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Comparison of common wheat and spelt by total lipids and fatty acid levels

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Nowadays the interest of breeders, producers and consumers is going back to ancient wheat species, such as *Triticum spelta*, which are often considered as more valuable for healthy nutrition. In this light, we compared spelt cultivars and breeding lines with commercial common wheat cultivars by total lipid content, fatty acid levels and unsaturated/saturated ratio in grain. Lipids were extracted by Soxhlet procedure. Fatty acid composition was determined by gas chromatography. On average, the total lipid content was higher in the spelt cultivars than in the breeding spelt lines (3.04±0.24 % vs. 2.23±0.69 %, $p < 0.05$). There was a significant difference between the average content of total lipids in the spelt cultivars, but not the breeding spelt lines, and the common wheat cultivars (3.04±0.24 % vs. 2.44±0.57 %, $p < 0.05$). Six major fatty acids were found in hexaploid wheat species, with linoleic acid being the most abundant. They are ranked in order of decreasing levels as follows: linoleic > oleic >palmitic > linolenic > stearic > palmitoleic. We also detected trace amounts of 3 minor fatty acids: eicosanoic (arachidic), eicosenoic and behenic acids. Common wheat is not inferior to spelt in terms of unsaturated fatty acid levels, because the ratios of unsaturated acids to saturated ones in grain of *T. spelta* accessions were similar to those in commercial common wheat cultivars. The oleic acid content was higher in spelt accessions; though the linoleic acid content was higher in *T. aestivum* cultivars. Spring common wheat cultivar Heroinia had the most beneficial unsaturated/saturated ratio of 4.5. We detected no differences in unsaturated acid amounts between spring and winter hexaploid wheats. We observed no patterns in variability of fatty acid contents across the accessions under investigation, because the same accession can be characterized by a wide variability in one fatty acid and by a narrow range for another, and, at the same time, the same fatty acid can be very variable within one accession and little variable in another. There were no significant differences in the total lipid content and fatty acid levels between the study years for the same accession.

Key words: *fatty acids, total lipids, unsaturated/saturated ratio, Triticum spelta, Triticum aestivum.*

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Introduction

The value of lipids for human and animal health lies in fatty acids being precursors of important classes of biomolecules in the body, which are involved in metabolic processes like regulation of blood lipid levels. Several unsaturated fatty acids (UFAs) are defined as ‘essential fatty acids’, because they are able to prevent some pathologies. Wheat is the main cereal crop used for humans’ and animals’ consumption worldwide, and despite the fact that it does not belong to oil crops, the contribution of wheat products to the intake of UFAs can be tangible. In addition, wheat germ oil is widely used in cosmetics industry. Such by-product as bran is also evaluated for fatty acid contents (Durante et al., 2012). Most of studies in this area are conducted on traditional commercial wheat cultivars. However, there is an opinion that the value of wheat oil reduced in the course of domestication. Beleggia et al. (2016) reported about a reduction in unsaturated fatty acids associated with selection during domestication of emmer (primary

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domestication). At the same time, nowadays the interest of breeders, producers and consumers is going back to ancient wheats (einkorn, emmer, spelt) as well as to domestic, but underutilized species (Gabrovská et al., 2002).

In this respect, it is prudent to analyze fatty acid contents in commercial common wheat (*Triticum aestivum* L.) cultivars and spelt (*Ttiticum spelta* L.) accessions.

Our purpose was to study the fatty acid composition in grain of different hexaploid wheat accessions.

Materials and methods

Test accessions

Common wheat cultivars and spelt lines were kindly provided by the Laboratory of Wheat Breeding and Physiology of the Plant Production Institute (PPI) named after V.Ya. Yuriev of NAAS. Cultivars of *Triticum spelta* Frankenkorn (UA0300103, DEU), Lohnauer Sommerspelz (IU067152, Austria), Tridentina (UA0300218, Italia), CDC Bavaria (UA0300391, Canada), CDC Zorba (UA0300392, Canada) were kindly provided by the National Center for Plant Genetic Resources of Ukraine (NCPGRU).

Wheat accessions were grown in the PPI's experimental plots in compliance with conventional farming techniques. Grain was harvested in 2015, 2016, 2017, 2018 and 2019. Whole kernels were milled on a laboratory mill LZM.

