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Triticum dicoccum as a source of nutritionally valuable proteins and essential microelements for human nutrition

Triticum dicoccum ako zdroj nutrične hodnotných bielkovín a esenciálnych mikroelementov vo výžive človeka

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ABSTRACT

This study aimed to analyze the protein complex and the content of selected microelements in the grain of seven *Triticum dicoccum* (Schrank ex. Schübl) genotypes. Discontinuous fractionation of the grain protein complex shows that gliadins (60.69%) were the most predominant fraction. Together with glutenins, they represent storage proteins with a share of 82.30%. Individual genotypes differed significantly in the amount of cytoplasmic proteins represented by albumins and globulins. SDS-PAGE results show that the majority of proteins were fractions with a relative molecular weight of 33 kDa – 96 kDa. Using ELISA with G12 monoclonal antibody high content of celiac active proteins was recorded, specifically 58.63 – 83.45 mg/kg of grain. *Triticum dicoccum* is therefore not suitable for celiacs. The ICP-OES method was used to determine the content of microelements. Of the nutritionally significant microelements, *Triticum dicoccum* contained important K, Mg, Ca, Zn, Fe and Mn concentrations.

Keywords: *Triticum dicoccum*, protein fractions, celiac active proteins, microelements

ABSTRAKT

Cieľom práce bolo analyzovať bielkovinový komplex a obsah vybraných mikroelementov v zrne siedmych genotypov *Triticum dicoccum* (Schrank ex. Schübl). Z diskontinuálnej frakcionácie bielkovinového komplexu zrna vyplýva, že najviac zastúpenou frakciou boli gliadíny (60.69%). Spolu s gluteníny tvoria zásobné bielkoviny s podielom 82.30%. Jednotlivé genotypy sa výrazne líšili v množstve cytoplazmatických bielkovín, predstavovaných albumínmi a globulínmi. Z výsledkov SDS-PAGE vyplýva, že majoritný podiel v bielkovinách tvoria frakcie s relatívnou molekulovou hmotnosťou 33 kDa - 96 kDa. Pomocou ELISA s monoklonálnou protilátkou G12 bol stanovený vysoký obsah celiakálne aktívnych bielkovín, a to 58.63 – 83.45 mg/kg zrna. *Triticum dicoccum* preto nie je vhodná pre celiatikov. Metóda ICP-OES bola použitá pre stanovenie obsahu mikroelementov. Z nutrične významných mikroelementov obsahuje *Triticum dicoccum* zaujímavé koncentrácie K, Mg, Ca, Zn, Fe a Mn.

Kľúčové slová: *Triticum dicoccum*, bielkovinové frakcie, celiakálne aktívne proteíny, mikroelementy

INTRODUCTION

Triticum dicoccum (Schrank ex. Schübl) farming spreads from Southwest Asia (Konvalina et al., 2008). In Central Europe, *Triticum* is primarily used for the preparation of porridge (Burešová and Palík, 2008) and unleavened products (Konvalina et al., 2008). Lately, this type of wheat, which is primarily grown in organic agriculture, has received an increasing interest from producers and customers. *Triticum dicoccum* has a nutritionally more interesting composition when compared to *Triticum monococcum* and *Triticum aestivum* (Lachman et al., 2012; Hammed and Simsek 2014).

From a nutritional and technological point of view, in addition to carbohydrates, including starch, proteins are of the greatest importance in the wheat grain, the content of which in mature grains has been reported to oscillate at 10 – 15% (Prugar, 2008), whereas other studies suggest a wider range (8.5 – 18%, Bojňanská et al., 2013). The classic division of wheat grain proteins follows the classification according to their solubility into albumins, globulins, gliadins, glutenins and insoluble residues (Michalík, 2002).

