Image Data of Crumb Structure of Bread from Flour of Czech Spring Wheat Cultivars

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Abstract

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Baking quality of flour from six wheat cultivars (harvest 2002 and 2003), belonging to the quality classes A and B, was evaluated using the fermented dough test. Analytical traits of kernel and flour showed differences between the classes which were confirmed by the baking test with the full-bread-formula according to Czech method. In addition to standard methods of the bread parameters description (specific bread volume and bread shape measurements) rheological measurements of penetrometer and image analysis were used in effort to differentiate wheat samples into the quality classes. The results of the baking test proved significant differences in specific bread volumes – the highest volume in class A was obtained with the cultivar Vinjet and in class B with SG-S1098 – approx. 410 and 420 ml/100 g. Although significant correlations among image analysis data and specific bread volume having been proved, any image analysis parameter did not distinguish the quality classes. Only the penetronetric measurements made with bread crumb were suitable for such purpose (r = 0.9083; for α = 0.01). Among image analysis data the total cell area of the crumb had the strongest correlation with specific bread volume (r = 0.7840; for α = 0.01).

Keywords: wheat cultivar; baking test; penetration; image analysis

The three-dimensional structure and appearance of a bakery product influences its textural and sensorial properties. The textural structure of bread is created by microscopic and macroscopic components. Interactions and steric hindrances of macromolecules govern the structure at the molecular level. Molecules with higher molecular weights such as proteins and starch granules determine the structure at the microscopic level. The macroscopic level depends on the size and shape of isolated components. The final appearance of the crumb produced as the overall texture is determined by the three-dimensional network formed by individual components (Crowley *et al*. 2000).

Bread grain is defined as visually perceived traits dealing with the size, shape, uniformity, and wall thickness of crumb cells (Rogers *et al*. 1995). These visual characteristics of crumb are elements of the quality of the final product. The sensorial description of a bakery product includes also mouthfeel and mechanical properties of bread crumb. The evaluation of these characteristics is possible by means of a panel (of 6 to 10 persons) trained in sensorial analysis. The bakery product assessment by a trained staff has subjective nature of scoring, and so differences between two scorings by the same expert over a period of days or months can be extreme (Rogers *et al*. 1995; Crowley *et al*. 2000). Nowadays, the method of image analysis is widely used for a detailed evaluation of crumb grain traits in different types of bakery products.

Image analysis is suitable to quantify crumb porosity and enables an objective assessment of the bread cut image texture. The amount and properties of gluten proteins, especially glutenin, govern the baking quality of flour. Relations between bread quality characteristics and HMW glutenin subunits were investigated by Magdic *et al*. (2002). Image analysis was used for the distinguishing of laboratory baked bread of wheat varieties and significant correlations were found between bread image traits vs. HMW glutenin subunits, and between wheat grain traits vs. bread characteristics. Bread brands differentiation was accomplished by Zayas (1993) and categorisation to the correct bread brand was reached for more than 95% of samples. Image analysis serves also for the study of the emulsifiers effect. DATEM and SSL were studied by Crowley *et al*. (2000), lecithin, phosphatidylcholine and sucrose esters by Bertrand *et al*. (1992). The mixing time also affects the bread crumb texture (Crowley *et al*. 2000).

Some further applications of image analysis in North America in the cereal area included discrimination between wheat and nonwheat components in grain, the direct quantification of technologically relevant bread crumb features, the discrimination between milling fractions of hard and soft wheats. European research activities included the development of a crumb grain score table, the extraction of bread crumb features from video images, and the description of the crumb structure of bakery goods (Crowley *et al*. 2000). For the image analysis application, both technical equipment (scanner, camera or video and personal computer) and a proper software are necessary. In the Institute of Chemical Technology in Prague, the commercial program Lucia G/Comet is commonly used, but for special occasions it is not sufficient – so it is possible to create own software for image analysis by a modification of threshold algorithm (Sapirstein *et al*. 1994), or to use Haar (Bertrand *et al*. 1992), eventually Fourier transformation (Rogers *et al*. 1995) for the assessment of the data measured.

