A Brief Review of a Nearly Half a Century Wheat Quality Breeding in Bulgaria

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1. Introduction

Wheat quality is a complex feature determined by the level of various indices and dependent on a number of factors. It is defined by different interactions involving glutenin and gliadin composition and abiotic stresses. The efforts of the wheat breeders are directed towards combining a high level of the indices in the new varieties with a stable expression of these indices in different years and environments.

The aim of this chapter is 1) to describe the glutenin and gliadin composition of Bulgarian winter bread wheat varieties, bred since the middle of 20th century; 2) to asses the quality indices of wheat varieties; to compare the differences between wheat quality groups as well as the different period of creating the varieties; 3) to determine the level of influence of various environmental factors on the quality indices of wheat; to follow the response of common winter wheat varieties to various combinations of growing conditions; to study the ability of the varieties to realize their genetic potential for quality under certain environments.

2. Genetic diversity of Bulgarian winter wheat varieties in relation to glutenin and gliadin compositions

Wheat storage proteins (gliadins and glutenins) are the main components of gluten which is the major determinant of end use quality. Glutenin proteins are divided into two groups: High and Low Molecular Weight Glutenin Subunits (HMW-GS and LMW-GS, respectively). HMW-GS are encoded by two type of genes (x and y) that are located on three loci (Glu-A1, Glu-B1 and Glu-D1) placed on the long arm of the group 1 chromosomes (Lawrence & Shepherd, 1981). LMW-GS are classically divided into B, C and D groups on the basis of molecular weight and isoelectric point (Jackson et al., 1983). They are coded by gene families located on the short arm of the group 1 chromosomes (Glu-A3, Glu-B3 and Glu-D3 loci). Gliadins are monomeric proteins and they are classified as α-, β-, γ- and ω-gliadins. Most of the α/ β-gliadins are encoded at the Gli-2 loci, located on the short arms of chromosomes 6A, 6B and 6D. Most of γ- and ω-gliadins are encoded at the Gli-1 loci, located on the short arms of chromosomes 1A, 1B and 1D (Masci et al., 2002). It has been reported a close linkage between the Glu-3 loci encoding LMW-GS and the Gli-1 loci for gliadins (Sing and Shepherd, 1988).

The bread making characteristics of wheat flour are closely related to the elasticity and extensibility of the gluten proteins. The seed storage proteins are associated with agriculturally significant traits and they are used in a legal protection of cultivars (Knoblochova & Galova, 2000). Many studies have been made in order to investigate the genetic diversity of the initial material (Atanasova et al., 2009b; Bradova, 2008; Bushehri et al., 2006; Li et al., 2005; Tabasum et al., 2011; Tohver, 2007; Tsenov et al., 2009).

Bulgarian wheat varieties, especially those developed at Dobrudzha Agricultural Institute - General Toshevo (DAI), are known to have good and very good end-use quality (Atanasova et al., 2008; Panayotov et al., 2004, Todorov, 2006; Tsenov et al., 2010a). Their glutenin composition has been investigated to various degrees (Atanasova et al., 2009b; Todorov et al., 2006; Tsenov et al., 2009).

In this review eighty-nine cultivars developed at Dobrudzha Agricultural Institute (DAI) – General Toshevo, Bulgaria, during 1962–2010, and nine cultivars of the Institute of Plant and Genetic Resources (IPGR) – Sadovo, Bulgaria were investigated. Some of these cultivars were heterogeneous and their biotypes were considered as separate varieties when determining the ratio of high- and low- molecular weight glutenin and gliadin subunits and spectra. The allelic frequency in loci *Glu-1, Glu-3,* and *Gli-1* was studied and the genetic variability in each allele was calculated. The percent of observed spectra was determined by decades.

In high-molecular weight glutenins, highest variability was registered in locus *Glu-B1* (fig. 1). Five alleles were identified – *a, b, c, d, f,* which expressed subunits 7, 7+8, 7+9, 6+8 and 13+16, as well as one untypical fraction pair 6+9 which was observed in a biotype of cultivar Skitiya. Allele *c* had highest frequency (65.4%), followed by allele *b* (17.7%) and allele *d* (10.8%). Three alleles were identified in locus *Glu-A1*: *a, b, c,* expressing the respective subunits 1 (24.6%), 2* (41.5) and N (33.8%). In locus *Glu-D1* allele *a* (subunit 2+12) had frequency 27.7%, and allele *d* (subunit 5+10) - 69.2%. Biotypes with the untypical fraction pair 5+12 were observed in cultivar Levent.

In the low-molecular weight glutenins, locus *Glu-B3* had highest variability, where 7 alleles were identified – *b, d, f, g, h, i, j*, followed by locus *Glu-A3* with 5 alleles – *b, c, d, e, f* ; in locus *Glu-D3* two alleles were identified – *a* and *c*. Allele *Glu-A3c* (69.2%) had highest frequency, followed by allele *Glu-A3e* (18.5%). The other alleles had frequency less than 10 %. Allele *Glu-B3b* had frequency 47.7%, followed by *Glu-B3j* (13.8%), *Glu-B3f* – 13.1%, *Glu-B3h* – 10.0%.

The gliadin fraction composition of the investigated wheat accessions was more variable than the fraction composition of the high- and low-molecular weight glutenins. In each of all three gliadins loci 9 alleles were observed. In locus *Gli-A1* the frequency of alleles *Gli-A1b* (40.8%), *Gli-A1m* (18.5%) and *Gli-A1a* (17.7%) was highest. In locus *Gli-B1* the alleles with highest frequency were: *Gli-B1b* (47.7%), *Gli-B1l* (13.8%), *Gli-B1g* (13.1%) and *Gli-B1d* (10.0%). In locus *Gli-D1* the alleles with highest frequency were *Gli-D1b* (56.2%), *Gli-D1j* (13.1%) and *Gli-D1a* (11.5%).

