

Nitrogen-bearing joints in grain of different varieties and lines of dinkel wheat

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The purpose. To determine formation of nitrogen-bearing joints in grain of different varieties and lines of dinkel wheat. **Methods.** Field, physical and chemical, chromatographic with the use of analyzer of amino acids T-339, calculation, analysis. **Results.** Formation is studied of the content of protein, protein in grain of dinkel wheat depending on selection-genetic features of variety and line. It is shown that the content of nitrogen-bearing joints in grain of dinkel wheat is essentially changed depending on selection-genetic parentage of variety and line. The highest content of protein was in grain of dinkel wheat of variety Zaria Ukrainy — 23,9%. The content of protein in grain of other varieties was 13,8 – 20,1%, i.e. was less on 16 – 42%, in grain of lines — was 13,2 – 21,5%, i.e. was less on 10 – 45% in comparison to control. The content of protein in grain of varieties of dinkel wheat was higher on 1,2 – 2,2%, of lines gained by hybridization of *Triticum aestivum* L./*Triticum spelta* L. — on 0,3 – 2,5, and of introgressive — on 1,0 – 1,9% in comparison with protein content. The content of amino acids, which were not a part of protein structure, essentially depended on variety and line of dinkel wheat. The highest amount of the sum of free amino acids contained grain of variety Zaria Ukrainy — 3,72%. In grain of other varieties the content of free amino acids made 0,41 – 2,02%, in grain of lines — 0,18 – 2,34%. The content of essential amino acids was evaluated by means of effectiveness ratio of metabolism and index of complex assessment. In particular, their content was within the limits of 0,10 – 0,85%, that made 23 – 36% of their general amount. **Conclusions.** The content of nitrogen-bearing joints in grain of dinkel wheat is essentially depends on variety, line and weather environment. Nitrogen-bearing joints in grain of dinkel wheat vary in wide range. The content of total nitrogen — from 13,2 up to 23,9%, protein - from 12 up to 21,1, free amino acids — from 0,18 up to 3,72 % depending on variety and line.

Key words: dinkel wheat, protein, protein, free amino acids, variety, line.

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One of the priority tasks of the agrarian science is the production of high biological value products. Wheat occupies a prominent position among the leading agricultural crops and is the diet basis of the population of many countries [1]. It is possible to solve the problem of vegetable protein production, valuable for baking and confectionery production, using the grain of infrequent species, introgressive, interspecific wheat varieties and strains [2].

World and domestic practice recognized that the quality of wheat grain depends on the breeding and genetic features of the variety. The specific proportion can be up to 50% [3, 4].

Spelt wheat grain is used to produce products of superior quality and biological value compared to soft wheat. This is due to the wheat ability to synthesize spontaneously higher protein content in the grain [5]. However, its content may vary from 12.5% to 28.7% depending on the variety, weather conditions and agricultural technologies [6]. In addition, soft wheat grain contains gluten protein which causes allergies in 5% of the population. Gluten protein is less in spelt wheat grain. Therefore, domestic and foreign producers successfully satisfy the growing demand for it [7].

Spelt wheat grain has higher content of essential amino acids, especially lysine (4.2-4.8 g/ kg of grain) and the basis is glutamic acid [8]. The content of non-protein nitrogen-containing compounds in soft wheat grain is 0.3-2.5% depending on the variety and agricultural technologies [9, 10]. However, the issue on the formation of non-protein nitrogen-containing compounds in spelt wheat grain was not investigated.

The problem is that non-protein nitrogen-containing compounds, represented by free amino acids, are digested by the human body in a similar way. These compounds are insufficiently studied for grain of new varieties and lines of spelt wheat which requires additional research.

The research purpose is to determine the formation of nitrogen-containing compounds in the grain of different spelt wheat varieties and strains.