Total lipid content

Lipids were extracted from dried (to the constant weight) whole wheat kernels (5 g, in two replications) by Soxhlet procedure (Juhaimi et al., 2019). Oil was repeatedly washed (percolated) with petroleum ether of boiling range between 40–60°C (Haltermann GmbH, Germany). The Soxhlet extractor was heated to 40°C (hot extraction). After 6-hour incubation at 40°C, the solvent was evaporated under vacuum using a rotary evaporator. The oil percentage in the initial sample was calculated using the following formula:

$$\text{Total lipids (crude oil), \%} = \text{weight of obtained oil} \times 100/\text{weight of absolutely dry milled kernels used in a run.}$$

Fatty acids

Two samples were analyzed for each year. Fatty acid methyl esters were prepared by the modified Peisker method (Peisker, 1964). Chloroform (Thermo Fisher Scientific Inc., USA) – methanol (Honeywell Research Chemicals, Romania) – 96 % sulfuric acid (Dneprochem, Ukraine) mixture in a ratio of 100 : 100 : 1 was used for methylation. 30–50 microliters of lipid extract was placed in a glass ampoule; 2.5 milliliters of methylation mixture was added, and the ampoule was sealed. Ampoules were incubated in a thermostat at 105°C for 3 hours. After methylation, ampoules were opened, the contents were transferred to test tubes, a pinch of powdered zinc sulfate (ChemElements, Ukraine) was added, and then 2 milliliters of distilled water and 2 milliliters of hexane (MOL Group, Hungary) were poured to extract methyl esters. After thoroughly stirring and settling, the hexane extracts were filtered and analyzed by gas chromatography (Prokhorova, 1982).

Fatty acid composition was determined using a gas chromatograph Selmikhrom 1 (OAO SELMI, Ukraine) equipped with a flame ionization detector (FID). The stainless steel column, 2.5 m length × 4 mm i.d., was packed with a stationary phase, Inerton AW-DMCS (0.16–0.20 mm) (Lachema, Czechia) processed with 10 % diethylene glycol succinate (BOC Sciences, USA). 2 microliters of hexane solution of fatty acid methyl esters was injected. Gas chromatography was operated under the following conditions: nitrogen flow 30 milliliters/min; hydrogen flow 30–35 milliliters/min; air flow 300 milliliters/min; column temperature 180°C; injector temperature 230°C and FID temperature 220°C. The fatty acids were identified by comparing the retention time of sample with those of reference fatty acid methyl esters (Sigma-Aldrich, USA).

Data processing

The percentages of fatty acid methyl esters were calculated by internal normalization. The data were statistically processed in STATGRAPHICS PLUS, using ANOVA method or the Mann–Whitney *U*-test for small samples with an unknown distribution, as appropriate. The results are presented as mean ± standard deviation (SD) and reported to three significant figures.

Results and discussion

Total lipids

Triticum spelta

The total lipid content in spelt accessions ranged from 1.16±0.14 % dry basis (d.b.) in spelt cultivar (cv.) Yevropa to 3.37±0.39 % d.b. in cv. Tridentina. This is in line with published data: Suchowilska et al. (2009) reported that the crude fat content in *T. spelta* grain was 2.4 %; in a study of hexaploid wheat species the total lipid content varied within 2.57–3.08 %, depending on the cultivar and averaging 2.92 % across the cultivars (Ruibal-Mendieta et al., 2005). In our experiments, differences between years for the same accession were not significant. Narducci et al. (2019) came to a similar conclusion in their study of tetraploid wheat. On average, the total lipid content was higher in the spelt cultivars than in the breeding spelt lines (3.04±0.24 % vs. 2.23±0.69 %, $p < 0.05$). Not being an oil crop, wheat is unlikely to be bred for oil content, but involvement of collection spelt accessions in wheat breeding can bring an additional benefit in terms of the lipid content.

Triticum aestivum

The total lipid content in common wheat cultivars ranged from 1.23±0.14 % d.b. in cv. Podolianka to 3.53±0.41 % d.b in cv. Doridna. Other researchers report similar values: common wheat cv. Gerek-79 contained 1.44 % of crude oil (Kan, 2016); *T. aestivum* cultivars contained 2.24 % to 2.61 % of total lipids (Ruibal-Mendieta et al., 2005). Like in spelt, there were no significant differences between years for the same accession.

