MODELLING OF WHEAT, FLOUR AND BREAD QUALITY PARAMETERS

I. Švec, M. Hrušková

Institute of Chemical Technology, Department of Carbohydrate Chemistry and Technology, Prague, Czech Republic

For statistical modelling of wheat grain, flour and bread parameters, 281 food wheat samples were collected during the years 2003–2006. Quality analysis approach was a complex procedure from-grain-to-bread, including grain and flour properties and analytics, rheology and a baking test. Correlation analysis (P = 99%) confirmed known bindings between protein content and quality, both for grain and flour, and also together with viscoelastic properties of non-fermented dough – significant correlation between alveograph energy and grain (GP) and flour protein (FP) contents and Zeleny's test (ZT) (r = 0.37, 0.64, and 0.43, respectively) were found. Specific bread volume (SBV) was affected by both protein properties (r = 0.19, 0.26 and 0.23 for GP, FP and ZT, respectively) and also by activity of amylases (correlation to flour FN was –0.26). Relation of SBV to alveograph parameters was not surprisingly verified (r = 0.27). Anyway, occurrence and strength of calculated correlations depended directly on set composition. Statistical model confirmed importance of features as FP and ZT or alveograph ones for SBV prediction, but an obtained model did not explained features variance in the tested sample set enough ($R^2_{adjusted}$ = 0.38).

wheat quality; correlation analysis; viscoelastic behaviour; baking test, regression model

INTRODUCTION

Food wheat quality is dependent on many factors; the main ones are usually cited in order of wheat variety, harvest year, planting regime and locality, crop and after-crop treatment, length and conditions of storage. Conformity of these factors to maintain the best product quality differs at single farmers, causing oscillation of the wheat quality features between following harvest years. Related to this, a permanent control of mill products quality is necessary, mainly for fine flour types used for bakery product manufacturing.

Several parameters are recommended for food wheat milling and baking treatment, which also determined final use of wheat flour. Milling praxis verified that e.g. semolina and edible milling products yields are affected by the test weight, the grain hardness and the grain ash content. Flour baking value is predetermined by quality and quantity of storage proteins, rate of the damaged starch and immanent enzyme activity. All parameters above indicate wheat quality indirectly – complex material quality description is by this way based on monitoring of its single component. However, wheat flour does not represent a chemical element, so during dough processing and further technological treatment an influence of protein and polysaccharide part is combined with ones of recipe components used. At a laboratory scale, baking process is simulated step-by-step with the help of some usage rheological apparatuses – wheat flour quality evaluation is extended about further indirect characteristics. There are two exceptions in terms of the direct assessment of milling and baking quality by the proper tests performed on laboratory equipment at strictly defined conditions. Output of the tests is a physical product (flour and bread, respectively), and sensory analysis could be considered with advantage of procedures common to consumer. Generally, demandingness of direct testing in terms of the technical supplement and time could not allow its usage in praxis – here screening methods are preferred with an aim to measure a few characteristics describing wheat quality at the best. Obligatory measured features are fixed into the Czech and EU legislation, which reflex requirements of farmers on the one side and millers and bakers on the opposite one.

It is well known, that quality parameters of food wheat, wheat flour, dough and bakery final product are tended to be dependent together or partially alternate themselves. Due to their affecting by many external factors, relations among them could be appraised as probable. To generalize it, a broad number of analyses and processes is necessary, performed always according to the same method. The mentioned type of the research was in the years 1980–1990 conducted at the Research Institute of Milling and Baking Industry Prague on different groups of wheat varieties as well as commercial wheat. Recent research in the field of wheat grain results represent papers of Monsalve-Gonzalez, Pomeranz (1993), Rharrabti et al. (2003), Capouchová, Petr (2004), Hrušková et al. (2004) and Souza et al. (2004). Dependences between wheat flour and dough features were studied in fewer rates; as the current could be considered papers published by Hrušková et al. (2000), Trethowan et al. (2001), Zanetti et al. (2001), Amiour et al. (2002), Konopka et al. (2004), and Pongráczné Barancsi et al. (2008). Interesting are also experiments' result referred to relation between bread volume and dough properties (Rasper et al., 1986; Cressey et al., 1987; Hrušková et al., 2006).

The aim of the present work was correlation analysis among 16 quality traits of wheat grain, wheat flour and bread parameters and bread volume modelling with consideration of the other parameters.

MATERIAL AND METHODS

For the present study, a set of the wheat varieties was collected during the period of 2003–2006. Samples according to origin within the Czech Republic area consist of four subsets as follows:

– *S1*, in total 51 Czech wheat varieties planted during 2003–2005 in the Central Bohemia,
– *S2*, containing in total 60 international wheat varieties planted during 2003–2005 in the Central Bohemia,
– *S3*, containing in total 90 Czech wheat varieties planted during 2004–2006 in the South Moravia,
– *S4*, containing in total 80 samples of commercial wheat planted during 2003–2006 in the Central Bohemia.

Subsets *S1*–*S4* were considered also in a complex group of 281 wheat samples and named "*Wheat*".

