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CULTIVAR SPECIFIC RESPONSE OF BREAD MAKING PARAMETERS TO GRAIN PROTEIN CONCENTRATION

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ABSTRACT

Samples of seven winter wheat cultivars, grown in several environments contrasting in N availability in 2013-2015, were analysed for grain protein concentration (by Perten Infrared analyser), and for two bread-making parameters estimated by Reomixer. Differences between cultivars in the response of bread volume and dough strength to grain protein concentration, as measured by the slope (b) of the linear regression were significant when tested against the variance of interaction Cultivars*Years. The regression coefficients (b) were not significantly correlated with the average values of the quality parameter (with the exception of the correlation between peakheight and the slope of its regression on protein concentration, which was significant in one of three years). This suggests that breeding for ensuring suitable bread-making quality with relatively lower protein content of the grain, based on studying the regression of bread-making parameters on grain protein concentration, might be feasible.

Key words: bread volume, dough strength, protein content,

INTRODUCTION

It is known that "loaf volume is a function of both quantity and quality of flour proteins", and that "loaf volume increases with increasing protein content within a cultivar" (Finney and Barmore, 1948; Finney et al., 1987). This makes grain protein concentration of wheat a basic requirement of the industry and consequently of traders.

Increasing grain protein concentration can be easily obtained by increased Nitrogen fertilization, especially by late applications. However, large N fertilizer applications can be expensive and can have negative environmental effects. High grain protein concentrations are difficult to obtain under organic agriculture practices, and the negative correlation between yield and grain protein content is an impediment in obtaining high yields of suitable protein content.

This research was aimed at detecting possible differences between cultivars in the relationship between grain protein concentration and bread-making properties.

MATERIAL AND METHODS

Samples of seven winter wheat cultivars, grown in 10 environments in 2013, 13 environments in 2014 and 4 environments in 2015, were analysed for grain protein concentration (by Perten Infrared analyser), and for two bread-making parameters estimated by Reomixer (estimated bread volume as a synthetic parameter of bread-making quality and Peakheight - as a measure of dough strength). The environments were contrasting in N availability due to contrasting N fertilization, soil type and different weather conditions.

RESULTS

Protein concentration averaged over all 7 studied cultivars varied among environments from 11.8 and 14.8% in 2013, from 10.2 to 15.8% in 2014, and from 11.6 to 13.0% in 2015. This large variation allowed examining the response of the two studied parameters of bread-making quality to the variation of grain protein concentration in the 7 cultivars, by calculating the slopes of

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regression of bread volume, and dough strength respectively, on grain protein content.

On average over the 7 studied cultivars, the grain protein concentration strongly influenced both the estimated bread volume and peakheight, especially in 2014 and 2015 (Table 1).

Table 1. Overall relationship between grain protein concentration and bread-making parameters, averaged over all cultivars

Year	Estimated Bread Volume		Reomixer Peakheight	
	R Square	b	R Square	b
2013	0.38	95.6±43.6	0.25	0.45±0.27
2014	0.96	104.7±6.2	0.96	0.54±0.03
2015	0.98	124.2±11.4	0.98	0.65±0.05

However, large differences between cultivars were observed when calculating the regression coefficients for each individual cultivar. For example, estimated bread volume increased in 2013 by 135 cm^3 per percent of grain protein increase in cultivar Otilia, and by only 54 cm^3 in cultivar Pajura (Table 2). The difference between the two contrasting cultivars was from 120 to 94 cm^3 in 2014, from 187 to 84 cm^3 in 2015, and from 148 to 77 on average for the three years.

Although standard errors of the regression coefficients are high, mainly because of the relatively small number of environments in which cultivars were compared, testing the variance due to cultivars against the variance of interaction Cultivars*Years suggests that differences between cultivars in the response of bread volume to grain protein concentration are significant (Table 3).

Table 2. Individual cultivars slopes of the regression of bread volume (estimated by Reomixer), on grain protein concentration

Cultivar	Regression coefficients (b)			
	2013	2014	2015	Average
Pajura	54.1±53.8	93.6±8.0	84.3±35.1	77.32
Pitar	86.4±47.3	98.1±10.7	79.8±31.4	88.09
Glosa	103.9±33.5	89.7±12.4	100.1±21.4	97.91
Litera	87.1±43.7	119.6±9.7	100.8±21.7	102.49
Izvor	100.7±49.5	102.3±13.1	166.5±62.0	123.17
Delabrad	113.7±40.1	109.3±11.4	153.7±25.6	125.58
Otilia	135.7±51.4	120.0±8.2	187.2±31.4	147.65

Table 3. ANOVA for the regression coefficients of the relationship between bread volume (estimated by Reomixer) and grain protein concentration

Source of variation	SS	df	MS	F	P-value	F crit
Cultivars	10718.75	6	1786.46	3.995*	0.0197	2.996
Years	2788.61	2	1394.31	3.117	0.0812	3.885
IA	5366.53	12	447.21			
Total	18873.89	20				

A similar situation was found by analysing the regressions of dough strength, estimated by the peakheight measured by Reomixer, on grain protein concentration. Peakheight increased in 2013 by 0.68 per percent of grain protein increase in cultivar Otilia, and by only 0.21 in cultivar Pajura (Table 4).