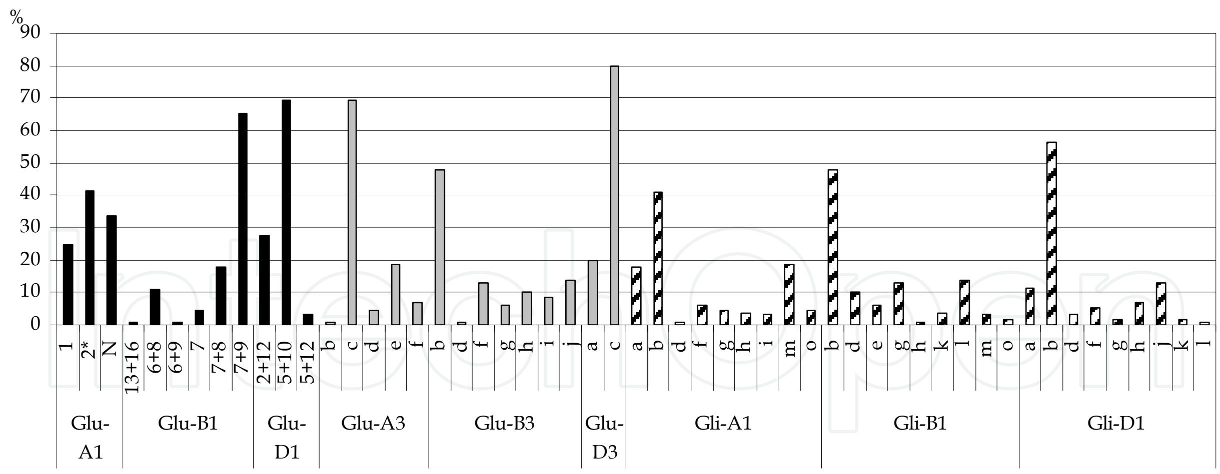


Fig. 1. The allelic frequency in loci *Glu-1*, *Glu-3*, and *Gli-1*

Twenty-four high-molecular weight, twenty-six low-molecular weight glutenin and fifty-seven gliadins spectra were identified in the investigated wheat accessions. The most frequent high-molecular weight spectra were 2* 7+9 5+10 (22.14%), N 7+9 5+10 (14.5%), 2* 7+9 2+12 (8.4%), 1 7+9 5+10 (8.4%) (table 1). Among the low-molecular weight glutenin spectra, the following had highest frequency: *c b c* (22.9%), *e b c* (12.2%), *c f c* (8.4%), *c h c* (6.9%), *c j c* (6.9%). In gliadins, most frequent were spectra *b b b* (12.2%), *m b b* (6.9%), *m b j* (6.1%).

Loci	Spectrum	%
Glu-1	2* 7+9 5+10	22.14
	N 7+9 5+10	14.5
	2* 7+9 2+12	8.4
	1 7+9 5+10	8.4
Glu-3	c b c	22.90
	e b c	12.21
	c f c	8.40
	c h c	6.9
	c j c	6.9
Gli-1	b b b	12.2
	m b b	6.9
	m b j	6.1

Table 1. The most frequent spectra in the *Glu-1*, *Glu-3* and *Gli-1* loci

The highest frequency of *Glu-1* spectra in the 70's was for N 7+9 5+10 (19.4%), 2* 7+9 2+12 (13.9%), 2* 7+9 5+10 (13.9%), N 7+9 2+12 (11.1%) (table 2). In the 80's these were 2* 7+9 5+10 (20.7%), 1 7+9 2+12 (10.3%), N 6+8 5+10 (10.3%), N 7+9 5+10 (10.3%). The most frequent in the 90's were the spectra 2* 7+9 5+10 (30.4%), N 7+9 5+10 (21.7%), 1 7+9 5+10 (17.4%), N 7+8 5+10 (13.0%). In the new century widespread were: 2* 7+9 5+10 (25.6%), 2* 7+8 5+10 (14.0%), 2* 7+9 2+12 (11.6%), 1 7+8 5+10 (9.3%), 1 7+9 5+10 (9.3%), N 7+9 5+10 (9.3%). The frequency of *Glu-3* and *Gli-1* spectra in the different decades is shown in the table.

Decade	Glu-1	Glu-3	Gli-1
70	N 7+9 5+10 (19.4)*	c b c (33.3)	b b b (14.3)
	2* 7+9 2+12 (13.9)	c i c (16.7)	a b b (5.7)
	2* 7+9 5+10 (13.9)	c h c (13.9)	g b b (5.7)
	N 7+9 2+12 (11.1)	c i a (11.1)	o b d (5.7)
	1 7+9 5+12 (5.6)	d b c (8.3)	b d b (5.7)
	N 6+8 5+10 (5.6)	c b a (2.8)	b d j (5.7)
80	2* 7+9 5+10 (20.7)	c f c (20.7)	m b b (10.3)
	1 7+9 2+12 (10.3)	e b c (17.2)	m b j (6.9)
	N 6+8 5+10 (10.3)	c h c (10.3)	b e a (6.9)
	N 7+9 5+10 (10.3)	c b c (6.9)	b g f (6.9)
	1 7 2+12 (6.9)	c f a (6.9)	I g f (6.9)
	1 7+8 5+10 (6.9)	c g a (6.9)	f l b (6.9)
	1 7+9 5+10 (6.9)	f j c (6.9)	b b a (3.45)
90	2* 7+9 5+10 (30.4)	c b c (21.7)	b b b (13.0)
	N 7+9 5+10 (21.7)	c j c (13.0)	a e b (8.7)
	1 7+9 5+10 (17.4)	c g a (8.7)	m l b (8.7)
	N 7+8 5+10 (13.0)	c g c (8.7)	a b b (4.3)
	1 7+9 2+12 (8.7)	c j a (8.7)	f b b (4.3)
	N 7+9 2+12 (8.7)	e j c (8.7)	b b g (4.3)
After 2000	2* 7+9 5+10 (25.6)	c b c (25.6)	b b b (16.3)
	2* 7+8 5+10 (14.0)	e b c (23.3)	m b b (13.95)
	2* 7+9 2+12 (11.6)	c j c (11.6)	m b j (9.3)
	1 7+8 5+10 (9.3)	c b a (7.0)	b l b (9.3)
	1 7+9 5+10 (9.3)	c f c (7.0)	g b b (4.7)
	N 7+9 5+10 (9.3)	d b c (4.7)	o b d (4.7)
	N 6+8 5+10 (4.7)	f b c (4.7)	b b h (4.7)

* - number in the parentheses indicates the percentage of frequencies

Table 2. Distribution of the most common spectra in decades

In order to improve the quality of new varieties, a narrowing of the genetic diversity was observed especially after the mass penetration of the variety Bezostaya 1 in the breeding programs after the 80's. The direct usage as a parent in the hybridization or indirectly as a participant in the pedigree of other varieties, led to unification of the spectra of new varieties with that of Bezostaya 1. It is necessary to broaden the genetic basis by including alleles with good influence over the wheat quality. Such alleles are *Glu-B1f* (subunit 13+16), *Glu-B1i* (subunit 17+18), *Glu-A3f*, *Glu-A3b*.

