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FLOUR AND BREAD QUALITY OF SPRING WHEAT CULTIVARS (*Triticum aestivum* L.) SOWN AT FACULTATIVE AND SPRING SOWING DATES

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ABSTRACT

Background. In an integrated wheat production, spring wheat provides a higher concentration of protein in the grain that affects the increase of wet gluten, which in turn may cause a greater baking value of flour obtained from this form of wheat. The aim of this study was to investigate the effect of a sowing date (facultative *vs*. spring) on the quality of flour and bread coming from various spring wheat cultivars.
Material and methods. In a field experiment carried out in the years 2012–2014, the effect of late autumn sowing date of four spring wheat cultivars on the flour and bread qualities without and with spelt additions was investigated. The particular measurements included: flour extract (flour yield), the content of mineral compounds in the form of ash determined according to PN-ISO 2171, protein content in flour according to ICC 105/2, water absorption of flour using Infratec 1241 Grain Analyzer (FOSS), test baking method – simulating the process in production conditions.
Results. The average values for flour yield was 69.2–70.1%. The highest protein content in flour at both sowing times was obtained from the cultivar 'Bombona' – at 117.5 $g \cdot kg^{-1}$ DM for facultative, and 146.3 $g \cdot kg^{-1}$ DM for spring sowing. The volume of bread from the flour of 'Monsun' and 'Tybalt' sown in spring was about 30–50 cm^3 higher than from the flour from the facultative sowing time. The weight of the loaves, however, had the opposite tendency, because those from flour from autumn crops were about 5.0 g heavier.
Conclusion. Among the tested cultivars, 'Bombona', 'Monsun' and 'Ostka Smolicka' were characterized by significantly higher water absorption of flour. The facultative sowing date resulted in a significantly less protein content in flour. Autumn sowing was favored to achieve the best result of the bread weight, while the addition of spelt bran to wheat flour caused a reduction in the bread volume. The greatest taste was obtained by baking from flour of 'Bombona' sown in March.

Key words: bread quality, facultative wheat, flour quality, spelled additions

INTRODUCTION

Growing spring wheat as a facultative crop means that plantations can be sown in late autumn, which often happens due to organizational reasons after late emerging previous crops (sugar beet or corn for grain). Facultative wheat plants, like typical spring plants, need a period of less than two weeks at 4–6ºC for vernalization (Wenda-Piesik and Wasilewski, 2015). Spring wheat cultivars recommended for such sowing have greater frost resistance and better winter hardiness than typical spring wheat cultivars. This is

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related to the level of expression of COR/LEA II genes, the so-called dehydrogenase expression genes (Geneshan *et al*., 2008; Holkova *et al*., 2009). Laboratory and field tests carried out on wheat cultivars of Dutch, Polish and German origin ('Tybalt', 'Bombona', 'Ostka Smolicka' and 'Monsun') have shown that they are tolerant enough for cultivation in the late-autumn period in the countries of Central Europe (Wenda-Piesik *et al*., 2016). Spring wheat is a plant susceptible to drought, due to the poorly developed root system and low water utilization efficiency. Water deficit in wheat causes a reduction in the number of grains per ear, the mass of the kernel, the photosynthetic quotients, as well as a reduction in dough extensibility and bread volume (Grudkowska *et al*., 2003; Olszewski *et al*., 2009; Li *et al*., 2013). The literature cites numerous attributes of facultative crops, e.g. the big advantage of these crops is the question of avoiding the consequences of drought, which often affects plantations sown in spring (Sułek *et al*., 2017). Earlier start of growth in spring and better use of water accumulated over winter in the field result in better productive tillering, ear development, grain plumpness and, as a consequence, increased yield of wheat sown as a facultative crop compared with the spring sowing date. The reports are in this respect consistent with numerous studies conducted in Poland in the last decade, in various locations and on different cultivars (Grocholski *et al*., 2007; Kardasz *et al*., 2010; Wenda-Piesik *et al*., 2016; Sułek *et al*., 2017).

