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Gluten as a Standard of Wheat Flour Quality

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Summary

The quantity and quality of gluten are considered the most important quality parameters of wheat flour. Gluten Index Method (GIM) is a rather new method for determining gluten quantity and quality in wheat semolina and flour. This study reports on values for flours obtained from the most important Croatian wheat cultivars. The gluten index value in the tested flour samples varied from 55.92 (Patria cultivar) to 99.60 % (Marija cultivar). This high variety was not only due to cultivar differences but also to different climate conditions (especially cultivars Žitarka and Sana). The determination of gluten quantity and quality by Gluten Index Method is compared with the determination by other methods. A significant positive linear correlation was observed between the values of gluten index and extensographic values of flour quality, *i.e.* between the gluten index and maximal resistance of dough to extensibility (r = 0.860), dough energy (r = 0.799) and dough resistance at 50 mm (r = 0.788). That indicates that the gluten index actually defines technological flour quality. The optimal gluten index values for bread production using Croatian wheat cultivars were between 75 and 90 %.

Key words: wheat, flour, gluten index, physical dough properties

Introduction

Gluten is a plastic-elastic protein fraction of wheat flour responsible for physical dough properties. It has been generally accepted that any increase in total protein content of the flour results in an increase in gluten content (*1*). It is important to note that the quantity of protein or gluten is not a measure for gluten quality. Gluten quality is characterized by the degree of extensibility and elasticity. Technologists consider gluten as the functional part of dough which influences many product qualities. Various analytical methods for determination of gluten quantity and quality have been applied in Croatia. The wet gluten quantity is determined by the method of »manual gluten washing«. Results are given as a mass fraction of flour (*2*), and Zeleny sedimentation test gives sedimentation values (*3*). Physical properties of the dough prepared from wheat flour, attributed primarily to gluten, can be described by farinographic and extensographic measurements using the Brabender farinograph and extensograph (*3*). The mentioned methods are time-consuming and require rather large quantity of flour. Rapid, fully automatic methods, such as Gluten Index Method, are applied instead worldwide (*4-6*). GIM provides information both on the wet gluten quantity in the tested sample of flour or semolina and on gluten strength expressed as the gluten index (mass fraction of gluten remaining on the sieve after centrifugation). The advantages of GIM are simplicity, short duration (7 minutes), small samples (10 g of flour or semolina) and the simultaneous determination of gluten quantity and quality. Tests carried out in many countries indicate that flours for the production of bakery products have the gluten index value from 60 to 90.

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Flours with the gluten index exceeding 95 are too strong and those with the index value less than 60 are too weak for bread production (*7*).

There are merely some ten wheat cultivars represented in bread wheat production in Croatia today. The most represented wheat cultivars of the harvest 1998 were Žitarka, Marija and Sana, followed by Srpanjka, Ana and Patria. All of the specified cultivars belong to high yielding cultivars of better or poorer quality. Divana is a variety of the highest quality cultivated in Croatia.

The purpose of this study was to determine gluten index in flours made from the most important Croatian wheat cultivars. The growing regions were Zagreb and Osijek. Moreover, GIM was compared with standard methods of analysis of gluten quantity and quality to evaluate GIM with respect to the daily practice.

Materials and Methods

Flours (28 samples) were obtained by milling seven cultivars on a Buhler automatic mill MLU-202 (Uzwil, Switzerland) without a bran shaker. Wheat harvested in the wheat-growing regions of Osijek and Zagreb in 1988 were used (Table 1).

Table 1. Croatian wheat cultivars and regions

Variety	Region (Mark)	Number of Samples
Divana	Zagreb (Dz)	2
	Osijek (Do)	3
Žitarka	Zagreb (Zz)	3
	Osijek (Zo)	3
Srpanjka	Zagreb (Sz)	2
	Osijek (So)	3
Sana	Zageb (SAz)	3
	Osijek (SAo)	2
Ana	Zagreb (Az)	1
	Osijek (Ao)	2
Marija	Zagreb (Mz)	1
	Osijek (Mo)	1
Patria	Zagreb (Pz)	1
	Osijek (Po)	1

The quantities of wet and dry gluten in the tested flour samples were determined by the method of manual gluten washing (*2*) and by GIM (*8,9*). In addition to wet gluten quantities, gluten index values for all 28 flour samples were determined using the Glutamatic 2200 system (Perten Instruments AB, Stockholm, Sweden). Two replicates from each flour sample were analyzed three times, respectively.

Total protein (Kjeldahl) and sedimentation value (Zeleny sedimentation test) was determined (*3*). Physical properties were determined with the Brabender farinograph and extensograph (*3*). Water absorption (w_a), dough development time (*Ddt*), dough stability at mixing (*Ds*) and softening degree at kneading (S_d) were measured. Extensograms measured dough extension energy (*E*), dough extensibility (*e*), resistance of the dough to extension (*rs* at 50 mm extension; rs_{max} – maximum resistance) and the ratio of resistance to extension and extensibility (*rs*/*e*).

Flour (100 %), baker's yeast (2 %), common salt (1.6 %) and a corresponding quantity of water (water absorption according to the farinogram) were mixed (2 + 6 min) and fermented (30 min at 28 °C). After dividing and rounding, dough pieces were left for 10 min at 28 °C. Final fermentation of the dough in moulds lasted 50 min (80 % of relative humidity, 33 °C). The dough was baked for 20 min at 230 °C. The volume of the finished product was measured after cooling to room temperature (after 4 h). The experiments were carried out twice.

Results and Discussion

The results of the evaluation of repeatability of the measuring results of the gluten index and wet gluten quantity in flours of the Croatian wheat cultivars, expressed by the mean value of measurement per sample, standard deviation of repeatability and standard error between six replicates, are presented in Figs. 1 and 2.