Fatty acid composition

Six major fatty acids were detected in all the wheat accessions under investigation. They are ranked in order of decreasing levels as follows: linoleic > oleic > palmitic > linolenic > stearic > palmitoleic. This distribution remains unchanged from year to year and is slightly different from the rankings reported by other authors. Research by Riubal-Mendieta et al. (2004, 2005) demonstrated the following ranking for spelt and common wheat: linoleic > oleic > palmitic > linolenic > stearic and linoleic > palmitic > oleic > linolenic > stearic, respectively. Grela (1996) found more fatty acids in spelt and common wheat: linoleic > oleic > palmitic > linolenic > stearic > eikosenoic > myristic > palmitoleic and linoleic > palmitic > oleic > linolenic > stearic > eikosenoic > myristic > palmitoleic, respectively. Suchowilska et al. (2009) studied *T. spelta* and arranged fatty acids in decreasing order of percentages: linoleic, oleic, palmitic, α-linolenic and stearic acids. We also detected trace amounts of 3 minor fatty acids: eicosanoic (arachidic) acid, eicosenoic acid and behenic acid. Their contents were 0.1 % in most of the species under investigation (below 0.5 % in all the species) and characterized by wide variability. However, the greatest variability was intrinsic to palmitoleic acid (its content was also very low – 0.14 % in cv. *T. spelta* CDC Zorba or lower in the other hexaploid wheat accessions): the peak variation coefficients amounted to 58.2 % in common wheat cvs. Doskonala and Pryvitna. Fig. 1A, B shows a typical chromatogram of two of the best (in terms of UFA contents) hexaploid wheat accessions.

We found no patterns in variability of fatty acid contents across the species under investigation. The same cultivar (e.g. common wheat cv. Podolianka with variation coefficients of 23.6 % and 0.50 % for palmitoleic and oleic acids, respectively*)* can be characterized by a wide variability in one fatty acid and by a narrow range for another. At the same time, the same fatty acid (e.g. stearic acid) can be very variable within one accession (*T. spelta* cv. Lohnauer Sommerspelz; variation coefficient = 9.78 %) and demonstrate a relatively stable content in another (*T. spelta* line 1145-16*;* variation coefficient = 0.49 %).

Triticum spelta

Spelt accessions had the unsaturated/saturated ratios within 3.9 (*T. spelta* cv. CDC Bavaria due to an increased palmitic acid content of 19.3±0.04 %) – 4.4 (cv. Frankenkorn due to an increased linoleic acid content of 52.7±0.07 % and an decreased palmitic acid content of 16.8±0.03 %; spelt breeding lines 1139-16 and 1140-16 due to an increased content of oleic acid of 27.4±0.12 % and 27.7±0.06 %, respectively, and a decreased palmitic acid content of 16.8±0.02 % and 16.6±0.05 %, respectively) (Table 1). These ratios are comparable with the literature data: 4.7 and 5.0 with a high content of linoleic acid of 61.0 % and 63.2 %, respectively, and a relatively low content of palmitic acid (16.7 % and 16.8 %, respectively) (Riubal-Mendieta et al., 2004, 2005), 4.0 as calculated from the data published in (Suchowilska et al., 2009) and 4.4 with unusually high levels of linolenic and eicosenoic acids (5.98 % and 0.87 %, respectively) as calculated from the USDA’s data (USDA, 2019). The linoleic acid content was the highest in cv. CDC Bavaria and cv. Lohnauer Sommerspelz grain (53.1±0.06 % and 53.1±0.13 %, respectively) and significantly higher than in cv. CDC Zorba grain. The oleic acid content was the highest in grain of spelt breeding line 1140-16 – 27.7±0.06 % and the lowest in cv. CDC Bavaria grain (22.7±0.06 %), which is significantly lower than in most of the other spelt accessions. The palmitoleic acid content was the highest in cv. CDC Zorba grain (0.14±0.02 %), though there were no significant differences between cv. CDC Zorba and the other spelt accessions. The linolenic acid content was the highest in cv. Lohnauer Sommerspelz grain (3.82±0.09 %), though there were no significant differences between cv. Lohnauer Sommerspelz and the other spelt accessions. The eicosenoic acid content was the highest in grain of spelt breeding line 1139-16 – 0.18±0.01 %. No significant differences were found in the eicosenoic acid content. The palmitic acid content was the highest in cv. CDC Bavaria grain (19.3±0.04 %), significantly higher than in grain of cv. CDC Zorba, cv. Lohnauer Sommerspelz and cv. Tridentina.