3. Progress in development of quality parameters of Bulgarian wheat varieties

The breeding for wheat quality started in 1962 when the first contemporary wheat breeding program in the Dobrudzha Agricultural Institute was adopted. In the two breeding centers (DAI and IPGR) 26 high quality varieties were created till now which was 1/3 of the entire variety list. During 2006 and 2008 sixty nine varieties were tested for their quality parameters. The varieties belonged to different quality groups according to Bulgarian State Standard (BSS). Based on the level of indices sedimentation value, wet glutenin content and valorimeter, varieties from this investigation were divided in three groups (table 3).

Level of indices	Varieties
	Strong wheat
sedim. > 47 WGC > 23 val. > 47	Aglika, Albena, Antitsa, Bezostaya 1, Goritsa, Ideal, Iveta, Laska, Lazarka, Merilin, Milena, Miziya, Pobeda, Slavyanka 196, Zlatina
	Medium wheat
sedim. 38 - 46 WGC 18 - 23 val. 40 - 47	Bolyarka, Charodeika, Enola, Karina, Liliya, Neda, Sadovo 552, Vratsa, Yanitsa, Yunak
	Weak wheat
sedim. < 38 WGC < 18 val. < 40	Antonovka, Kaliakra 2, Karat, Kristi, Petya, Pliska, Prelom, Svilena, Todora, Yantar, Zlatitsa

Table 3. Grouping of varieties according to the level of sedimentation (sedim.), wet glutenin content (WGC) and valorimeter (val.)

Some of the strong wheat varieties, according to BSS, failed to enter the first group in this investigation. Such varieties were: Demetra - with lower WGC; Preslav – with lower WGC and valorimeter; Dona – with lower sedimentation and WGC and Ludogorka and Momchil with lower levels for all three indices. A tendency in breeding of high quality varieties with low wet gluten content, even in comparison to medium and low-quality varieties, has been reported by Atanasova et al. (2010), Panayotov & Rachinsky (2002). One of the reasons for this is the use of Russian and Ukrainian sources in the breeding programs for wheat quality improvement. These sources have high quality of gluten but in lower amounts.

Wheat varieties, belonging to second group by BSS, in this investigation showed level of indices for the first group. With higher level of all three indices were varieties Bozhana and Stoyana. With higher sedimentation and valorimeter were Slaveya and Venka 1. Varieties Galateya, Prostor, Zagore had higher WGC and valorimeter value. Some varieties from third

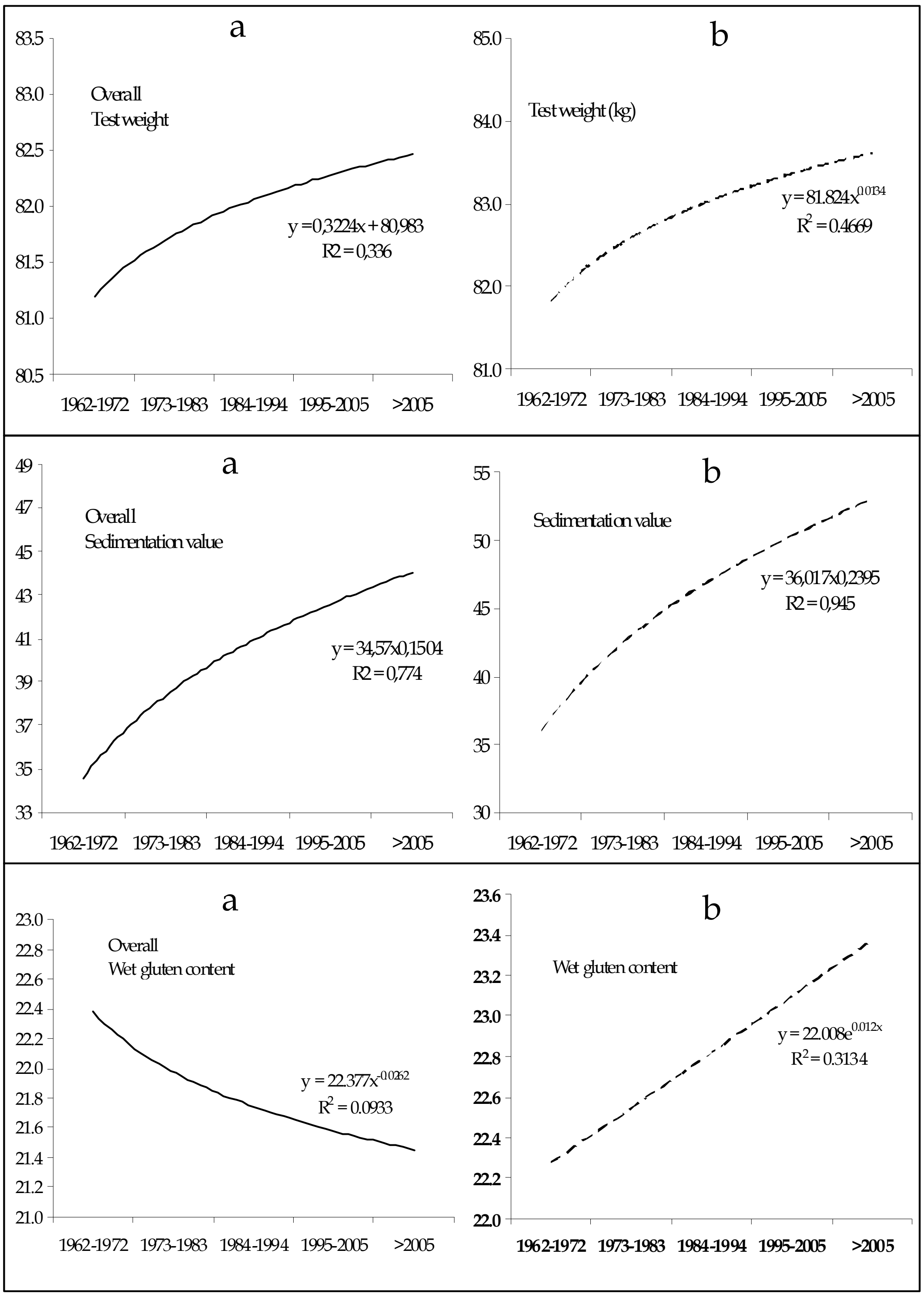


Fig. 2. Changes of quality indices by decades for the entire group (a) and for the quality group (b) of wheat varieties

group by BSS, also, showed higher level of some of the indices. For example varieties Trakiya and Ogosta had higher level of valorimeter value. Variety Pryaspa had higher WGC and varieties Charodeika and N 100-10 had higher level of the two indices. Similar discrepancies in the level of indices were observed in other investigations (Atanasova et al., 2009a; Atanasova et al., 2010). This demonstrates the complex nature of the wheat quality, which is affected not only by genotype but by environments as well.

