The use of spelt wheat (*Triticum spelta* L.) for baking applications

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ABSTRACT

Five cultivars of spelt wheat (Rouquin, Bauländer Spelz, Schwabenkorn, Franckenkorn and Holstenkorn) have been evaluated for baking quality by means of direct and indirect indicators. Three-year values of the indirect indicators have been statistically processed by the analysis of variance. Based on the results obtained we can say that all evaluated indicators except the extensibility of gluten were significantly influenced mainly by the year of growing. The cultivar itself was a less important source of variance, although some values of important indicators differed significantly according to cultivars. Based on indirect indicators such as the content of wet gluten, its extensibility and swelling, the content of N-substances, the sedimentation test in the modification with SDS, the falling number and the content of starch, the cultivars Schwabenkorn and Rouquin are considered as the most suitable and of the highest quality. In general all the cultivars of *Triticum spelta* L. showed high contents of N-substances ($\bar{x}$ = 15.46%) and wet gluten contents ($\bar{x}$ = 37.12%). Their disadvantages are lower swelling values ($\bar{x}$ = 9.3 ml) and lower sedimentation values ($\bar{x}$ = 37.4 ml) which have a negative influence on the bread volume and the specific volume (under 310 ml.100 g^{-1}). The predicted good baking quality of Schwabenkorn has been comfirmed in a baking experiment (direct method of evaluating the baking quality). There were good baking quality results for Bauländer Spelz as well. Unexpectedly bad results have been found with Rouquin, which showed the lowest water absorbing capacity of flour, the lowest bread volume, specific volume and baking extraction. The bread was just acceptable as far as taste is concerned. The baking from Holstenkorn was evaluated as excellent.

Keywords: spelt wheat (*Triticum spelta* L.); technological quality; baking quality

Spelt wheat (*Triticum spelta* L.) is a chaffy wheat which is an alternative culture with undemanding growing requirements. It shows a very good adaptability (Laghetti et al. 1999), and at higher elevations it can yield better than *Triticum aestivum* L. (Ruegger and Winzeler 1993). According to Háp (1995) spelt wheat belongs to the ecological crops and it is advisable to grow it in water protected areas. Even with low fertilizing spelt wheat gives a good harvest and has a better minerals uptake in comparison with *Triticum aestivum* L. (Moudrý and Dvořáček 1999).

In prehistorical times spelta was grown mainly in the Near East. Currently it is more grown in the European countries. The widest spread of spelt wheat as agricultural crops is traditionally found in southwestern Germany and in Switzerland. It is used for food products such as pasta products, muesli and flakes.

The nutritive value of spelt wheat is high and it contains all the basic components which are necessary for human beings such as saccharides, proteins, lipids, vitamines and minerals (Bognar and Kellermann 1993, Michalová et al. 2000). Bognar and Kellermann (1993) and Abdel et al. (1995) determined, however, that protein, fiber, vitamin and the mineral composition of spelt flours (grains) were similar to those of common wheat flours. Spelt wheat is reported to have a higher protein content too: thanks to the higher portion of aleuron layer *Triticum spelta* L. contains more proteins (16–17%) than *Triticum aestivum* L. There are no important differences in the aminoacid composition (Smolková et al. 2000), this means that products from spelt wheat as well as *Triticum aestivum* L. are not suitable for people with celiac disease (Kasarda and D'Olivio 1999).

The use of *Triticum spelta* L. in bread production is possible: bread with the addition of spelt flour is characterised by a strong bread smell, big volume, excellent taste and it stays longer fresh and soft (Michalová et al. 2000). Abdel et al. (1997) made bread from spelt flour only, but such bread had worse volume, texture and crumb colour in comparison to bread made from hard red spring wheat. The sensory aspect of such bread was evaluated as average.

Bonafacia et al. (2000) reports that bread (or dough) made from spelt flour has a different saccharide and protein complex (more rapidly digested starch, less rapidly digested proteins) in comparison to bread made from wheat flour (*Triticum aestivum* L.). Dough made from spelt wheat flours is characterised by lower stability and elasticity and higher extensibility and dissolubility.