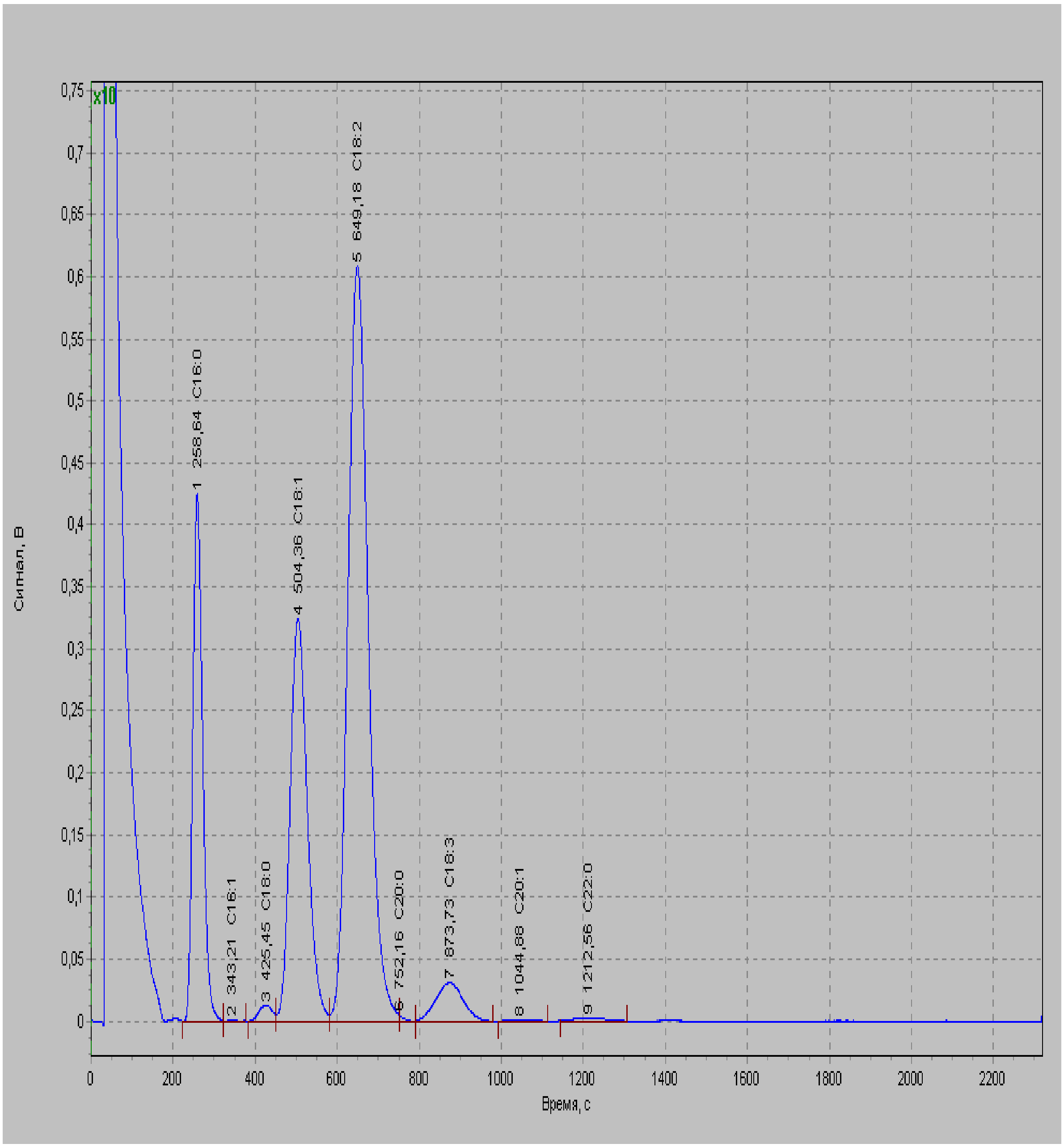

Fig. 1. A. Chromatograms of fatty acid methyl esters. *T. spelta* Lohnauer Sommerspelz, harvested in 2019. Y – Signal, V; X – Retention time, sec

When it comes to comparison between the breeding lines of spelt and original spelt accessions from the NCPGRU's collection, they differed in 3 unsaturated acids (oleic, linoleic and linolenic) and 1 saturated acid (palmitic) (Table 2). There were no differences in fatty acid contents between the breeding lines of spelt, which is attributed to their close origin. The breeding lines were richer in oleic only, and their unsaturated/saturated ratios were not superior to that of *T. spelta* cv. Frankenkorn. Check spelt cv. Yevropa did not have the best unsaturated/saturated ratio 4.0); its oleic content was lower than that of the breeding lines, on the contrary, the palmitic acid content was higher than in the breeding lines, and the only unsaturated acid that was more abundant in Yevropa grain was linoleic.