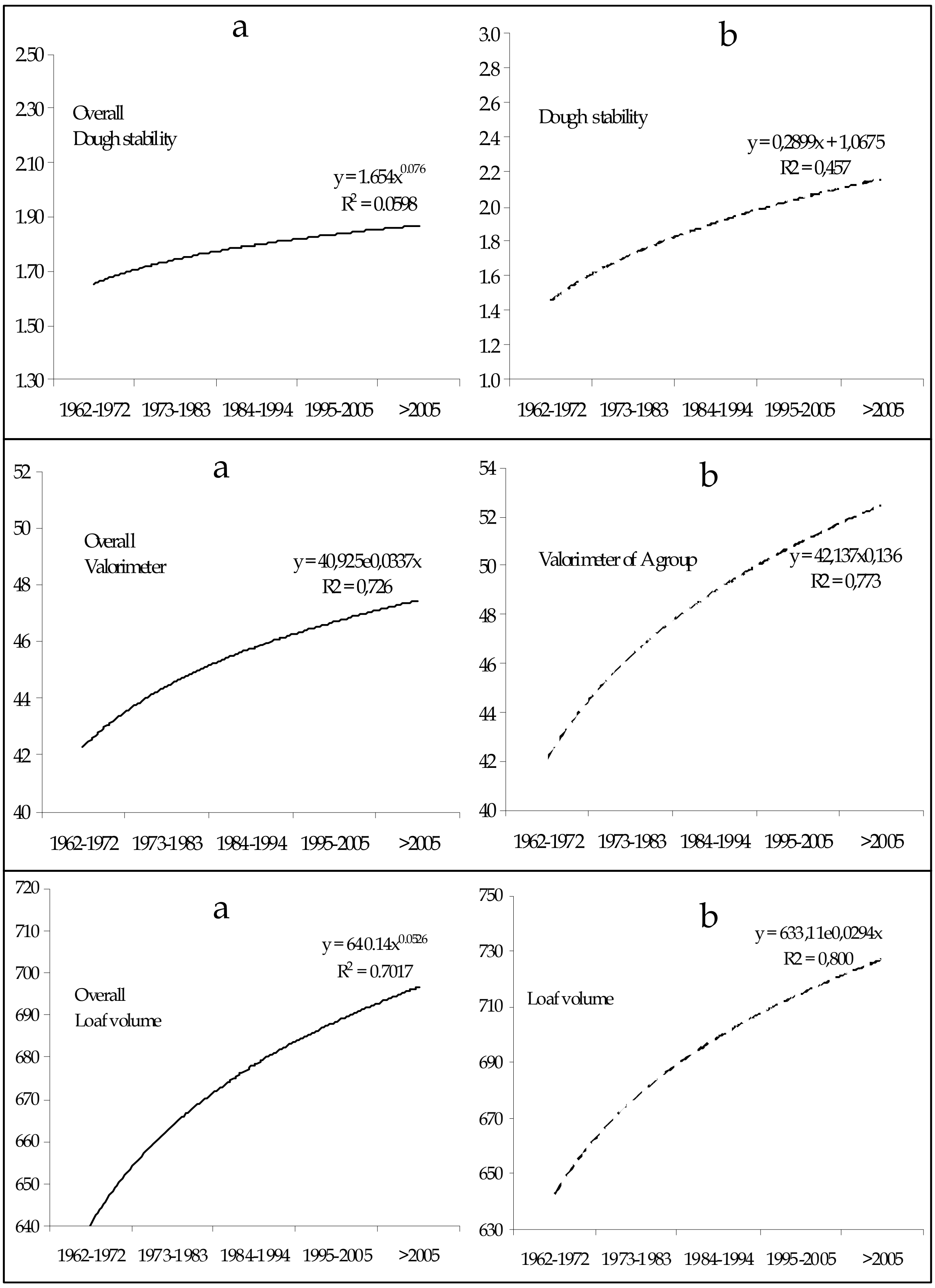


Fig. 2. Continue

As a result of breeding a progress was determined in almost all the indices defining end-use quality in wheat. The breeding periods were divided into decades as follows: 1962-1972; 1973-1983; 1984-1994; 1995-2005 and after 2005. The average values of the whole group of sixty-nine wheat varieties and that of the high-quality group were compared. The most strongly modification was observed for the indices: dough stability, where the enlargement was 24% for the entire group and 60% for the quality group; sedimentation value – 26%for whole group and 44% for quality group (figure 2). For the indices valorimeter and loaf volume a high level had been reached which changed very slowly through the years. The group of quality wheat varieties had greater progress compared to the all varieties regardless of the quality index and its behavior. It was valid even to the indices for which the breeding progress was not statistically proven.

4. Evaluation of genotype, environment and their interaction for quality parameters of Bulgarian varieties

The complex nature of wheat quality is determined by the level of various indices and dependent on a number of factors. One of the problems of breeding for quality is not only achieving a high level of the indices in the new varieties, but also achieving a stable expression of these indices in different years and environments (Atanasova et al., 2008; Johansson et al., 2001; Williams et al., 2008). It is valuable for breeding to determine the nature and direction of the effects of different genetic and environmental factors on the specific quality indices (Hristov et al., 2010; Panozzo & Eagles, 2000; Tsenov et al., 2004), and to study the performance of the varieties under changeable growing conditions. This would allow predicting to some degree their response to certain combinations of environmental factors (Atanasova et al., 2010; Drezner et al., 2006; Yong et al., 2004). The variation of the quality indices when growing each individual variety under different environments is always helpful both for the distribution of the new varieties and for their improvement in breeding programs (Gomez-Becera et al., 2010). The data on the variation of winter wheat quality is contradictable with regard to the level of genotype effect (Gomez-Beccera et al., 2010; Williams et al., 2008). In breeding there is always the question whether the high quality of a given variety under favorable environments is a prerequisite for the realization of its high-quality potential under unfavorable environments, too, or is it and impediment for its stability (Hristov et al., 2010; Tsenov et al., 2004).