Standard deviation of the repeatability for wet gluten quantity determined by GIM amounts to 0.528 and the variability coefficient of the results of the measurement within the same sample amounts to mere 1.85 %. The maximal differences between six replicates are within the range from 0.17 to 2.42 % for the measured wet gluten quantities. Standard deviation of repeatability for the gluten index amounts to 2.943 and the variability coefficient of the results of measurement around the mean sample value amounts to 3.55 %. The difference between six replicates per sample amounts to 0.41–21.80 %. The obtained results are in accordance with the results of the performed ICC ring test (*6*).

Table 2 shows gluten index and other indices of the tested flours of the most representative Croatian wheat cultivars of the harvest 1998 (mean value of measurement between the samples of the same variety, measuring range between the tested samples of the same variety and standard deviation between the tested samples of the same variety).

The indices were very different suggesting differing baking properties. The results of testing the cultivar Divana (5 samples) indicate that Divana had high protein quantity which does not change significantly with the region of cultivation. High values of wet gluten quantity, sedimentation value, high quality number, high resistance to extension and extensographic energy, high gluten index (96.98 %) and a small range of variation of the same values indicate that Divana is a high quality cultivar (Table 2). With respect to lower yields, this cultivar is grown on a limited area. The average protein quantity in the tested flour samples of the variety Žitarka (6 samples) amounted to a high value of 14.27 %.

The average wet gluten quantity was also high. However, the strength of gluten of the variety Žitarka varied significantly depending on the conditions and region of cultivation (70.77 ± 13.35 %). The variety Žitarka has been classified into bread high yielding cultivars. The variety Marija belongs to high yielding basic cultivars which alone, *i.e.* without addition of cultivar-im-

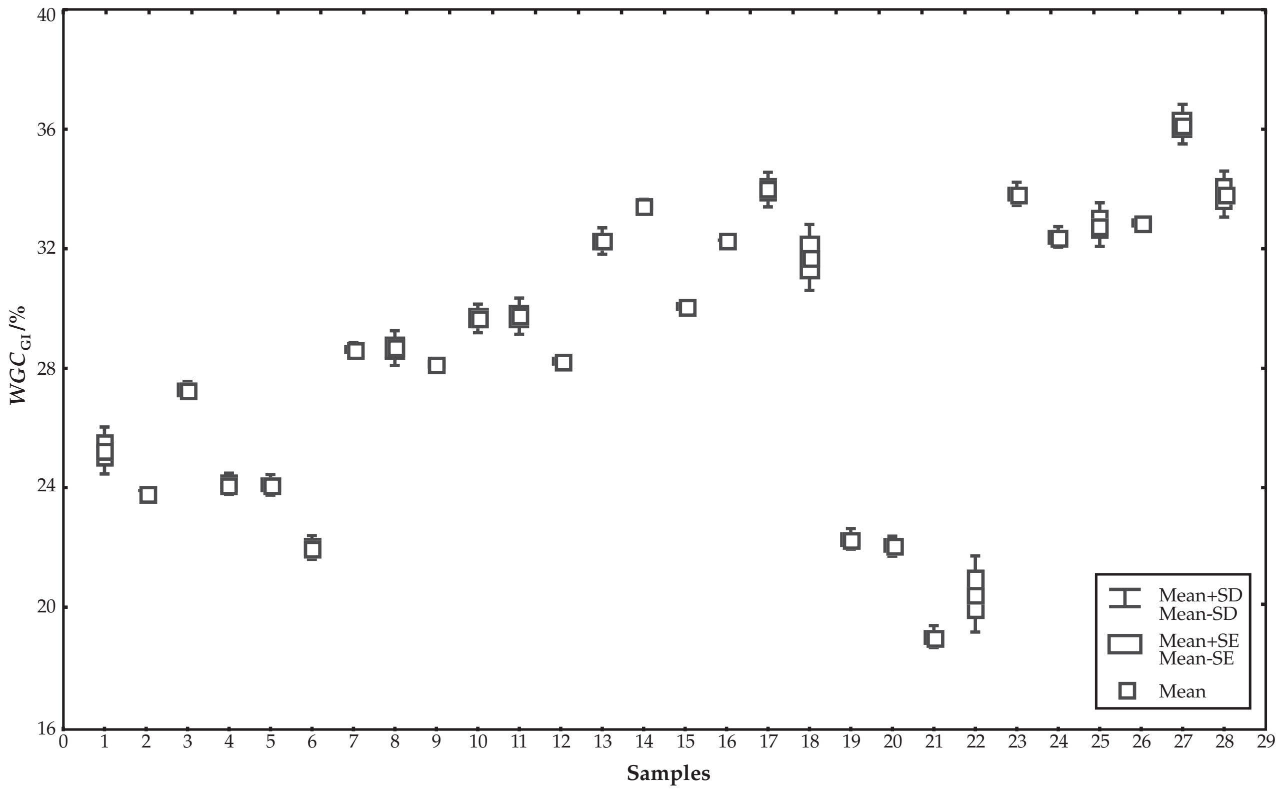

Fig. 1. Repeatability of Wet Gluten Quantity (*WGC*$_{GI}$) including all subsamples (SD-Standard Deviation; SE-Standard Error); error bar represents the maximum difference between the six replicates