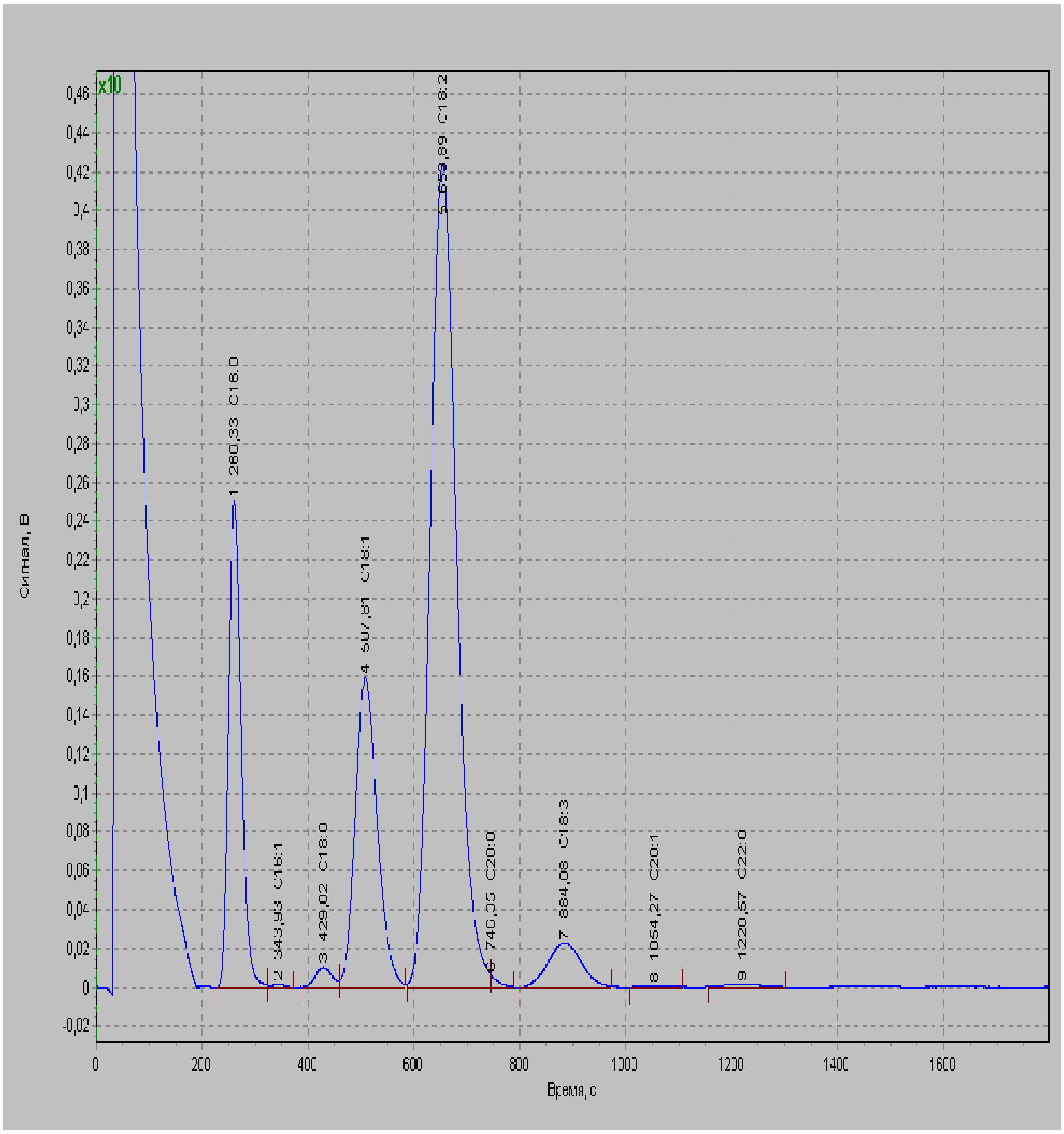

Fig. 1. B. Chromatograms of fatty acid methyl esters. Spring common wheat Heroinia, harvested in 2019. Y – Signal, V; X – Retention time, sec

Table 1. Fatty acid composition in grain of hexaploid wheat accessions (relative content, %)