Bakery products have a characteristic shape and definite texture that is accepted by the consumers. Any significant deviation from the optimal texture characteristics of the product can be considered as a reduction in the quality. Texture has a significant influence on the consumer's perception of a good bread quality. The most important attributes of bread include hardness and springiness, and further parameters such as chewiness, gumminess and cohesiveness can be taken into account as well. Hardness is defined as the force required for biting bread samples, springiness is the degree to which the sample returns to its original thickness after compression. Cohesiveness is a characteristic of mastication, gumminess depends on hardness and cohesiveness; chewiness depends on gumminess and springiness. For the consumer, gumminess presents the density that persists throughout chewing; chewiness describes how long it takes to chew a sample of bread to the consistency suitable for swallowing (Meterei *et al*. 2004). Bread crumb hardness was studied extensively by means of various instruments such as texturometers, precision penetrometers, Instron tensile testing machine, Voland-Stevens texture analyser, baker compressimeter and other special-purpose texture analysers (Meterei *et al*. 2004).

The aim of this work was to evaluate the baking quality of six Czech spring wheat varieties from quality classes A and B by mean of image analysis method. The samples of wheat came from the harvest of 2002 and of 2003. The flour quality was investigated by means of fermented dough, and the results served to compare penetration and image analysis traits related to the baking test results, especially to specific bread volume.

MATERIALS AND METHODS

Six Czech spring wheat varieties, namely Saxana (1), Aranka (2), Vinjet (3), Leguan (4), Zuzana (5) and SG-S1098 (6), from the harvest of 2002 and of 2003 were used for this work. The first three varieties belong to the quality class A, the others to the class B according to Czech grading system.

Variety flours were prepared by Czech standard milling test (protocol Chopin) at CD1AutoMill (Chopin, France).

The basic kernel and flour quality was determined according to the Czech standard methods – ČSN 55 0512 for ash, wet gluten and protein content, ČSN ISO 3039 for Falling Number and ČSN ISO 5529 for Zeleny sedimentation test. Bulk density was assessed according to ČSN 46 1011-5, test weight in compliance with the internal method of the Institute of Chemical Technology in Prague, and hardness by using Inframatic 8620 (Perten Instr., Sweden).

The baking test was performed according to the Czech method and the formula used was: flour – 100%, compressed yeast – 4.0%, sugar – 1.5%, fat – 1.0%, salt – 1.7%, and water to optimal dough consistency (600 ± 20 FU). The dough from 300 g of flour was prepared in farinograph (Brabender, Germany) under standard conditions. Optimally kneeded dough was allowed to leaven in thermostat for 50 min. Splitting and moulding of the dough was made by hand. After standard leavening (45 min), the dough pieces were baked at 240°C for 14 min. The bread form and volume were measured after two hours of cooling under laboratory conditions; the bread volume was determined by the seed displacement method using rapeseeds. The penetration measurements were performed after the evaluation of the bread characteristics (specific volume and shape of bread). Crumb samples (height 35 mm and diameter 30 mm) were cut out of the bread center and the mean value of penetration was calculated from 5 measurements at Penetrometer PNR 10 (Petrotest Instruments, Germany). Metal hemisphere (30 mm in diameter) was used for the penetration determination, that was expessed as depth of deformation in milimeters.

For image analysis, negative copies of bread samples were made in a darkroom with the help of xerox Canon iR1210 under the lowest contrast possible. Photos were scanned at blank white paper A4 size as pictures of 2 halves of the same bread sample approx. 1 cm thick. Image analysis was practised by using Lucia G/Comet V3.52a (Laboratory Imaging, Czech Republic) on a personal computer with the processor Pentium® (150 MHz, 32 MB RAM). The data measured were exported to Microsoft Excel V7.0 and statistically evaluated. Also correlation analysis between the baking test, penetration, and image analysis characteristics was completed in Microsoft Excel.

Bread pictures were used for planimetry of bread cut areas as baking test traits. Triple measurement with the help of planimeter Plancom KP-92N (Koiyumi, Japan) was performed and finite value is the arithmetic mean of these values.