The sowing date is a key agricultural factor affecting the spring wheat grain quality. Podolska (2004) emphasizes that the mechanism of action of this factor is comprehensive through temperature, day length and intensity of light, which for wheat, which is a plant of the long day, affects the proper vegetative and generative growth. A delay in sowing of spring wheat causes a significant reduction in yield and an increase in protein content in the grain (Sułek, 2009). At the delayed sowing date, under thermal stress conditions, an increase in protein content in the grain was noted in all tested cultivars (Hakim *et al*., 2012).

The purpose of this study was to determine the effect of the sowing date on selected technological value indicators for flour of spring wheat cultivars.

The research hypothesis assumed differentiation within parameters of flour and bread quality depending on the sowing date and cultivar.

MATERIAL AND METHODS

Location and description of the experiment

The field experiment was established at the Research Station of the Faculty of Agriculture and Biotechnology at the UTP University of Sciences and Technology in Bydgoszcz. The station is located in Mochełek, the community of Sicienko (53º12' N; 18º01' E), the district of Bydgoszcz, in the Kuyavian-Pomeranian Voivodeship.

The study was conducted in the growing seasons 2012–2013 and 2013–2014.

The two-factor experiment was conducted in a randomized block design.

The following factors were adopted in the study:

1) sowing dates of wheat:
- late autumn (the so-called facultative), performed on 06.12.2012 and 19.11.2013,
- spring – on 18.03.2013 and 10.03.2014;

2) spring wheat cultivars: 'Ostka Smolicka', 'Monsun', 'Tybalt', 'Bombona'.

Soil and agricultural conditions

The experiment was carried out on the soil of the good rye complex, with soil quality class IVa. In both years, the previous crop for spring wheat was yellow lupine. The seedbed preparation for sowing the spring wheat form was carried out in accordance with the IUNG recommendations. Classic ploughing was applied, with pre-planting soil cultivation (cultivator + harrow). Sowing seeds was made with a Wintersteiger OYORD type plot seeder, with a row spacing of 12 cm.

The sowing density of each cultivar was equal and amounted to 550 grains per 1 m^2 in the case of a late-autumn sowing date and 400 grains per 1 m^2 at a spring date. Certified seed was sown with a germination capacity above 95% and purity above 98%. Before sowing the seed was treated with the seed dressing Baytan Uniwersal 094 FS (triadimenol + imazalil + fuberidazole) in a dose of 100 ml per 100 kg of seeds.

In autumn, during pre-sowing soil cultivation, 50 kg $P_2O_5 \cdot ha^{-1}$ and 80 kg $K_2O \cdot ha^{-1}$ was applied at a single rate. Nitrogen fertilization was given at three rates. The first of them, in the amount of 50 kg N·ha^{-1}, was sown in spring for the start of growth (BBCH 23), the second – 30 kg N·ha^{-1}, at the node 3 stage (BBCH 33), while the third – 30 kg N·ha^{-1}, at the stage of flag leaf sheath visibly swollen (BBCH 43).

In order to control weeds, a mixture of herbicides: Helmstar 75 WG (methyl tribenuron) 40 g·ha^{-1} + Apyros 75 WG (sulfosulfuron) 15 g·ha^{-1} with the adjuvant Atpolan 80 EC 1.5 dm^3·ha^{-1} was used. The application was made with a field sprayer at the BBCH 32 stage for a facultative date of wheat sowing and BBCH 27 for a spring sowing date.

In case of a disease, appropriate plant protection products were applied in accordance with the IOR recommendations. The intervention against powdery mildew and leaf spotting consisted of spraying plants in the T2 phase with Fandango 200 EC (prothioconazole + fluoxastrobin) in a dose of 1.2 dm^3·ha^{-1}. Magnesium sulphate (5% solution) was also used, in combination with urea 46% (10% solution), 3 days after the fungicide treatment.

Harvesting was carried out with a Wintersteiger plot combine harvester, at the stage of full grain maturity, during the last ten days of July for wheat from facultative sowing and 10 days later for wheat from spring sowing.