In 2014, the difference between these two cultivars was smaller, but the maximum value of 0.65, found in cultivar Litera, was much larger than 0.45 found in cultivar Glosa. In 2015, the highest value of the regression coefficient (1.07) was determined in cultivar Otilia, contrasting with the value of 0.35 found in cultivar Pitar. On average, the highest response of peakheight to the grain protein concentration was found in Otilia (0.73), and the lowest in cultivar Pajura (0.34).

Table 4. Individual cultivars slopes of the regression of dough strength (Reomixer peakheight) on grain protein concentration

Cultivar	Regression coefficients (b)			
	2013	2014	2015	Average
Pajura	0.21±0.34	0.46±0.06	0.47±0.24	0.34
Pitar	0.36±0.29	0.50±0.06	0.35±0.16	0.44
Glosa	0.48±0.21	0.45±0.08	0.58±0.15	0.52
Litera	0.37±0.28	0.65±0.06	0.63±0.10	0.53
Izvor	0.52±0.29	0.51±0.10	0.70±0.31	0.56
Delabrad	0.61±0.26	0.54±0.07	0.64±0.24	0.62
Otilia	0.68±0.32	0.49±0.04	1.03±0.27	0.73

Despite this, year to year variation in the classification of cultivars, testing the variance due to cultivars against the variance of interaction Cultivars * Years suggests that differences between cultivars in the response of dough strength to grain protein concentration are significant (Table 5).

Table 5. ANOVA for the regression coefficients of the relationship between dough strength (Reomixer peakheight) and grain protein concentration

Source of variation	SS	df	MS	F	P-value	F crit
Cultivars	0.279	6	0.0466	3.201*	0.0409	2.996
Years	0.102	2	0.0511	3.512	0.0630	3.885
IA	0.174	12	0.0145			
Total	0.555	20				

DISCUSSION

It is known that dough strength and bread-making performance can be improved without increasing grain protein levels, mainly by manipulating the alleles of low and high molecular-weight glutenins (Luo et al., 2001). Our results suggest that the strength of the relationship between grain protein concentration and both bread volume and peak height estimated by Reomixer, differed among cultivars, despite the fact that all analysed cultivars had the same HMW fractions (namely 2*, 7+9 and 5+10). On the other hand, "although HMW subunits are the main determinants of glutenin elasticity relationships between other gluten proteins and functional properties have also been reported" (Shewry, 2009).

„Results of dough testing with blends of constant glutenin-to-gliadin ratio showed increases in the mixing time, mixograph peak resistance, maximum resistance to extension, extensibility, and loaf volume as the protein content increased" (Uthayakumaran et al., 1999). But, according to Pechanek et al. (1997), the effect of increased protein content on gliadin to glutenin (gli-glu) ratio is inconsistent and varies among cultivars. This is an additional mechanism that might be exploited to breed cultivars where the effect of reduced grain protein concentration on bread-making quality could be weaker.

The correlation between the average value of estimated bread volume and the slope of its regression on grain protein concentration was not significant, suggesting that breeding for increased average values of bread volume could not weaken the dependence on protein content. The correlation between peakheight and the slope of its regression on protein concentration was significant in only one of three years (Table 6).

Table 6. Correlation coefficients between average values of bread-making properties and the slopes of their regression on grain protein concentration

Year	Correlation between	
	Average value of bread volume and the slope (b) of regression of bread volume on protein concentration	Average value of peakheight and the slope (b) of regre-ssion of peakheight on protein concentration
2013	- 0.20 n.s.	0.39 n.s.
2014	0.14 n.s.	0.50 n.s.
2015	0.69 n.s.	0.93**

CONCLUSIONS

Differences between wheat cultivars in the response of bread volume and dough strength to grain protein concentration were significant when tested against cultivar*years interaction.

This suggests a possible breeding objective for ensuring suitable bread-making quality with relatively lower protein content of the grain, based on studying the regression of bread-making parameters on grain protein concentration.

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