GENOTYPIC AND ENVIRONMENTAL EFFECTS ON BREAD-MAKING QUALITY OF WINTER WHEAT IN ROMANIA

Mihaela Tianu, Nicolae N. Săulescu and Gheorghe Ittu

ABSTRACT

Bread-making quality was analysed in two sets of wheat samples collected from yield trials with winter wheat cultivars, including seven cultivars recommended for South Romania, grown in 11 environments (locations x years) and nine cultivars recommended for Northern Romania, grown in 8 environments. Quality indices were differentially influenced by genotype and environment. SDS sedimentation volume was least influenced by environment and genotype x environment interaction, while wet gluten content had the largest environmental influence. Despite being an index of gluten quality, gluten deformation was strongly influenced by environment. On an average across environments, all studied cultivars met the standards for baking, and only few cultivars occasionally produced flour below these standards. The best bread-making quality was found in the cultivars Dropia, Flamura 85, Rapid, Lovrin 34, Moldova 83 and Apullum.

Key words: bread-making quality, winter wheat

INTRODUCTION

Suitability of wheat for bread-making industry is largely controlled by the quantity and quality of flour proteins (Pomeranz et al., 1970; Pyler, 1983; Mailhot and Patton, 1988). There are significant genetic differences in both quantity and quality of flour proteins, but environment can also affect bread-making quality through temperature and moisture variation during the grain filling period, through nitrogen availability and through the effect of diseases and pests (Blumenthal et al., 1991; Cox et al., 1989; Typpler, 1992). Baking quality is the final result of an interaction between the genetic potential of cultivars and the environment where the cultivar was grown (Randel and Moss, 1990; Eskridge et al., 1994).

This paper is an attempt to quantify the effect of the genotype and environment on several bread-making indices in the main winter wheat cultivars grown in yield trials in Romania.

MATERIALS AND METHODS

Two sets of wheat samples from yield trials with winter wheat cultivars were analysed. The first set included seven of the most popular cultivars recommended for South Romania (Flamura 85, Fundulea 4, Dropia, Rapid, Lovrin 34, Lovrin 41 and Delia), grown in 11 environments (locations x years). The second set included nine cultivars recommended for Northern Romania (Apullum, Arieșan, Transilvania 1, Turda 81, Aniversar, Suceava 84, Moldova 83, Fundulea 4 and Flamura 85), grown in 8 environments. Agricultural practices applied in the yield trials were those recommended for each region.

Bread-making quality was estimated by the following indices:

-wet gluten content from a 70% extraction flour was washed with 2% NaCl solution, according to I.C.C. standard 137/1;

-gluten deformation index was determined according to the Romanian standard 6283/1-75;

-SDS sedimentation index was determined according to a modification of I.C.C. standard 116/1;

-a farinograph score was computed from Brabender farinograms, according to I.C.C. standard 115;

-loaf volume for 100 g flour was determined by baking bread using a simple formula including water added to a dough consistency of 500 F.U., 3.5% yeast and 1.5% salt.

Data were analyzed by ANOVA and environmental variation was estimated by computing the variation coefficient (s%).

RESULTS AND DISCUSSIONS

In the samples from Southern Romania, variation due to genotypes was similar to environmental variation for wet gluten content and gluten deformation, but considerably larger for the other quality indices, and especially for sedimentation (Table 1).

In the samples from Northern Romania, genotypic variation was only about half of that produced by environment for wet gluten content and gluten deformation, but more than two times larger for sedimentation and farino-

Table 1. ANOVA for several bread-making quality indices in samples from Southern Romania

Quality index		Source of variation		
		Environments	Genotypes	Interaction
	D.F.	10	6	60
Wet gluten content	S.S.	281.3	215.8	263.7
	M.S.	28.1	36.0	4.4
Gluten deformation	S.S.	159.7	134.1	154.0
	M.S.	16.0	22.3	2.6
Sedimentation value	S.S.	1472	7136	1035
	M.S.	147	1189	17
Loaf volume	S.S.	14950	54268	44114
	M.S.	1495	9045	735
Farinograph score	S.S.	1136	2229	779
	M.S.	126	371	14