From the point of view of the baking quality, the content of proteins and wet gluten are important indicators. The content of gluten is higher in *Triticum spelta* L. in comparison to *Triticum aestivum* L. (Moudrý and Vlasák 1996, Stehno et al. 1998 and others) but gluten is more dispersed with less flexibility. Abdel et al. (1998) suggest to use spelt flour for making two-layer flat breads. Spelt flour is most often used in a mixture with wheat flour.

MATERIAL AND METHODS

In the framework of the research VEGA 1/6124 during the years 1998–2000 we analysed selected indicators for the milling and baking quality of five cultivars of *Triticum spelta* L. – Rouquin, Bauländer Spelz, Schwaben-

korn, Franckenkorn and Holstenkorn grown in an ecological system of the locality Dolna Malanta near Nitra. In this article we present the indicators of the baking quality of the cultivars evaluated in three-years study.

The samples were dehulled and the hull-free grains analysed. We determined the moisture in crushed grains and – as indirect indicators for the baking quality – the wet gluten content (Go), the extensibility of gluten (To), the swelling of gluten (Qo), the content of N-substances (%N × 5.7), the sedimentation test in modification with sodium dodecyl sulphate (SDS), the falling number, the starch content and the ash content.

For the baking experiment the dehulled grains were milled in the mill (M3), a combination of a disc and roll mill which is milling and separating in one working process. During milling three fractions were separated:

– crude (rough) bran, which remains on a sieve with meshes of 475 µm; was not used in further processing
– soft bran, which formed siftings in case of a sieve with meshes of 475 µm and remains on a sieve with meshes of 275 µm (we used it as a mixture with wheat flour in another baking experiment)
– flour (medium – ground), which formed siftings with meshes of 275 µm; we used this flour in a baking experiment for preparing loaves according to methods applied in our department

From flour (under 275 µm) obtained by milling dehulled grains of five cultivars of spelt wheat in 2000, we prepared dough (100 g spelt flour + additives = two pieces of dough) which we kneaded for 5 minutes, it swelled for 30 minutes and baked it for 15 minutes in a bread oven.

The baked loaves were evaluated by means of subjective and objective criteria: water-absorbing capacity (%), bread volume (ml), cambering (height/width ratio), specific volume (ml.100 g^{-1} of loaf), bulk productivity (ml.100 g^{-1} of flour), baking extraction (%), baking loss (%), crust colour (pale chestnut, chestnut, dark chestnut) crumb porosity (according to Dallmann 1981), crumb colour and crumb flexibility, smell, taste and complex evaluation.

RESULTS AND DISCUSSION

The results of the three-year research on crushed spelt grains are given in Table 1. These were statistically evaluated by an analysis of variance followed by an *LSD* test (low significant differences). The average values for the observed indicators in different *Triticum spelta* L. cultivars during three years as well as the average values for the observed indicators in specific years (Table 2) are given.

For evaluating the baking quality of spelt wheat, we relied on our experience with evaluating wheat for human consumption.

The amount of wet gluten as an indicator is closely connected with the baking quality of bread grain. For food wheat the demand is minimum 25% of gluten. The gluten content of the spelt wheat samples ranged from 30.6% to 51.8%. Statistically this amount was significantly influenced by the year of growing, it means, in fact, by the climatic conditions. In the year 2000, which was extremely dry, the gluten content in our samples was aver-

Table 1. The indicators of a baking quality of spelt wheat (*Triticum spelta* L.)