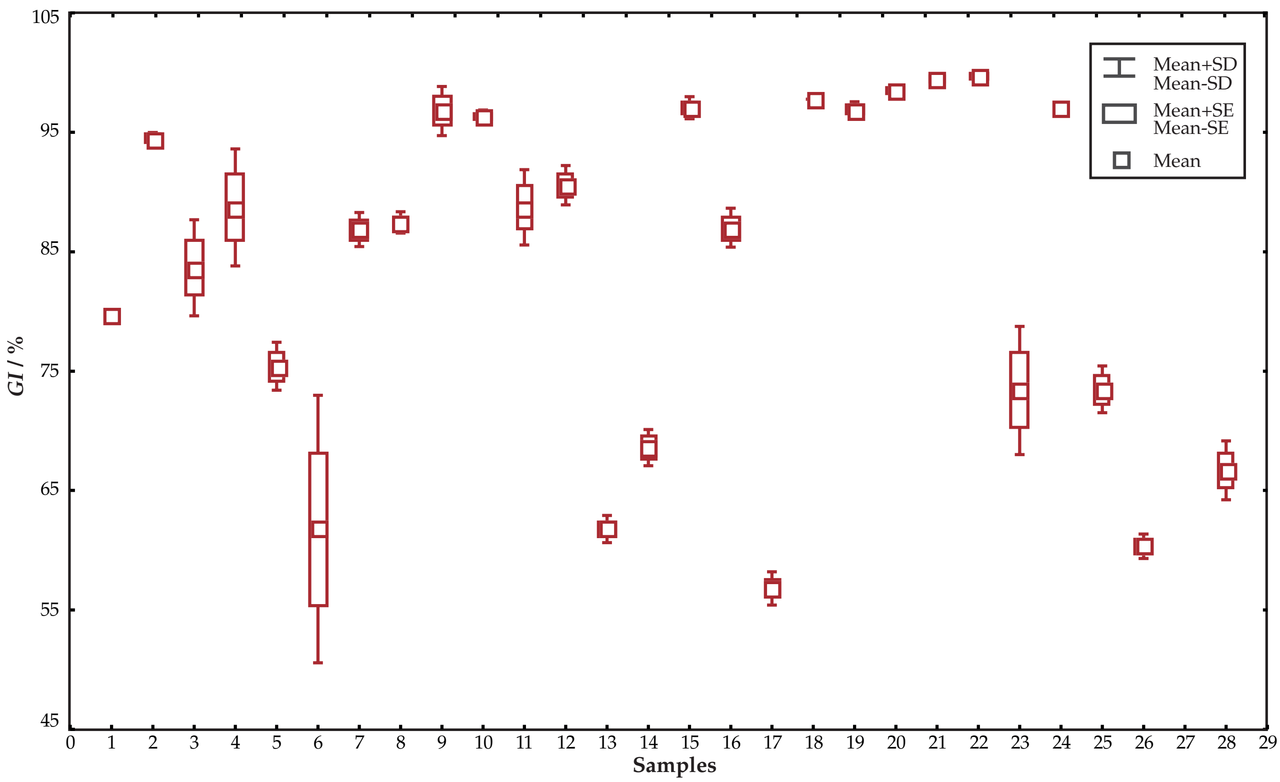

Fig. 2. Repeatability of Gluten Index (*GI*) including all subsamples (SD-Standard Deviation; SE-Standard Error); error bar represents the maximum difference between the six replicates

provers or without mixing with varieties of superior quality, cannot be used for bread production. The performed study (2 samples) showed that flours obtained by milling the grains of the Marija variety have a low gluten quantity of great strength (99.60 %). The evaluated samples of flour obtained by milling the grains (5 samples) of the cultivar Sana indicate that a bread variety of lesser quality is in question, the quality parameters of which vary in dependence on the region of cultivation (Table 2). All of the tested flour samples had gluten strength optimal for bread production (81.80 ± 13.89 %). The tested samples of flour of the Srpanjka cultivar (5 samples) indicate that the cultivar is a bread producing one, of good baking properties, with substantial protein quantity, with considerable wet gluten quantity, high Zeleny sedimentation and the optimal extensographic and farinographic quality indices (Table 2). The gluten index in the samples of the cultivar Srpanjka amounted to 86.64 ± 5.49 %. These flour samples resulted at test baking in the largest bread loaf volume (Table 2). The test results of flour samples of the Ana (3 samples) and Patria (2 samples) cultivars indicate that basic wheat cultivars are in question which, without blending with cultivars of superior quality, cannot be used for bread production (Table 2).

The wet gluten quantity in the analyzed samples of wheat flour was determined by the classical method of manual gluten washing (WGC_{MW}) and by GIM (WGC_{GI}). By applying statistical evaluation of comparability of the two methods, one can determine whether the new, rapid and simple GIM is suitable for use. The comparability of the two methods can be described as the comparison of precision between the two methods and can be statistically determined by means of an F-test comparing the variances of the two data rows. The basic prerequisite or a zero hypothesis of this test is that there is no significant difference between the variances of the two data rows and consequently, in the accuracy of the two methods. The Student t-test is applied to compare relative accuracy of the two methods, or to find out, if there is a significant difference between the two methods of analysis. This statistical test compares the mean values of the replicates obtained by the two methods. The basic presumption or the zero hypothesis of this test is that there is no significant difference between the mean values of the two data rows (*10*). The results of statistical evaluation of comparability and relative accuracy of the methods for assessment of wet gluten quantity in the tested samples of wheat flour (28 samples), *i.e.* by the GIM and by the method of manual gluten washing, are presented in Table 3.

Table 3 demonstrates that there is no statistically significant difference between the tested methods, *i.e.* that there is no statistically significant difference between the measured mean values of wet gluten quantities assessed by GIM and by the method of manual gluten washing ($t_{calc.} = 0.397 < t_{tab.\ (0.05)} = 1.675$), and none between the variances of the same methods ($F_{calc.} = 1.353 < F_{tab.\ (0.05)} = 1.905$).