Table 2. ANOVA for several bread-making quality indices in samples from Northern Romania

Quality index		Source of variation		
		Environments	Genotypes	Interaction
	D.F.	7	8	56
Wet gluten content	S.S.	497.0	306.6	245.6
	M.S.	71.0	38.3	4.4
Gluten deformation	S.S.	471.5	353.6	200.8
	M.S.	67.4	44.2	3.6
Sedimentation value	S.S.	1765	4532	1062
	M.S.	259	567	19
Loaf volume	S.S.	36288	45613	44778
	M.S.	5184	5702	780
Farinograph score	S.S.	314.7	865.5	833.8
	M.S.	45.0	109.2	14.9

graph score. Loaf volume was almost equally influenced by the two sources of variation (Table 2).

Variance components computed by ANOVA were expressed as percentage of total variation for each analysed quality index (Figures 1 and 2). In both sample sets and for all analysed indices, the genotype x environment interaction was significantly smaller than both genotypic and environmental variation. SDS sedimentation volume proved to be less influenced by environment and showed the smallest G x E interaction. Wet gluten content and gluten deformation were mostly influenced by environment.

These results are in agreement with the general belief that environment has a strong influence on the quantity of gluten, while gluten quality is mainly genetically controlled. Although gluten deformation reflects gluten quality it has a somewhat unexpected position, as it appears to be strongly influenced by environment.

Averaged over environments in Southern Romania, wet gluten content varied from 27.2% in Fundulea 4 to 32.7% in Lovrin 41; the minimum values found in all cultivars were superior to the present standard used by the baking industry (Table 3). This proves that, under a proper management, all recommended cultivars can easily meet the requirements regarding the gluten quantity. Environmental variation was moderately large, with coefficients of variation of 6.9-11.7%. Culti-

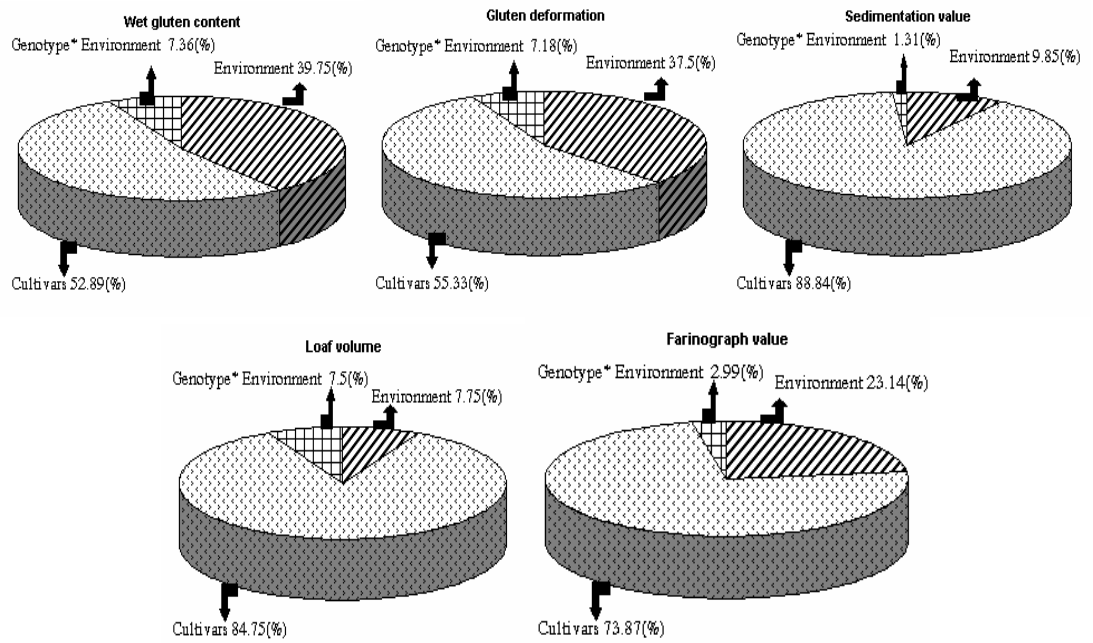

Figure 1. Percentage of total variation of several quality indices, due to genotype, environment and cultivar by environment interaction, in a set of wheat samples from Southern Romania