Year	Cultivar	Moisture	Gluten			N-substances	Seditest SDS	Falling number	Starch content	Ash content
		(%)	Go (%)	To (cm)	Qo (ml)	N.5.7 (%)	(ml)	(s)	(%)	(%)
1998	Rouquin	9.48	30.9	12	11	12.97	32	295	66.5	1.88
	Bauländer Spelz	9.11	30.8	10	13	12.49	33	295	67.4	1.83
	Schwabenkorn	9.04	34.1	15	11	12.96	33	299	66.7	1.79
	Franckenkorn	9.1	36.3	19	9	13.74	34	304	66.8	1.89
	Holstenkorn	9.05	30.8	16	7	13.6	32	279	61.6	1.95
	average	9.16	32.6	14.4	10.2	13.15	33	294	65.8	1.87
1999	Rouquin	9.7	32.97	14	12	14.72	38	349	58.79	2.14
	Bauländer Spelz	9.1	30.6	16	10	14.55	36	338	59.37	2.36
	Schwabenkorn	9.1	34.07	15	12	14.39	40	327	62.07	2.18
	Franckenkorn	8.95	30.59	18	10	12.85	31	381	49.03	2.21
	Holstenkorn	9.35	30.71	16.5	10	13.92	32	374	59.91	2.2
	average	9.24	31.78	15.9	10.8	14.09	35.4	353.8	57.83	2.22
2000	Rouquin	9.5	48.32	18	7	19.33	46	294	46.07	2.21
	Bauländer Spelz	8.2	47.12	13	4	19.43	43	288	48.33	2.11
	Schwabenkorn	8.3	51.8	17	8	19.48	46	286	48.29	2.17
	Franckenkorn	8.8	42.88	18	7	18.98	43	331	49.69	2.31
	Holstenkorn	8.6	45	16	8	18.57	42	319	57.45	2.23
	average	8.68	47.02	16.4	6.8	19.16	44	303.6	49.97	2.21

Go – wet gluten content, To – extensibility of gluten, Qo – swelling of gluten

Table 2. The average values of the indicators of a baking quality of spelt wheat *(Triticum spelta* L.)

		Moisture	Gluten			N-substances	Seditest SDS	Falling number	Starch content	Ash content
		(%)	Go (%)	To (cm)	Qo (ml)	N.5.7 (%)	(ml)	(s)	(%)	(%)
Cultivar	Rouquin	9.56	37.39	14.66	10.00	15.67	38.66	312.33	57.12	2.07
	Bauländer spelt	8.80	36.17	13.00	9.00	15.49	37.33	307.00	58.36	2.10
	Schwabenkorn	8.81	39.99	15.66	10.33	15.61	39.66	340.00	59.02	2.04
	Franckenkorn	8.95	36.59	18.33	8.66	15.19	36.00	338.66	55.17	2.13
	Holstenkorn	9.00	35.50	16.16	8.33	15.36	35.33	324.00	59.65	2.12
	average	9.02	37.13	15.56	9.26	15.46	37.40	317.20	57.86	2.09
	1998	9.16	32.58	14.40	10.20	13.15	32.80	294.40	65.80	1.87
	1999	9.24	31.78	15.90	10.80	14.08	35.40	353.80	57.83	2.22
Year	2000	8.68	47.02	16.40	6.80	19.15	44.00	303.60	49.96	2.21
	average	9.03	37.13	15.68	9.27	15.46	37.40	317.27	57.86	2.10

Go – wet gluten content, To – extensibility of gluten, Qo – swelling of gluten

aging 47%. The cultivar was not an important source of variability although there were significant differences in the gluten content among the evaluated cultivars. The highest gluten content was in Schwabenkorn (40%), the cultivar Holstenkorn had a significantly lower gluten content (35.5%).

The extensibility of wet gluten was not influenced by the seasonal conditions. Our tests showed significant differences among some evaluated cultivars. The highest extensibility was found in Franckenkorn (18.3 cm), the lowest one in Bauländer Spelz (13 cm). For baking purposes the wheat with middle extensibility is the best. Gluten with an extensibility of more than 15 cm is more difficult to process, the dough is sticky (Háp 1995), and is mainly suitable for biscuits with a potential application in for example two-layer flat breads (Abdel et al. 1998).