Image analysis. For image texture analysis, a Cohu 2252 TV CCD camera was used. Controllable central and two point source lights ensured the illumination. Also diffusive underneath fluorescent lamp was used as the base for the image scanning. Clingfilm with rectangular cross was put under paper with the negative scan of bread sample to equalise bread cut area into four quadrants. These two lists were placed on the fluorescent lamp. Total area measured was 250 mm^2, i.e. 62.5 mm^2 in each quadrant (field of view 9 × 7 mm). Two digital images were processed and four measurements were analysed in each quadrant. This gave 32 images for one bread picture. The resolution was 5775 pixel/mm^2. Parameters including total cell number, total cell area, the mean cell area were investigated; cells/cm^2 and cell to total area ratio were calculated.

RESULTS AND DISCUSSION

Kernel and flour analytical traits (Tables 1–4)

Generally, baking quality of wheat varieties belonging to class A should be higher than the quality of those from class B. Actually, the comparison of the values of kernel and flour analytical traits for the varieties from class A vs. B shows that the class A varieties had a higher quality in the harvests of both years. Flour quality always depends on kernel quality as well – flours from the class A varieties had a higher baking quality as a reflection of a higher protein content in the kernel. The differences between the flour protein

Table 1. Kernel analytic traits – spring varieties class A

Harvest	Cultivar	Bulk density (kg/hl)	Thousand kernel weight (g)	Hardness (1)	Wet gluten (%)	Protein (%)	Ash (%)	Zeleny test (ml)	Falling Number (s)
2002	Saxana	71.65	32.0	44	23.8	12.7	1.99	43	171
	Aranka	71.15	32.0	48	24.9	13.0	2.01	53	131
	Vinjet	74.15	28.0	54	28.7	14.3	1.85	68	139
	Average	*72.32*	*30.7*	*49*	*25.8*	*13.3*	*1.95*	*55*	*147*
2003	Saxana	80.10	36.0	45	21.4	12.0	1.81	41	371
	Aranka	79.40	42.0	51	22.1	12.2	1.81	52	377
	Vinjet	79.70	38.0	54	21.4	12.0	1.78	50	363
	Average	*79.73*	*38.7*	*50*	*21.6*	*12.1*	*1.80*	*48*	*370*

Table 2. Kernel analytical traits – spring varieties class B

Harvest	Variety	Bulk density (kg/hl)	Thousand kernel weight (g)	Hardness (1)	Wet gluten (%)	Protein (%)	Ash (%)	Zeleny test (ml)	Falling Number (s)
2002	Leguan	69.65	38.0	49	23.1	14.4	1.97	48	164
	Zuzana	69.65	32.0	50	21.3	11.8	2.01	47	248
	SG-S1098	67.15	21.0	40	22.5	12.2	2.05	36	173
	Average	*68.82*	*30.3*	*46*	*22.3*	*12.8*	*2.01*	*44*	*195*
2003	Leguan	79.50	34.0	50	19.6	11.4	1.78	41	393
	Zuzana	78.40	32.0	51	17.9	10.9	1.83	42	363
	SG-S1098	75.35	32.0	42	19.1	11.3	1.92	31	359
	Average	*77.75*	*32.7*	*48*	*18.9*	*11.2*	*1.84*	*38*	*372*

Table 3. Flour analytical traits – spring varieties class A

Harvest	Cultivar	Moisture (%)	Ash (%)	Protein (%)	Wet gluten (%)	Falling Number (s)	Zeleny test (ml)
2002	Saxana	14.5	0.65	11.5	32.0	209	55
	Aranka	14.9	0.68	11.5	32.0	164	44
	Vinjet	15.5	0.64	13.2	38.9	191	46
	Average	*15.0*	*0.66*	*12.1*	*34.3*	*188*	*49*
2003	Saxana	14.8	0.55	11.2	30.6	440	48
	Aranka	14.2	0.55	11.6	29.8	432	48
	Vinjet	14.0	0.50	11.7	28.8	429	46
	Average	*14.3*	*0.53*	*11.5*	*29.7*	*434*	*47*

Table 4. Flour analytical traits – spring varieties class B

Harvest	Cultivar	Moisture (%)	Ash (%)	Protein (%)	Wet gluten (%)	Falling Number (s)	Zeleny test (ml)
2002	Leguan	14.7	0.62	11.3	29.7	216	46
	Zuzana	14.8	0.62	10.7	28.2	296	39
	SG-S1098	15.1	0.66	10.1	30.1	174	38
	Average	*14.9*	*0.63*	*10.7*	*29.3*	*229*	*41*
2003	Leguan	14.6	0.53	10.6	26.4	443	41
	Zuzana	14.9	0.53	10.1	25.2	393	31
	SG-S1098	14.1	0.56	10.6	29.1	378	33
	Average	*14.5*	*0.54*	*10.4*	*26.9*	*405*	*35*

contents were significant – flours milled from the harvest of 2002 wheat contained on average 12.1% (class A) and to 10.7% (class B) proteins. A similar difference was found for the harvest of 2003 wheat flours – in class A flours the mean protein content was 11.5% and in class B flours 10.4%.