Table 2. Summary of the results for wheat flour samples from different varieties

Cultivar / Number of samples	Divana /5			Zitarka /6			Srpanjka /5			Sana /5			Ana /3			Marija /2			Patria /2		
Flour Quality Data	Mean	Range	StDev	Mean	Range	StDev	Mean	Range	StDev	Mean	Range	StDev	Mean	Range	StDev	Mean	Range	StDev	Mean	Range	StDev
Gluten Index Method																					
Gluten Index, *GI*/ %	96.98	1.37	0.50	70.77	26.69	9.72	86.64	10.98	4.19	81.80	27.79	10.97	85.71	36.66	20.74	99.60	0.15	0.11	55.92	1.78	1.26
Wet Gluten Quantity, WGC_{GI} / %	30.40	4.26	1.70	32.93	1.58	0.64	28.11	4.50	1.69	26.64	9.98	4.26	22.11	0.29	0.16	19.73	1.43	1.01	35.08	2.19	1.55
Protein mass fraction, P_{mf} / % (db)	15.68	2.15	0.88	14.27	0.44	0.15	13.77	1.15	0.57	12.46	2.00	0.81	12.43	4.05	2.03	12.16	2.79	1.97	11.79	0.00	0.00
Manual Gluten Washing Method																					
Wet Gluten Quantity, WGC_{MW} / %	30.38	4.90	2.26	32.37	3.90	1.76	27.96	1.60	0.67	24.86	6.20	2.56	23.07	1.50	0.82	21.30	3.00	2.12	32.00	0.00	0.00
Dry Gluten Quantity, *DGC* / % (db)	11.77	3.98	2.04	11.49	1.40	0.59	10.02	2.42	0.93	8.68	3.00	1.16	8.63	2.51	1.26	8.44	0.88	0.62	10.90	0.00	0.00
Zeleny Sedimentation, *SE* /cm^3	58.60	14.00	6.23	40.17	7.00	2.48	41.40	3.00	1.34	28.00	5.00	2.76	17.67	17.00	8.51	31.00	4.00	2.83	10.00	0.00	0.00
Brabender Extensograph Values																					
Maximum Resistance, r_{max} /EU	544	170	60.25	258	120	49.97	361	90	45.88	227	310	129.9	422	365	191.9	572	55	38.90	125	0.00	0.00
Extensibility, *e* /mm	186	36	15.72	165	27	10.17	156	54	22.34	138	48	19.35	138	11	5.51	128	4	2.83	145	0.00	0.00
Energy, *E* /cm^2	140	30	12.08	62	30	12.53	79	17	8.21	48	75	31.33	77	78	40.95	107	20	14.43	26	0.00	0.00
Resistance at a 50mm Extension, *r* /EU	292	110	43.24	193	100	35.59	250	40	18.71	173	185	79.66	323	210	109.7	430	60	42.43	120	0.00	0.00
Resistance/Extensibility ratio, *r/e*	1.54	1.40	0.66	1.18	0.80	0.27	1.62	0.50	0.21	1.26	1.20	0.53	2.40	1.7	0.85	3.35	0.30	0.21	0.90	0.00	0.00
Brabender Farinograph Values																					
Water Absorption, *WA* / % (db)	61.20	3.00	1.26	64.08	5.50	1.88	62.00	2.00	1.00	61.60	6.50	2.63	53.33	5.50	2.84	54.75	0.50	0.35	71.00	0.00	0.00
Dough Development Time, *DDT* /min	3.00	2.00	0.79	3.03	1.00	0.38	2.50	0.00	0.00	2.30	2.00	0.76	1.50	0.00	0.00	1.50	0.00	0.00	3.00	0.00	0.00
Dough Stability, *DS* /min	1.70	3.50	1.40	0.50	1.00	0.55	0.20	1.00	0.45	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Softening Degree, *SD* /FU	57	45	18.57	103	55	18.10	70	75	33.73	113	35	14.83	167	55	28.43	150	40	28.28	115	0.00	0.00
Hankocy Quality Number, HQ_n	65.68	22.70	9.26	52.03	19.70	7.37	57.04	22.90	10.68	43.80	16.90	6.90	27.13	16.30	8.74	30.55	11.30	7.99	45.40	0.00	0.00
Baking Test																					
Loaf Volume, *LV*/ cm^3/100 g flour	344.4	15.00	6.66	380.5	67.00	27.86	417.6	15.00	6.05	390.7	73.00	25.99	355.0	10.00	5.00	334.0	12.00	8.49	290.0	0.00	0.00

db=dry basis

Table 3. Results of statistical evaluation of comparability and relative accuracy of the methods for assessment of wet gluten quantity in the tested samples

Value	WGC_{GI} (Gluten Index Method)	WGC_{MW} (Gluten Manual Washing Method)
Number of samples	28	28
Mean	28.545	27.151
Variance	22.864	16.872
Standard Deviation	4.782	4.108
DEGREES OF FREEDOM (n-1)	27	27
$F_{calculated}$-TEST	1.353	
$F_{tab\ 0.05}(27/27)$	1.905	
$t_{calculated}$-TEST	0.397	
$t_{tab\ 0.05}(54)$	1.675	