Sixteen Bulgarian winter wheat varieties from first and second quality group according to BSS were tested at two locations: Dobrudzha Agricultural Institute – General Toshevo (DAI) and Institute of Agriculture and Seed Science, Obraztsov Chiflik, Rouse (OCH) during 2004–2007. The expression of 5 grain quality indices which give information about various quality aspects was analyzed: test weight (kg) (BSS 7971-2:2000), sedimentation value of flour (ml) (Pumpyanskii, 1971), wet gluten content in grain (%) (BSS 13375-88), valorimeric value (valorimeter, conditional units) (BSS 16759-88), and loaf volume, determined according to the methods adopted at the DAI laboratory.

The effect of the location was highest on wet gluten content and valorimeric value (table 4). The traits test weight and loaf volume were affected most by the year conditions. The distribution of the varieties into groups according to their quality had highest influence on the expression of sedimentation. The independent influence of the genotype on the variation of most of the investigated indices was lowest. Atanasova et al. (2008) and Zhang et al.

(2005) have found out that the genotype had higher effect on the expression of sedimentation, while Drezner et al. (2006, 2007), Panozzo and Eagles (2000), Tsenov et al. (2004) have proved that the environment has greater effect on the quality indices of wheat. Among the various combinations between the factors, the interaction *quality group x genotype* had the highest effect on almost all investigated traits. The exception was wet gluten content, which was affected most by the interaction *location x year*. Hristov et al. (2010), Mladenov et al. (2001), Williams et al. (2008) have found out that in spite of the significant effect of the interaction *genotype x environment* on the expression of the quality parameters of wheat, this effect was less significant than the independent influences of the genotype and the location.

Source of variation	TW	SDS	WGC	Val	Lvol
Main effects					
A: Location	161.1***	1250.0***	170.4***	1058.0***	43512.5***
B: Year	205.5***	876.6***	91.6***	173.0***	72179.4***
C: Group	76.3***	2032.0***	7.9 ns	666.1***	39903.1***
D: Genotype	11.2***	28.9**	22.2***	48.7**	3868.2***
Interactions					
A x B	4.7***	94.6***	76.1***	8.4ns	703.6ns
A x C	7.3***	101.5***	17.3**	63.3**	2032.0ns
A x D	1.1*	4.0ns	1.5 ns	13.5ns	942.4ns
B x C	0.3ns	15.6ns	13.0**	26.4*	3650.5***
B x D	0.4ns	21.5**	5.3ns	9.0ns	2273.9***
C x D	17.4***	172.7***	13.2**	157.4***	11036.6***

**P*<0.1; ***P*<0.05; ****P*<0.01; *ns*-not significant

Table 4. Analysis of variance for mean squares of 16 wheat varieties

The growing conditions at DAI were more favorable for expressing genetic potential of wheat varieties as it is revealed by mean values of the indices (table 5). It is logical to expect higher values for the indices of the varieties from the first quality group. The results from the variance analysis were once again confirmed; the values for wet gluten content were not significant and there were no considerable differences between the two quality groups.

It is difficult in breeding for wheat quality to develop varieties with high quality indices, which remain stable under various growing conditions (Atanasova et al., 2008; Johansson et al., 2001; Williams et al., 2008). According to Finlay & Wilkinson (1963), Sudaric et al. (2006) genotypes with coefficient of regression (b_i) under 0.7 were considered unresponsive to changeable environments; with b_i between 0.7 and 1.3 had average stability; and >1.3 were considered responsive to good environments. Most of the varieties involved in this investigation have moderate stability for all the indices with some exceptions (table 6). There wasn't any regularity in manifestation of the stability. For some traits varieties showed stable reaction as b_i was near 1.0. For other traits varieties were specifically adapted to growing in unfavorable environments as b_i was below 0.7. For example variety Enola was with stable reaction for test weight, sedimentation value, WGC (b_i was 1.01, 1.15, 1.08, respectively) and with b_i=0.598 for loaf volume.

Factors	TW	SDS	WGC	Val	Lvol
Location					
DAI	81,2^{b}	39,4^{b}	21,6^{b}	43,7^{b}	673,8^{b}
OCH	78,9^{a}	33,1^{a}	19,3^{a}	38^{a}	636,9^{a}
Year					
2004	81,5^{c}	36,5^{b}	20,0^{a}	42,4^{b}	641,1^{a}
2005	76,5^{a}	43,4^{c}	22,4^{b}	41,8^{b}	725,6^{b}
2006	80,2^{b}	31,3^{a}	18,4^{a}	41,7^{b}	633,1^{a}
2007	82,2^{c}	33,8^{ab}	21,0^{ab}	37,4^{a}	621,7^{a}
Group of quality					
I-group	80,8^{b}	40,2^{b}	20,7^{a}	43,1^{b}	673,0^{b}
II-group	79,3^{a}	32,3^{a}	20,2^{a}	38,5^{a}	637,7^{a}

Numbers with different letters differ significantly

Table 5. Mean values of the investigated traits according to different factors of variation

The valorimeric value is an index which determines gluten quality and which correlates strongly with end-use quality. Most of the investigated varieties possess moderate stability (b_i from 0.7 to 1.3) with regard to this trait. Varieties Milena and Aglika (b_i = 1.00 and b_i = 1.25, respectively) from first quality group were an evidence that high values of the traits can be observed in stable genotypes, too (Hristov et al., 2010; Mladenov et al., 2001; Sudaric et al., 2006) and that stability is not necessarily related to low mean values, as previously stated (Becker and Leon, 1988). The ecovalence values of the individual varieties for this trait were very high, which brings forth the strong effect of the environment. The variation expressed through the ecovalence was much lower in the wheat varieties from the second group in comparison to the varieties from the first group (56.8 and 99.6, respectively) (table 6).