The average portion of albumins in wheat grain is 12.4%, whereas globulins represent 5.4%, gliadins 29.6%, glutenins 17.3% and insoluble residues make up 35.3% (Bojňanská et al., 2013). Albumins are soluble in water; they may be characterized as neutral proteins that irreversibly coagulate at a temperature of 75 °C. Globulins are soluble in saline solutions and present with a catalytic activity which is subject to thermal denaturation. The primary structure of albumins and globulins comprises nutritionally significant essential amino acids. Gliadins are soluble in 70 - 80% aqueous alcohol (ethanol). They are divided into α-, β-, γ- and ω-gliadins, and are characterized by a higher content of glutamine and proline coupled with a lower proportion of aspartic acid and glutamic acid. Basic amino acids (lysine, arginine and histidine) are found in very low amounts, which is ultimately related to the low solubility of gliadins (Velíšek, 2002). Glutelins are soluble in dilute acids or bases (Čepička, 1995; Velíšek, 2002). The most important characteristic of wheat grain proteins is their ability to create gluten, the quality and quantity of which depends on gliadins and glutenins. These proteins, also called storage proteins, increase their volume in water – they swell and due to mechanical energy create a network, gluten, which will capture carbon dioxide during dough leavening. The amount and properties of the protein complex have significant importance in the determination of the baking quality of wheat (Bojňanská et al., 2013). From a nutritional point of view, however, a serious negative aspect of wheat storage proteins is that they may cause the malabsorption syndrome of gluten-sensitive enteropathy, in other words, the celiac sprue. Among the most active celiac agents are α-gliadin fractions with a relatively low molecular weight of around 30 kDa (Michalík and Bauerová, 2001).

It is known that the content of mineral substances in cereal grains is 1.6 – 2.5% (Bojňanská et al., 2013), depending on climatic conditions, nutrition and variety. The highest concentrations are found in the germ and the aleurone layer (Muchová, 2005; Padovani et al., 2007). The concentration of minerals is of great processing importance, as it is an important indicator of the degree of flour grinding and is used for flour classification.

MATERIALS AND METHODS

Seven genotypes of *Triticum dicoccum* obtained from the Gene Bank of the Slovak Republic which is located at the Research Institute of Plant Production Piešťany were analysed: PN 4-41, PN 8-26, PN 2-43, PN 3-13, PN 6-8, PN 6-37, PN 8-23.

The Kjeldahl method (Velp Scientifica, Italy) was used to determine the total nitrogen content and crude protein (N x 5,7) as well as the concentration of specific protein fractions (Michalík, 2002). Albumins and globulins were extracted using 10% (w/v) NaCl, gliadins were extracted with 70% (v/v) ethanol and glutelins were extracted using 0,2% NaOH (w/v). Each extraction was performed at 20 °C for 1 hour in triplicates.

To determine the reactivity of celiac active proteins the sandwich AgraQuant® Gluten G12 enzyme-linked immunosorbent assay (ELISA) (Romer Labs GmbH, Austria)

was carried out following a standard protocol designed by Romer Labs. The assay takes advantage of the G12 antibody which targets a 33-mer peptide representing the fragment of the gliadin proteins. The antibody will recognise the amino acid sequences QPQLPY and QPQLPF, present only in α-gliadins and some ω-1,2- and γ-gliadins (Lexhaller et al., 2017).

Polyacrylamide gel electrophoresis in the presence of sodium dodecyl sulphate (SDS-PAGE; Bio-Rad, USA) was performed according to a standard ISTA methodology (Wrigley, 1992, 2004). The electrophoreograms were evaluated with the help of the CCD camera UVP and the GelWorks 1D software.

Analysis of the element contents was carried out by ICP Thermo ICAP 7000 Dual (Thermo Fisher Scientific, USA). Five hundred mg of each sample were mixed with 10 mL 69% nitric acid (v/v, TraceSELECT® grade) and 2 mL 30% hydrogen peroxide (v/v). Subsequently, the mixture was mineralised in a closed vessel according to the manual for the Berghof SpeedwaveXpert high-efficiency microwave digestion system (Berghof, Germany). After mineralization, the samples were cooled to 50 °C and filtered through Sartorius filtration disks, grade 390 (Sartorius AG, Germany) into a volumetric flask. The resulting volume was adjusted to 50 mL with ultrapure water. The parameters of the analysis were as follows: plasma RF power 1150 W, argon auxiliary gas flow 0.50 L/min, coolant gas flow 12 L/min, nebulizer gas flow 0.40 L/min, nebulizer gas pressure 120 kPa and pump speed 50 rpm. The multielement standard solution V for ICP (Sigma-Aldrich, Germany) was used for calibration. The analyses were carried out at least in triplicates.

Microsoft Excel (Microsoft Corporation, 2018) was used to evaluate the obtained data, and the XLSTAT 2020.5.1 program (Lumivero, 2023) was used for statistical analysis. Analysis of variance – ANOVA Duncan's test was used to determine the evidence of statistically significant differences between the individual samples ($P \leq 0.05$).

All chemicals used in the analyses were purchased from Sigma-Aldrich (Germany), Fluka (Switzerland) and Applichem (Germany). Protein markers for SDS-PAGE were purchased from Fermentas International Inc. (Canada).