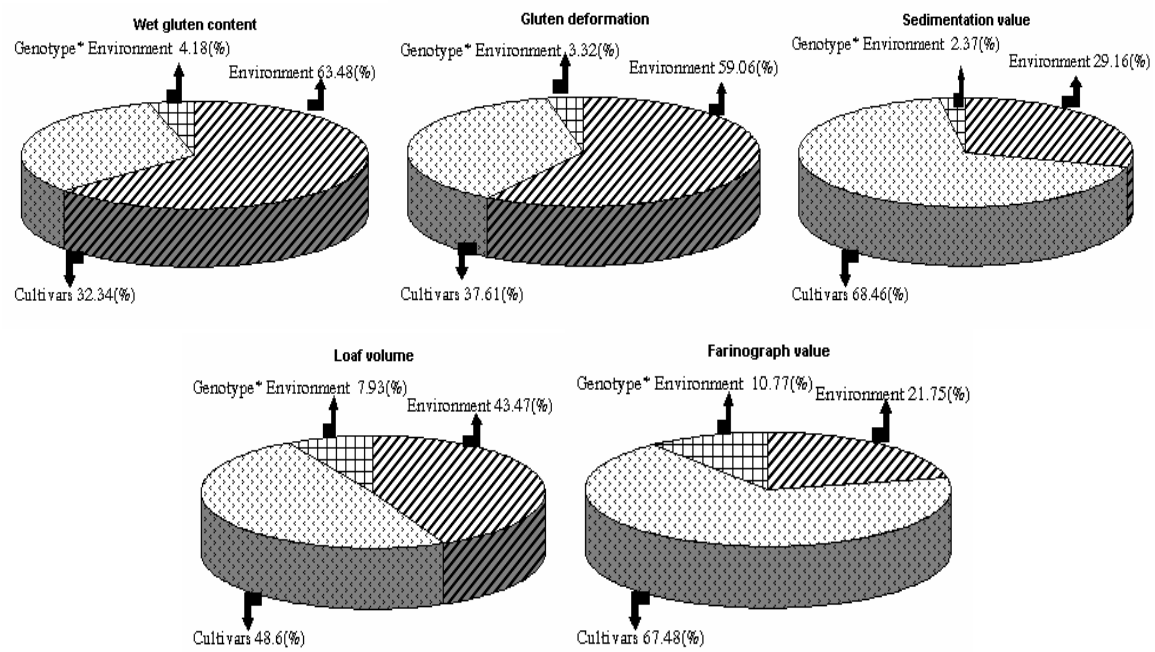

Figure 2. Percentage of total variation of several quality indices, due to genotype, environment and genotype by environment interaction, in a set of wheat samples from Northern Romania

vars Dropia and Lovrin 34 are notable for their lower variation of gluten content across environments.

Gluten deformation, averaged over environments varied from 5.6 mm in Flamura 85 to 10 mm in Lovrin 41, average values of all cultivars meeting the standard for baking (max. 13 mm). Only Lovrin 41 occasionally produced gluten with higher deformation. Environmental variation for this index was very high, as shown by coefficients of variation of 18 to 41%.

Average sedimentation values, varying from 49.9 to 76.7 ml clearly differentiated cultivars into a high quality group, with values over 60 ml (Dropia, Flamura 85, Rapid and Lovrin 34) and a medium quality group, with values from 49.9 to 55 ml (Fundulea 4, Lovrin