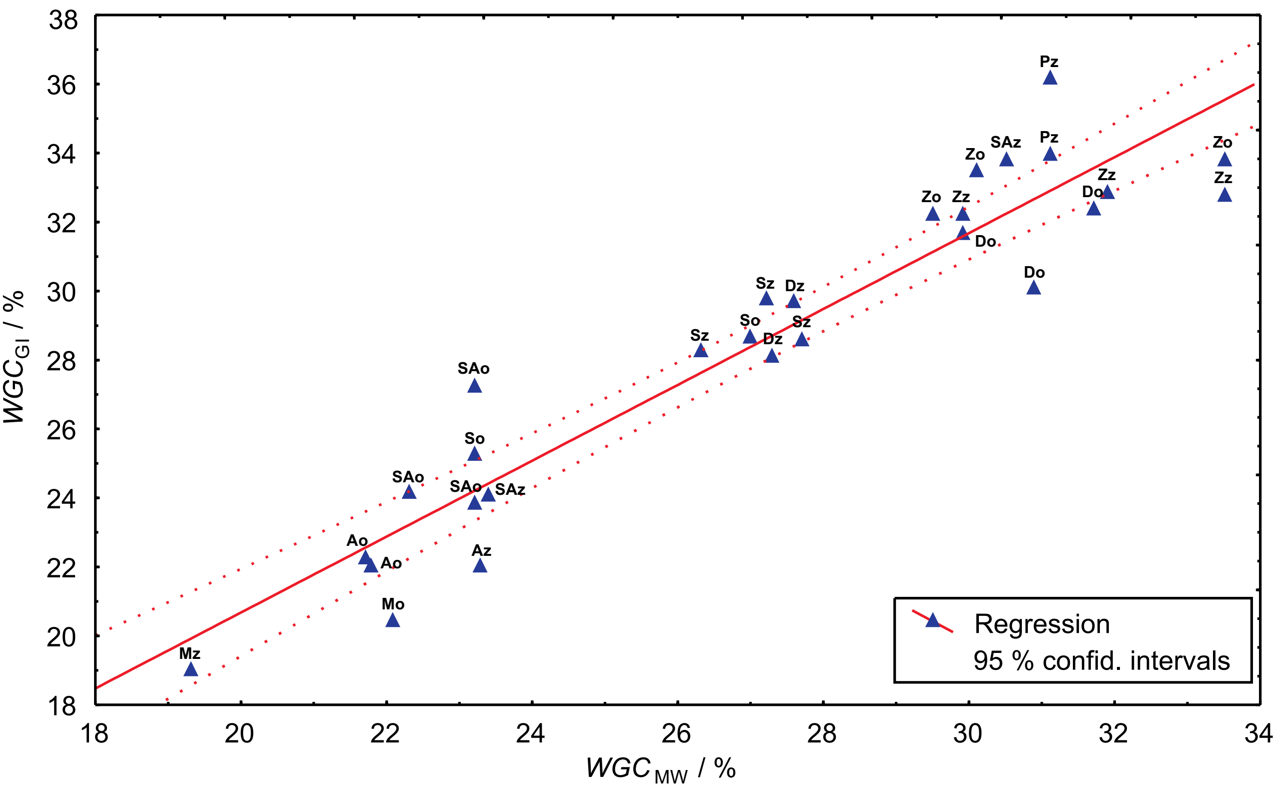

Fig. 3. Correlation between different methods for determination of Wet Gluten Quantity (*WGC*) (r = 0.945). Abbreviations: Dz-Divana Zagreb, Do-Divana Osijek, Zz-Žitarka Zagreb, Zo-Žitarka Osijek, Sz-Srpanjka Zagreb, So-Srpanjka Osijek, SAz-Sana Zagreb, SAo-Sana Osijek, Az-Ana Zagreb, Ao-Ana Osijek, Mz-Marija Zagreb, Mo-Marija Osijek, Pz-Patria Zagreb, Po-Patria Osijek

The insight into the qualitative connection of the two methods was obtained by calculating the linear correlation coefficient (r) amounting for the quantities of wet gluten measured by different methods to r = 0.945 (Table 4) and indicating to high connection of the two data rows.

Quantitative connection of the results of the tested methods was obtained by solving the equation of the first order by the method of the least squares (Fig. 3. and Equation 1):

$$WGC_{GI} = 1.329 + 1.1003 \cdot WGC_{MW} \qquad /1/$$

The presented results of statistical evaluation show that GIM can be recommended for determination of wet gluten quantity and replace the classical method of manual gluten washing, the accuracy of which depends exclusively on the analyst's experience.

Qualitative connection between the measured values of the tested samples of wheat flours is presented in Table 4 and expressed as the linear correlation coefficient, r, at different probability levels.

Table 4 indicates a significant positive linear correlation between the measured values of the protein quantity and dry gluten quantity r = 0.698**. An increase in the protein quantity results in an increase in gluten quantity in the flour, whereas an increase in the gluten quantity results in an increase in the volume of the finished product, which is confirmed by the positive linear correlation coefficient r = 0.534**. There is no correlation between the