Determination of quality characteristics of flour

- flour extraction rate (flour yield);
- the content of mineral compounds in the form of ash was determined according to the standard PN-ISO 2171;
- protein content in flour acc. to ICC 105/2 [12];
- water absorption of flour using Infratec 1241 Grain Analyzer (FOSS). It is a near-infrared transmission spectrometer, capable of simultaneously and accurately identifying several features in whole grain samples and flour obtained from it;
- trial baking method – simulating the process in production conditions. The dough (400 g flour, 6 g table salt, 12 g baker's yeast and the appropriate amount of water which depends on the water absorption of a given flour sample) is formed as a result of kneading in a laboratory mixer for 15 minutes. After this time, they were placed three times in a fermentation chamber (30°C) for 30 minutes each time, stopping fermentation by kneading the dough. Also, after the second fermentation, two 300-gram pieces moistened with water were formed and placed in laboratory moulds for baking bread. After the dough had risen to the top edge of the mould, it was moistened again with water and put into the oven (230°C) for 30–35 minutes. The volume of baked bread was measured using a volumeter (Sa-wy apparatus), with the amount of millet grain displaced by the baked sample. The bread volume from 100 g of flour was calculated according to the formula:

$$\mathbf{X = (a \cdot b) : c}$$

where:

X – bread volume per 100 g of flour (volumetric yield),
a – bread volume in cm^3,
b – dough yield (weight of dough obtained from 100 g of flour),
c – weight of dough formed for baking in grams;

- assessment of the taste values of bread – carried out 6 hours after baking by a 10-person commission. Each person awarded points on a scale from 1 to 5 (1 – the weakest, 2 – less tasty, 3 – medium taste, 4 – good taste, 5 – very good taste), and the average results are given in Tables 3 and 5.

Statistical analysis of results

Data concerning all functional traits of wheat were analysed by the two-way analysis of variance in a randomized block design after previous verification of normality using the *W* Shapiro-Wilk test. Verifications of null hypotheses were based on the *F* test for $P < 0.05$. For proven effects of experimental factors in wheat traits, the differences between treatment-related means were tested using the *post-hoc* Tukey's HSD test at 0.05. Statistical analyses of data for biological and biotic characteristics of wheat were performed in the software Statistica 12.0, StatSoft Poland.

RESULTS

Characteristics of quality traits of spring common wheat flour

Analyses carried out prove that the yield of flour is affected only by the interaction of the sowing date and cultivar (Table 1). The highest flour yield was obtained in the cultivar 'Ostka Smolicka' sown in March – at the level of 70.9%, while the smallest yield was obtained by the cultivar 'Tybalt', also from spring sowing, i.e. 68.3%. Differences in the mean flour yield turned out to be small and oscillated within 69.2–70.1%.

The experiment proved that the ash content in the flour of the spring wheat form was statistically significantly affected only by the wheat cultivar (Table 2), while sowing dates were characterized by uniform ash content. For the cultivars 'Ostka Smolicka', 'Monsun' and 'Tybalt', the ash content oscillated around 0.7%, while 'Bombona' contained 0.8% of ash.

Statistical analysis showed that both the cultivar and the date of sowing have a significant influence on content protein in flour (Table 3). The cultivar 'Bombona' had the highest protein content in flour, this value was 117.5 $g \cdot kg^{-1}$ DM for facultative sowing and 146.3 $g \cdot kg^{-1}$ DM for spring sowing. The lowest protein content was observed in the cultivar 'Monsun', 102.0 and 120.5 $g \cdot kg^{-1}$ DM, respectively. The protein content in spring wheat sown in November was 109.3 $g \cdot kg^{-1}$, while spring wheat sown in March contained as much as 128.3 $g \cdot kg^{-1}$. The analysis shows that spring sowing contained 19 $g \cdot kg^{-1}$ (17%) more protein than autumn one.

The interaction between the sowing date and the cultivar had a significant impact on the water absorption of spring wheat flour (Table 4). The study has proven a greater water absorption in three cultivars: 'Bombona' – 60.9%, 'Monsun' – 60.7% and 'Ostka Smolicka' – 60.6%. 'Tybalt' was characterized by a much lower water absorption, both from autumn and spring sowing, and oscillated around 58.0%. The mean value of the examined trait in the experiment was 60.0% ± 0.28.