Table 3. Quality indices of winter wheat cultivars grown in Southern Romania

	Wet gluten %		Gluten deformation		Sedimentation value		Loaf volume		Farinograph score	
Cultivar	Avg. Min-Max	s%	Avg. Min-Max	s%	Avg. Min-Max	s%	Avg. Min-Max	s%	Avg. Min-Max	s%
Dropia	30.0 27.0-34.3	6.9	6.45 4 - 11	29.7	76.8 69.5-81	7.4	523.4 456-563	6.9	56.1 45-68	14.0
Flamura 85	30.1 24.5-32.8	9.1	5.63 3 - 8	28.9	72.3 60-81	9.6	516.7 475-560	5.4	52.0 44-62	10.9
Rapid	28.7 24.6-34	11.7	6.63 3 - 11	31.8	67.0 58-80	9.1	490.2 446-528	5.4	50.6 45-60	9.8
Lovrin 34	29.6 25.6-33.3	6.9	6.72 3 - 12	41.6	64.3 58-72.5	7.6	509.7 450-554	6.0	46.2 34-55	10.6
Fundulea 4	27.2 22.8-30.5	10.0	7.45 5 - 10	19.3	52.2 44-65	11.4	463.1 419-507	4.9	42.6 35-51	10.6
Delia	27.7 23.3-33.0	11.4	8.09 6 - 10	17.9	49.9 43-61.5	10.1	456.9 422-511	6.1	41.5 32-45	11.9
Lovrin 41	32.7 25.6-37.0	9.6	10.0 6 - 15	29.3	54.6 42-68.5	12.7	458.7 410-511	6.6	39.8 34-48	10.0
LSD for P<0.05	1.79		1.37		3.54		23.12		3.4	
Average across cultivars	29.42 26.5-32.6		7.29 4.9 - 8.7		62.44 54.9-71.9		488.2 461-505		46.97 39.6-54.0	

Table 4. Quality indices of winter wheat cultivars grown in Northern Romania

	Wet gluten %		Gluten deformation		Sedimentation value		Loaf volume		Farinograph score	
Cultivar	Avg. Min-Max	s%	Avg. Min-Max	s%	Avg. Min-Max	s%	Avg. Min-Max	s%	Avg. Min-Max	s%
Flamura 85	30.1 24.5-35.1	12.0	4.75 2 - 8	44.7	74.9 68-81	7.4	506.6 464-565	6.7	49.3 40-58	10.6
Fundulea 4	28.0 22.8-36.0	14.9	6.12 3 - 9	34.3	58.8 54-62	5.3	455.6 430-497	5.3	42.1 38-47	7.6
Apullum	29.8 22.6-34.5	12.6	6.62 3 - 10	39.5	61.9 53.5-74	13.1	507.0 479-562	5.3	45.3 41-56	11.5
Arieşan	30.6 26.9-33.0	6.8	7.62 4 - 12	42.0	62.6 49-73.0	14.1	452.8 400-515	9.5	42.4 38-49	8.7
Turda 81	27.3 19.2-33.5	15.9	7.62 3 - 10	32.1	52.6 46-62	12.1	466.5 405-516	9.8	41.3 34-55	16.7
Transilvania 1	28.6 22.6-33.0	10.9	8.50 4 - 14	53.7	50.3 42-61	12.7	450.8 396-515	8.7	39.0 34-42	7.3
Aniversar	34.1 31.6-40.5	9.8	7.8 4 - 12	38.9	58.9 53-68	10.0	480.4 404-555	10.0	40.4 35-46	10.0
Moldova 83	29.0 25.0-34.2	10.7	5.50 3 - 9	32.2	70.4 59-80.5	9.4	505.9 484-535	3.8	47.3 44-52	6.4
Suceava 84	32.6 29.1-38.0	8.7	12.9 5 - 20	43.2	51.6 40-60	15.1	440.8 378-440	7.1	38.6 36-42	5.9
LSD for P<0.05	2.09		1.89		4.36		28.28		3.86	
Average across cultivars	30.0 25.7-34.1		7.49 3.6 - 10.9		60.21 52.2-66.9		474.0 432-499		42.83 39.3-46.8	

41 and Delia). Environmental variation was moderate, with coefficients of variation lower than 13%. Dropia and Lovrin 34 had the best stability of sedimentation values across environments.