Performed process of complex analysis of food wheat quality is illustrated in Fig. 1 correspondingly to the model of laboratory wheat quality determination. Measured quality characteristics with used abbreviations are specified in Table 1. Grain quality was evaluated according to ČSN 46 1011-5 (test weight; TW), internal method (thousand kernel weight; TKW), ČSN 56 05 12 for grain analytical traits measured through the use of the Inframatic 8600 (Perten Instruments, Sweden), and ČSN ISO 30 93 (Falling Number; GFN). Wheat samples were milled under standard conditions at laboratory mill CD-1 Auto (Chopin, France) following the internal procedure. For an analytical flour features assay, the Inframatic apparatus was used comparably to grain analytics. Falling Number and Zeleny's sedimentation test (FFN and ZT; ČSN ISO 30 93 and ISO 55 29, respectively) terminated flour composition analysis.

Rheological properties of flour in the form of non-fermented dough (flour-water-salt system) were measured at alveograph (Chopin, France; ISO 5530-4). Baking test was performed according to the internal method described in previous papers (Š v e c et al., 2004, 2005). Specific bread volume (SBV) was measured by rapeseed displacement.

Statistical data processing in terms of the Pearson correlation analysis and critical coefficient values calculation was performed in Statistica CZ, version 7.1 (StatSoft Inc., USA), while for a plot construction both Statistica and MS Excel 2003 were used. Correlation matrix was calculated for complex group *Wheat* from 34 variables and 281 cases. Correlation analyses were performed at the probability level of 95 and 99%, and correlation coefficients representing the latter level were considered as valid for this work. Further, relations specified as at least middle strong ($r \geq 0.50$, $P = 99\%$) were emphasized. Selected relations between wheat grain, flour, dough and bread characteristics as the reference data were compared to own also graphically.

Models were calculated by means of general linear regression at first to test accuracy of prediction, and by means of stepwise regression to find the best subgroup of tested variables with the highest multiple correlation coefficient ($R^2_{adjusted}$). Both statistics were calculated on $P = 95\%$.

RESULTS AND DISCUSSION

Quality profile of evaluated samples set

Quality of collected wheat and wheat flour samples reflects a broad variation of quality features according to its origin – it was described by minimum, maximum and average value. Their distribution in a studied collection

Table 1. Quality profile of assessed samples set ($N = 281$)

Feature	Average	Minimum	Maximum	SD	RSD (%)
TW	81	71	90	3	4
TKW*	42.6	30.7	70.0	5.5	12.9
GH	51	36	60	5	10
GWG	24.7	13.0	34.4	3.4	13.7
GP	13.0	9.2	16.3	1.1	8.4
GFN	321	62	477	65	20
FA	0.58	0.48	0.76	0.06	10.36
FWG	33.1	18.4	46.9	4.3	12.9
FP	12.2	8.6	16.1	1.2	10.2
ZT	48	20	72	11	24
FFN	353	89	482	62	17
P	108	46	213	32	29
L	53	15	109	18	34
P/L	2.40	0.60	10.14	1.39	57.77
W	179	48	390	61	34
SBV	334	211	459	48	14

For abbreviations see Fig. 1
* $N = 221$
SD, RSD – standard deviation and relative standard deviation, respectively