RESULTS AND DISCUSSION

Individual protein fractions in Triticum dicoccum grains

The analysis of the protein content and individual protein fractions revealed that *Triticum dicoccum* contains an average of 13.23% proteins (crude protein, Table 1).

In the *Triticum dicoccum* grain, the gliadin fraction was the most prevalent (60.96% on average), with the least amount (54.63 ± 0.35%) being present in the PN 4-41 genotype and the most gliadin content (69.57 ± 0.37%) being found in the PN 6-37 genotype. Glutenins accounted for 21.44% on average. The highest concentration of this protein fraction was recorded in the genotype PN 2-43 (22.58 ± 0.21%), while the least amount of glutenins was found in the genotype PN 4-41 (19.32 ± 0.20%). The major protein fractions of wheat grain are reported to be gliadins and glutenins, which represent more than 80% of the total protein content. In contrast, the amount of albumins and globulins is much lower, about 10 – 18%. Bekes et al. (2004) and van den Broeck et al. (2010) reported a similar content of individual fractions. The analysed genotypes differed significantly in the content of the albumin and globulin fraction, which was on average 17.79%. Exceptionally low concentrations were detected in the genotypes PN 6-37 and PN 8-23 (9.52 ± 0.21% and 8.27 ± 0.25%, respectively). It is generally known that albumins and globulins are proteins in which essential amino acids are found, and therefore, from the point of view of human nutrition, the three genotypes PN 4-41 (26.28 ± 0.28 %), PN 6-8 (23.60 ± 0.26 %) and PN 3-13 (22.56 ± 0.19%) could be interesting as potential sources of essential amino acids in food.

Wheat is unique in that it is the only cereal that contains a protein complex called gluten, which is responsible for forming a dough with specific rheological properties (Bekes et al., 2004). This protein complex acts as a heterogeneous system, containing different fractions and subfractions of proteins with a characteristic amino acid composition.

Table 1. Determination of protein content and individual protein fractions in *Triticum dicoccum* grains (n = 6)

Triticum dicoccum	Crude protein, %	Albumins and globulins, %	Gliadins, %	Glutenins, %
PN 4-41	12.56 ± 0.12^{d}	26.28 ± 0.28^{a}	54.63 ± 0.35^{e}	19.32 ± 0.20^{d}
PN 8-26	11.31 ± 0.18^{e}	18.02 ± 0.14^{d}	59.34 ± 0.41^{c}	22.43 ± 0.27^{a}
PN 2-43	12.40 ± 0.16^{d}	16.28 ± 0.28^{e}	60.97 ± 0.26^{b}	22.58 ± 0.21^{a}
PN 3-13	12.42 ± 0.15^{d}	22.56 ± 0.19^{c}	56.28 ± 0.29^{d}	21.49 ± 0.18^{b}
PN 6-8	14.80 ± 0.20^{b}	23.60 ± 0.26^{b}	56.40 ± 0.30^{e}	20.54 ± 0.17^{c}
PN 6-37	15.32 ± 0.13^{a}	9.52 ± 0.21^{f}	69.56 ± 0.33^{a}	21.49 ± 0.33^{b}
PN 8-23	13.82 ± 0.16^{c}	8.27 ± 0.25^{g}	69.57 ± 0.37^{a}	22.20 ± 0.17^{a}

Values in each column are displayed as mean ± standard deviation out of six replications. Different letters $^{a, b, c, d, e, f, g}$ represent significant differences between the analysed genotypes ($P \leq 0.05$)

From a nutritional point of view, these proteins are not valuable, however, they present with a significant impact on the technological quality of wheat (Bojňanská and Urminská, 2010). High-quality food wheat, suitable for bakery processing, should have a high proportion of gluten-forming proteins. Out of the analysed wheat, gliadins and glutenins made up 91.05% and 91.77%, respectively, of all proteins in the genotypes PN 6-37 and PN 8-23.

Celiac active proteins

ELISA is the most suitable method for the detection of celiac active proteins in plant material and food, with specificity and sufficient sensitivity. Using the ELISA AgraQuant® Gluten G12 assay, the content of celiac active proteins was determined by their interaction with the monoclonal G12 antibody, which could be converted to the total gluten content based on the test methodology. In the analysed genotypes of *Triticum dicoccum* the gluten content was on average 67.06 g/kg grain (Table 2). The highest content of celiac active proteins was found in the PN 8-23 genotype (83.45 ± 0.07 g/kg). Celiac active epitopes are found primarily in the gliadin fraction; hence this value corresponds to the finding that the PN 8-23 genotype had the highest content of these proteins out of all analysed genotypes.