Source	Palmitic C16:0	Stearic C18:0	Oleic C18:1	Linoleic C18:2	Linolenic C18:3	Behenic C22:0	Unsaturated/ Saturated Ratio
Triticum spelta							
Based on the National Nutrient Database of the US of Agriculture (USDA, 2019)	17.0	1.10	19.5	54.9	5.98	0.37	4.4
Ruibal-Mendieta et al. (2004)	16.7	0.7	17.3	61.0	4.00	Not detected	4.7
Ruibal-Mendieta et al. (2005)	16.8	Not detected	16.1	63.2	3.90	Not detected	5.0
Suchowilska et al. (2009)	18.8	1.1	19.4	55.9	3.5	Not detected	4.0
Our data. Species or cultivar/growth habit							
T. spelta line 1139-16/winter	16.8±0.02	1.32±0.09	27.4±0.12	50.8±0.06	2.84±0.20	0.45±0.01	4.4
T. spelta line 1140-16/winter	16.6±0.05	1.42±0.03	27.7±0.06	50.8±0.11	2.83±0.04	0.36±0.01	4.4
T. spelta line 1145-16/winter	16.9±0.11	1.46±0.01	27.2±0.02	50.9±0.14	2.82±0.06	0.40±0.11	4.3
T. spelta Frankenkorn/winter	16.8±0.03	1.15±0.07	25.5±0.05	52.7±0.07	3.25±0.08	0.35±0.07	4.4
T. spelta Yevropa	18.0±0.09	1.38±0.11	24.4±0.09	52.3±0.33	3.01±0.06	0.49±0.02	4.0
T. spelta Lohnauer Sommerspelz/spring	17.8±0.09	0.80±0.08	23.9±0.04	53.1±0.13	3.82±0.09	0.37±0.02	4.3
T. spelta Tridentina/spring	18.0±0.03	1.14±0.02	24.7±0.04	52.4±0.07	3.34±0.09	0.24±0.01	4.1
T. spelta CDC Bavaria/spring	19.3±0.04	0.87±0.02	22.7±0.06	53.1±0.06	3.63±0.18	0.19±0.02	3.9
T. spelta CDC Zorba/spring	17.5±0.14	1.06±0.07	24.9±0.16	52.5±0.26	3.31±0.09	0.34±0.05	4.3
Triticum aestivum							
Ruibal-Mendieta et al. (2004)	19.1	0.9	11.6	63.5	5.11	Not detected	4.0
Ruibal-Mendieta et al. (2005)	19.3	Not detected	10.7	64.6	5.3	Not detected	4.2
Kan (2015)	18.3	1.20	14.9	59.1	3.81	Not detected	4.0

Table 1 – Continued

Our data. Species or cultivar/growth habit							
Common wheat Doskonala/winter	17.3±0.18	1.20±0.08	23.2±0.18	53.7±0.13	3.97±0.10	0.41±0.08	4.3
Common wheat Pryvablyva/winter	17.0±0.14	1.09±0.02	23.2±0.23	54.3±0.33	3.85±0.10	0.32±0.03	4.4
Common wheat Pryvitna/winter	17.0±0.04	1.12±0.12	22.5±0.18	55.0±0.35	3.80±0.07	0.34±0.02	4.4
Common wheat Doridna/winter	18.2±0.35	1.31±0.04	23.0±0.11	53.6±0.40	3.25±0.07	0.41±0.01	4.0
Common wheat Podoplianka/winter	18.2±0.14	1.26±0.06	22.5±0.11	53.4±0.25	3.8±0.07	0.47±0.02	4.0
Common wheat Heroinia/spring	16.9±0.22	0.95±0.04	18.9±0.24	58.5±0.40	4.12±0.06	0.31±0.02	4.5
Common wheat Uliublena/spring	18.0±0.17	0.90±0.56	19.1±0.12	57.7±0.18	3.72±0.12	0.35±0.05	4.2
Common wheat Barvysta/spring	18.1±0.23	0.88±0.08	19.2±0.09	57.6±0.37	3.54±0.05	0.37±0.05	4.1

Triticum aestivum

The common wheat cultivars under investigation had the unsaturated/saturated ratios within 4.0 (winter common wheat cv. Podolianka) – 4.5 (spring common wheat cv. Heroinia), which is in accordance with the literature data (4.0 (Kan, 2015), 4.0 and 4.2 (Riubal-Mendieta et al., 2004, 2005) (Table 1). The highest contents of linoleic and linolenic acids were recorded in spring common wheat Heroinia – 58.5±0.40 % and 4.12±0.06 %, respectively. The highest content of oleic acid was observed in common wheat cultivars Doskonala (23.2±0.18 %) and Pryvablyva (23.2±0.23 %). The content of eicosenoic and palmitoleic acids little differed between the common wheat cultivars.

Among the winter common cultivars under investigation, Pryvablyva and Pryvitna had the best unsaturated/saturated ratios – 4.4, mainly due to higher contents of oleic and linoleic acids and a lower content of palmitic acid (Table 1). Among the spring common cultivars under investigation, Heroinia was distinguished by the unsaturated/saturated ratio of 4.5 due to highest contents of linoleic and linolenic acids and the lowest content of palmitic acid (16.9±0.22 %), while grain of cultivars Uliublena and Barvysta contained slightly more of oleic acid.

Triticum spelta vs. Triticum aestivum

Analysis of wholemeal samples demonstrated that the total lipid content was, on average, significantly higher (by 18 %) in spelt grain than in common wheat grain (Riubal-Mendieta et al., 2005). In contrast to our assumption, we detected no significant differences in the total lipid content between the breeding lines of spelt and the common wheat cultivars under investigation. However, there was a significant difference between the average total contents of lipids in the spelt cultivars and the common wheat cultivars (3.04±0.24 % vs. 2.44±0.57 %, $p < 0.05$), indicating deterioration in the grain quality in terms of oil content in the process of spelt breeding for high yield capacity, easy threshing, etc.