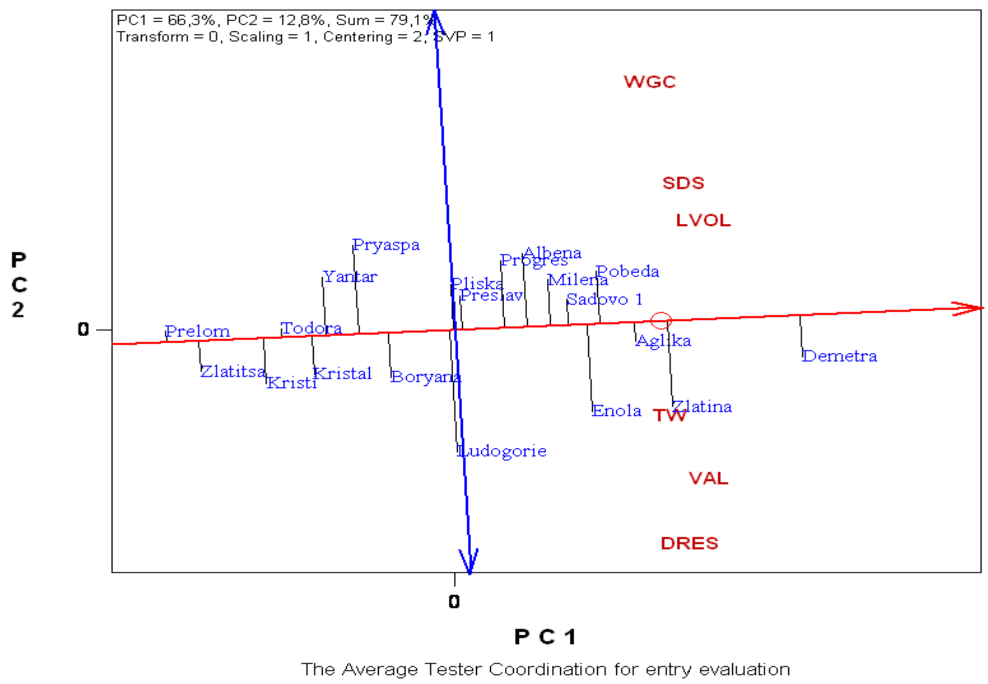
A number of researchers have found out that the varieties with lower quality potential are considerably more stable, especially under stress (Atanasova et al., 2010; Tsenov et al., 2004). The values of the regression coefficient of the separate groups are quite indicative in this respect. The regression coefficient in the first group was above 1.0. This means that that the varieties from this group realized their quality potential under conditions more favorable for its formation. Therefore the W_i values of variety Zlatina, which is a quality variety, were several times higher than the mean values for this group. On the other hand, varieties like Aglika, Milena and Preslav demonstrated considerably lower variation of their quality indices in comparison to the other varieties from the group. It can be suggested that such stability is due to the fact that the absolute values of the indices in this case were low. These data once again prove that when comparing the response of the varieties to the environment with regard to their quality, conclusions should be made very carefully. The results for the individual varieties and their indices are not unidirectional and therefore when selecting a variety for mass production it is necessary to consider the purpose for its cultivation, the potential of the given variety and its ability to realize this potential with stability and adequacy.

Variety	Test weight		Sedimentation		Wet gluten content		Valorimetric value		Loaf volume	
	bi	Wi	bi	Wi	bi	Wi	bi	Wi	bi	Wi
Igroup										
Pobeda	1.09	2.75	0.84	8.48	1.174	21.2	1.552	121.2	1.300	7.04
Albena	0.92	1.85	1.29	15.4	0.854	12.2	1.020	59.67	0.650	9.67
Preslav	1.05	2.73	1.43	8.01	1.226	9.37	0.648	26.26	1.015	10.59
Milena	1.07	1.54	0.91	10.7	1.219	36.5	1.000	21.33	0.834	4.56
Aglika	1.26	6.24	1.01	18.2	1.022	10.5	1.251	89.42	1.166	12.45
Progres	1.40	9.48	1.28	6.39	0.656	36.7	0.700	42.86	1.283	9.32
Zlatina	1.10	2.40	1.11	10.2	0.800	23.1	1.855	274.2	1.350	12.36
Demetra	0.95	3.16	1.62	22.3	1.709	40.4	0.754	162	0.987	2.46
Average	1.104	3.77	1.186	12.46	1.080	23.72	1.100	99.62	1.073	8.56
II group										
Sadovo 1	1.3	5.24	1.21	5.52	1.154	14.5	1.331	133.1	1.303	5.45
Enola	1.01	3.53	1.15	16.3	1.078	82.6	0.963	86.11	0.598	11.00
Pliska	1.13	2.24	1.20	11.5	0.645	47.0	0.814	14.58	1.019	4.22
Pryaspa	1.07	3.00	0.88	5.33	1.229	14.3	0.912	23.51	0.905	10.67
Yantar	0.4	25.8	0.65	6.46	0.860	15.4	0.658	41.83	0.909	2.72
Kristi	0.61	8.35	0.75	5.86	0.900	25.6	0.736	70.67	0.789	8.09
Prelom	0.85	3.05	0.85	9.18	0.671	19.3	0.648	28.39	0.960	11.77
Boryana	1.19	3.52	0.69	2.88	0.803	86.6	1.158	56.17	1.198	8.69
Average	0.944	6.84	0.923	7.88	0.920	38.16	0.900	56.79	0.960	7.83

Table 6. Stability parameters of varieties from different quality groups

When compare the mean values of varieties with their stability it can be seen that for the conditions of DAI varieties Demetra, Zlatina, Aglika differ from the total group with higher levels of the indices (figure 3). For the other location (OCH) these varieties were Demetra, Enola, Aglika. The most poorly performing variety for the two locations was Prelom.

Projection to the ordinate of the two-dimensional matrix genotype x character, regardless of the direction, determines the stability of the varieties (Yan et al., 2007). For the conditions of DAI as most stable and exceeding the mean level were varieties Aglika, Sadovo 1, Preslav, Demetra. Varieties Milena and Preslav had most stable reaction at OCH location as they had almost null projection to the ordinate. Under the same conditions with high variability stand out varieties Enola and Pliska.