Table 1. Flour yield of spring wheat cultivars sown at two dates, %

Sowing date	Cultivar				Mean
	Ostka Smolicka	Monsun	Bombona	Tybalt	
Autumn	69.3 ± 0.39 ab[&]	69.0 ± 0.24 ab	69.6 ± 0.22 ab	70.1 ± 0.32 ab	69.5 ± 0.17
Spring	70.9 ± 0.12 a	69.6 ± 0.29 ab	70.0 ± 0.20 ab	68.3 ± 1.01 b	69.7 ± 0.34
Mean	70.1 ± 0.35	69.3 ± 0.21	69.8 ± 0.16	69.2 ± 0.60	**69.6 ± 0.19**

[&] uniform letters indicate the homogenous group according to the post hoc Tukey's HSD test, at $P < 0.05$
a, b .. for interaction cultivar × sowing date

Table 2. Ash content of spring wheat cultivars sown at two dates, %

Sowing date	Cultivar				Mean
	Ostka Smolicka	Monsun	Bombona	Tybalt	
Autumn	0.7 ± 0.02	0.7 ± 0.01	0.8 ± 0.03	0.7 ± 0.01	0.7 ± 0.01
Spring	0.7 ± 0.02	0.7 ± 0.01	0.8 ± 0.02	0.7 ± 0.01	0.7 ± 0.01
Mean	0.7 ± 0.01 B*	0.7 ± 0.01 B	0.8 ± 0.02 A	0.7 ± 0.01 B	**0.7 ± 0.01**

* uniform letters indicate the homogenous group according to the post hoc Tukey's HSD test, at $P < 0.05$
A, B ... for cultivars

Table 3. Protein content of flour of spring wheat cultivars sown at two dates, $g \cdot kg^{-1}$ DM

Sowing date	Cultivar				Mean
	Ostka Smolicka	Monsun	Bombona	Tybalt	
Autumn	110.5 ± 3.66 cd$^{\&}$	102.0 ± 1.47 e	117.5 ± 2.06 bc	107.0 ± 1.41 de	109.3 ± 1.79 Y
Spring	122.3 ± 1.25 b	120.5 ± 1.85 b	146.3 ± 2.75 a	124.0 ± 2.61 b	128.3 ± 2.88 X
Mean	116.4 ± 2.85 B*	111.3 ± 3.66 C	131.9 ± 5.66 A	115.5 ± 3.50 B	**118.8 ± 2.39**

*; $^{\&}$ uniform letters indicate the homogenous group according to the post hoc Tukey's HSD test, at $P < 0.05$
A, B ... for cultivars, X, Y for sowing date, a, b .. for interaction cultivar × sowing date

Table 4. Water absorption of flour of spring wheat cultivars sown at two dates, %

Sowing date	Cultivar				Mean
	Ostka Smolicka	Monsun	Bombona	Tybalt	
Autumn	62.0 ± 0.40 a$^{\&}$	61.2 ± 0.30 ab	60.6 ± 0.26 abc	58.5 ± 0.35 de	60.6 ± 0.36 X
Spring	59.3 ± 0.18 cd	60.1 ± 0.21 bc	61.2 ± 0.49 ab	57.5 ± 0.38 e	59.5 ± 0.38 Y
Mean	60.6 ± 0.54 A*	60.7 ± 0.27 A	60.9 ± 0.27 A	58.0 ± 0.31 B	**60.0 ± 0.28**

*; $^{\&}$ uniform letters indicate the homogenous group according to the post hoc Tukey's HSD test, at $P < 0.05$
A, B ... for cultivars, X, Y for sowing date, a, b .. for interaction cultivar × sowing date

Baking value of breads

The final product of the study of common wheat (*Triticum aestivum* L. *Emend. Fiori et Paol.*) was baked bread. The baking took place in a standard, single-phase technology.

Among the products from the spring sowing, the largest volume of bread was obtained from flour of 'Tybalt', on average 524.5 cm^3, the smallest bread was obtained from 'Monsun', on average 483 cm^3 (Table 5). Among products from the autumn sowing, the largest volume of bread was obtained from flour of 'Ostka Smolicka', on average 510 cm^3, and the smallest from 'Monsun', on average 445.5 cm^3. To sum up, the volume of bread from spring sowing was about 30-50 cm^3 higher than from the facultative sowing of these cultivars.