Loaf volume was less differentiated among cultivars (from 457 cm^3 in Delia to 525 cm^3 in Dropia) and across environments (coefficients of variation from 4.9 to 6.9%). This is probably due to the simple formula used for baking. However, the cultivars Dropia, Flamura 85, Rapid and Lovrin 34 consistently produced higher loaf volumes, on an average more than 490 cm^3.

Average farinograph scores varied from 40 F.U. in Lovrin 41 to 56 F.U. in Dropia. Environmental variation was moderate, with coefficients of variation of 9.8-14%.

In the samples from Northern Romania, wet gluten content had a relatively small variation among cultivars, from 27.3% in Turda 81 to 34.1% in Aniversar (Table 4).

On an average, all cultivars had more gluten than the minimum required by the standard, and only Turda 81 occasionally produced values below the standard. Environmental variation was relatively large, with coefficients of variation from 6.8 to 15.9%. The cultivar Aniversar was notable for its high and relatively stable gluten content.

In this set of data, gluten deformation index shows more variation among cultivars, with average values from 4.8 mm in Flamura 85 to 12.9 mm in Suceava 84. With this last cultivar there is a high risk of not meeting the standard for gluten deformation. Similarly to Southern region, environmental variation for gluten deformation is very high, with coefficients of variation higher than 30%.

Sedimentation values, averaged over 8 environments, varied from 50 to 75 ml, clearly differentiating a group of higher quality cultivars (Flamura 85, Moldova 83 Arieșan and Apullum), in contrast with a lower quality group (Fundulea 4, Aniversar, Turda 81, Transilvania 1 and Suceava 84). Coefficients of variation across environments were relatively small, varying from 5.3 to 15.1%.

Loaf volume showed relatively low variation both across cultivars (from 441 cm^3 in Suceava 84 to 507 cm^3 in Flamura 85) and across environments (coefficients of variation below 10%). The highest average loaf volumes, over 500 cm^3, were recorded in the cultivars Apullum, Flamura 85 and Moldova 83.

Average farinograph values in the samples from Northern Romania varied from 38 U.F. in Suceava 84 and Transilvania 1 to 49 U.F. in Flamura 85. Environmental variation of this index was moderate, with coefficients of variation from 5.9 to 16.7%.

CONCLUSIONS

Quality indices were differentially influenced by genotype and environment. SDS sedimentation volume was least influenced by environment and genotype by environment interaction, while wet gluten content had the largest environmental influence. Despite being an index of gluten quality, gluten deformation was strongly influenced by environment.

On an average across environments, all studied cultivars met the standards for baking, and only few cultivars occasionally produced flour below these standards.

The best bread-making quality was found in the cultivars Dropia, Flamura 85, Rapid, Lovrin 34, Moldova 83 and Apullum.

REFERENCES

Blumenthal, C. S., Bekes F., Batey I. L., Wrigley C. W., Moss J. H., Mares D. J., Barlow E. W. R., 1991 - Interpretation of grain quality results from yield trials, with reference to high temperature stress. J. Agric. Res. 42:323-334.

Cox, T. S., Shogren M. O., Sears R. G., Martin T. J., Bolte L. C., 1989 - Genetic improvement in milling and baking quality of hard red winter wheat cultivars, 1919 to 1988. Crop Sci., 29(3):625-631.

Eskridge, K. M., Peterson C. J., Grombacher A. W., 1994 - Probability of wheat quality traits falling within acceptable limits. Crop Sci., 34(4):866-869.

Mailhot, C. W., Patton C. J., 1988 - Criteria of flour quality. In: Wheat chemistry and technology. Second ed., J. Pomeranz Eds.

Pomeranz, J., Finney K. F., Hoseney R. C., 1970 - Molecular approach to bread making. Science, 167:944.

Pyler, E. J., 1983 - Flour proteins role in baking performances. Baker Digest, 57:24-33.

Randel, P. J., Moss J., 1990 - Some effects of temperature regime during grain filling on wheat quality. Aust. J. Agric. Res., 41:603-617.

Typpler K. H., 1992 - Quality evaluation methods for red spring wheat. Grain Research Laboratory Division of the Canadian Grain Commission: 9.