The quality of bread wheat gluten depends on its swelling. For very good wheat this value should be more than 13 ml. In samples of spelt wheat the swelling varied between 4 and 13 ml (the average value in three years was 9.3 ml). In 2000 the average value was 6.8 ml (which is lower than the requirement for baking quality) although the amount of gluten was extremely high. Because of the low swelling ability of gluten spelt wheat would be more suitable for pasta production. There were no significant differences in the swelling of gluten among the evaluated cultivars, only the cultivars Schwabenkorn and Rouquin had a swelling of more than 10 ml on average over the three years, which was confirmed by a baking experiment. The swelling of gluten as an indicator in case of spelt wheat did not correlate positively with the sedimentation test (SDS) values although such a correlation existed for common wheat (Bojňanská 1995). Zanetti et al. (1998) found out the correlation between Zeleny values and the quality and quantity of gluten in spelt wheat.

The sedimentation test is an important and quick indicator, which can be determined with different modifications. The sedimentation test values in a modification with sodium dodecyl sulphate (SDS) according to the Slovak technical norms 46 1100-2 for food wheat should be minimum 45 ml for bread-making wheat marked by letter B. In the evaluated samples of spelt wheat the SDS test values varied between 31 and 46 ml. Significantly high values were recorded in the dry year of 2000 (x = 44 ml) although the values did not reach the level of good quality bread wheat (*Triticum aestivum* L.). Statistically the amount of wet gluten and the SDS values were significantly higher in Schwabenkorn in comparison to Holstenkorn. The content of N-substances was significantly influenced by the year of growing. The cultivar influence was not significant (Table 5). The N-substances content was positively correlated to SDS values ($r = +0.940^{++}$) and the wet gluten content ($r = +0.944^{++}$) and negatively correlated to the swelling of gluten ($r = -0.742^{++}$) and the starch content ($r = -0.777^{++}$). There was a high N-substances content in the climatically exceptional year 2000 (x = 19.16%) in comparison to the years 1998 and 1999. According to some authors the high N-substances content in spelt wheat is not exceptional. Marconi et al. (1999) reports about 17.7%, Moudrý (1996) even 18.2%, Háp (1995) between 12.7 and 19.0%.

The falling number, which is the indicator of the enzymatic activity, was influenced mainly by the year of growing. The highest values of the falling number were found in 1999, which means that the enzymatic activity of *Triticum spelta* L. was the lowest in that year. In the other evaluated years the falling number values did not decrease under the requested value (that means that the enzymatic activity was not high). Similar data are reported by Háp (1995). Based on this it can be said that the enzymatic activity of the evaluated spelt wheat was satisfactory although values above 300s are considered as too high. A shortage of activity can be solved technologically by adding amylolytic enzymes. Certain statistically significant differences were confirmed among the cultivars (Table 5). From all evaluated samples, the cultivar Franckenkorn had the lowest enzymatic activity. The product made from it had a low bread volume but a very good height/width – cambering effect (above 0.7).