Table 4. Summary of Simple Correlations Between Quality Tests

Variable	*GI*	WGC_{GI}	P_{mf}	WGC_{MW}	*DGC*	*SE*	rs_{max}	*e*	*E*	*rs*	*rs/e*	W_a	*Ddt*	*Ds*	S_d	*HQn*	L_v
Gluten Index, *GI*/%	1.00	-0.528**	0.381*	-0.452*	-0.082	0.458*	0.860**	0.148	0.799**	0.788**	0.635**	-0.565**	-0.340	0.233	-0.204	0.306	0.280
Wet Gluten Quantity, WGC_{GI}/%		1.00	0.382*	0.945**	0.720**	0.300	-0.468*	0.479**	-0.225	-0.664**	-0.770**	0.806**	0.790**	0.226	-0.463*	0.380	0.271
Protein mass fraction, P_{mf}/% (db)			1.00	0.528**	0.698**	0.838**	0.445*	0.695**	0.645**	0.165	-0.142	0.201	0.355	0.465*	-0.456*	0.568**	0.511**
Wet Gluten Quantity Manual Washing, WGC_{MW}/%				1.00	0.840**	0.425*	-0.310	0.578**	-0.070	-0.519**	-0.702**	0.716**	0.707**	0.275	-0.414*	0.364**	0.320
Dry Gluten Quantity, *DGC*/% (db)					1.00	0.601**	0.055	0.769**	0.259	-0.219	-0.524**	0.508**	0.456*	0.240	-0.412*	0.380	0.534**
Zeleny Sedimentation, *SE*/cm^3						1.00	0.479**	0.702**	0.672**	0.182	-0.136	0.079	0.374	0.535**	-0.672**	0.791**	0.434*
Maximum Resistance, rs_{max}/EU							1.00	0.327	0.943**	0.910**	0.688**	-0.573**	-0.289	0.710	-0.158	0.243	0.484**
Extensibility, *e*/mm								1.00	0.565**	0.024	-0.309	0.199	0.413*	0.559**	-0.612**	0.618**	0.556**
Energy, *E*/cm^2									1.00	0.758**	0.476**	-0.386*	-0.078	0.525**	-0.356	0.434	0.602**
Resistance at a 50mm Extension, *rs*/EU										1.00	0.908**	-0.738**	-0.462*	0.184	0.088	-0.179	0.308
Resistance/Extensibility ratio, *rs/e*											1.00	-0.748**	-0.493**	0.064	0.281	-0.185	0.127
Water Absorption, *WA*/% (db)												1.00	0.585**	0.022	-0.331	0.128	0.133
Dough Development Time, *DDT*/min													1.00	0.553**	-0.599**	0.589**	0.251
Dough Stability, *Ds*/min														1.00	-0.576**	0.625**	0.384*
Softening Degree, *SD*/FU															1.00	-0.920**	-0.282
Hankocy Quality Number, HQ_n																1.00	0.385
Loaf Volume, (*LV*/cm^3)/100 g flour																	1.00

*and ** correlation is significantly different from zero at the 0.05 and 0.01 level of probability, respectively

***mass fraction/%

gluten index and dry gluten quantity in the flour (r = –0.082). Consequently, one cannot expect any significant correlation between the values of the gluten index and protein quantity in the flour (r = 0.381) and the gluten index and volume of the finished product (r = 0.280). Similar results, presented in the »French Study« are reported by Grootenboer who had obtained them by analyzing 84 flour samples from seven wheat cultivars (correlation between *GI* and *DGC* amounted to r = 0.083) (*7*).

Perten *et al.* (*1*), have found out that there was no correlation between gluten index values and wet gluten quantity (*r* = 0.18). Koscak and Dragon observed great variability between the samples in gluten quantity and quality (*WGC* and *GI*) in wheat sorts of some cultivars and found a significant negative linear correlation coefficient between them (*11*). In this study, a significant negative linear correlation (r = –0.528**) was also observed between the *GI* and *WGC* values (Fig. 4.) for the analyzed wheat varieties. The obtained results confirm the fact that, in addition to wet gluten quantity in the flour, it is also indispensable to know its physical characteristics (strong or weak) for the production of bakery products.

A strong positive linear correlation has been observed between the gluten index values and the extensographic quality indices of the flour: between the gluten index and the maximum resistance of the dough to extension, r = 0.860**; the gluten index and dough energy, r = 0.799** (Fig. 5.); the gluten index and resistance of the dough to extension at 50 mm, r = 0,788**; the gluten index and the resistance to extensibility ratio, r = 0.635**.

Similar results were obtained by Johnsson (*11*) when analyzing 43 samples of the Swedish wheat cultivars - the correlation coefficient between the gluten index and extensographic flour quality indices amounted to r = 0.76. Such a strong correlation between the extensographic indices and gluten index values indicates that the gluten index can be accepted as one of the qualitative parameters of wheat flour describing its technological properties (gluten strength).

There was no strong linear correlation observed between the gluten index values and farinographic quality indices. Flours of the gluten index smaller than 75 % had explicitly increased water absorption, the dough released water, and it was sticky and unsuitable for processing. Flours with the gluten index exceeding 90 % produced too strong doughs resulting in bread of small volume. Flours with the gluten index between 75 and 90 % resulted at test baking in loaves of largest volumes and best sensory properties (Fig. 6.).

It was also observed that wheat sorts cultivated in the wheat-growing region of Osijek have superior physicochemical properties caused by better quality of the soil and smaller quantity of rainfall.

Conclusion

The gluten index value in the tested flour samples varied from 55.92 % (Patria cultivar) to 99.60 % (Marija cultivar). This high variety was not only due to cultivar differences but also to different climate conditions (especially Žitarka and Sana cultivars).

The statistical evaluation of the comparability of the standard method for determination of wet gluten quantity and GIM shows that the rapid and simple GIM can