Research content and methods. The experimental work was carried out in the laboratory "Evaluation of quality of grain and grain products" of Department of Technology of Grain Storage and Processing at Uman National University of Horticulture. Grain of spelt wheat varieties of selection of the European countries was used, such as Schwabenkorn (Austria), NSS 6/01 (Serbia), Shvedska 1 (Sweden); LPP 1197, LPP 3117, LPP 1304, LPP 1224, LPP 3122/2, P 3, LPP 3132, LPP 3373 and LPP 1221 strains obtained by hybridization of *Triticum aestivum*/ *Triticum spelta*; NAK 34/12-2 and NAK 22/12 introgressive strains obtained by hybridization of *Triticum aestivum*/ amphiploid (*Triticum durum*/ *Aegilops tauschii*) and TV 1100 introgressive strain obtained by hybridization of *Triticum aestivum* (Kharkivska 26 variety)/ *Triticum kiharae* with a selection of winter forms grown under the conditions of Right Bank Forest Steppe of Ukraine. The check variant (standard) was a released spelt wheat variety of Zoria Ukrainy (st).

The technology of growing winter wheat for Right Bank Forest Steppe was used in the research. The predecessor was vetch and oat mix used for green fodder. The method of systematic plot allocation was used. The area of the experimental plot was 10 m². The number of replications was four.

Protein content was determined by the amount of total nitrogen (conversion factor of 6.25), protein content was determined by ДСТУ 4117 and free amino acid content was determined by ion exchange liquid chromatography on the amino acid analyzer T-339.

The metabolisation efficiency coefficient (MEC) of essential amino acids was determined by the formula

$$MEC = \frac{\sum EA}{\sum SA},$$

In which Σ_{EA} is content of essential amino acids, %; Σ_{SA} is content of substitutable amino acids, %.

The Integrated assessment index (IAI) was determined by the formula

$$IAI = \sqrt{\frac{A_1}{O_1} \times \frac{A_2}{O_2} \times \dots \times \frac{A_n}{O_n} \times \frac{Ac_1}{A_1} \times \frac{Ac_n}{A_n}},$$

In which A is the actual value of the indicator; O is the optimal value of the indicator; Ac is the acceptable value of the indicator; $\frac{A}{O}$ is the ratio used for indicators which actual value should be more optimal; $\frac{Ac}{A}$ is the ratio used for indicators which actual value should be less than the permissible level; n is the number of indicators used in the model.

Mathematical processing of data was carried out by the method of single-factor dispersion analysis [11].

Research results. Nitrogen-containing compounds in spelt wheat grain significantly varied depending on the breeding and genetic origin of the variety and strain. The highest protein content was in wheat grain of Zoria Ukrainy variety (23.9%) (Table1). The protein content in the grain of other varieties varied from 13.8 to 20.1% or was lower by 16-42%, in strain grain it was from 13.2 to 21.5% or was lower by 10-45% compared with the check variant. Protein content in grain of spelt wheat varieties was 1.2-2.2% and in strains obtained by hybridization of *Triticum aestivum* L./ *Triticum spelta* L. it was by 0.3-2.5 and in introgressive strains it was by 1.0-1.9% higher than the protein content.

1. Protein content in grain of different varieties and strains of spelt wheat, %

Variety, strain	Research year				Average for four years
	2013	2014	2015	2016	
Zoria Ukrainy (st)	23.2	24.0	23.1	25.3	23.9
Shvedska 1	13.7	12.0	15.5	14.1	13.8
NSS 6/01	15.8	22.9	17.3	18.2	18.6
Schwabenkorn	17.6	21.1	19.8	22.0	20.1
LPP 3117	12.9	13.7	14.3	11.9	13.2
LPP 3122/2	13.9	13.3	14.2	14.8	14.1
LPP 1224	13.8	14.6	15.4	13.3	14.3
LPP 1304	12.8	13.1	15.7	18.8	15.1
LPP 1197	15.7	16.6	15.2	16.0	15.9
LPP 3373	17.6	14.3	19.4	13.7	16.3
LPP 3132	16.2	17.9	17.1	14.9	16.5
P 3	15.4	16.5	16.8	17.7	16.6
LPP 1221	19.9	21.3	22.0	22.8	21.5
NAK34/12–2	15.1	16.7	17.0	18.1	16.7
NAK 22/12	16.5	14.2	18.1	18.9	16.9
TV 1100	19.2	21.3	20.1	19.3	20.0
<i>HIP₀₅</i>	0.7	0.9	0.6	0.9	–