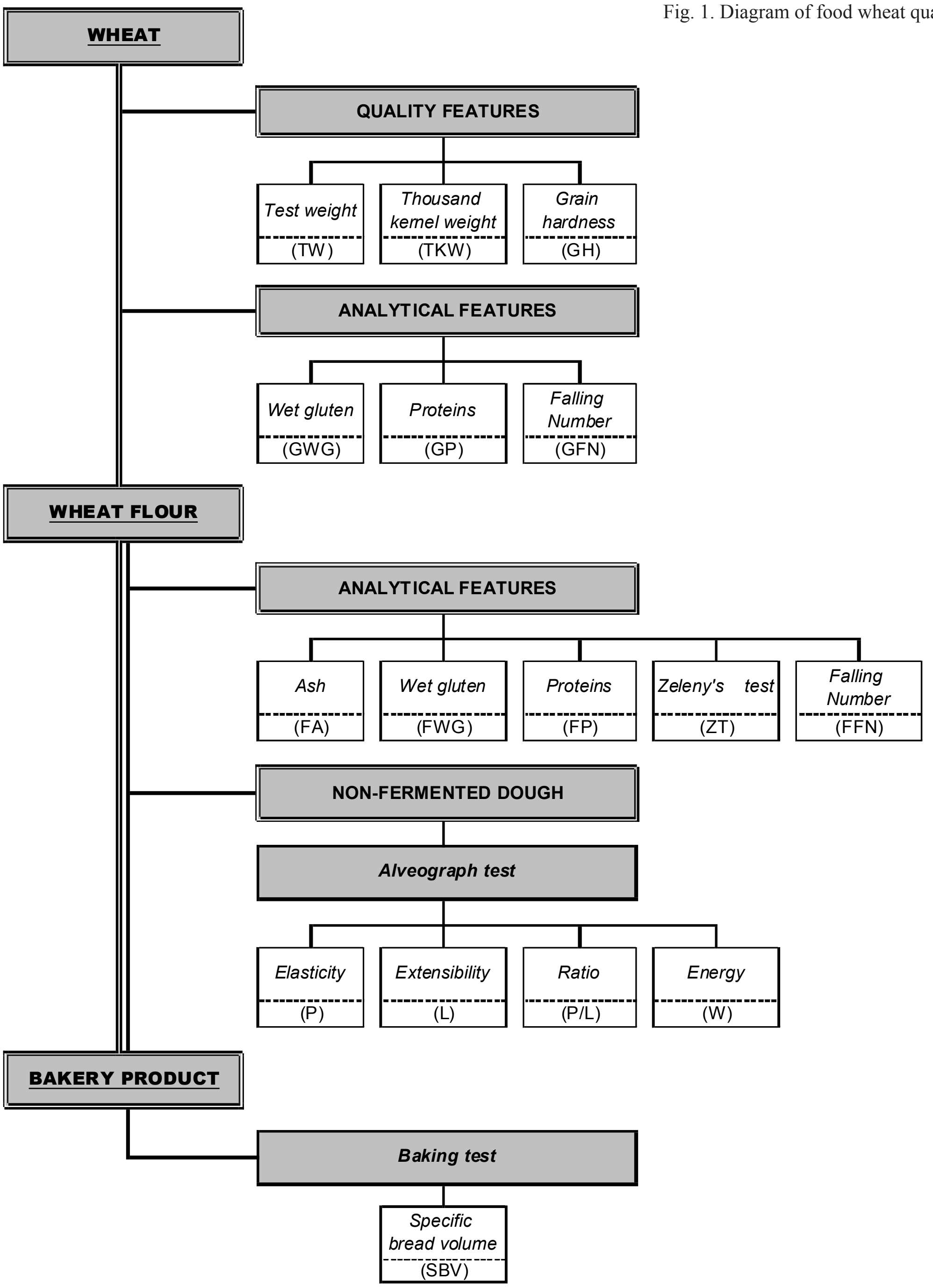

Fig. 1. Diagram of food wheat quality analysis

was evaluated in terms of standard deviation and relative standard deviation (SD and RSD, respectively; Table 1). A comparison of the calculated items in a part of the grain quality brings knowledge about the strongest oscillations for TKW, wet gluten content and Falling Number. In case of wheat flour observation, the highest variation coefficient was determined for Zeleny's sedimentation test (22.9%). The opposite trend was identified for TW and GA. Dough viscoelastic characteristics of the alveograph test were measured in broader range. Bread quality assessment (SBV) demonstrated the same rate fluctuation as some flour features. Generally, robustness of the selected complex set adequately represents wheat and flour quality and supports well aim of this work.

Correlation analysis results for set *Wheat*

Results of correlation analysis significant on 99% level of wheat varieties set of 281 samples is given in Table 2. For better comprehensibility, measured characteristics were segmented into blocks in accordance to the steps of food wheat quality analysis.

Grain and milling characteristics

It is known for a long time that grain properties predetermine both milling quality and final end-use of food wheat; for description serve usually TW, TKW and GH as

Table 2. Correlation analysis of the set Wheat (P = 99%, N = 281, r_{crit} = 0.1534, * N = 221, r_{crit} = 0.1729)

Feature	TW	*TKW	GH	GWG	GP	GFN	FA	FWG	FP	ZT	FFN	P	L	P/L	W	SBV
TW	1	<u>0.58</u>	0.26			0.17	<u>–0.52</u>			0.18	0.24	0.50	–0.25	0.42	0.25	
TKW*		1	0.24	–0.37	–0.40		–0.19	–0.27			0.18	0.39	–0.18	0.45		
GH			1	0.18	0.19		–0.16		0.42	0.32		0.58		0.38	0.37	0.17
GWG				1	<u>0.98</u>		0.33	<u>0.92</u>	<u>0.84</u>	<u>0.55</u>			0.31	–0.28	0.38	0.20
GP					1		0.33	<u>0.90</u>	<u>0.83</u>	<u>0.57</u>			0.29	–0.28	0.36	0.19
GFN						1	–0.19				<u>0.84</u>	0.16		0.16		–0.33
FA							1	0.39	0.40		–0.32	–0.39	0.64	<u>–0.50</u>	0.32	
FWG								1	<u>0.90</u>	<u>0.53</u>			0.42	–0.33	0.48	0.22
FP									1	<u>0.52</u>			0.47	–0.27	0.63	0.26
ZT										1		0.31			0.39	0.23
FFN											1	0.30	–0.17	0.27		–0.26
P												1	<u>–0.49</u>	0.81	0.39	
L													1	–0.75	<u>0.51</u>	
P/L														1		
W															1	
SBV																1

For abbreviations see Fig. 1
Underlined values signify at least middle strong relation in a pair of the proper features (r > 0.50)

well as grain analytics (GA, GWG, GP, and GFN). In studied set *Wheat*, all mentioned traits more or less affected further characteristics measured. As at least middle strong relations were found those between GA vs. TW, TKW and GH and well as between GP and GWG.