Although spelt is praised owing to its high nutritional value, including UFA levels (the unsaturated/saturated ratios were 4.7 and 5.0 in spelt and 4.0 and 4.2 in common wheat; calculated from the data published in (Riubal-Mendieta et al., 2004, 2005), our spelt accessions did not best modern common wheat cultivars in terms of UFA contents, judging from the unsaturated/saturated ratios. The oleic acid content was higher in spelt accessions, though the linoleic (contributing to higher unsaturated acid levels) acid content was higher in *T. aestivum* cultivars (Table 2).

Table 2. Averaged amounts of fatty acids in spelt and common wheat (relative content, %)

Palmitic C16:0	Stearic C18:0	Oleic C18:1	Linoleic C18:2	Linolenic C18:3	Behenic C22:0
Collection spelt cultivars					
17.1±0.63	1.40±0.06	26.7±1.53*	51.2±0.74*	2.89±0.09	0.43±0.06
Breeding spelt lines					
17.9±0.92	1.00±0.16	24.3±1.08*	52.8±0.33*	3.47±0.25	0.30±0.09
Commercial common wheat cultivars					
17.4±0.74	1.11±0.17	21.7±2.05	55.3±2.04	3.79±0.27	0.37±0.05

*Note: * significant difference between spelt and common wheat, $p < 0.05$.*

Winter cultivars vs. spring cultivars

Previously (Relina et al., 2020), we found no differences in UFA contents between spring and winter tetraploid wheat cultivars, and this study on hexaploid accessions confirmed this conclusion (Table 3). The spring and winter hexaploid accessions differed in oleic and linoleic acids: the winter accessions contained more oleic acid than the spring ones (22.9±0.35 % vs. 19.1±0.20 %, respectively), while linoleic acid was more abundant in grain of the spring accessions (54.0±0.64 % vs. 57.9±0.52 %, respectively).

Table 3. Averaged amounts of fatty acids in wheat cultivars of different growth habits (relative content, %)

Palmitic C16:0	Stearic C18:0	Oleic C18:1	Linoleic C18:2	Linolenic C18:3	Behenic C22:0
Spring growth habit					
17.7±0.59	0.91±0.06*	19.1±0.20*	57.9±0.52*	3.79±0.26	0.34±0.05
Winter growth habit					
17.5±0.58	1.19±0.10	22.9±0.35	54.0±0.64	3.73±0.27	0.39±0.06

*Note: * - significant difference between spring and winter cultivars, $p < 0.05$.*

Conclusions

1) On average, the total lipid content was higher in the spelt cultivars than in the breeding spelt lines (3.04±0.24 % vs. 2.23±0.69 %, $p < 0.05$); 2) There was a significant difference between the average content of total lipids in the spelt cultivars, but not the breeding spelt lines, and the common wheat cultivars, indicating deterioration in the grain quality in terms of oil content in the process of spelt breeding; 3) Six major fatty acids were found in hexaploid wheat species, with linoleic acid being the most abundant; 4) Common wheat is not inferior to spelt in terms of unsaturated fatty acid levels, as the ratios of unsaturated acids to saturated ones in grain of *T. spelt* accessions were similar to those in commercial common wheat cultivars; 4) Common wheat cultivar Heroinia had the most beneficial unsaturated/saturated ratio of 4.5; 5) We detected no differences in unsaturated acid amounts between spring and winter hexaploid wheat accessions; 6) We observed no patterns in variability of fatty acid contents across the accessions under investigation, because same accession can be characterized by a wide variability in one fatty acid and by a narrow range for another, and, at the same time, the same fatty acid can be very variable within one accession and little variable in another; 7) There were no significant differences in the total lipid content and fatty acid levels between the study years for the same accession.

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Порівняння м’якої пшениці та спельти за вмістом загальних ліпідів та рівнем жирних кислот

