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EFFECT OF INTERACTION OF PARENTAL COMPONENTS ON THE CONTENT OF PROTEIN AND AMINO ACIDS IN TRITICALE GRAIN

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ABSTRACT

The research defined the effect of parent components of rye, 'Donar' cultivar, and wheat cultivars, 'Aurora' and 'Liwilla', on the content of total protein and protein amino acid composition of grain of primary forms of octoploid triticale (♀Aurora x ♂Donar, ♀Liwilla x ♂Donar). There was also determined the effect of crossing of the octoploid triticale forms obtained with hexaploid triticale CZR142/79 on the chemical characteristics (qualitative). The results obtained showed that primary forms of octoploid triticale contained more protein in grain than the parent plants. It can give a potential in further breeding work of giving high-protein high-starch cultivars. Both forms of octoploid triticale showed a higher level of lysine. Also the marked amino acids show that the biological value protein of triticale 'Liwilla' x 'Donar' was more similar to wheat protein, which points to a considerable effect of components derived from the basic form on the nutritional value of triticale grain.

Key words: triticale, protein, amino acids.

INTRODUCTION

The domestic breeding researches into triticale aim mainly at creating cultivars of adequately high fertility [3,13]. The combination of positive characters of wheat and rye in triticale grain can limit rye cultivation, especially in soils of very good rye complex and rye good complex. In the process of breeding new triticale cultivars it is essential to make a possibly earliest selection towards the level and biological value of protein and the qualification of nutritional applicability of the parent material. At the stage of synthesis of the primary octoploid triticale, data on the content of protein and amino acids can make the selection of the parent material easier as a donor of these characteristics. Cytogenetic and physiological instability of octoploid triticale results in

this form is no practically cultivated in Poland. However with an inadequate selection, it is used to obtain high-yielding cultivars of secondary hexapolid triticale. For that reason the evaluation of the nutritive value of selected octoploid triticale forms and their parental components can help to obtain from still 'evolutionary young' fodder grain cereal species [2,8].

The aim of the present research was to define the effect of parental components (♀ hexaploid 'Aurora', 'Liwilla' wheat and ♂ diploid 'Donar' rye) on the content of total protein and the composition of amino acids of octoploid triticale grain protein. Also there was defined the effect of hexaploid CZR-142/78 triticale (octoploid triticale x 'Grana' wheat not containing genomes of tetraploid wheat but exclusively hexaploid AABB) on the content of the researched compounds in octoploid triticale.

MATERIAL AND METHODS

The research included grain obtained from the glasshouse of the Institute of Genetics and Plant Breeding, the Agricultural University in Lublin. The research material was divided into two crossing combinations (Table 1). Primary octoploid triticale was created due to pollination of two cultivars of hexaploid wheat ('Aurora', 'Liwilla') with pollen of diploid rye ('Donar'). The primary forms of octoploid triticale obtained were additionally pollinated with pollen of hexaploid triticale CZR142/79 which showed high-yield values.

Table 1. Cereals crossing combinations

Combination I	Combination II
Wheat (6x) Aurora	Wheat (6x) Liwilla
Rye (2x) Donar	Rye (2x) Donar
Triticale (8x) Aurora x Donar	Triticale (8x) Liwilla x Donar
Triticale (6x) CZR142/79	Triticale (6x) CZR142/79
Triticale (8x x 6x) Aurora x Donar x CZR142/79	Triticale (8x x 6x) Liwilla x Donar x CZR142/79

Grain was harvested at full cereal ripening stage. The grain sample of 50 g was crushed with grinder. Total protein was defined from total nitrogen, using the protein conversion factor 5.70. Total nitrogen was determined with the Kjeldahl method [8,9]. Amino acids were determined with ion-exchange chromatography using autoanalyser of amino acids AAA-881. Grain samples prior to analysis were treated with a formic acid and hydrogen peroxide (9:1) solution and hydrogen bromide (40%) to transform methionine into $MeSO_2$, and cysteine into $CySO_3H$. Having completed the vaporisation, hydrolysis of 6n HCl was carried out at 120°C over 20 hours. After hydrolysis, the excessive amount of hydrochloric acid was vaporised, and diluted to 25 cm^3 [7,8,9]. All the chemical analyses were made in three replications. The evaluation of significance of differences in the chemical composition researched was made with variance analysis in completely randomised design and Duncan test at the significance level of P = 95% [6].