Table 1. ANOVA for several bread-making quality indices in samples from Southern Romania

Quality index		Source of variation		
		Environments	Genotypes	Interaction
	D.F.	10	6	60
Wet gluten content	S.S.	281.3	215.8	263.7
	M.S.	28.1	36.0	4.4
Gluten deformation	S.S.	159.7	134.1	154.0
	M.S.	16.0	22.3	2.6
Sedimentation value	S.S.	1472	7136	1035
	M.S.	147	1189	17
Loaf volume	S.S.	14950	54268	44114
	M.S.	1495	9045	735
Farinograph score	S.S.	1136	2229	779
	M.S.	126	371	14

Table 2. ANOVA for several bread-making quality indices in samples from Northern Romania

Quality index		Source of variation		
		Environments	Genotypes	Interaction
	D.F.	10	6	60
Wet gluten content	S.S.	497.0	306.6	245.6
	M.S.	71.0	38.3	4.4
Gluten deformation	S.S.	471.5	353.6	200.8
	M.S.	67.4	44.2	3.6
Sedimentation value	S.S.	1765	4532	1062
	M.S.	259	567	19
Loaf volume	S.S.	36288	45613	44778
	M.S.	5184	5702	780
Farinograph score	S.S.	314.7	865.5	833.8
	M.S.	45.0	109.2	14.9

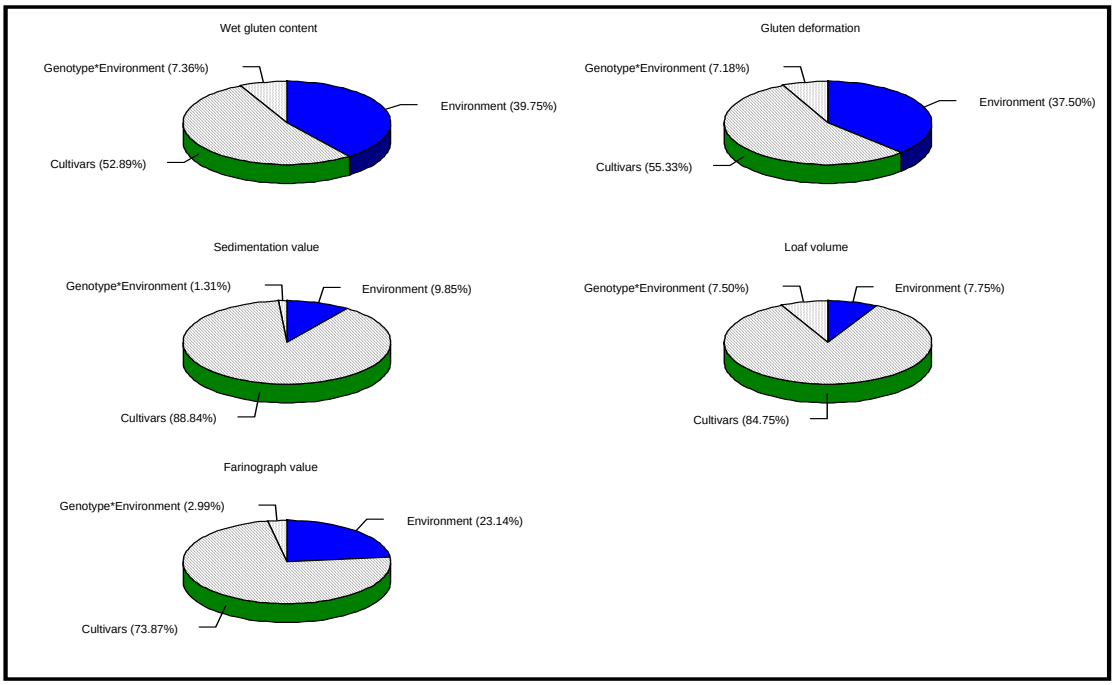

Figure 1. Percentage of total variation of several quality indices, due to genotype, environment and cultivar by environment interaction, in a set of wheat samples from Southern Romania