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Сьогодні інтерес селекціонерів, виробників та споживачів повертається до стародавніх пшениць, таких як *Triticum spelta*, які часто вважають більш цінними для здорового харчування. В світлі цього ми порівняли сорти, зразки та селекційні лінії спельти з комерційними сортами м’якої пшениці за вмістом загальних ліпідів, рівнем жирних кислот та співвідношенням ненасичені/насичені жирні кислоти в зерні. Ліпіди екстрагували в апараті Сокслета. Склад жирних кислот визначали методом газової хроматографії. В середньому вміст загальних ліпідів був вище в сортах спельти, ніж в селекційних лініях (3,04±0,24 % проти 2,23±0,69 %, $p < 0,05$). Виявлена істотна різниця за середнім вмістом загальних ліпідів між сортами спельти та сортами м’якої пшениці (3,04±0,24 % проти 2,44±0,57 %, $p < 0,05$), проте селекційні лінії спельти не відрізнялись від сортів м’якої пшениці. У гексаплоїдних видах пшениці було виявлено 6 головних жирних кислот, серед яких переважала лінолева кислота. Вони розташовуються у порядку зниження вмісту наступним чином: лінолева > олеїнова > пальмітинова > ліноленова > стеаринова > пальмітолеїнова. Ми також виявили 3 мінорні жирні кислоти у слідовій кількості: ейкозанова (арахінова), ейкозенова та бегенова кислоти. М’яка пшениця не поступається спельті за рівнем ненасичених жирних кислот, оскільки відношення ненасичених кислот до насичених у зерні зразків *T. spelta* подібне до такого у комерційних сортах м'якої пшениці. Вміст олеїнової кислоти вищий у зразках спельти, тоді як вміст лінолевої кислоти був вищим у сортах *T. aestivum*. Сорт ярої м'якої пшениці Героїня мав найкраще ввідношення ненасичених кислот до насичених – 4,5. Ми не виявили відмінностей у кількості ненасичених жирних кислот між зразками ярої та озимої гексаплоїдної пшениці. Ми не спостерігали закономірностей варіабельності вмісту жирних кислот у досліджених зразках, оскільки один і той же зразок характеризувався широкою варіабельністю вмісту однієї жирної кислоти і вузькою варіабельністю вмісту іншої, і у той же самий час одна і та ж сама жирна кислота могла відрізнятись дуже варіабельним вмістом у одному зразку і маловаріабельним в іншому. Не виявлено істотної різниці у вмісті загальних ліпідів та рівнями жирних кислот за роками в межах одного зразка.

Ключові слова: *жирні кислоти, загальні ліпіди, відношення ненасичених кислот до насичених, Triticum spelta, Triticum aestivum.*

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Сравнение мягкой пшеницы и спельты по содержанию общих липидов и уровню жирных кислот

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Сегодня интерес селекционеров, производителей и потребителей возвращается к древним пшеницам, таким как *Triticum spelta*, которые часто считают более ценными для здорового питания. В свете этого мы сравнили сорта, образцы и селекционные линии спельты с коммерческими сортами мягкой пшеницы по содержанию общих липидов, уровню жирных кислот и соотношению ненасыщенные/насыщенные жирные кислоты в зерне. Липиды экстрагировали в аппарате Сокслета. Состав жирных кислот определяли методом газовой хроматографии. В среднем содержание общих липидов был выше в сортах спельты, чем в селекционных линиях (3,04±0,24 % против 2,23±0,69 %, $p < 0,05$). Обнаружена существенная разница по среднему содержанию общих липидов между сортами спельты и сортами мягкой пшеницы (3,04±0,24 % против 2,44±0,57 %, $p < 0,05$), однако селекционные линии спельты не отличались от сортов мягкой пшеницы. У гексаплоидных видов пшеницы было выявлено 6 главных жирных кислот, среди которых преобладала линолевая кислота. Они располагаются в порядке убывания содержания следующим образом: линолевая > олеиновая > пальмитиновая > линоленовая > стеариновая > пальмитолеиновая. Мы также обнаружили 3 минорные жирные кислоты в следовом количестве: эйкозановая (арахиновая), эйкозеновая и бегеновая кислоты. Мягкая пшеница не уступает спельте по уровню ненасыщенных жирных кислот, поскольку отношение ненасыщенных кислот к насыщенным в зерне образцов *T. spelta* подобно таковому в коммерческих сортах мягкой пшеницы. Содержание олеиновой кислоты выше в образцах спельты, тогда как содержание линолевой кислоты было выше в сортах *T. aestivum*. Сорт яровой мягкой пшеницы Героиня имел лучшее отношение ненасыщенных кислот к насыщенным – 4,5. Мы не обнаружили различий в количестве ненасыщенных жирных кислот между образцами яровой и озимой гексаплоидной пшеницы. Мы не наблюдали закономерностей вариабельности содержания жирных кислот в исследованных образцах, поскольку один и тот же образец характеризовался широкой вариабельностью содержания одной жирной кислоты и узкой вариабельностью содержания другой, и в то же время одна и та же жирная кислота могла отличаться очень вариабельным содержанием в одном образце и маловариабельным в другом. Не выявлено существенной разницы в содержании общих липидов и уровнях жирных кислот по годам в пределах одного образца.

Ключевые слова: *жирные кислоты, общие липиды, отношение ненасыщенных кислот к насыщенным, Triticum spelta, Triticum aestivum.*

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