Relation of TW and TKW to milling quality (i.e. FY) was provable (r = 0.74 and 0.54, respectively, P = 99%), as previously proved Monsalve-Gonzalez, Pomeranz (1993) on seven winter and seven spring wheat varieties. Further, TW/TKW affected FA and FP, too (r = –0.83/–0.79; and –0.76/–0.81, respectively; P = 99%), while ash and protein contents in grain and flour corresponded together (0.65–0.98, P = 99%).

Capouchová and Petr (2004) tested reaction of 8 varieties sorted into quality classes A, B and C on two planting regimes applied into four localities. Wheat quality was described by 13 parameters including grain properties, analytics and milling test. Besides the parameter FY, TW did not affect also GA, GFN and ZT. Contrary to that, GWG and GP were statistically dependent on it (–0.22 and –0.19, respectively; P = 99%). Compared to our study, provided results were generally reverse: bindings of GA, GFN, FY and ZT to TW were more or less provable (–0.55, 0.17, 0.19 and 0.18, respectively; P = 95%), while ones of GWG and GP did not. It corresponds to different sample set composition, which determines set quality profiles.

Hrušková et al. (2004) tested milling quality of 20 wheat varieties from international breeding test CIMMYT 2003. Grain traits TW, GH, GP and GA did not correlate together, but affected FY, FA, FP and ABS in different rates. It is interesting, that the number of relations to TW was lower compared to one related to GH (3 vs. 5, respectively). Moreover, correlations to GH were significant also on both 95 and 99% level. Both remarks were confirmed in the set *Wheat*, when 8 from 15 traits correlated to TW compared to 11 related to GH.

Cited parameters connection are valid also for durum wheat – Rharrabti et al. (2003) carried out 10 field experiments in 2 localities on the North and South Spain with 10 durum wheat genotypes. Correlation analysis (P = 95%) was calculated for both genotypic and trial mean values for TW, TKW, GP and SDS test (alternative of the ZT for groats). In the first case of genotypic means, protein content and quality provably correlated together (GP vs. SDS test, r = –0.683) and both features were affected by GA (0.746 and –0,680 for GP and SDS test, respectively). In the second case of planting locality, TW significantly affected GA (r = –0.758) similarly to TKW and GP (r = 0.655).

Flour analytic and viscoelastic properties

The first step of flour quality analysis in our procedure of food wheat quality analysis consists of five analytical traits measurement, followed by determination of range of the dough characteristics (Fig. 1). Between flour analytical features, protein properties (FWG, FP, and ZT) were correlated together as middle strong relations. As could be presumed, these traits were correlated with the same strength to grain counterparts GWG and GP (r = 0.55–0.92). Moreover, also GFN strongly influenced FFN (r = 0.84).

Hrušková et al. (2000) received 40 wheat flour samples of bread-making quality from a commercial mill. Standard analytical methods were applied, and measured results were compared to ones predicted by NIR tech-

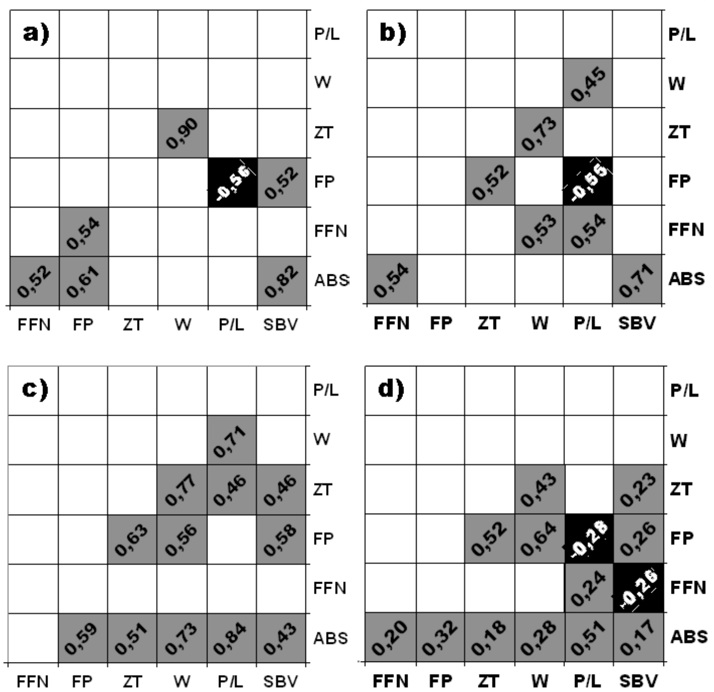

Fig. 2. Comparison of correlations occurence for wheat variety groups and set *Wheat*
a–c) Polish wheat variety samples sorted into quality classes A, B, C, respectively (K o n o p k a et al., 2004), d) studied sample set *Wheat*
For abbreviations see Fig. 1; ABS – flour water absorption