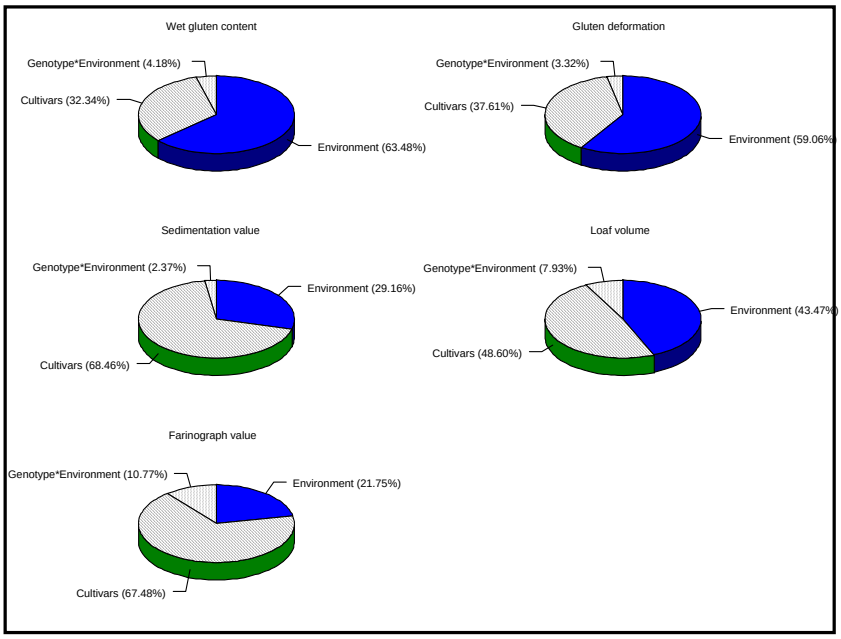

Figure 2. Percentage of total variation of several quality indices, due to genotype, environment and genotype by environment interaction, in a set of wheat samples from Northern Romania