Table 2. Amount of celiac active proteins in *Triticum dicoccum* grains (n = 6)

Triticum dicoccum	Gluten, g/kg
PN 4-41	58.89 ± 0.08^{f}
PN 8-26	63.74 ± 0.05^{d}
PN 2-43	67.43 ± 0.05^{c}
PN 3-13	58.63 ± 0.08^{g}
PN 6-8	59.17 ± 0.07^{e}
PN 6-37	78.24 ± 0.08^{b}
PN 8-23	83.45 ± 0.07^{a}

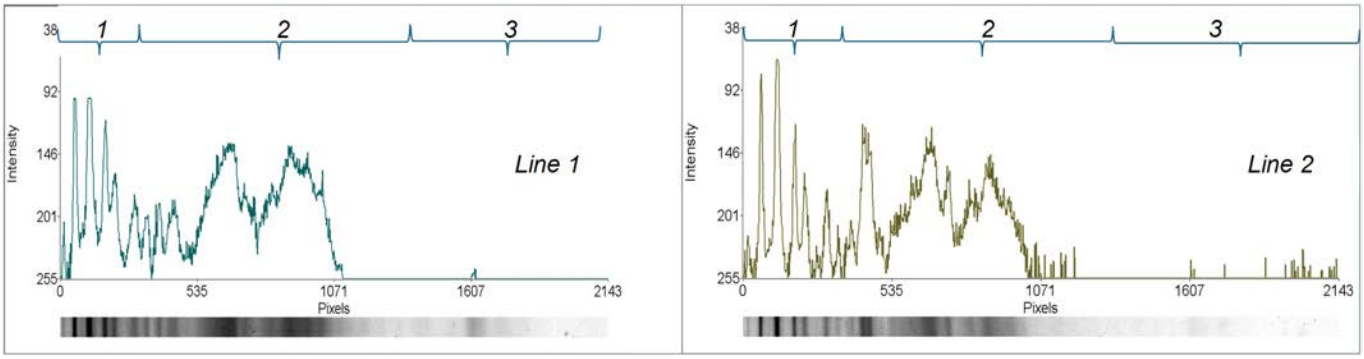
Values in each column are displayed as mean ± standard deviation out of six replications. Different letters $^{a, b, c, d, e, f, g}$ represent significant differences between the analysed genotypes ($P \leq 0.05$)

Naturally, gluten-free are foods with a gluten content of less than 20 mg/kg. High gluten levels mean that *Triticum dicoccum*, like other wheat, is not a suitable food for patients diagnosed with celiac disease. To expand the spectrum of food ingredients for celiacs, some authors (Nijhawan and Goyal, 2015) analysed alternative types of wheat to produce bakery goods for celiacs. The results of their work are consistent with our findings, that the proteins found in *Triticum* grains present a high celiac activity and hence are not suitable to produce foods for celiacs.

SDS-PAGE of Triticum dicoccum proteins

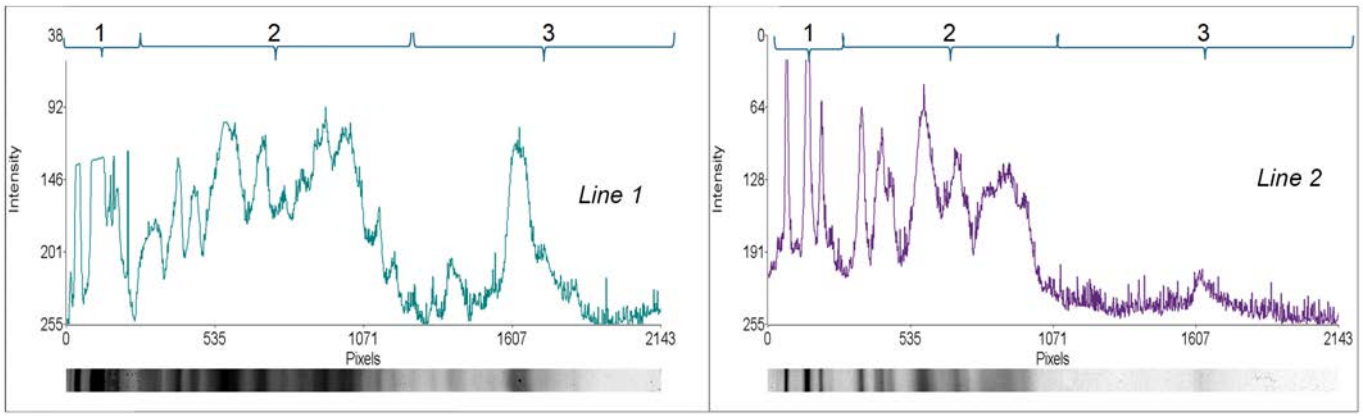
Proteins found in wheat grains may be divided into two groups, based on their function: cytoplasmatic (albumins and globulins) and storage proteins (gliadins and glutenins) (Ciccocioppo et al., 2005; Yalçin, 2010). The technique of protein fractionation does not possess the ability to provide absolute unambiguous results, as the solubility of specific fractions is not strict and well-defined. More precise results may be obtained using electrophoretic methods. Wheat storage proteins may be divided into high molecular weight (HMW) and low molecular weight (LMW) proteins. The basic LMW proteins include α-, β- and γ-gliadins which are rich in amino acids containing sulphur (Wieser and Koehler, 2008). This fact is important for gluten formation. The medium molecular weight group of wheat proteins is represented by ω-gliadins (Shewry, 2004).