Starch damage of wheat from the harvest of 2002 was expressed by a higher Falling Number, independently on the quality class, were significantly lower both for kernel (approx. 180 s) and for flour (approx. 200 s). The hardness of kernel was affected by the climate, too, but differences were not significant. A higher kernel hardness was observed in the harvest of 2003 in varieties ranked to both classes.

Baking test and penetration bread characteristics (Tables 5 and 6)

Basic bread characteristics evaluated in this work included specific bread volume, shape of bread, and bread cut area. Bread cut area was measured in the negative scan of the bread sample with the help of planimeter.

Specific bread volumes were affected by wheat quality class. Higher bread volumes for class A variety flours were caused by higher protein contents and higher amylases activities. A small difference was noticed between specific volumes of bread from A class varieties flour – 396 ml/100 g (harvest 2002) and 387 ml/100 g (harvest 2003). The best results of baking test in class A were obtained with the variety Vinjet in the harvests of both years (over 410 ml/100 g). The kernel of this variety had also the highest bulk density and hardness. A provable difference was found between breads from class B flour – 366 ml/100 g (harvest 2002) and 336 ml/100 g (harvest 2003). The variety SG-S1098 was dominant in class B – specific bread volumes from this variety flour was over 420 ml/100 g in both years' harvests.

The wheat quality class did not significantly influence the shape of bread or year harvest, however slightly higher values of the ratio height/diameter were found in the bread of the class B varieties flour. Total average value of the bread shape was 0.60. Bread cut area was also independent from the harvest of the respective years or wheat quality class – the mean value in class A was 34.7 cm^2, in class B 33.5 cm^2. There exists a relation between

Table 5. Bread characteristics – spring varieties class A

Harvest	Cultivar	Specific volume (ml/100 g)	Bread shape h/d (1)	Bread cut area (cm^2)	Penetration (mm)
2002	Saxana	410	0.56	36.3	16.6
	Aranka	363	0.59	31.2	12.7
	Vinjet	415	0.63	37.0	22.4
	Average	*396*	*0.59*	*34.8*	*17.2*
2003	Saxana	352	0.62	34.8	15.6
	Aranka	388	0.61	34.7	16.2
	Vinjet	420	0.62	33.9	20.7
	Average	*387*	*0.62*	*34.5*	*17.5*

Table 6. Bread characteristics – spring varieties class B

Harvest	Cultivar	Specific volume (ml/100 g)	Bread shape h/d (1)	Bread cut area (cm^2)	Penetration (mm)
2002	Leguan	361	0.57	34.4	14.9
	Zuzana	313	0.53	28.8	8.7
	SG-S1098	423	0.60	36.4	19.9
	Average	*366*	*0.57*	*33.2*	*14.5*
2003	Leguan	296	0.60	30.8	12.9
	Zuzana	285	0.59	31.4	8.5
	SG-S1098	428	0.64	38.8	20.6
	Average	*336*	*0.61*	*33.7*	*14.0*

specific bread volume and penetration as shown in Table 9. Consequently, the samples of bread from the varieties with the best baking test results reached the highest values of penetration – for the variety Vinjet (class A) penetration was 21.6 mm (average of both harvests) and for SG-S1098 (class B) it was 20.3 mm. At the same time, the mean penetration of the bread samples from class A variety flour was 17.2 mm and of those from class B variety flour 14.5 mm; this means that penetration can significantly distinguish the quality classes of wheat.