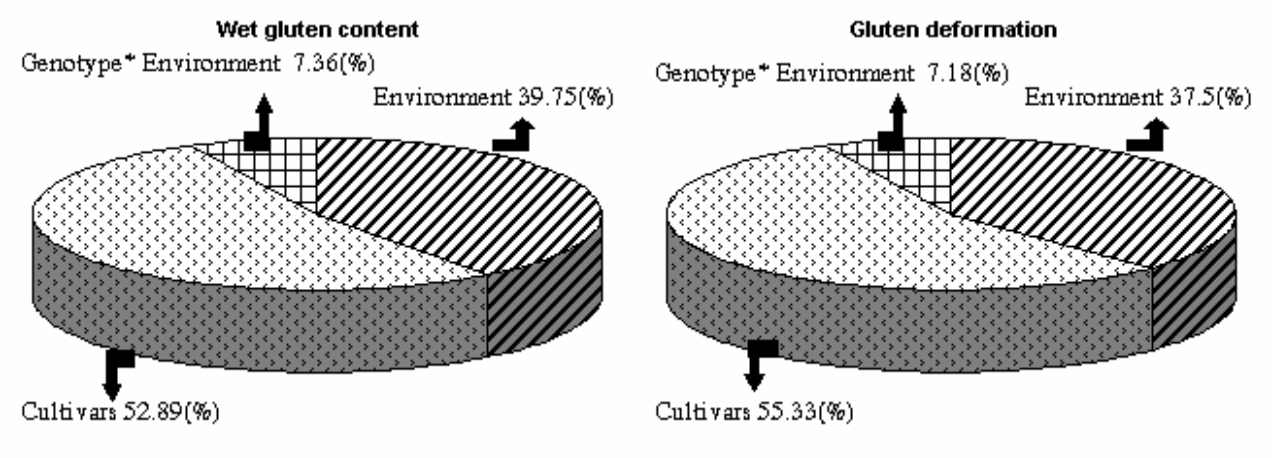

Table 3. Quality indices of winter wheat cultivars grown in Southern Romania

	Wet gluten %		Gluten deformation		Sedimentation value		Loaf volume		Farinograph score	
Cultivar	Avg. Min-Max	s%	Avg. Min-Max	s%	Avg. Min-Max	s%	Avg. Min-Max	s%	Avg. Min-Max	s%
Dropia	30.0 27.0-34.3	6.9	6.45 4 - 11	29.7	76.8 69.5-81	7.4	523.4 456-563	6.9	56.1 45-68	14.0
Flamura 85	30.1 24.5-32.8	9.1	5.63 3 - 8	28.9	72.3 60-81	9.6	516.7 475-560	5.4	52.0 44-62	10.9
Rapid	28.7 24.6-34	11.7	6.63 3 - 11	31.8	67.0 58-80	9.1	490.2 446-528	5.4	50.6 45-60	9.8
Lovrin 34	29.6 25.6-33.3	6.9	6.72 3 - 12	41.6	64.3 58-72.5	7.6	509.7 450-554	6.0	46.2 34-55	10.6
Fundulea 4	27.2 22.8-30.5	10.0	7.45 5 - 10	19.3	52.2 44-65	11.4	463.1 419-507	4.9	42.6 35-51	10.6
Delia	27.7 23.3-33.0	11.4	8.09 6 - 10	17.9	49.9 43-61.5	10.1	456.9 422-511	6.1	41.5 32-45	11.9
Lovrin 41	32.7 25.6-37.0	9.6	10.0 6 - 15	29.3	54.6 42-68.5	12.7	458.7 410-511	6.6	39.8 34-48	10.0
LSD for P<0.05	1.79		1.37		3.54		23.12		3.4	
Average across cultivars	29.42 26.5-32.6		7.29 4.9 - 8.7		62.44 54.9-71.9		488.2 461-505		46.97 39.6-54.0	

Table 4. Quality indices of winter wheat cultivars grown in Northern Romania

	Wet gluten %		Gluten deformation		Sedimentation value		Loaf volume		Farinograph score	
Cultivar	Avg. Min-Max	s%	Avg. Min-Max	s%	Avg. Min-Max	s%	Avg. Min-Max	s%	Avg. Min-Max	s%
Flamura 85	30.1 24.5-35.1	12.0	4.75 2 - 8	44.7	74.9 68-81	7.4	506.6 464-565	6.7	49.3 40-58	10.6
Fundulea 4	28.0 22.8-36.0	14.9	6.12 3 - 9	34.3	58.8 54-62	5.3	455.6 430-497	5.3	42.1 38-47	7.6
Apullum	29.8 22.6-34.5	12.6	6.62 3 - 10	39.5	61.9 53.5-74	13.1	507.0 479-562	5.3	45.3 41-56	11.5
Arieșan	30.6 26.9-33.0	6.8	7.62 4 - 12	42.0	62.6 49-73.0	14.1	452.8 400-515	9.5	42.4 38-49	8.7
Turda 81	27.3 19.2-33.5	15.9	7.62 3 - 10	32.1	52.6 46-62	12.1	466.5 405-516	9.8	41.3 34-55	16.7
Transilvania 1	28.6 22.6-33.0	10.9	8.50 4 - 14	53.7	50.3 42-61	12.7	450.8 396-515	8.7	39.0 34-42	7.3
Aniversar	34.1 31.6-40.5	9.8	7.8 4 - 12	38.9	58.9 53-68	10.0	480.4 404-555	10.0	40.4 35-46	10.0

Moldova 83	29.0 25.0-34.2	10.7	5.50 3 - 9	32.2	70.4 59-80.5	9.4	505.9 484-535	3.8	47.3 44-52	6.4
Suceava 84	32.6 29.1-38.0	8.7	12.9 5 - 20	43.2	51.6 40-60	15.1	440.8 378-440	7.1	38.6 36-42	5.9
LSD for P<0.05	2.09		1.89		4.36		28.28		3.86	
Average across cultivars	30.0 25.7-34.1		7.49 3.6 - 10.9		60.21 52.2-66.9		474.0 432-499		42.83 39.3-46.8	