nique. This work supports our survey, since provable relations of FWG and WP to GWG together with GFN vs. FFN have been detected ($r = 0.68$ and 0.69, $P = 99\%$; $r = 0.76$, $P = 99\%$, respectively). K o n o p k a et al. (2004) compared quality of 42 Polish wheat flour milled from 15 varieties sorted into classes A, B and C. The flours were tested for WP, ZT, FFN, farinograph water absorption, alveograph and baking test. Published results were for proper features compared graphically with correlation analysis results in the set *Wheat* (Fig. 2). It could be noticed an increase of a number of discovered correlations from A to C class varieties (7, 8, and 12, respectively, Fig. 2a–c). Wheat varieties of C class are known to be the most adaptable to planting conditions, thus growing of the tested varieties in different regions of Poland caused the smallest oscillation in flour quality just for C ones. Through all three quality classes of Polish wheat, correlations ZT vs. W and SBV vs. ABS were common only, and those were detected also in the set *Wheat*. In the mentioned four groups, more or less provable relations between FP and its quality (ZT, W, P/L), and binding to baking test results (SBV) could be noticed. Above Fig. 2 it could be concluded, that 281 wheat samples included into the correlation analysis represent well wheat quality spectrum.

R a s p e r et al. (1987) with the help of alveograph assessed quality of 19 soft white winter wheat cultivars. Samples (49 in total) were planted in Ontario during the years 1983 and 1984. Alveograph test results were correlated to FP – Fig. 3 compares these statistics to ones from the set *Wheat*. Between both wheat groups, differences in proved relations strength could be noticed only. Softer bindings to protein content in case of the set *Wheat* were caused by less uniform quality of studied samples.

T r e t h o w a n et al. (2001) studied the effect of indirect tests for grain and industrial quality of bread wheat on

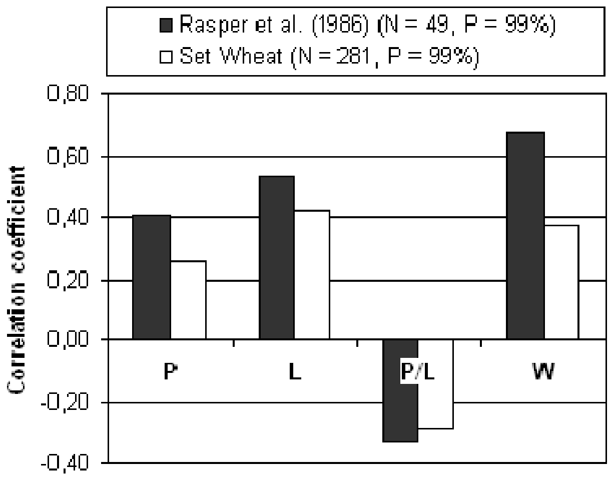

Fig. 3. Alveograph features relation to grain protein content

1267 wheat genotypes at CIMMYT research centre. Replicated trials were performed during a period of 1994–1995, when 84 lines were common to both years. Wheat quality was described in terms of grain and flour protein contents, SDS and alveograph tests; measured values were related to baking test results (SBV) by way of correlation analysis. Detected relations strength of protein properties was due to multiple samples count (related to the presented set *Wheat*) understandably higher, in majority cases was probability of 99.9%. Fig. 4 compares correlations in both wheat sets for five protein features in terms of their binding to alveograph energy (W). It could be noticed the same "charge" of correlations for GP, FP, SDS-test/ZT and P/L; non-significance between P/L vs. W and SBV vs. W in case of the set *Wheat* was caused by higher values variance in less-numerous wheat sample group as well as influence of different harvest year and planting locality.

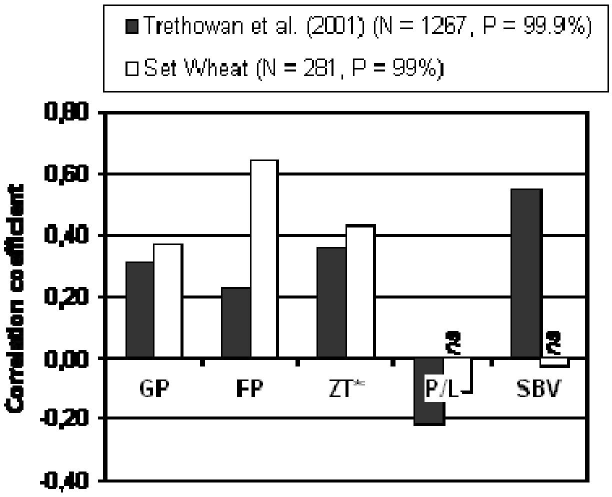

Fig. 4. Protein features and bread volume relation to alveograph energy
For abbreviations see Fig. 1
* SDS-test (T r e t h o v a n et al., 2001), *ns* = non-significant

Non-fermented dough rheological behaviour in terms of alveograph and extensigraph tests was the aim of the study published in 2008 by P o n g r á c z n é B a r a n c s i et al. Results of the alveograph testing confirmed possibility to substitute the features P, L, P/L and W by each other. Presented results showed a positive correlation of W to P and P/L (0.88 and 0.69, respectively; *P* = 99%), and its negative but insignificant connection to L. It demonstrates trends, which were expected also in the set *Wheat*, but were not proved.