RESULTS AND DISCUSSION

The content of total protein in grain of the researched combination of crossings is given in Figs. 1-2. Octoploid triticale forms contained significantly more protein as compared with the parent plants. Crossing octoploid triticale 'Liwilla' x 'Donar' with hexaploid triticale CZR-142/79 significantly decreased the protein content in grain. However the content of total protein in octoploid triticale grain 'Aurora' x 'Donar', after being crossed with CZR-149/79 line did not undergo significant changes. The present research results obtained do not fully coincide with the results reported by some authors [10,14]. According to reports by Żurek et al. [14] the lowest content of total protein was observed in rye grain, while the highest – triticale grain. The content of protein in wheat grain was intermediate, while Sudba et al. [10] claim that the content of total protein in triticale grain of lines and cultivars remains similar to that of wheat and is higher than that of rye.

Fig. 1. Content of total protein in cereal grain – combination I
A – Aurora wheat,
C – CZR 142/79 triticale,
D – Donar rye, (A x D) x C – triticale,
A x D – triticale Aurora x Donar
Columns marked with the same letters did not differ significantly at P = 95%

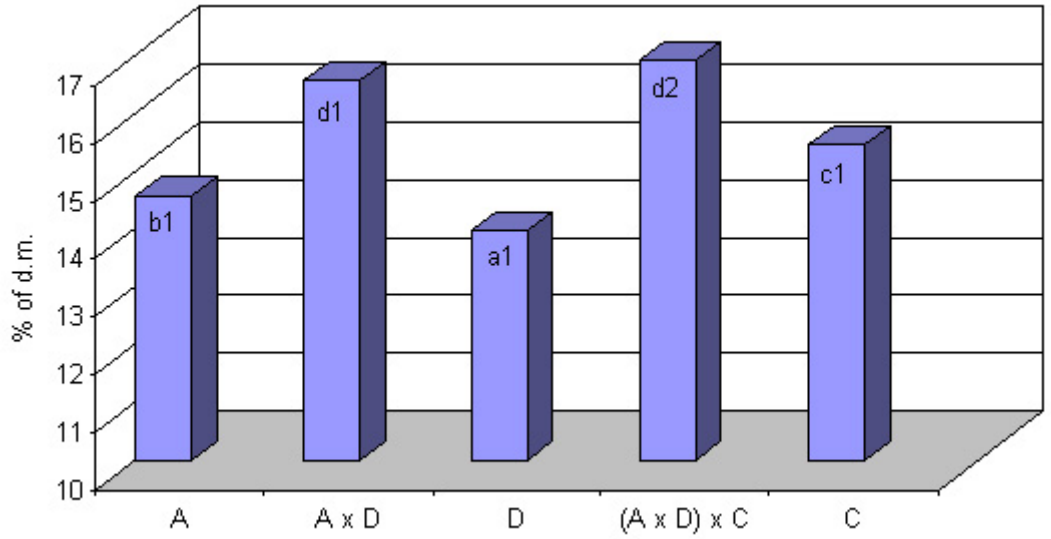
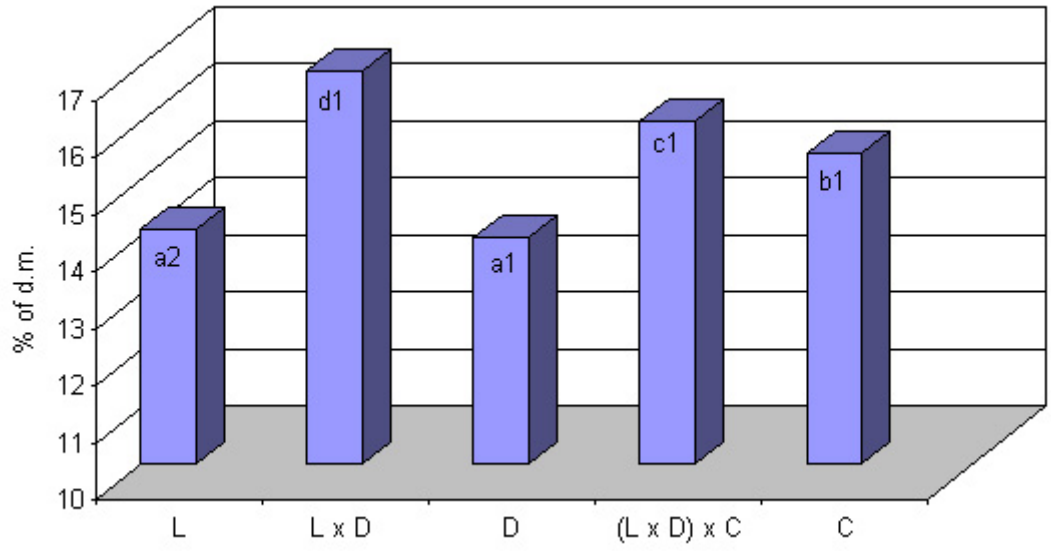