Studies have shown that the protein content varies depending on the weather conditions of the growing season. Thus, in 2013 and 2016, weather conditions were characterized by less rainfall. In April-July there were 209 and 236 mm of precipitation or by 15-25% less than the average long-term indicator (277 mm). Sufficient rainfall was in 2014 and 2015. In April-July, there were 292 and 271 mm of precipitation but their distribution was different. In 2013, there was only 13.3 mm of precipitation in the shooting stage; it was 45.8 mm in 2015; it was 140.8 mm in 2014 and 179.5 mm in 2016. The air temperature also affected the growth and development of spelt wheat varieties and strains. Thus, in the period of intensive growth of the stem (shooting stage – earing) in 2013, it was unfavorable compared with the optimal (9-16°C) and was 18-21°C. During the rest of the years of research, the air temperature was optimal during this period.

The protein content of Schwabenkorn, NSS 6/01, Zoria Ukrainy and Shvedska 1 varieties, LPP 1197, NAK34/12–2, LPP 1304, P 3, LPP 1221, LPP 3122/2 and TV 1100 strains also depended on the plant height which has changed over the years of research. It is obvious that with the increase in plant height, the proportion of the reutilised nitrogen from the vegetative mass in the formation of nitrogen-containing compounds. Falling did not significantly affect the protein content, since wheat plants restored the vertical position of the stem after falling. However, there is an inverse strong relationship between protein content and plant height for LPP 3373 strain, since its resistance to falling in 2016 was low (3 points).

Reducing protein content in wheat grain of Shvedska 1 variety, LPP 3132, LPP 3373, LPP 3117, LPP 1197, LPP 1224 and LPP 3122/2 strains is due to the lesion of plants caused by brown leaf rust and septoriosiis.

It is known that for wheat, the protein content > 18% is considered to be very high, high (within 16-18%), medium (14-16%), low (12-14%) and very low (< 12%).

The results of the conducted studies indicate that the protein content of wheat grain varied from 12.0 to 21.1% depending on the variety and strain (Fig. 1).