From spring sowing, bread obtained from 'Monsun' reached the highest weight – 266–267 g, while the lowest weight was obtained from 'Bombona' – 256-261g. From autumn sowing, the highest weight of bread was obtained from flour of 'Monsun' and 'Tybalt' – 271–272 g, while the lowest from flour of 'Bombona' – 262–266 g. This proves that despite the larger volume of bread from the spring sowing wheat flour, a higher weight the bread was obtained from the flour from autumn sowing. The difference in weight was on average 5.0 g (Table 5).

The bread made of flour from the cultivar 'Bombona' sown in March had the highest palatability and was the only one to be rated 4.0. The bread of the cultivar 'Monsun' of facultative sowing was slightly less rated – 3.5. The least tasty was the bread made of the flour obtained from 'Ostka Smolicka' from spring sowing, which was only rated 2.0 (Table 6).

The addition of spelt bran, in an amount of 10%, to wheat flour resulted in a reduction in the bread volume (Table 7). The bread made of flour originating from spring sowing was characterized by a larger volume than that made of flour originating from autumn sowing, and the differences oscillated within 20-50 cm^3, respectively, for 'Ostka Smolicka' and 'Tybalt' (Table 7).

The assessment of the taste values of bread with the addition of spelt bran showed that the bread obtained from the spring sowing wheat flour gained a better taste. The bread from 'Monsun' of spring sowing was rated as the best and scored 4.5 (Table 8).

The lowest rating of 3.0 was obtained by the bread made of 'Bombona' flour from autumn sowing. To sum up, the addition of spelt bran to flour increased the overall taste of bread. Breads made of 'Monsun', 'Tybalt' and 'Bombona' from spring sowing received much better scores than those from autumn sowing. Only 'Ostka Smolicka' was assessed in both cases at the same level 3.7 (Table 8). In the case of flour of 'Monsun' from autumn sowing, the quality of bread increased from a score of 2.5 to 4.5. This proves how much you can improve the value of the obtained bread by adding 10% spelt bran to flour.

Table. 5. Evaluation of the baking value of bread without the addition of bran

Cultivar	Parameter	
	bread volume, cm^3	weight of bread, g
Autumn sowing date		
Monsun	442–449$^{\$}$	271–272
Tybalt	471–473	271–272
Bombona	503–506	262–266
Ostka Smolicka	507–513	267–268
Spring sowing date		
Monsun	476–490	266–267
Tybalt	522–527	264–265
Bombona	487–498	256–261
Ostka Smolicka	490–495	262–266

$^{\$}$ min – max

Table. 6. Evaluation of taste values of bread without bran based on consumer research

Cultivar	Sowing date	
	autumn	spring
Monsun	3.5	2.5
Tybalt	3.0	3.0
Bombona	3.0	4.0
Ostka Smolicka	3.0	2.0

1 – the weakest, 2 – less tasty, 3 – medium taste, 4 – good, 5 – very good

Table 7. Evaluation of the baking value of bread with the 10% addition of bran

Cultivar	Parameter	
	bread volume, cm^3	weight of bread, g
Autumn sowing date		
Monsun	415–420$^{\$}$	268–274
Tybalt	431–437	271–275
Bombona	460–463	269–273
Ostka Smolicka	473–476	263–270
Spring sowing date		
Monsun	451–459	267–269
Tybalt	492–497	263–269
Bombona	483–489	263–266
Ostka Smolicka	484 - 486	264 - 265

$^{\$}$ min – max

Table. 8. Evaluation of taste values of bread with the 10% addition of bran based on consumer research

Cultivar	Sowing date	
	autumn	spring
Monsun	3.3	4.5
Tybalt	3.7	4.0
Bombona	3.0	4.0
Ostka Smolicka	3.7	3.7

1 – the weakest, 2 – less tasty, 3 – medium taste, 4 – good, 5 – very good

DISCUSSION

The most important baking characteristics include those included in the grain protein complex composition: protein content in grain, wet gluten content and Zeleny sedimentation value. Wheat grain intended for baking purposes should meet certain requirements in terms of protein content, i.e. not less than 11.5% DM (Stępniewska, 2015), have a wet gluten content of at least 25% and a sedimentation value of more than 30 cm^3 (Knapowski *et al.*, 2015a and b). The quality parameters of spring wheat grain from facultative sowing are generally worse than those of grain of the same cultivars from spring sowing. The autumn sowing date contributes to a lower content of total protein, including gluten proteins, and poorer sedimentation, while it promotes a higher bulk density and a higher falling number (Sułek *et al*., 2017; Wenda-Piesik *et al*., 2017).