Crumb grain features (Tables 7 and 8)

Image analysis proved great differences between bread crumb texture characteristics as measured for the varieties of classes A and B. The higher the number of cells together a with higher mean cell area, the better the bread crumb porosity. Total cell number for the wheat of A class was lower in the samples from the harvest of 2002 (113 cells) than in those from the harvest of 2003 (170 cells). The bread of class B variety flour (harvest 2002) contained on average 256 cells – that is comparable with 243 cells observed in the bread from the cultivars of harvest 2003. Crowley *et al*. (2000) reported that the mean cell area for bread without/with fat was 0.80/1.05 mm^2. In our research, bread was prepared with fat and the mean cell areas found were 1.13 mm^2 in class A, and 0.96 mm^2 in class B (average values of harvests 2002, 2003).

The values of cells/cm^2 given by the same author are: for bread without fat 40 cells/cm^2; and for bread with fat 35 cells/cm^2. In full-formula-bread of the flour of class A varieties, 40 cells/cm^2 were found and in the flour of class B varieties it was 50 cells/cm^2. The cell to total area ratio expresses the proportion of cells in the measured area, i.e. relative porosity (void fraction). The lowest value of this ratio (0.38) was observed in the bread from

Table 7. Crumb grain feature from bread – spring varieties class A

Harvest	Cultivar	Total cell number	Total cell area (mm^2)	Mean cell area (mm^2)	Cells/cm^2	Cell to total area ratio (1)
2002	Saxana	100	110.1	1.10	40	0.44
	Aranka	164	92.6	0.56	67	0.37
	Vinjet	76	130.6	1.70	31	0.52
	Average	*113*	*111.1*	*1.12*	*46*	*0.45*
2003	Saxana	147	82.4	1.12	29	0.33
	Aranka	217	90.8	0.84	43	0.36
	Vinjet	147	107.1	1.46	29	0.43
	Average	*170*	*93.4*	*1.14*	*34*	*0.38*

Table 8. Crumb grain feature from bread – spring varieties class B

Harvest	Cultivar	Total cell number	Total cell area (mm^2)	Mean cell area (mm^2)	Cells/cm^2	Cell to total area ratio (1)
2002	Leguan	237	98.7	0.83	48	0.40
	Zuzana	258	101.5	0.79	52	0.41
	SG-S1098	273	123.4	0.90	55	0.50
	Average	*256*	*107.9*	*0.84*	*51*	*0.43*
2003	Leguan	268	94.7	0.71	53	0.38
	Zuzana	347	85.5	0.49	69	0.34
	SG-S1098	115	118.1	2.05	22	0.47
	Average	*243*	*99.4*	*1.08*	*48*	*0.40*

A class varieties (harvest 2003), the highest (0.45) in the bread from A class varieties (harvest 2002). Crowley *et al*. (2000) found 0.32 in non-fat bread and 0.36 in bread with fat. The comparison of these three crumb texture features shows that the bread from Czech varieties had a higher porosity than the bread from Irish commercial flour. A further comparison of the data computed from image analysis features is with Canadian spring wheat flour. Sapirstein *et al*. (1994) studied the influence of oxidants on bread crumb texture, however, with standard bread (without oxidants) a high number of very small cells was observed (97 cells/cm^2, the mean cell area 0.47 mm^2). Bread from Czech wheat cultivars had on average a lower number of cells/cm^2 (45), but the mean cell area was at least twofold (1.00). The cell to total area ratio was slightly higher for bread of Canadian commercial flour – 0.45 vs. 0.42 for bread from Czech variety flour.

The total crumb cell area of the total surface area is porosity related to the bread cut area – between breads from Croatian wheat cultivars flours was a great variation – from 0.66 to 5.78% (Magdic *et al*. 2002). For bread from Czech wheat varieties the mean values of the total crumb cell area of the total surface area in the quality classes were 2.94% for class A and 3.10% for class B (results not shown). This difference is imperceptible, so in our case there was no possibility to categorise the wheat varieties into quality classes using porosity as a trait of image analysis.

The total cell area was de facto independent from the harvest year – average values of this crumb characteristic were higher for bread from harvest 2002. They ranked from 93.4 to 111.1 mm^2 while the highest cell total area was found with Vinjet (class A) –130.6 mm^2 and SG-S1098 (class B) – 123.4 mm^2.