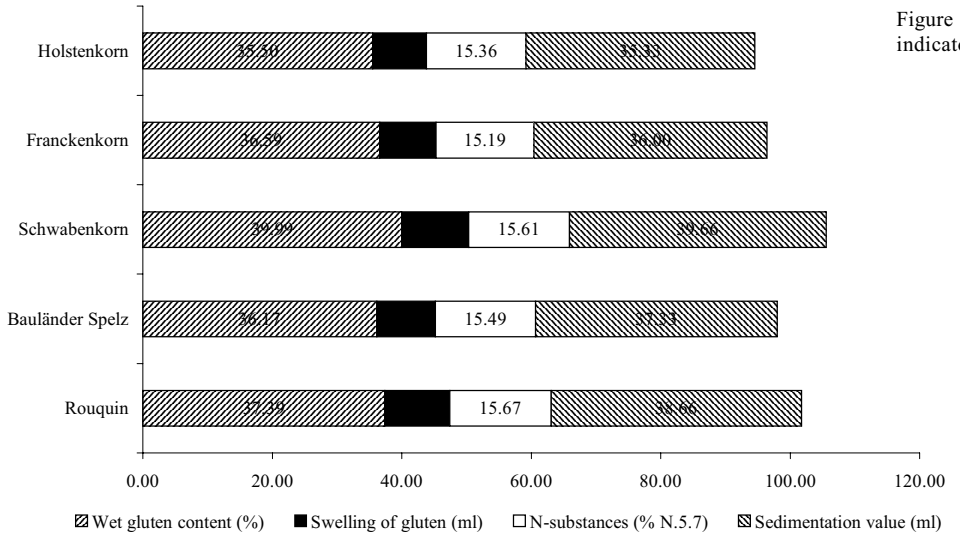

Figure 1. Total evaluation based on four indicators of the baking quality

The content of starch was statistically influenced to a great extent by the year of growing. The highest starch content was found in 1998 (65.8%), the lowest in 2000 (49.9%) – a difference of nearly 16%. There were no significant differences in the starch content among the cultivars.

The content of ash reached significantly lower values in 1998 in comparison to the two other years (Tables 1 and 2).

The complex evaluation based on four indicators of the baking quality (gluten content, swelling of gluten, N-substance content and the values of the sedimentation test) is shown in Figure 1. We predicted that the cultivar Schwabenkorn offers wheat of the best quality from the baking point of view, then Rouquin and Holstenkorn being the worst. Lacko-Bartošová et al. (2000) determined the Glu-score (in direct correlation with the bread-making quality) in a collection of 33 spelt wheat cultivars and found out that the higher values for the Glu-score (food quality wheat) are also found in Bauländer Spelz, Franckenkorn, Holstenkorn, and Rouquin.

Based on a baking experiment (Tables 3 and 4) we can claim that there were considerable differences among the evaluated cultivars of *Triticum spelta* L., mainly as far as objective indicators are concerned (Figure 2). The water-absorbing capacity of flour varied between 53 and 64.4%. The highest value was found for Schwabenkorn. For Schwabenkorn we measured the highest weight of loaves after baking, the highest baking extraction of loaves, but also the highest baking loss. The loaf volume (bread volume) and its specific volume or specific weight or bulk productivity (the volume of bread from 100 g of flour) are very important indicators for the bread-making quality. Loaves made from Schwabenkorn and Bauländer Spelz had the highest volume, loaves from Rouquin the lowest although the indirect parameters for the bread-making quality (Figure 1) were favourable for Rouquin. The value for the specific volume for 100 g bread should be as high as possible. Lower values than 210 ml for 100 g are considered as unsatisfactory and to this category belonged the loaves made from Rouquin (199.2 ml.100 g^{-1}). Loaves made from all other cultivars of spelt wheat had a low specific volume (from 211 to 310 ml.100 g^{-1}). The highest specific volume had loaves made from the cultivars Bauländer Spelz and Schwabenkorn (Table 3).

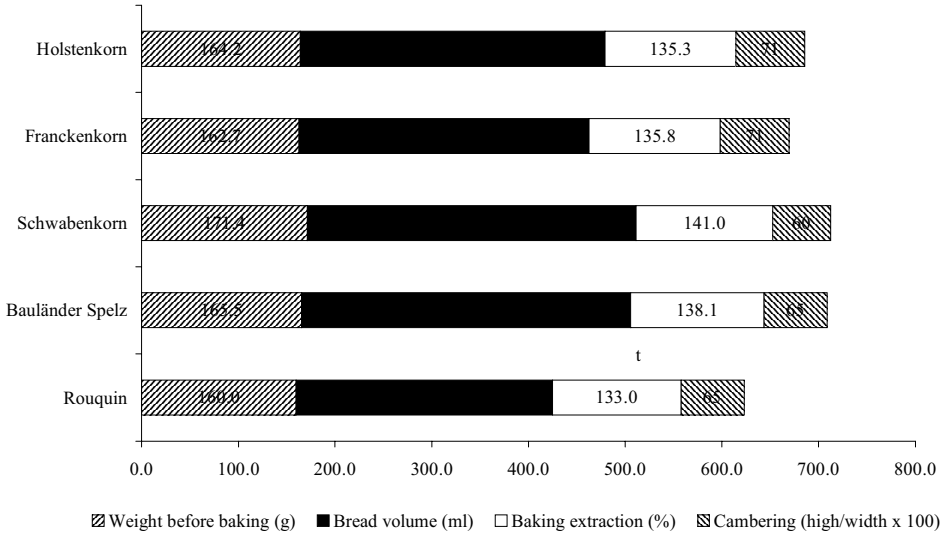

Figure 2. The evaluation of the baking quality

Table 3. The results of a baking experiment (five cultivars of spelt wheat)

