
	Legumes	62.36			27.006			0.038			0.482		

* NBI: Nitrogen balance index, CHL: Chlorophyll, ANTS: Anthocyanin, FLAV: Flavonol
There is no statistically significant difference between the values shown with the same uppercase and lowercase letters in the same column. For a better understanding of precise values, numbers are used after the dot.

CONCLUSION

In the research, it was determined that cereal and legume microgreens have rich contents in terms of polyphenolics such as chlorophyll, anthocyanin, and flavonols, and their nitrogen balance index is high.

The legume forage crop group has the highest Nitrogen Balance Index and the Lutfibey sainfoin in this group has the highest index, the barley group has the highest index value among cereals.

The chlorophyll content of wheat group has the lowest chlorophyll content, and the other groups show approximate values to each other in this respect, it was determined that the edible legume group had the lowest anthocyanin contents, and the legume forage plants group had the lowest flavonol contents.

It was evaluated that some polyphenolic measurements in microgreens produced from the material used in the research could be made easily and quickly with the Dualex 4 Scientific device, the nitrogen balance index related to N evaluation was also determined, and that it would be useful to conduct similar studies on a limited number of cereals and legumes, especially microgreens, compared to other plants.

Conflict of Interest

The article authors declare that there is no conflict of interest between them.

Author's Contributions

The authors declare that they have contributed equally to the article

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