Correlation analysis (Table 9)

Correlation analysis between baking test, penetration, and image analysis characteristics for all 12 wheat varieties regardless of the quality classes was performed to find out statistically conclusive relationships on significancy levels P = 95% and P = 99% (n = 12; r_{crit} = 0.5760 for α = 0.05; r_{crit} = 0.7079 for α = 0.01). Seven parameters of bread crumb were correlated to specific bread volume. The shape of bread (ratio height/diameter) did not correlate with any of the others features, therefore it is not shown.

It was observed that all seven bread parameters correlated to specific bread volume, but each relation had a different strength. For comparison, the same dependence was assessed for Czech commercial wheat and winter varieties, altogether 37 samples (Švec & Hrušková 2004). The most strong dependence was proved with penetration (r = 0.9083; α = 0.01) and further with bread cut area (r = 0.8354; α = 0.01). Bread area expresses bread volume in 2-D extent and so a strong de-

Table 9. Correlation analysis of bread characteristics

	Specific bread volume (ml/100 g)	Bread cut area (cm^2)	Penetration (mm)	Total cell number	Cell total area (mm^2)	Mean cell area (mm^2)	Cells/cm^2	Cell to total area ratio (1)
	1	2	3	4	5	6	7	8
1	1	0.8354	0.9083	–0.6609	0.7840	0.7145	–0.5832	0.7840
2		1	0.8562	–0.6209	0.6702	0.8174	–0.6920	0.6702
3			1		0.8704	0.7602	–0.6053	0.8704
4				1		–0.7443	0.7461	
5					1	0.6612		1.0000
6						1	–0.8909	0.6612
7							1	
8								1

n = 12; r_{crit} = 0.5760 for α = 0.05; r_{crit} = 0.7079 for α = 0.01

pendence was found between penetration and this area (r = 0.8562; α = 0.01). It might be supposed that a higher number of smaller cells causes a lower specific bread volume – negative relation was found between specific bread volume and total cell number (r = –0.6609; α = 0.05), perhaps cells/cm^2 (r = –0.5832; α = 0.05). The most intensive dependence among image data was assessed between cells/cm^2 and the mean cell area (r = 0.8909; α = 0.01). The lowest significant relation was found between the total cell number and the bread cut area (r = 0.6209; α = 0.05).

Relations between specific bread volume, penetration and bread crumb texture characteristics (Figures 1 and 2)

As correlation analysis shown, a strong dependence exists between bread sample penetration and specific bread volume. Figure 1 categorised spring wheat cultivars into three groups: the varieties with specific bread volume below 330 ml/100 g and penetration below 12 mm – this was the case only with the variety Zuzana (number 5, class B). The values of penetration are comparable in both years' harvests but bread volume of the flour of harvest 2003 represents only 85% of that of the flour of harvest 2002. The second group provided bread volumes between 330 and 400 ml/100 g and bread petration between 12 and 18 mm. The varieties Saxana (1, class A), Aranka (2, class A) and Leguan (4, class B) fell into this group with two exceptions: bread of Leguan from harvest 2003 had specific volume below 300 ml/100 g; bread of Saxana from harvest 2002 had specific volume over 400 ml/100 g. The dispersion of the data measured in this group was great – no influence of either quality class or the harvest of the respective years was observed. The group of the best baking test results (specific bread volume over 400 ml/100 g and crumb penetration over 20 mm) involved two varieties from both classes – Vinjet (3, class A) and SG-S1098 (6, class B). The results reached with the bread of cv. SG-S1098 were mutually more comparable than those with the bread of Vinjet – 423/428 ml/100 g and penetration 19.9/20.6 mm (harvests 2002, 2003).

Figure 2 compares specific bread volume, the total cell number, and the mean cell area of variety flour bread – image analysis features were related to specific bread volume; also, the higher the total cell number, the lower the mean cell area (Table 9). The highest specific volume was found with the bread of SG-S1098 from harvest 2003 (428 ml/100 g), and also the mean cell area of this bread crumb was the