Z a n e t t i et al. (2001) used 226 samples derived from a cross of Swiss common wheat and Swiss spelt to express bread making quality as depend on the variety genetic potential. The four alveograph parameters P, L, P/L and W correlated surely mostly on 95% level with FP and ZT – e.g. calculated correlation between W vs. FP was weaker than in the set *Wheat* (0.25 and 0.64, respectively), and contrary in the case of W vs. ZT (0.87 and 0.43, respectively). Moreover, a negative interference of P/L and W with GH was observed (*r* = 0.43 and –0.28, respectively), although in the set *Wheat* were correlations of both pairs positive (*r* = 0.36 and 0.39, respectively).

Similar study of genes substitution effect on bread wheat technological value was published by A m i o u r et al. (2002). Three genes substitution by 1R rye chromosome caused adequate variation in analytical (GH, GP, ZT, GFN) and alveograph data measured, confirming gliadin-to-glutenin ratio responsibility for a bread wheat technological quality. Features ZT, P and W were also in this case connected to GH (*r* = 0.65, 0.52 and 0.63, respectively; *P* = 99%), and alveograph parameters correlated together (*r* from –0.64 to 0.88). Authors specified also bread volume and wheat properties mutual affinity – both protein descriptors (ZT, P, W) and damaged starch ratio (GFN) participated on baking test results.

Bread features

Bread in its many different types is demanded product in the field of cereal chemistry research, and approved baking tests represent ways of the direct wheat flour end-use quality analysis. In the set *Wheat*, impact of 8 parameters on baking test results was identified (Table 2). The strongest effect could be attributed to amylases activity (GFN and FFN) and to FP – correlation coefficients were –0.33, –0.26 and 0.26, respectively.

Data of some cereal scientists linked to relation of SBV to wheat grain, flour and dough were gathered into Table 3. The proved correlations summary verifies well

Table 3. Provable correlations between SBV and the commonly measured wheat grain and flour features (P = 99%)

Authors	GP	FP	ZT*	P/L	W
Cressey et al. (1987)	0.39		0.50		
Monsalve Gonzalez and Pomeranz (1993)		0.68			
Zhao et al. (1999)					
a) harvest year 1995	–0.27				
b) harvest year 1996	0.49				
Mikhaylenko et al. (2000)		0.74	0.73		
Trethowan et al. (2001)	0.47	0.35	0.28	–0.37	0.55
Amiour et al. (2002)			0.78		0.76
Konopka et al. (2003)					
a) A-class varieties		0.52			
b) B-class varieties					
c) C-class varieties		0.58	0.46		
Tronsmo et al. (2003)			0.94		
Souza et al. (2004)	–0.53				
Hrušková et al. (2006)		0.57			
Set Wheat	0.19	0.26	0.23		

For abbreviations see Fig. 1
* Zeleny's or SDS sedimentation test

a premise about impact of sample group composition on results measured. In an overall view, wheat bread volume is undoubtedly based on protein content and its quality assessed by sedimentation and/or the alveograph tests. During baking process, evaporation of water absorbed in dough at kneading stage supports bread volume increase, so a positive interaction between ABS and SBV could be also presumed. Partial discrepancies in a positive/negative relation in columns of Table 3 (e.g. data of K a l d y et al. (1987) for FP and ABS) reflect different quality profile of the tested wheat as an impact on the factors planting locality and harvest year.

Models of bread volume from grain and flour quality features

For SBV prediction, a general linear regression model (GRM) was used at the first step of modelling, and secondly an order of variables significance was determined by the best subgroup refined model, both on 95% confidence level. Coefficients of single variables from obtained equations with the proper probabilities α are given in Table 4, independent traits are denoted by an asterisk (“*”). Due to the same data base, coefficient values were similar in both calculated models. Per contra, an importance of the tested quality features of both models was a little different as illustrate Fig. 5a and 5b, respectively.

Table 4. Regression equations obtained from multiple regression

	General model		Refined model	
	regression coefficient	probability α	regression coefficient	probability α
Constant *	673.84	0.00	668.15	0.00
TW *	–3.25	0.04	–3.32	0.01
TKW	0.35	0.61	–	–
GH	0.36	0.71	–	–
GWG	3.01	0.52	–	–
GP *	–32.86	0.01	–26.12	0.00
GFN	–0.15	0.09	–0.16	0.06
FA *	–221.27	0.00	–231.76	0.00
FWG	–0.21	0.93	–	–
FP *	35.66	0.00	37.68	0.00
ZT *	1.09	0.00	1.09	0.00
FFN *	–0.18	0.04	–0.17	0.05
P	0.60	0.07	0.44	0.01
L *	0.84	0.01	0.87	0.01
P/L	–4.73	0.38	–	–
W *	–0.53	0.00	–0.48	0.00