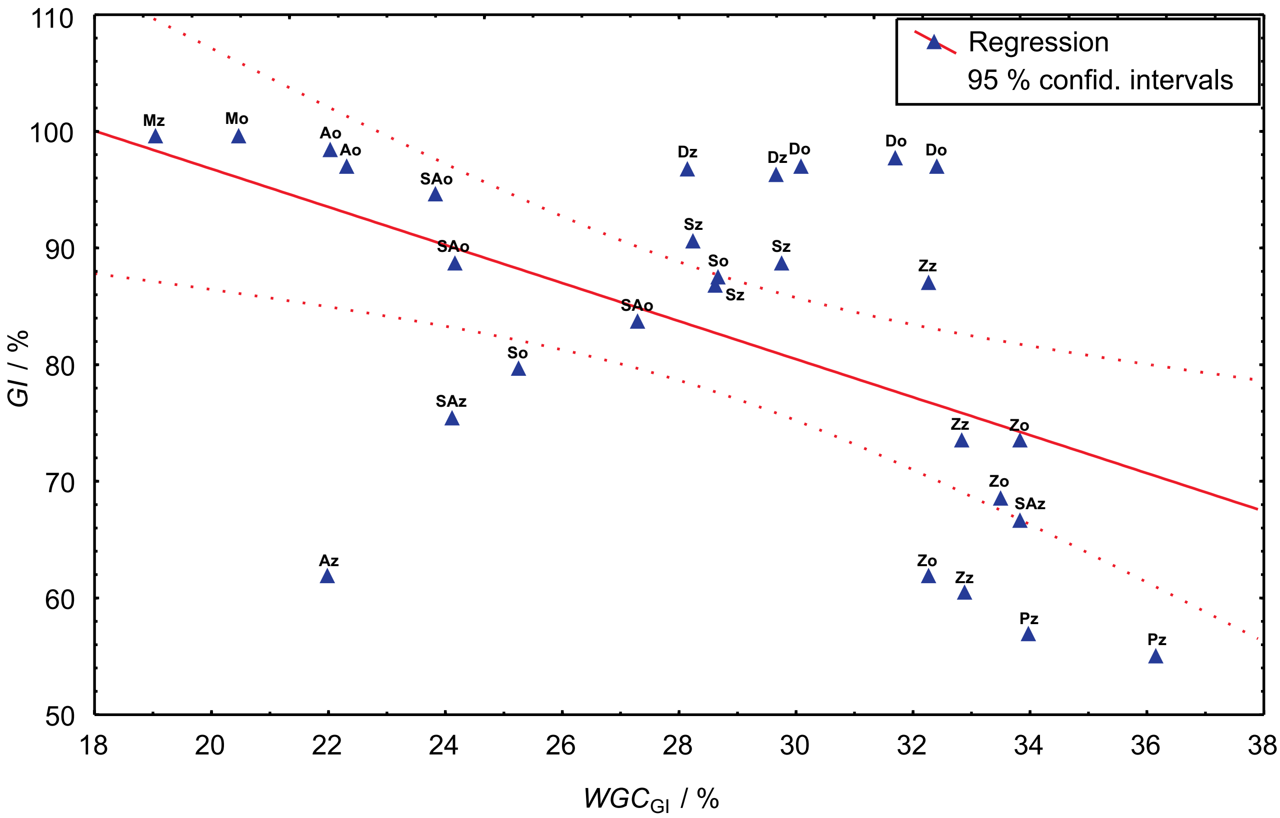

Fig. 4. **Correlation between Wet Gluten Quantity (*WGC_{GI}*) and Gluten Index (*GI*)** for 28 wheat samples (r = –0.528). Abbreviations, see Fig. 3.

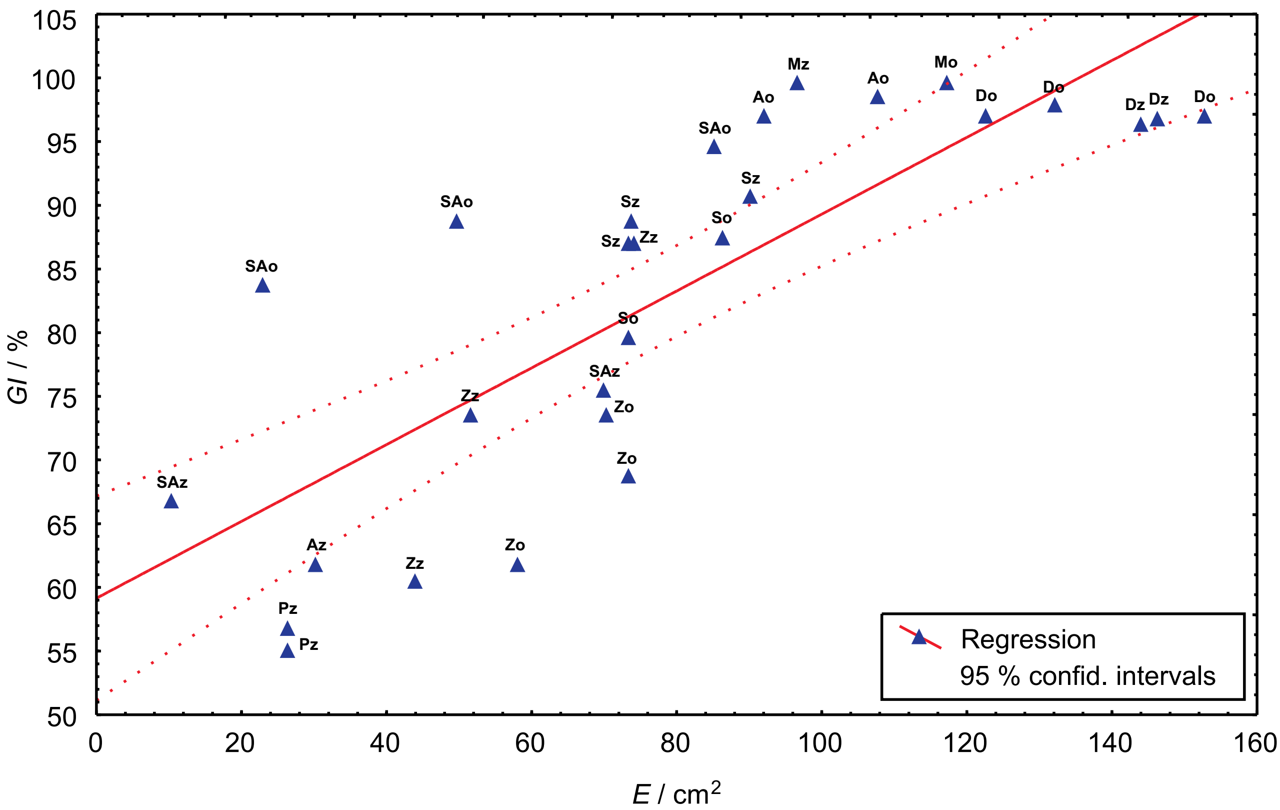

Fig. 5. Correlation between Extensograph value-Energy (*E*) and Gluten Index (*GI*) for 28 wheat samples (r = 0.799). Abbreviations, see Fig. 3.