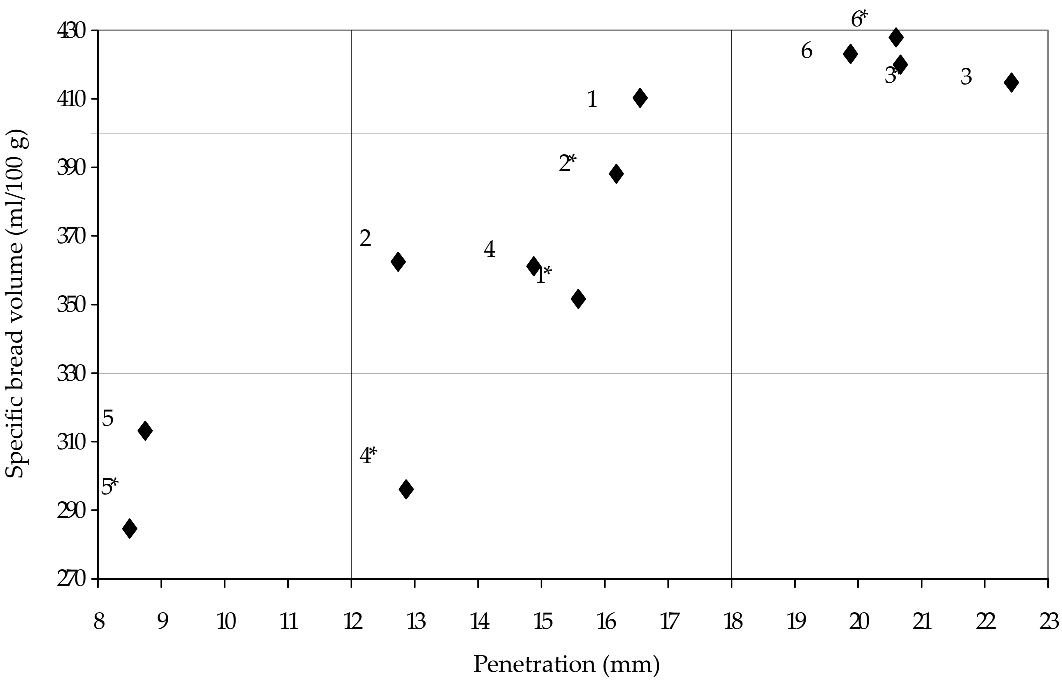

Figure 1. Relation between specific bread volume and penetration of wheat bread crumb (1–6 = varieties of harvest 2002, 1*–6* = varieties of harvest 2003)

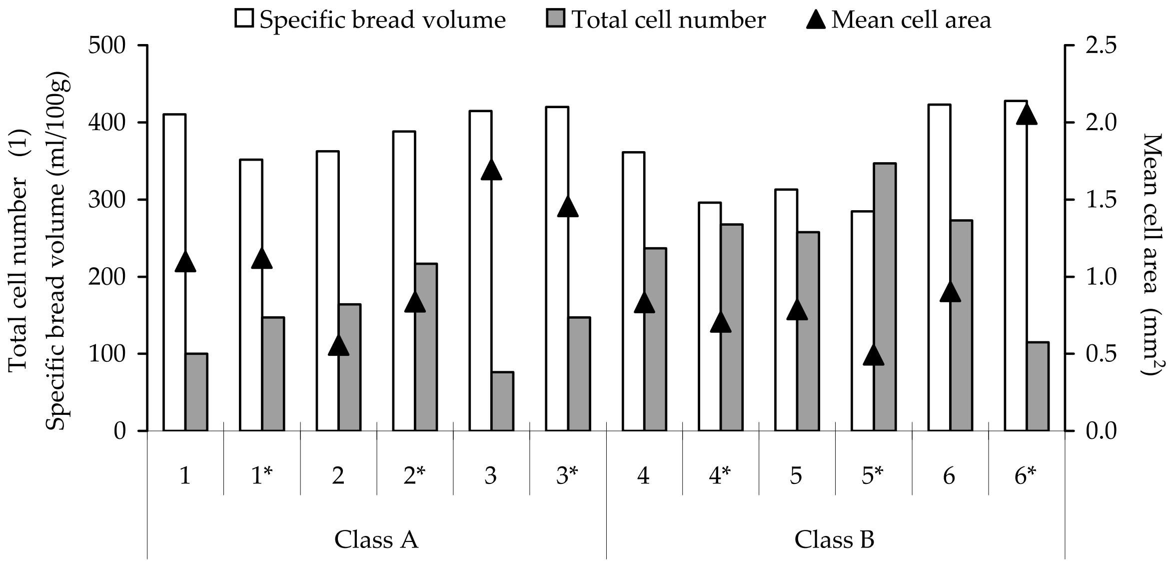

Figure 2. Comparison of specific bread volume and image analysis features (1–6 = varieties of harvest 2002; 1*–6* = varieties of harvest 2003)