Cultivar	Before baking weight (g)	After baking weight (g)	Bread volume (ml)	Specific volume (ml/100 g)	Cambering heigh/width	Baking extraction (%)	Baking loss (%)
Rouquin	160.0	133.0	265	199.2	0.65	133.0	16.9
Bauländer Spelz	165.5	138.1	340	246.2	0.65	138.1	16.6
Schwabenkorn	171.4	141.0	340	241.1	0.60	141.0	17.7
Franckenkorn	162.7	135.8	300	220.9	0.71	135.8	16.5
Holstenkorn	164.2	135.3	315	232.8	0.71	135.3	17.6
Average	164.8	136.6	312	228.0	0.66	136.6	17.1

Table 4. Sensoric evaluation of a baking experiment (five cultivars of spelt wheat)

Cultivar	Crust colour	Crumb porousness	Crumb colour	Crumb flexibility	Appearance	Smell	Taste	Complex evaluated
Rouquin	chestnut	good	creamy	good	very good	pleasant	satisfactory	satisfactory
Bauländer Spelz	chestnut	good	creamy	good	very good	pleasant	good	good
Schwabenkorn	chestnut	good	creamy	good	very good	pleasant	good	good
Franckenkorn	chestnut	good	creamy	good	very good	pleasant	satisfactory	satisfactory
Holstenkorn	chestnut	good	creamy	good	very good	pleasant	excellent	excellent

These values are lower in comparison with the volume of loaves made from *Triticum aestivum* L. cultivars during long-term experiments in our department. For example, for the cultivar Ilona with a high protein content (13.8%) and gluten content (36%) and with good swelling (19 ml), Muchová (1992) found a bread volume of 345 ml. For the cultivar Hana the bread volume was 320 ml. For the other tested cultivars (Vlada, Jubilejna, Kosutka), the value of bread volume amounted to 350 ml (Muchová 2001).

In our experiment, the volume of efficiency is equal to the baking extraction and this varies in a scale between 133 and 141% (the highest value had Schwabenkorn, the lowest Rouquin). In relation to the height/width ratio (cambering) of the loaf however, we found the lowest value for Schwabenkorn. This means that this cultivar with a big volume had loaves with a weakly cambered form. A very good height/width ratio was found for Franckenkorn and Holstenkorn, and a good ratio for Rouquin and Bauländer Spelz.

No considerable differences were found during the sensory evaluation of the baked loaves (Table 4). The acceptability of spelt breads in the sensory test was good and the loaves made from Holstenkorn, Schwabenkorn

Table 5. Analysis of the variance of the technological quality indicators

Indicator	Gluten			N-substances	Seditest SDS	Falling number	Starch content	Ash content
	Go (%)	To (cm)	Qo (ml)	N.5.7 (%)	(ml)	(s)	(%)	(%)
Year	++	–	+	++	++	++	++	++
Cultivar	–	–	–	–	–	–	–	–
1998	–b	–	–b	–b	–b	a–	a	ab
1999	a–	–	a–	a–	a–	ab	a	a–
2000	ab	–	ab	ab	ab	–b	a	–b
Rouquin	–	a–	–	–	–	––	–	–
Bauländer Spelz	–	–b	–	–	–	a–	–	–
Schwabenkorn	a	––	–	–	a	–b	–	–
Franckenkorn	–	ab	–	–	–	ab	–	–
Holstenkorn	a	––	–	–	a	––	–	–

Go – wet gluten content, To – extensibility of gluten, Qo – swelling of gluten
++ highly significant, + significant, – not significant
Differences between mean values designated with the same letters are significant

and Bauländer Spelz were evaluated as the best ones according to the taste evaluation.