In the conducted experiment, an average flour yield obtained was at 69.6%. In the study of other authors (Bac and Chrzanowska-Drożdż, 1999), who used different factors in their research, the value of the parameter examined oscillated between 60.3% and 68.3%. Sułek *et al*. (2002) in the experiment carried out with three cultivars of spring wheat obtained flour yield within the range from 56.0% to 70.1%, depending on the year of research and the cultivar. In the experiment by these authors, the value of the discussed parameter depended on varietal properties and the course of weather in the harvest years. In the present study, the flour yield was determined solely by the interaction of the sowing date and the cultivar.

The present study showed that the interaction between the cultivar and the sowing date had a significant influence on protein content in the flour. The protein content in spring wheat sown in autumn was 109.3 $g \cdot kg^{-1}$, while spring wheat sown in March contained as much as 128.3 $g \cdot kg^{-1}$ (Table 1). The analysis shows that spring sowing wheat contained by 19 $g \cdot kg^{-1}$ (17%) more protein than autumn one. The study by other authors (Sułek *et al*., 2017) confirms the thesis that grain from spring sowing had the most total protein.

In our study, the mean water absorption of flour, depending on the cultivar, ranged from 58.0% to 60.9%, and the mean value of this index in the experiment - 60.0%. The flour obtained from spring sowing showed a lower water absorption. The lowest value was obtained by the cultivar 'Ostka Smolicka' – 59.3%. Lower values of water absorption in the studied wheat flours were reported by Ellmann (2011). The influence of all the studied factors, i.e. the sowing date, the cultivar and their interaction, on water absorption of flour was statistically proven. Definitely higher values of this trait were obtained Sułek *et al.* (2002). These authors stated that regardless of the year of research, as well as varietal properties, the flour was characterized by quite high water absorption that was within the range 64.4–71.0%. Knapowski *et al.* (2015a), in turn, report that the value of this trait depended on the cultivar and was characterized by a level ranging from 57.3% to 64.7%. Water absorption, which informs not only about the water binding capacity of flour, but also about the possible yield of the dough obtained from it, allows for the conclusion that all tested wheats (Table 4) meet the standards of wheats belonging to the elite group in respect of this trait (Podolska and Sułek, 2003).

The assessment of the technological suitability of grain is a multi-characteristics rating. The baking value of flour characterizes its suitability for making bread with appropriate physical and organoleptic characteristics (Stępniewska and Słowik, 2016). The bread volume allows for a comprehensive assessment of the baking value, because it allows for the direct observation of the prepared dough and baking bread in laboratory conditions resembling the course of these processes during baking on an industrial scale. The mean volumes of bread obtained from the flours of studied wheat cultivars ranged from 420 cm^3 to 473 cm^3 for autumn sowing, and from 459 cm^3 to 484 cm^3 for the same cultivars for spring sowing (Table 2). This means that the larger volume of bread was obtained from flour from spring sowing cereals. Knapowski and Ralcewicz (2004) found a bread volume of 549 cm^3 for the wheat flour of the cultivar Mikon. Other authors, while baking breads from wheat flours, obtained in their experiments mean values of this index ranging from 367 to 520 cm^3 (Ralcewicz and Knapowski 2004, Knapowski *et al*., 2015a; Hassan *et al*., 2017). The wheat of the cultivar Tonacja in Szumiło *et al.* (2009) was characterized by a much smaller volume of bread obtained from 100 g of flour. The bakery product obtained during the test baking process was characterized by a volume of 348 cm^3.