For abbreviations see Fig. 1
* Variables significant for regression at $P = 95\%$

GRM set as independent 8 of 15 quality features, from which W, FP and ZT affected SVB in the strongest rate, respectively (Fig. 5a). A final equation could be written in the form of:

$$SBV = 673.84 – 3.25 * TW – 32.86 * GP – 221.27 * FA + 35.66 * FP + 1.09 * ZT – 0.18 * FFN + 0.84 * L – 0.53 * W$$

with a rate of explained variability $R^2_{adjusted} = 0.3747$ only. The model refined by stepwise procedure (the best variables subgroup) did not allow to generalize the dependence of SBV on the selected grain and flour properties ($R^2_{adjusted} = 0.3850$), although predicted and observed values correlated together at middle strong level ($r = 0.65$ and 0.64, respectively). Moreover, in the second step of regression an order of quality features has softly changed, but a trend was kept the same. First of all, protein quality and quantity affect baking test results, and then amylolytic activity contributed to it. Also a relation of the grain parameters TW and GH as well as FA to SBV was confirmed, although correlation dependence was insignificant.

CONCLUSIONS

Food wheat quality evaluation is aimed at such quality traits, by which it is possible to predict market end-use. Great part of food wheat planted is assigned for milling-baking usage, so there were approved many quality features with different testifying worth. It is a reflex of cereal chemistry history longer than 50 years, when steadily more precise and effective methods of quality evaluation were developed. Associated to it, numerous innovations allowed an expansion in laboratory equipments offer, and, a demand to reduce number of mandatory features monitored intensified keeping accent to hold a good information level at purchase and subsequent commodity processing. In this way, a certain diversification of requirements could be noticed – on a trading level, an effort of wheat grain criteria reduction and their supplement by limits for price differentiating of quality classes could be seen. On a level of new technologies and new cereal food products, requirements of further quality parameters interfere to breeders’ selection of varieties suitable for the actual purpose.

Analysis of the wide set of food wheat and flour from the years 2003–2006 as well as its specified parts demonstrated a dependence of the pair correlations on data source. Correlation analysis results confirmed that crumb penetration measurement appropriately supported baking quality description by bread volume. As is known, it reflects quality view of common consumers.

Regression analysis verified a known fact, that specific bread volume as a direct indicator of the baking quality is mostly affected by protein properties, i.e. the by content and quality. Between grain traits, the strongest impact on baking test results was identified for flour ash content and test weight. Anyway, prediction models do not reach usual precision and in the set *Wheat* of 281 samples explained closely to 40% of data variability only. Relatively low prediction level could be caused by great differences between the tested wheat subgroups, which partially enhanced data variance. In individual subsets *S1–S4*, calculated $R^2_{adjusted}$ values increased (from 0.53 to 0.66).