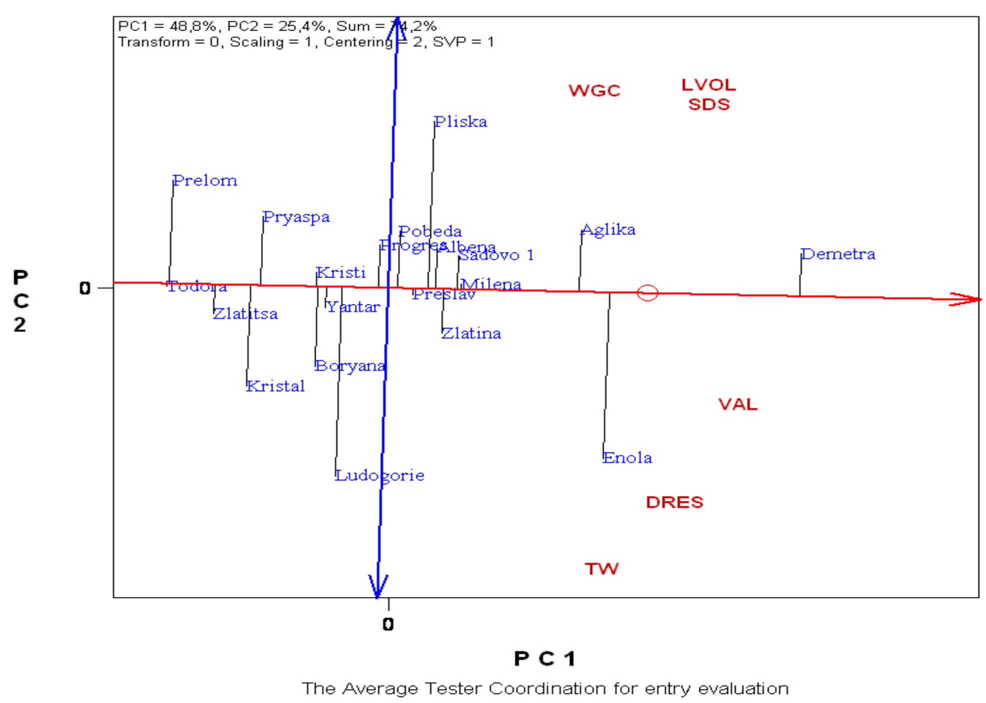


Fig. 3. Comparison between mean values of the varieties and their stability for investigated indices for conditions of DAI (up) and OCH (down)

Another investigation was carried out during 2001-2003 with 10 varieties with different quality in two typical for grain production in Bulgaria regions – Dobrudzha Agricultural Institute (DAI) in North-East Bulgaria and Chirpan in South Bulgaria. Data presentation by Principal Component Analysis (PCA) allows more comprehensive explanation of the variation of quality indices of studied varieties in the two locations (Stoeva et al., 2006). There was a similar component structure of the factors which mainly influence the variation of the quality over locations. About 65% of the total variation of the two-dimensional matrix variety x character for each location is for first and second PC. The biggest part is for PC1 (table 7).

Indices	DAI		Chirpan	
	PC1	PC2	PC1	PC2
Test weight, kg	0.647	-0.385	0.587	0.395
Vitreousness, %	0.603	-0.459	0.358	0.845
Endosperm hardiness, %	0.835*	-0.258	0.674	0.678
Wet gluten content, %	0.493	0.421	0.325	-0.361
Sedimentation value, ml	0.910**	0.206	0.916**	-2,362
Dough stability, min	0.805*	1,841	0.971**	-2,149
Valorimeric value,	0.922**	2,983	0.990**	-2,017
Bread loaf, ml	0.778*	0.181	0.742*	-0.505

Table 7. Correlation between quality indices, PC1 and PC2 over locations

Indices endosperm hardiness, sedimentation value, dough stability, valorimeter and bread loaf were determinative for the quality of the studied varieties in DAI as the levels of the PC1 were positive and higher than 0.700. For the other location (Chirpan) these were sedimentation value, dough stability, valorimeter and bread loaf.

Varieties from this investigation had different reaction to the environment in the two locations. Varieties with lower quality such as Pryaspa, Karat, Todora showed low variability connected with not linear reaction to the environments as their PC1 and PC2 were negative (table 8). High quality varieties Aglika, MIlena, Galateya showed high stability in the two locations irrespective of the direction in the changing environments. The different sing in the reaction of varieties show that some of them react specifically to the environments. For example in poor environments some varieties managed to save higher levels of indices and vice versa.

Variety	DAI		Chirpan	
	PC1	PC2	PC1	PC2
Yantar	0.334	0.684	0.452	0.731
Pryaspa	-0.166	-0.490	-0.121	-0.395
Milena	0.722	0.764	0.801	0.884
Aglika	2.001	-0.103	1.120	0.030
Galateya	0.922	-0.386	0.793	-0.268
Albena	-0.507	0.957	-0.317	0.784
Enola	-0.080	1.130	0.009	0.922
Karat	-0.406	-0.814	-0.566	-0.753
Kristal	-1.668	0.388	-1.284	0.299
Todora	-0.493	-2.131	-0.569	-1.977

Table 8. Values of principal components of varieties

Wheat growing depends on environments although the right technologies and new varieties can manage to lower this dependence. That's why it is valuable to select varieties which give high quality in different environments.

5. Breeding of wheat quality in Bulgaria – Steps, drawbacks, prospects

Breeding of new varieties with good quality has always been on the attention of the breeding programs in Bulgaria (Boyadjieva et al., 1999; Panayotov et al., 1994; Rachinski, 1966; Stoeva & Ivanova, 2009). Combining high yield and quality in wheat is a challenge for the contemporary breeding as it is connected with many obstacles with different nature (Baenziger et al., 2001; Dencic et al., 2007; Eagles et al., 2002; Trethowan et al., 2001). Analysis of wheat quality begins with studying the initial material (Tsenov et al., 2010c). When foreign samples are received they are study for three years for a set of quality indices. Those with high levels are included in hybridization programs especially if they show high yield potential, stress tolerance, disease resistance. The basic foreign parent components for hybridization are from breeding centers with traditions and excellent achievements in breeding for wheat quality (table 9).

The quality of Bulgarian wheat varieties is based on the widespread use of variety Bezostaya 1 and other Russian and Ukraine sources (Panayotov & Kostov, 2007; Todorov et al., 1998; Tsenov et al., 2010b). During the last years samples with different origin are widely used as they possess high level of productivity combined with high end-used quality. The quality analysis during the breeding process is made according the scheme described in the table 10.