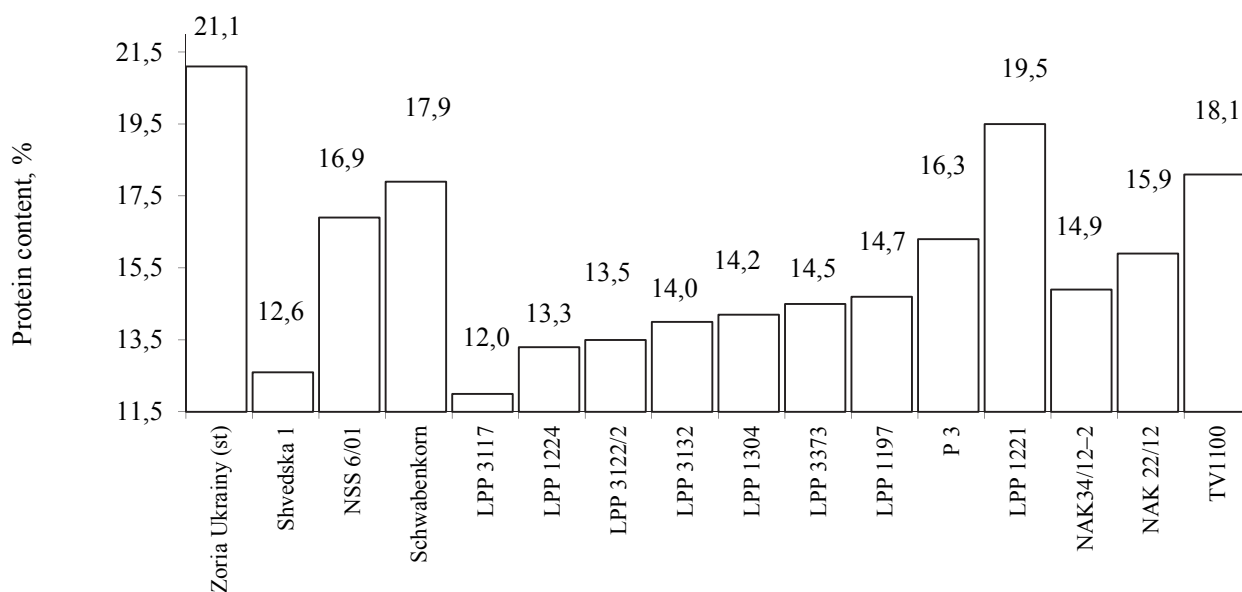


Fig.1 Protein content in grain of different varieties and strains of spelt wheat, in 2013-2016

On average, over four years of the research, very high protein content was in the grain of Zoria Ukrainy variety (21.1%), LPP 1221 (19.5%) and TV 1100 strains (18.1%); it was high in the grain of NSS 6/ 01 (16.9%) and Schwabenkorn varieties (17.9%) and P 3 strain (16.3%); it was average in the grain of LPP 3132, LPP 1304, LPP 3373 and LPP 1197 strains (14.0-14.7%); it was low in the grain of Shvedska 1 variety (12.6%), LPP 1224, LPP 3117 and LPP 3122/2 strains (12.0-13.5%).

Proportion of non-protein nitrogen-containing compounds of spelt wheat grain was in the range of 2-18% depending on the variety and strain corresponding to a specific genotype (Fig. 2).

The proportion of non-protein nitrogen-containing compounds in grain varieties was 10-13% among spelt wheat varieties. It was 2-18% in the grain of spelt wheat strains. Grain of LPP 3132 strain had the largest proportion of non-protein nitrogen-containing compounds (18%).