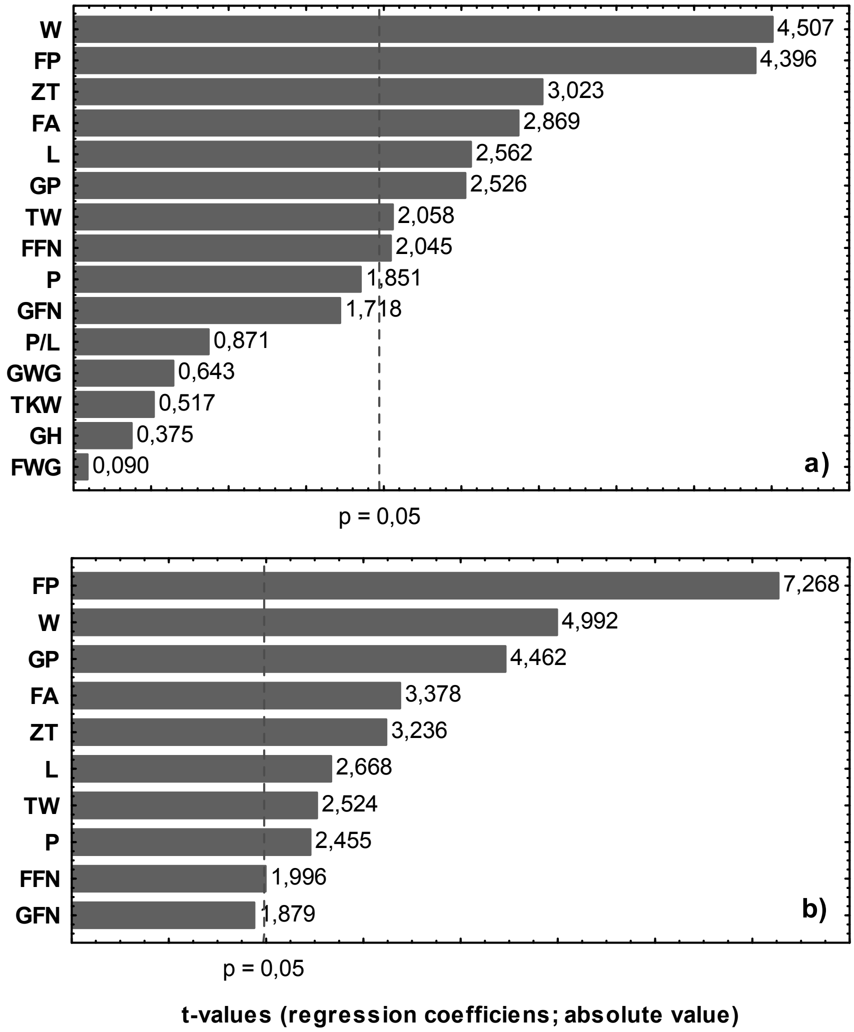

Fig. 5. Pareto chart of variables contribution to SBV prediction
a) general linear regression model
b) the best subgroup regression model
For abbreviations see Fig. 1

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ŠVEC, I. – HRUŠKOVÁ, M. (Vysoká škola chemicko-technologická, Ústav chemie a technologie sacharidů, Praha, Česká republika):

Modelování jakostních znaků potravinářské pšenice, pšeničné mouky a pečiva.

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Statistická analýza vzájemných vztahů znaků zrna, mlecího pokusu, mouky, těsta a pečiva byla provedena v souboru 281 vzorků pšenice a mouky, který zahrnoval jak odrůdy (201 vzorků), tak komerční pšenici (80 vzorků). Dílčí soubory byly shromážděny v letech 2003–2006 ze tří výzkumných pracovišť, komerčního mlýna a maloobchodní sítě (soubory *S1–S4*). Skupina *S5* „*Pšenice*“ byla vytvořena sloučením odrůdových a komerčních vzorků, zahrnovala tedy 281 členů. K hodnocení jakosti potravinářské pšenice/mouky byl využit komplexní rozbor kvality potravinářské pšenice, zavedený v cereální laboratoři VŠCHT Praha. Postupně byly stanoveny vlastnosti a analytické parametry zrna (OH, HTZ, tvrdost zrna; obsah popela, mokrého lepku a bílkovin, Zelenyho test, číslo poklesu), bylo provedeno pokusné mletí (výtěžnost krupic, luštitelnost krupic, výtěžnost mouk) a hodnocení vlastností mouky (obsah popela, mokrého lepku a bílkovin, Zelenyho test, číslo poklesu; alveografický test – pružnost, tažnost, poměr, energie). Byl rovněž proveden pekařský pokus, během něhož byla stanovena vaznost mouky, objem a tvar pečiva a penetrace střídy a byl zhodnocen senzorický profil pekařského výrobku. Korelační a regresní analýza na hladině P = 99 %, resp. 95 % byla vypočtena v programu Statistica 7.1 a pro grafické porovnání výsledků byl použit MS Excel.

Porovnáním korelačních matic dílčích souborů se pro všech 34 jakostních a technologických znaků potvrdil vliv lokality pěstování. Tento závěr potvrzují práce autorů Souza et al. (2004), Konopka et al. (2004) a Zhao et al. (1999). Statistická analýza v souboru *Pšenice* potvrdila známé vazby mezi množstvím a kvalitou bílkovin jak pro zrno, tak pro mouku a viskoelastické vlastnosti nefermentovaného těsta. Alveografická energie významně korelovala s obsahem bílkovin jak v zrnu, tak v mouce a také se Zelenyho testem (r = 0,37; 0,64 a 0,43). Měrný objem pečiva byl ovlivněn obsahem bílkovin a jejich kvalitou podle Zelenyho (r = 0,19, 0,26 a 0,23), ale pro nesourodost souboru nebyla prokázána vazba s výsledky alveografického testu. V dílčích souborech však byla tato logická souvislost mezi výsledkem pekařského pokusu a alveografickou pružností a tažností prostřednictvím korelací potvrzena statisticky. Korelační analýza v souboru *Pšenice* potvrdila význam znaku měrný objem pečiva pro posouzení pekařské kvality pšenice, neboť s ním korelovala polovina sledovaných znaků. Podrobnější popis kvality pekařského výrobku oprávněně zahrnuje také měření penetrace střídy, která s ostatními znaky korelovala v 75 % případů.

Predikci měrného objemu pečiva regresní analýzou z 15 jakostních a technologických znaků zrna a mouky lze v souboru 281 vzorků pro vyšší rozptyl dat považovat za orientační, a to v případě jak obecného regresního modelu, tak metody nejlepší podskupiny – koeficienty determinace R^2 dosáhly hodnot 0,37 a 0,38. Vysvětlení lze hledat v rozdílné skladbě testovaných dílčích souborů, kde bylo zjištěno R^2 vyšší (od 0,53 do 0,66).

kvalita pšenice; korelační analýza, lineární regrese; viskoelastické chování; pekařský pokus

Contact Address:

Ing. Ivan Švec, Ph.D., Vysoká škola chemicko-technologická, Ústav chemie a technologie sacharidů, Technická 5, 166 28 Praha 6, Česká republika, tel.: +420 220 443 206, e-mail: Ivan.Svec@vscht.cz