The beginning of quality analysis of the breeding lines is in the screening nursery. The main tests in this unit are sedimentation value of the flour and grain protein content. Quality index of each line and quality standard varieties is calculated by these two parameters. These indices are defined as they possess high and positive correlation with the main parameters, connected with the strength of flour and dough (Bona et al., 2003, Dacheva & Boydjieva, 2002).

Country	Grain properties	Dough properties	Gluten properties	Bread making	End-use quality
Bulgaria	*	*	*	*	*
Romania	*		*		*
Serbia	*				*
Turkey	*		*		*
Odessa, Ukraine	*	*	*	*	*
Harkov, Ukraine	*	*		*	
Mironovka, Ukraine		*		*	*
Ktrasnodar, Russia	*	*	*		*
Nebraska, USA	*	*		*	
Oklahoma, USA	*	*		*	
Texas, USA	*	*		*	
Australia		*		*	
Canada		*		*	
Argentina	*		*		*

Table 9. Origin of the initial breeding material for wheat quality

Quality traits	Screening Nursery (SN)	Preliminary Yield Trail (PYT)	Competitive Yield Trails (CYT)
Sedimentation value	+	+	+
Grain Protein Content	+	+	+
Quality index*	+	+	+
Test weight		+	+
Farinograph characteristics			+
End-use quality			+
Bread making characteristics			+
SDS-PAGE			+

* Quality index=Sedimentation/Protein content

Table 10. Quality indices, used for breeding in the separate trial units

In the next trial units (PYT, CYT) the analysis extend and cover almost all aspects of quality of grain, flour, dough and bread. Along with this an analysis is made to determine the allelic diversity of the lines. At least three year data from CYT, which is the last level of screening of breeding materials, are needed in order to be able to assign each line in the following quality group: A – strong wheat; B – medium and C – wheat with soft endosperm (figure 4).

In the yield trails of Executive Agency of Variety Testing, Field Inspection and Seed Control (EAVTFIS) the candidate-varieties are also testing in these three groups at least 2 or 3 years. Each group has specific standards for comparison.

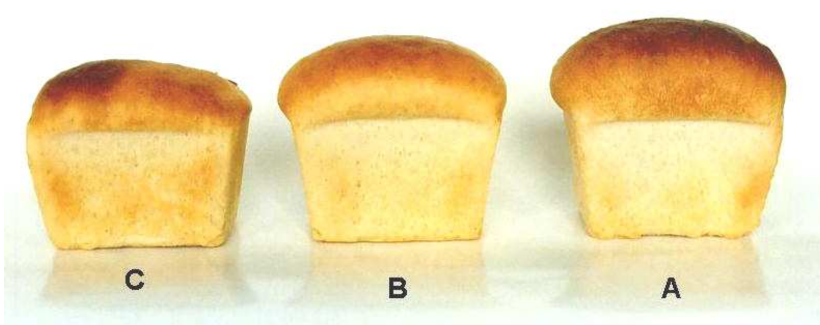


Fig. 4. Bread-making quality groups

The evaluation and selection for quality is associated with many difficulties from different nature. They can be determined as follows:

1. There is a wide genetic variation for each index caused by three genomic structure of the crop.
2. Environments have an enormous share in wheat quality formation and embarrassed the genetic expression of the varieties (Dencic et al., 2011, Tayyar, 2010).
3. Wheat quality is reduced in the presence of biotic and abiotic stress (Atanasova et al., 2010).
4. The inheritance of quality indices is complicated and polygenic (Tsenov, 1994, Tsenov et al., 1995, Tsenov & Stoeva, 1997).

5. Samples with high combining ability for quality are limited.
6. Complex genetics suggests a special selection procedure (Tsenov & Stoeva, 1998).
7. The selection in the early hybrid populations is not effective because of fading forming process and restricted amount of grain for analysis.
8. There is a lack of breeding indices for parallel selection for quality and yield potential and other parameters.

6. Conclusions

As a result of a nearly half a century breeding in Dobrudzha Agricultural Institute 26 varieties from the first quality group are created. This is nearly one third of the entire variety list. The massive usage of variety Bezostaya 1 in the breeding programs direct or indirect narrowed the genetic diversity of the materials and to some extent unified their glutenin and gliadin spectra. The efforts to include foreign initial materials in hybridization, with alleles with good influence over the wheat quality, will probably be rewarded in the near future.

A breeding progress is determined for almost all the indices, defining end-use quality in wheat. The group of high quality wheat varieties has greater progress compared to all varieties irrespective of the indices.

Different factors influence on the wheat quality and on the expression of different indices. The knowledge of the nature and direction of the effect of these factors is valuable for predicting to some extend the performance of wheat varieties in certain growing conditions. Most of the Bulgarian varieties show moderate stability at different environments. But the results for the individual varieties and their indices are not unidirectional and therefore when selecting a variety for mass production it is necessary to consider the purpose for its cultivation, the potential of the given variety and its ability to realize this potential with stability and adequacy.

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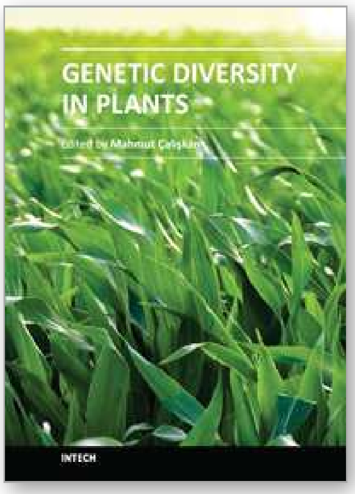

Genetic Diversity in Plants

Edited by Prof. Mahmut Caliskan

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Genetic diversity is of fundamental importance in the continuity of a species as it provides the necessary adaptation to the prevailing biotic and abiotic environmental conditions, and enables change in the genetic composition to cope with changes in the environment. Genetic Diversity in Plants presents chapters revealing the magnitude of genetic variation existing in plant populations. The increasing availability of PCR-based molecular markers allows the detailed analyses and evaluation of genetic diversity in plants and also, the detection of genes influencing economically important traits. The purpose of the book is to provide a glimpse into the dynamic process of genetic variation by presenting the thoughts of scientists who are engaged in the generation of new ideas and techniques employed for the assessment of genetic diversity, often from very different perspectives. The book should prove useful to students, researchers, and experts in the area of conservation biology, genetic diversity, and molecular biology.