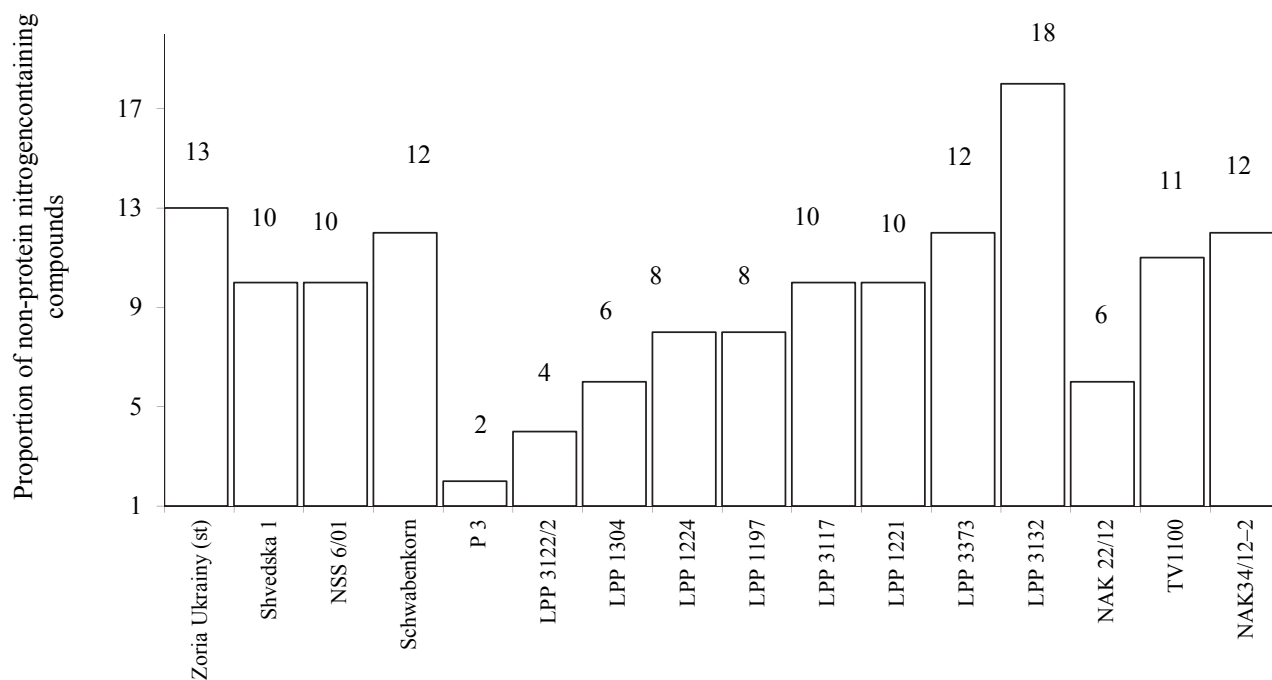


Fig. 1 Proportion of non-protein nitrogen-containing compounds in the grain of various spelt wheat varieties and strains (in 2013-2015), %

The content of amino acids that were not part of the protein structure depended substantially on the variety and strain of spelt wheat (Fig.3).

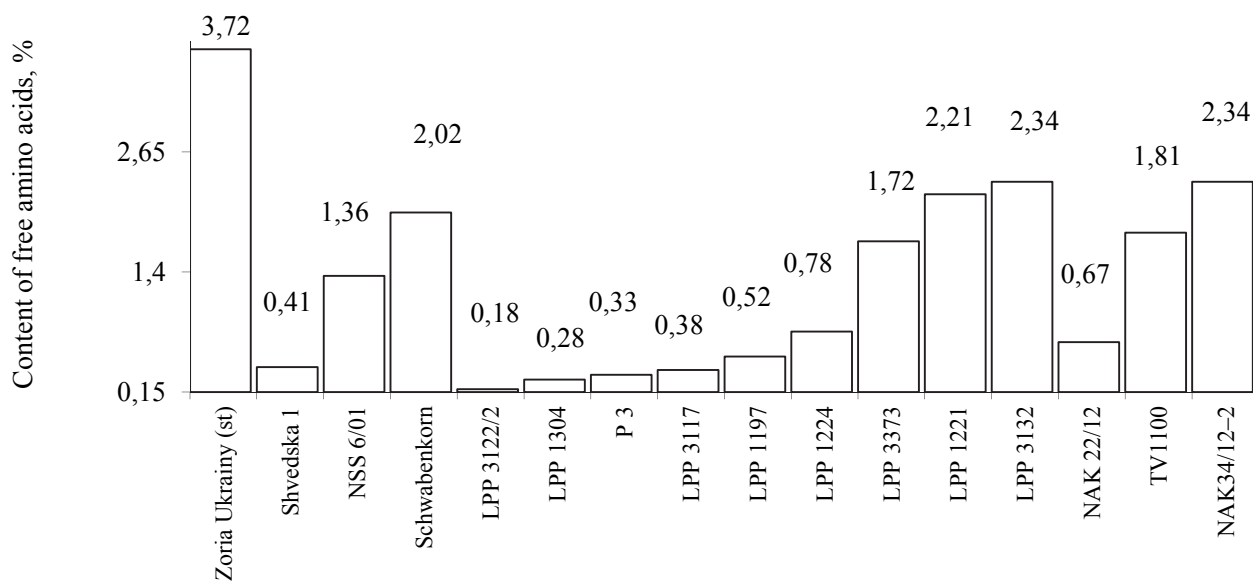


Fig. 3 Amount of free amino acids in the grain of different varieties and strains of spelt wheat (in 2014-2016), %

The grain of Zoria Ukrainy variety had the highest amount of free amino acids (3.72%). The content of free amino acids was from 0.41 to 2.02% in the grain of remaining varieties and it was from 0.18 to 2.34% in the grain of strains. The content of essential amino acids was from 0.10 to 0.85% which was 23-36% of their total amount.