Capouchová (1996) states that – for the technological treatment – flour from spelt wheat requires in comparison with flours from common wheat the addition of ascorbic acid because of the strength of the gluten structure and the reduction of the dough extensibility. Abdel et al. (1997) found out that with the addition of only 15 ppm of bromate to the spelt wheat resulted in breads with loaf volumes similar to those of common wheat breads.

CONCLUSION

A three-year research based on the evaluation of direct and indirect indicators of the baking quality of five *Triticum spelta* L. cultivars showed the following results:

Our research proved that the selected indicators were significantly influenced by the year of growing (except for the extensibility of gluten). The cultivar itself was a less important source of variance although statistically some important indicators differed significantly according to cultivar.

Based on the indirect indicators we consider the cultivars Schwabenkorn and Rouquin as the most suitable and of the best quality from the baking point of view. In general, all cultivars had high contents of N-substances (x = 15.46%) and wet gluten (x = 37.12%). They had lower swelling of gluten (x = 9.3 ml) and lower SDS sedimentation values (x = 37.4 ml).

In a baking experiment (direct method of evaluating the baking quality), a correlation was found between the swelling of gluten and the bread volume. The bread volume and the specific volume were low (under 310 ml.100 g^{-1}).

The predicted good baking quality of Schwabenkorn (based on indirect indicators) has been confirmed. There were also good results with relation to the bread-making quality for Bauländer Spelz. Unexpectedly bad results have been found with Rouquin, which showed the lowest water absorbing capacity of flour, the lowest bread volume, specific volume, and baking extraction. Moreover, the bread was just acceptable as far as taste is concerned. The baking from Holstenkorn was evaluated as having an excellent taste with a very good cambering as well.

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ABSTRAKT

Možnosti využití pšenice špaldy (*Triticum spelta* L.) pro pekařské účely

Pět odrůd pšenice špalda (Rouquin, Bauländer Spelz, Schwabenkorn, Frackenkorn a Holstenkorn) bylo hodnoceno pomocí přímých a nepřímých znaků pekařské jakosti. Ze statistického hodnocení tříletých výsledků metodou analýzy rozptylu u nepřímých znaků vyplynulo, že je průkazně ovlivňoval především ročník pěstování (s výjimkou tažnosti lepku). Méně významným zdrojem proměnlivosti byla odrůda, avšak mezi některými odrůdami byly nalezeny statisticky průkazné rozdíly důležitých ukazatelů. Na základě nepřímých ukazatelů (obsah mokrého lepku, tažnost a bobtnavost lepku, obsah dusíkatých látek, sedimentační test v modifikaci SDS, číslo poklesu, obsah škrobu) jsou za nejkvalitnější považovány odrůdy Schwabenkorn a Rouquin. Všeobecně se však všechny odrůdy *Triticum spelta* L. vyznačovaly vysokým obsahem N-látek ($\bar{x}$ = 15,46 %) a mokrého lepku ($\bar{x}$ = 37,12 %). Nevýhodou však byla menší bobtnavost lepku ($\bar{x}$ = 9,3 ml) a nižší hodnota sedimentačního SDS testu ($\bar{x}$ = 37,4 ml), což při následném hodnocení potvrdil i pekařský pokus, neboť objem pečiva, resp. měrný objem byl nízký (pod 310 ml.100 g^{-1}). Při hodnocení pekařského pokusu (přímá metoda stanovení pekařské kvality) byla potvrzena predikovaná pekařská kvalita u odrůdy Schwabenkorn a dobré výsledky byly získány i u odrůdy Bauländer Spelz. Neočekávaně špatné výsledky byly zjištěny u odrůdy Rouquin, která měla nejnižší vaznost mouky, objem pečiva, měrný objem i výtěžnost pečiva a rovněž chuťové charakteristiky byly pouze uspokojivé. Chuťově nejvýraznější pečivo, hodnocené jako výborné, poskytovala odrůda Holstenkorn.

Klíčová slova: pšenice špalda (*Triticum spelta* L.); technologická kvalita; pekařská kvalita

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