Proteins from *Triticum dicoccum* were studied using SDS-PAGE, and individual fractions were identified based on the comparison with *Triticum aestivum*, L. variety Chinese Spring and the molecular weight marker (2 – 212 kDa). From our results, it seems that the analysed genotypes of *Triticum dicoccum* were no single-line or homogeneous wheat species in comparison to *Triticum aestivum* since they revealed the presence of two protein profiles, primarily in the case of the genotypes PN 2-43, PN 8-23 and PN 6-37 (Figure 1, 2, 3). Unilinearity is not a natural feature of wheat. This property was acquired by *Triticum aestivum* only in the breeding process to ensure the necessary uniformity of the offspring, required by the food processing industry. The results are consistent with the findings of other authors (Singh et al., 2017), who observed a notable variability within individual wheat species.



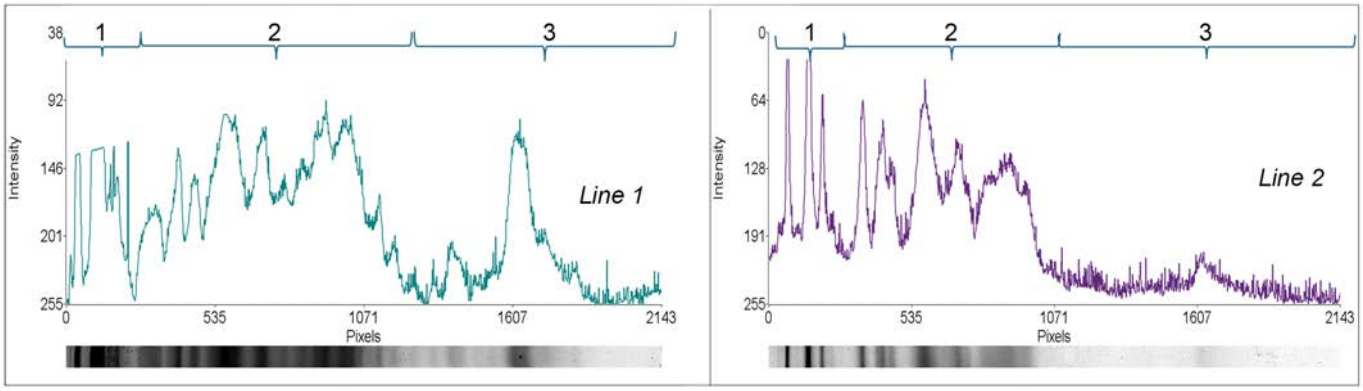
Notes: 1 – High molecular weight glutenin subunits; 2 – Gliadins; 3 – Albumins and globulins

Figure 1. Densitogram of *Triticum dicoccum* PN 2-43 proteins



Notes: 1 – High molecular weight glutenin subunits; 2 – Gliadins; 3 – Albumins and globulins