Fig. 2. Content of total protein in cereal grain – combination II
L– Liwilla wheat,
C– CZR 142/79 triticale,
D – Donar rye, (Lx D) x C – triticale,
Lx D – Liwilla x Donar triticale
Columns marked with the same letters did not differ significantly at P = 95%



One of the methods leading to obtaining high-protein cultivars is the selection of the adequate parent material. The present research confirms that relationship. Also Larter et al. [4] presented the effect of parental forms on the content of protein in grain of primary hexaploids. The authors showed that the effect of tetraploid wheat is much stronger here than the effect of rye inbred lines used in crossing, although it was also significant.

A special importance for the biological value of triticale protein is attributed to exogenous amino acids, with lysine being one of the most important amino acids defining the fodder value of triticale grain [8,9,10,11,12,14].

The content of amino acids in the protein of cereals researched is presented in Tables 2-3. 'Aurora' x 'Donar' triticale grain protein did not show significant differences in the contents of lysine and valine as compared with the protein of 'Aurora' wheat and 'Donar' rye. Neither were there observed significant differences between octoploid triticale protein and wheat in their contents of arginine, $CySO_3H$, $MeSO_2$, threonine, serine, glutamic acid and valine. Octoploid triticale protein contained significantly less aspartic acid, glycine, alanine, isoleucine and phenylalanine and contained more slightly proline and leucine than the wheat grain protein. Octoploid triticale protein, as compared with rye protein did not differ significantly in their content of $CySO_3H$, $MeSO_2$, threonine, proline, glycine, methionine and phenylalanine. Additionally, as compared with the protein of rye grain, the triticale protein 'Aurora' x 'Donar' showed higher contents of: arginine, serine, glutamic acid and leucine and a lower level of aspartic acid, alanine and isoleucine. All that shows that the protein of octoploid triticale grain is similar in its contents of arginine, serine, and glutamic acid to rye grain protein and in the contents of proline, glycine and phenylalanine to wheat grain content.

Table 2. Content of amino acids in cereal protein grain, g·100 g of protein^{-1} – combination I

Amino acids	Cereals				
	Wheat Aurora	Triticale Aurora x Donar	Rye Donar	Triticale (Aurora x Donar) x CZR142/79	Triticale CZR142/79
Lys	3.36 a_2	3.65 a_4	3.80 a_5	3.51 a_3	3.28 a_1
Arg	3.50 b_1	3.88 b_3	2.56 a_2	3.76 b_2	2.49 a_1
$CySO_3H$	2.61 a_5	1.55 a_4	1.45 a_2	1.51 a_3	1.43 a_1
Asp	6.03 c_1	5.54 b_2	6.46 d_1	4.17 a_1	5.41 b_1
$MeSO_2$	2.07 b_2c_2	2.14 c_1	2.25 c_2	1.29 a_1	1.90 b_1
Thr	1.91 a_2b_2	1.98 b_1	2.13 b_3	1.79 a_1	2.03 b_2
Ser	2.82 a_3b_2	3.22 b_2	2.75 a_2b_1	3.01 b_1	2.49 a_1
Glu	29.43 d_1	29.58 d_2	25.25 a_1	25.76 b_1	28.22 c_1
Pro	8.74 a_1	9.91 b_2	9.83 b_1	8.77 a_2	10.27 c_1
Gly	3.42 b_1	3.19 a_1	3.39 a_2b_3	3.54 b_3	3.49 b_2
Ala	2.49 b_1	2.29 a_1	2.73 c_1	2.62 b_3c_1	2.59 b_2c_1
Val	3.65 a_1	3.33 a_3	3.63 a_5	3.26 a_2	3.40 a_4
Ileu	3.06 c_2	1.68 a_1	2.27 b_2	2.01 b_1	2.86 c_1
Leu	5.97 b_1	5.60 c_1	4.80 a_3b_1	4.58 a_1	4.68 a_2
Phe	4.12 c_1	3.93 b_1	3.87 a_2b_1	4.48 d_1	3.74 a_1

Values in rows marked with the same letters did not differ significantly at P = 95%

Table 3. Content of amino acids in cereal grain protein, g·100g of protein^{-1} – combination II