highest (2.05 mm^2). Contrary, the total cell number was the third lowest (115 cells). On the other side, the lowest specific bread volume (258 ml/100 g) and the lowest mean cell (0.49 mm^2) area were observed with the bread of Zuzana (harvest 2003) while the total cell number was the highest of them all (347 cells). The absolutely lowest total cell number was revealed by the bread from flour of Vinjet from harvest 2002 (76 cells) with the mean cell area 1.7 mm^2.

CONCLUSIONS

Baking quality was evaluated of flours from six wheat varieties (harvest 2002 and 2003) belonging to the quality classes A and B. Analytical traits of kernel and flour showed differences in quality between these classes, which were confirmed by baking test with the full-bread-formula according to Czech method. Penetration and image analysis were subjoined to the standard methods of the bread parameters description (specific bread volume and bread shape measurements) in the effort to better differentiate wheat samples into quality classes. Correlation analyses were performed to comprehend relations between bread and bread crumb features.

The results of baking test proved significant differences in specific bread volumes – the highest volumes were obtained with the cultivars Vinjet (class A) and SG-S1098 (class B) – approx. 410 and 420 ml/100 g, respectively, the texture features of bread from Czech spring varieties provided results comparable with Irish, Canadian or Croatian wheats. The mean cell area of the bread from Czech cultivars was circa equal to that measured in the bread of Irish flour, 1.05 mm^2 (Crowley *et al*. 2000) vs. 1.13 mm^2 in class A and 0.96 mm^2 in class B; the values of the mean cell area of the bread from commercial Canadian spring wheat were half (0.47 mm^2) (Sapirstein *et al*. 1994). The number of cells/cm^2 was slightly higher in the bread of Czech wheat than of Irish wheat, but lower than in the of Canadian wheat (around 45 cells/cm^2). Total crumb cell area of total surface area value for the bread of Czech flour (approx. 3%) was in the middle of the range estimated for Croatian cultivar bread (0.66–5.78%) (Magdic *et al*. 2002).

Penetration measurement proved significant differences between breads from the two quality classes. The mean bread penetration was about 17 mm in class A and 14 mm in class B.

The methods under study used for the description of bread crumb texture characterise in detail wheat bread sensorial quality important for consumer's perception.

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Souhrn

Švec I., Hrušková M. (2004): **Znaky analýzy obrazu střídy chleba z mouk českých jarních odrůd pšenice.** Czech J. Food Sci., **22**: 133–142.

Pekařská kvalita mouk ze šesti odrůd pšenic (sklizeň 2002, 2003) patřících do jakostních tříd A a B byla hodnocena formou fermentovaného těsta. Analytické znaky zrna a mouky ukázaly rozdíly mezi jakostními třídami, které byl potvrzeny výsledky laboratorního pekařského pokusu s recepturou kynutého těsta podle interní metody. Standardní metody popisu znaků pečiva (měření měrného objemu a tvaru pečiva) byly rozšířeny o penetraci a analýzu obrazu za účelem rozlišení pšeničných odrůd do jakostních tříd. Výsledky pekařského pokusu prokázaly významné rozdíly v měrných objemech – nejvyšší objem ve třídě A byl změřen pro odrůdu Vinjet a ve třídě B pro odrůdu SG-S1098 – průměrně 410 a 420 ml/100 g. Ačkoli korelační analýza prokázala významné vztahy mezi znaky analýzy obrazu a měrným objemem pečiva, žádný z nich nedokázal prokazatelně odlišit pšenice podle jakostních tříd. Spolehlivého rozlišení odrůd tříd A a B bylo dosaženo měřením penetrace střídy pečiva (r = 0,9083 pro α = 0,01). Nejvyšší korelační koeficient mezi měrným objemem a znaky střídy pečiva (podle obrazové analýzy) byl zjištěn pro celkovou plochu pórů (r = 0,7840 pro α = 0,01).

Klíčová slova: odrůda pšenice; pekařský pokus; penetrace; analýza obrazu

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