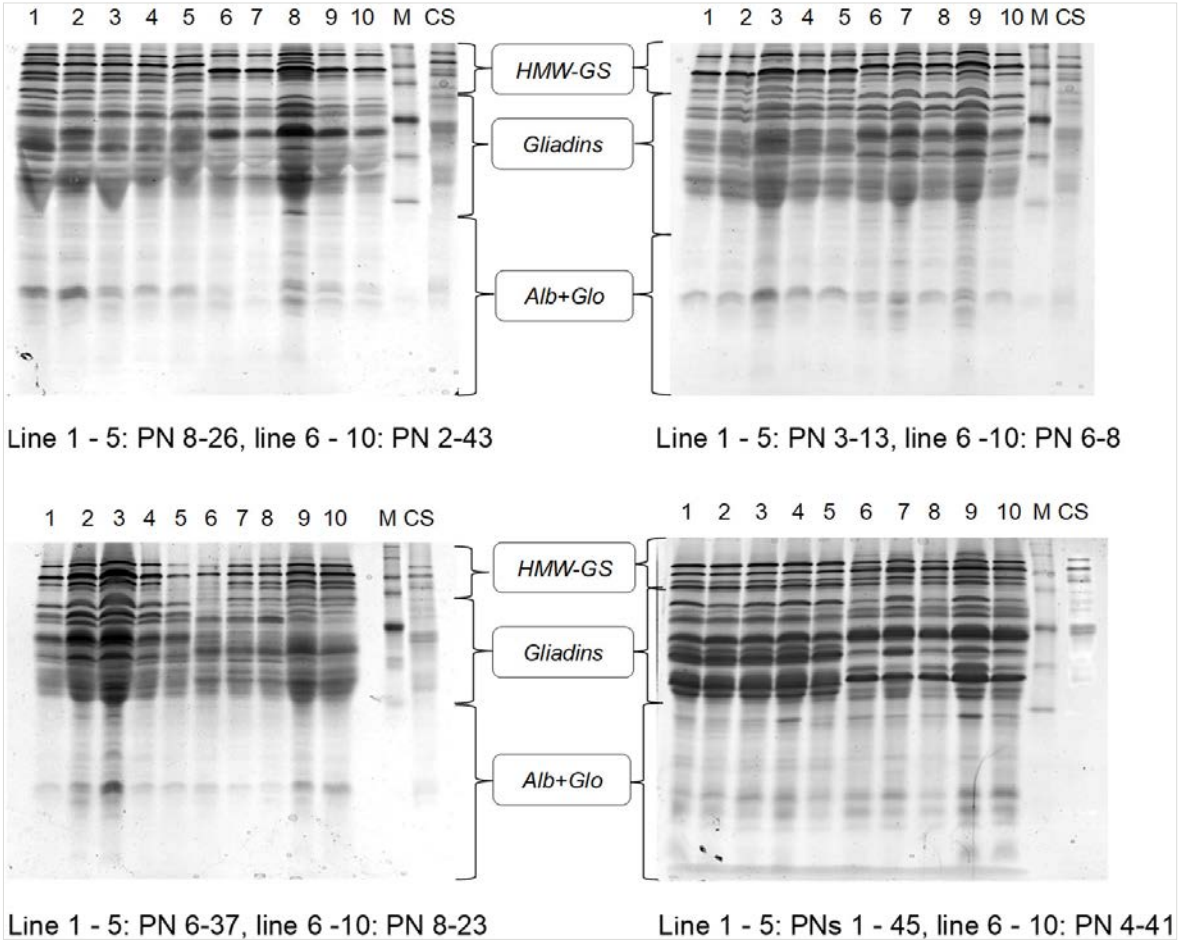
Figure 2. Densitogram of *Triticum dicoccum* PN 8-23 proteins



Notes: 1 – High molecular weight glutenin subunits; 2 – Gliadins; 3 – Albumins and globulins

Figure 3. Densitogram of *Triticum dicoccum* PN 6-37 proteins

Macromolecular glutenin subunits (HMW-GS) located in the area with a relative molecular weight ranging from 97.2 to 158 kDa (Figure 4) were found in *Triticum dicoccum* proteins. The dominant protein fraction consisted of proteins with a molecular weight of about 33 to 96 kDa. Albumins and globulins formed a fraction of proteins with a relative molecular weight lower than 27 kDa.



Notes: M (molecular standard) bands from up to down: 212 kDa, 158 kDa, 116 kDa, 97.2 kDa, 66.4 kDa, 55.6 kDa, 42.7 kDa, 34.6 kDa, 27 kDa, 14.3 kDa. CS - *Triticum aestivum* var. Chinnese Spring, PNs *Triticum spelta* genotyp 1-45. HMW-GS High molecular weight glutenin subunits.

Figure 4. Electrophoreogram of *Triticum dicoccum* proteins

From the densitometric evaluation of electrophoretic analyses, it can be concluded that all genotypes of *Triticum dicoccum* had a high content of storage proteins that varied from 73.45% (PN 4-41) to 91.98% (PN 8-23, Table 3). The assessed genotypes were quite different in the proportion of cytoplasmic proteins. The biggest difference (in the range of up to 69.79%) was found amongst the genotypes PN 8-23 and PN 4-41.