Amino acids	Cereals				
	Wheat Liwilla	Triticale Liwilla x Donar	Rye Donar	Triticale (Liwilla x Donar) x CZR142/79	Triticale CZR142/79
Lys	3.45 b_1	3.27 a_2b_1	3.80 c_1	2.97 a_1	3.28 a_3b_1
Arg	3.08 a_5	2.68 a_4	2.56 a_3	2.39 a_1	2.49 a_2
$CySO_3H$	1.20 a_1	1.69 c_1	1.45 b_2	1.29 a_2b_2	1.43 b_1
Asp	5.08 a_2	5.71 b_2	6.46 c_1	5.05 a_1	5.41 b_1
$MeSO_2$	1.38 a_1	1.81 b_2	2.25 c_1	1.74 b_1	1.90 b_3
Thr	1.43 a_1	2.43 d_1	2.13 c_2	1.61 b_1	2.03 c_1
Ser	3.01 a_1	3.70 d_1	2.75 b_2c_1	2.02 a_1	2.49 b_1
Glu	22.40 a_1	30.65 a_1	25.25 b_1	26.38 c_1	28.22 d_1
Pro	8.85 a_2	8.73 c_1	9.83 b_1	8.89 a_3	10.27 b_2
Gly	2.92 a_1	3.74 c_1	3.39 b_1	3.08 a_2	3.49 b_2
Ala	2.58 a_2	3.17 b_1	2.73 a_4	2.52 a_1	2.59 a_3
Val	3.70 b_3	3.64 b_2	3.63 b_1	3.17 a_1	3.40 a_2b_2
Ileu	2.06 a_2b_1	3.25 d_1	2.27 b_1	1.99 a_1	2.86 c_1
Leu	4.77 b_2	6.11 c_1	4.80 b_3	3.28 a_1	4.68 b_1
Phe	4.09 b_2	4.12 b_3	3.87 a_2b_3	4.02 b_1	3.74 a_1

Values in rows marked with the same letters did not differ significantly at P = 95%

Crossing octoploid triticale ‘Aurora’ x ‘Donar’ with hexaploid triticale CZR142/79 decreased the contents of aspartic acid, $MeSO_2$, threonine, glutamine, proline, leucine or increased glycine, alanine, isoleucine and phenylalanine. The content of lysine, arginine, $CySO_3H$, serine, valine did not undergo significant changes. The content of lysine in octoploid triticale ‘Liwilla’ x ‘Donar’ grain protein was significantly lower, as compared with ‘Donar’ rye grain protein. However the octoploid triticale protein researched did not differ in the level of this amino acid as compared with ‘Liwilla’ grain protein. The octoploid triticale grain protein did not differ significantly in its content of arginine, glutamic acid, valine and phenylalanine from wheat grain protein. The content of the other amino acids researched in octoploid triticale grain protein was significantly higher as compared with wheat protein. Octoploid ‘Liwilla’ x ‘Donar’ triticale grain protein did not differ significantly in their content of arginine, valine and phenyloalanine as compared with rye protein. Octoploid triticale grain protein contained significantly less aspartic acid, $MeSO_2$ and proline, as compared with rye grain protein. At the same time triticale protein contained more of the other amino acids researched as compared with ‘Donar’ rye protein. The results obtained show that ‘Liwilla’ x ‘Donar’ triticale grain protein is similar in its content of amino acids researched to ‘Liwilla’ wheat grain protein than to ‘Donar’ rye grain protein. Crossing octoploid ‘Liwilla’ x ‘Donar’ (♀) triticale with CZR 142/79 (♂) triticale decreased the content in grain protein of $CySO_3H$, aspartic acid, threonine, serine, glutamic acid, proline, glycine, alanine, isoleucine and leucine. The content of lysine, arginine, $MeSO_2$, proline and phenylalanine did not undergo significant changes. The results obtained are partially confirmed by reports of other authors [1,5,14].

CONCLUSIONS

1. The primary forms of octoploid ‘Aurora’ x ‘Donar and ‘Liwilla’ x ‘Donar’ triticale obtained showed a higher level of protein than the parent plants (wheat, rye), which can show potential in further breeding and creating high-protein triticale cultivars.
2. Crossing the octoploid triticale forms researched with hexaploid triticale CZR142/79 decreases significantly the content of protein only in ‘Liwilla’ x ‘Donar’ triticale grain. However introducing components of this line of hexaploid triticale can increase grain yield.
3. Octoploid ‘Liwilla’ x ‘Donar’ triticale protein contained less lysine as compared with ‘Donar’ rye protein. However both octoploid triticale forms contained more of this amino acid in protein than the grain protein of the wheat cultivars researched (‘Aurora’, ‘Liwilla’).
4. Amino acids marked in protein of octoploid triticale forms researched show that ‘Aurora’ x ‘Donar’ triticale protein is in this respect more similar to rye protein and ‘Liwilla’ x ‘Donar’ triticale protein to wheat protein.

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