CONCLUSIONS

1. Protein content in the flour obtained from the grain of spring wheat depended on the sowing date and cultivar and on the interaction of these factors. Spring wheat sown in the autumn period was characterized by a lower protein content in flour. The cultivar 'Bombona' was characterized by the highest value of this parameter.
2. Flour yield was within 69.2–70.1%. Only interaction of the sowing date with the cultivar had an impact on the value of this parameter.
3. Among the tested cultivars, 'Bombona', 'Monsun' and 'Ostka Smolicka' were characterized by a significantly higher water absorption of flour than 'Tybalt'.
4. The bread obtained from the flour of 'Monsun' and 'Tybalt' sown in spring was characterized by a higher mass, whereas the bread obtained from the flour of 'Bombona' and 'Ostka Smolicka' sown at an autumn date was characterized by a larger volume. The addition of spelt bran to common wheat flour caused a reduction in the bread volume.
5. The bread obtained from the flour of 'Bombona' sown in spring had the greatest palatability. The bread made of the flour of 'Ostka Smolicka', also from spring sowing, was the least tasty. The bread made of the flower of 'Monsun' from spring sowing was considered the most delicious baking made of wheat flour with the addition of spelt bran.
6. The analysis of qualitative parameters showed that in general, flour obtained from the grain of spring wheat cultivars sown in spring was characterized by a better technological value (protein content, water absorption of the flour) than from the autumn sowings.

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JAKOŚĆ MĄKI I CHLEBA Z JARYCH ODMIAN PSZENICY (*Triticum aestivum* L.) UPRAWIANYCH W PÓŹNOJESIENNYM I WIOSENNYM TERMINIE SIEWU

Streszczenie

W zintegrowanej produkcji pszenicy jej forma jara charakteryzuje się wyższą zawartością białka w ziarnie, która wpływa na większą wydajność glutenu mokrego. To z kolei może determinować większą wartość wypiekową mąki uzyskanej z tego zboża. Celem pracy było zbadanie wpływu terminu siewu na jakość mąki i chleba pochodzących z różnych odmian pszenicy jarej. Hipoteza badawcza zakładała zróżnicowanie w obrębie parametrów jakości mąki i wypieków w zależności od terminu siewu i odmiany. Doświadczenie polowe założono w Stacji Badawczej Wydziału Rolnictwa i Biotechnologii Uniwersytetu Technologiczno-Przyrodniczego w Bydgoszczy. Stacja położona jest w miejscowości Mochełek w gminie Sicienko (53º12’ N; 18º01’ E), w powiecie bydgoskim, w województwie kujawsko-pomorskim. Badania prowadzono w układzie losowanych bloków w sezonie wegetacyjnym 2012–2013 i 2013–2014. Czynnikami eksperymentu były 2 terminy siewu (późnojesienny – przewódkowy i wiosenny) oraz odmiany pszenicy jarej: Ostka Smolicka, Monsun, Tybalt, Bombona. W mące wymielonej z ziarna powyższych odmian oznaczono jej wydajność, zawartość popiołu i białka ogólnego oraz wodochłonność. Wykonano również próbny wypiek chlebów (symulowane warunki produkcyjne) bez dodatku otrąb orkiszowych i z 10% ich dodatkiem oraz określono objętość, ciężar i smakowitość pieczywa. Średnia wydajność mąki mieściła się w przedziale od 69,2% do 70,1%. Najwyższą zawartość białka, w obydwu terminach siewu, stwierdzono dla odmiany Bombona (117,5 $g \cdot kg^{-1}$ DM – siew późnojesienny, 146,3 $g \cdot kg^{-1}$ DM – siew wiosenny). Największą objętość pieczywa uzyskano z mąki wymielonej z ziarna odmian Monsun i Tybalt zasianych na wiosnę i była ona o około 30-50 cm^3 wyższa w porównaniu z objętością chleba wypieczonego z mąk wymielonych z ziarna z poźnojesiennego terminu siewu. Z kolei średni ciężar bochenka wypieczonego z mąki z jesiennych zbiorów ziarna był o 5,0 g większy. Wśród badanych odmian pszenic 'Bombona', 'Monsun' i 'Ostka Smolicka' charakteryzowały się istotnie wyższą wodochłonnością mąki w stosunku do odmiany Tybalt. Późnojesienny siew spowodował uzyskanie znacznie mniejszej zawartości białka w badanej mące, natomiast wykazano najwyższą wartość w stosunku do masy chleba. Dodatek otrębów orkiszowych w ilości 10% do mąki pszennej spowodowało zmniejszenie objętości chleba w obydwu terminach siewu. Z kolei najsmaczniejszy chleb wypieczono z mąki 'Bombony' wysianej w marcu.

Słowa kluczowe: dodatki orkiszowe, jakość chleba, jakość mąki, pszenica przewódkowa