It is found that the highest metabolisation of essential amino acids was in the grain of Shvedska 1 and Schwabenkorn varieties (0.46-0.48); it was 0.52-0.62 of LPP 1304, LPP 3122/2, P 3 and NAK 22/12 strains which is more by 24-48% in comparison with the check variant (Table 2).

This indicator was the smallest in the grain of Shvedska 1 variety (0.40) and it was 0.42-0.48 in the remaining studied varieties and strains. Values of metabolisation efficiency coefficient show that the increase in the content of amino acids in the grain of spelt wheat is due to the replacement of their compounds.

2. Metabolisation efficiency coefficient and integrated assessment index of the content of essential amino acids in the grain of different varieties and strains of spelt wheat, in 2014-2016

Variety, strain	MEC*	± до ст	IAI**	± до ст
Zoria Ukrainy (st)	0.42	–	1.58	–
NSS 6/01	0.40	-0.02	1.11	-0.47
Shvedska 1	0.48	0.06	1.31	-0.27
Schwabenkorn	0.46	0.04	1.42	-0.16
LPP 3117	0.42	0.00	1.06	-0.52
LPP 1224	0.45	0.03	1.13	-0.45
LPP 3132	0.42	0.00	1.16	-0.42
LPP 1197	0.44	0.02	1.27	-0.31
LPP 3122/2	0.62	0.20	1.31	-0.27
LPP 1304	0.52	0.10	1.41	-0.17
P 3	0.62	0.20	1.57	-0.01
LPP 3373	0.48	0.06	1.72	0.14
LPP 1221	0.42	0.00	1.75	0.17
NAK 34/12–2	0.45	0.03	1.28	-0.30
TV 1100	0.42	0.00	1.60	0.02
NAK 22/12	0.53	0.11	1.64	0.06
<i>HIP</i> ₀₅	0.02	–	0.07	–

Note. MEC is metabolisation efficiency coefficient, IAI is integrated assessment index.

The content of essential amino acids is best balanced in the grain of Zoria Ukrainy variety, R 3, LPP 3373, LPP 1221, NAK 22/12 and TV 1100 strains. This is evidenced by integrated assessment index (IAI) – 1.57-1.72. The smallest IAI indicator was found in the grain of NSS 6/01 variety, LPP 1224, LPP 1197 and LPP 3117 strains, obtained by hybridization of *Triticum aestivum* L. / *Triticum spelta* L. (1.06-1.16). IAI indicator of the remaining studied varieties and strains of spelt wheat was from 1.27 to 1.42.

Conclusions

The content of nitrogen-containing compounds in spelt wheat grain is significantly dependent on the variety, strain and weather conditions. Nitrogen-containing compounds in wheat grain vary in a wide range. The protein content ranges from 13.2 to 23.9%; protein content ranges from 12.0 to 21.1%, the content of free amino acids is from 0.18 to 3.72%, depending on the variety and strain. The high protein content (16.3-23.9%) with a percentage of non-protein nitrogen-containing compounds of 10-18%, which is represented by free amino acids in the grain, is provided by Zoria Ukrainy, NSS 6/01 and Schwabenkorn varieties, LPP 1221, LPP 3373, LPP 3132 and P 3 strains obtained by the hybridization of *Triticum aestivum*/ *Triticum spelta* and introgressive strains. Grain of spelt wheat of Zoria Ukrainy and Schwabenkorn varieties, R 3, LPP 3373, LPP 1221, NAK 22/12 and TV 1100 strains contains the most essential amino acids (MEC of 0.42-0.62) which are best balanced (IAI is 1.42-1.75).

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