Table 3. Percentage of individual protein fractions in *Triticum dicoccum* grains

Triticum dicoccum	Storage proteins (Gliadins + Glutenins) %	Cytoplasmatic proteins (Albumins + Globulins) %
PN 4-41	73.45	26.55
PN 8-26	81.92	18.08
PN 2-43	83.78	16.22
PN 3-13	77.65	22.36
PN 6-8	76.65	23.35
PN 6-37	90.69	9.30
PN 8-23	91.98	8.02

Mineral element composition of Triticum dicoccum

The agroecological conditions of growth have a significant impact on the representation of elements in the plant material. Approximately half of the global population has zinc deficiency, and anemia induced by iron deficiency is the most common phenomenon observed in Europe (Kan, 2015; Winiarska-Mieczan et al., 2019). In this context, the increase of micronutrient concentrations in cereal grain has become a high-priority research area (Çakmak et al., 2010; Kutlu, 2018).

The analysed *Triticum diccocum* genotypes were obtained from the gene bank, which is why the conditions of their cultivation are not known. No risk elements (Ba, Cd, Pb, Ni, Cr, As, Sr, Ag) were determined, and their concentrations were below the detection limit in all genotypes. From the trace elements that are valuable for human nutrition, the most abundant elements detected included potassium (3647.43 ± 16.3 – 4389.56 ± 25.4 mg/kg) and magnesium (1184.75 ± 5.6 – 1320.66 ± 9.7 mg/kg) (Table 4).

Table 4. Mineral element analysis of *Triticum dicoccum* grains

Triticum dicoccum	Ca, mg/kg	Cu, mg/kg	Fe, mg/kg
PN 4-41	414.57 ± 37	4.55 ± 0.03	37.82 ± 0.4
PN 8-26	384. 25 ± 35	4.51 ± 0.03	39.04 ± 0.4
PN 2-43	431.89 ± 39	4.53 ± 0.02	28.86 ± 0.5
PN 3-13	469.54 ± 42	4.51 ± 0.01	37.58 ± 0.4
PN 6-8	375.55 ± 34	4.81 ± 0.08	37.89 ± 0.2
PN 6-37	435.06 ± 39	5,05 ± 0.11	41.29 ± 0.6
PN 8-23	302.18 ± 27	4.40 ± 0.07	41.40 ± 0.7
LOQ_{500mg}	0.5	3.10	0.52
	Mn, mg/kg	Na, mg/kg	Zn, mg/kg
PN 4-41	36.82 ± 0.27	8.12 ± 0.8	38.95 ± 0.3
PN 8-26	39.26 ± 0.21	9.98 ± 0.4	30.95 ± 0.5
PN 2-43	29.70 ± 0.41	10.91 ± 0.7	40.95 ± 0.6
PN 3-13	30.72 ± 0.35	17.76 ± 0.6	32.86 ± 0.4
PN 6-8	32.83 ± 0.13	35.26 ± 0.7	42.24 ± 0.4
PN 6-37	35.13 ± 0.48	24.14 ± 0.5	44.27 ± 0.7
PN 8-23	33.91 ± 0.35	13.37 ± 1.4	49.98 ± 0.5
LOQ_{500mg}	0.12	2.00	0.18
	K, mg/kg	Mg, mg/kg	Al, mg/kg
PN 4-41	3647.43 ± 16.3	1301.08 ± 6.9	1.11 ± 0.01
PN 8-26	4152.99 ± 40.7	1184.75 ± 5.6	1.35 ± 0.02
PN 2-43	4287.40 ± 42.5	1144.03 ± 34.6	0.98 ± 0.02
PN 3-13	3914.76 ± 15.9	1221.44 ± 11.6	2.79 ± 0.01
PN 6-8	4389.56 ± 25.4	1320.66 ± 9.7	5.79 ± 0.06
PN 6-37	4137.62 ± 34.6	1305.37 ± 19.0	2.65 ± 0.04
PN 8-23	4093.60 ± 54.7	1189.32 ± 4.6	1.62 ± 0.03
LOQ_{500mg}	335.00	0.18	0.12

Relatively high concentrations of calcium (302.18 ± 27 – 469.54 ± 42 mg/kg) and zinc (30.95 ± 0.5 – 49.98 ± 0.5 mg/kg) are also important. The assessed genotypes differed in the sodium content. Low concentrations ranged from 8.12 ± 0.8 mg/kg in PN 4-41 to 35.26 ± 0.7 mg/kg in PN 6-8. Genotype PN 6-37 contained the most elements forming divalent cations (Ca, Mg and Fe). The highest concentrations of Na, K and Al were found in the PN 6-8 genotype. Aluminium is not a biogenic element and there are several discussions about its toxicity for the organism. It is thought that the levels of aluminium present in the body remain low, controlled by a low absorption from the intestinal tract and efficient excretion via the kidneys. As such, dietary aluminium is not a source of concern in people with normal kidney function. In 2008, the EFSA Panel on Food Additives, Flavourings, Processing Aids and Food Contact Materials established a tolerable weekly intake of 1 mg of aluminium/kg body weight from all relevant sources. In 2011, the Joint FAO/WHO Expert Committee on Food Additives established a provisional tolerable weekly intake of 2 mg aluminium/kg body weight (EFSA, 2013). The concentration of aluminium in the analysed *Triticum dicoccum* genotypes is not considered as risky for the human body.

These results are like other reports. For example, the content of elements in mature grains of bread and durum wheat grown in Portugal showed to be increasing in the order of Sc < Co < Mo < Cr < Br < Rb < Na < Zn < Fe < Ca < K (Galinha et al., 2013). In the case of the common winter wheat cultivar Azract, the concentrations of macroelements, expressed in mg/kg, were recorded in the following order: P (4058.89) > K (3350.33) > Mg (1169.55) > S (996.89) > Ca (171.33). Concentrations of Al, Cr and Hg were below the limit of detection (LOD) and the concentrations of microelements, expressed in mg/kg, were found in the following order: Fe (38.10) > Zn (27.90) > Mn(22.26) > Cu (3.87) > Ba (2.65) > Sr (0.83) > V (0.35) > Ni (0.29) > As (0.11) > Co (0.06) (Dolijanović et al., 2019). The effect of different variants of N, P, K fertilization on the concentration of minerals in several varieties of Chinese winter wheat was studied in the seasons of 2013 – 2014 and 2014 – 2015. Depending on the fertilization and variety, Zn concentrations in the wheat grain varied between 16.3 – 49.8 mg/kg while Fe levels ranged between 16.1 – 39.2 mg/kg, respectively (Han et al., 2022). An interesting conclusion of the study was that various nutrient inputs relative to the unfertilized control reduced both Zn and Fe concentrations in the grain. In the assessed *Triticum dicoccum* genotypes Zn content ranged from 30.95 ± 0.5 to 49.98 ± 0.5 mg/kg and Fe levels ranged from 28.86 ± 0.5 to 41.40 ± 0.7 mg/kg. It is plausible that *Triticum dicoccum* (grown without special fertilization) may improve the mineral profile of cereal products concerning human nutrition.

The study of mineral composition of flours produced from twenty-four different wheat varieties (*Triticum aestivum* L., *T. monococcum* L., *T. spelta* L.) collected from the Plant Genetic Resources Bank in Romania cultivated under the same conditions indicates higher levels of mineral content in ancient wheat species. The *Triticum monococcum* sample presented with the highest Ca amount of all wheat samples (8.29 % of the total mineral composition). *Triticum monoccocum* also had relatively high concentrations of Fe (0.52 – 1.31% of the total mineral composition) when compared to *Triticum aestivum*. Zn levels (from 0.145 to 0.966 % of the total mineral composition) were found to significantly differ between the wheat varieties with the modern varieties containing less Zn than the ancient ones. The authors explain this phenomenon by suggesting that wheat lines that produce higher grain yields may present with lower contents of trace elements (Golea et al., 2022). This confirms the hypothesis that the varieties of *Triticum dicoccum* assessed in this study could be an interesting enrichment for the assortment of raw materials to produce cereal products.

CONCLUSIONS

The evaluated *Triticum dicoccum* genotypes presented with a high content of storage proteins (82.30% on average). Significant differences were found in the amount of cytoplasmic proteins, where three times more albumins and globulins were detected in the PN 4-41 genotype than in the PN 8-23 genotype. The reaction

with the G12 antibody showed that *Triticum dicoccum* is not suitable for the nutrition of celiacs, since the average content of celiac active proteins was 67.07 g/kg of wheat grain. Concentrations of microelements, expressed in mg/kg, decreased in the following order: K (on average 4089.05) > Mg (1238.09) > Ca (401.86) > Zn (39.96) > Fe (37.69) > Mn (34.05) > Na (17.07) > Cu (4.62) > Al (2.30). *Triticum dicoccum* as an alternative species is a suitable addition of raw materials to produce bread and bakery products to diversify the assortment of cereal foods.

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