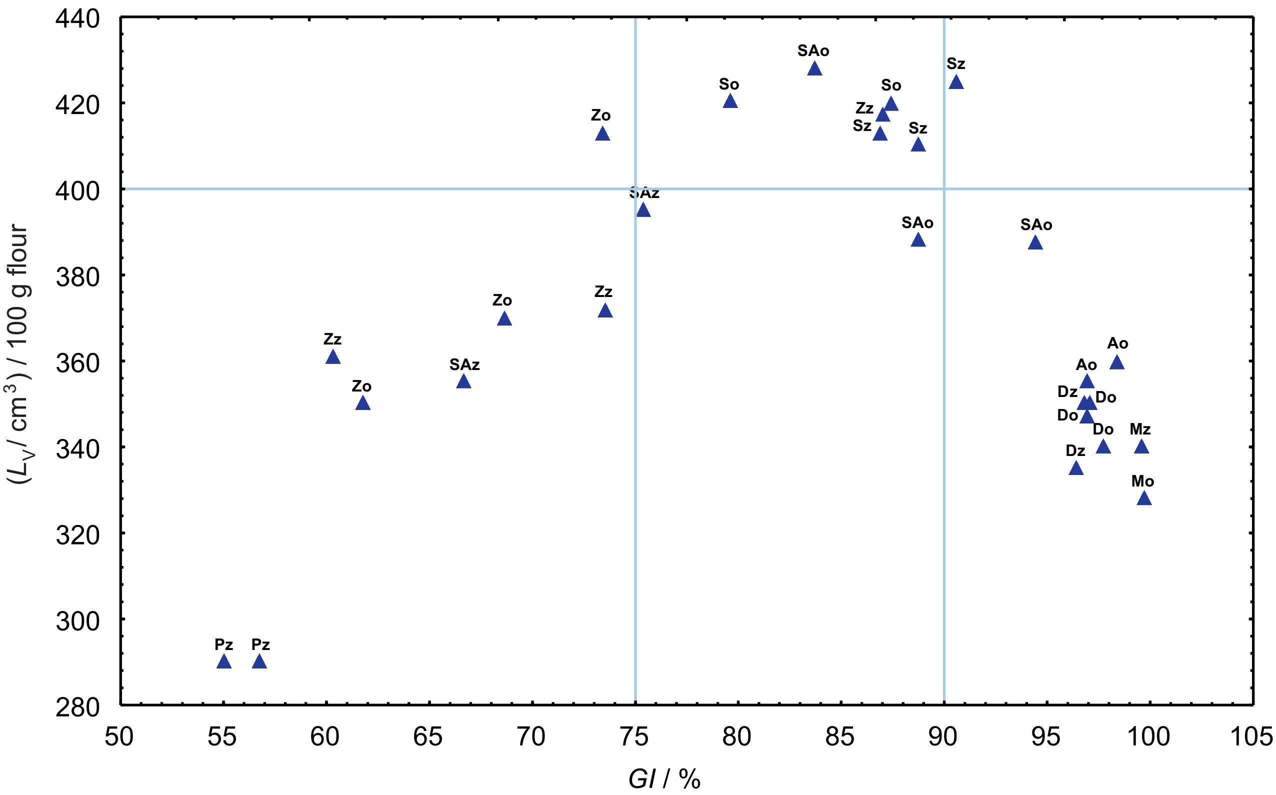

Fig. 6. Influence of flour Gluten Index (*GI*) on bread Loaf Volume (*LV*) for 28 wheat samples. Abbreviations, see Fig. 3.

be recommended for determination of wet gluten content in the flour.

Qualitative analysis of wheat flour quality factors indicates that the obtained values of the gluten index correlate well with the extensographic indices of flour quality. It was also found out that there was no significant correlation between the gluten quantity in the flour and the gluten index value and consequently between the gluten index and the volume of the finished product which mainly depends on the gluten quantity. On the basis of the obtained results it can be concluded that the gluten index is a good and reliable measure for the technological quality of Croatian wheat varieties.

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Količina i kakvoća glutena kao mjerilo kakvoće pšeničnog brašna

Sažetak

Količina i kakvoća glutena su osnovni pokazatelji kakvoće pšeničnog brašna. Metoda određivanja glutenskog indeksa je relativno novi postupak za određivanje količine i kakvoće glutena u pšeničnoj krupici i brašnu. U ovom su radu prikazane vrijednosti glutenskog indeksa u brašnima najvažnijih hrvatskih sorta pšenice. Vrijednosti glutenskog indeksa u ispitivanim uzorcima brašna iznosile su 55,72 (sorta Patria) do 99,60 % (sorta Marija). Tako velika varijabilnost nije ovisila samo o sorti nego i o različitim klimatskim uvjetima uzgoja (posebno sorte Žitarka i Sana). Metoda određivanja glutenskog indeksa također je uspoređena s drugim metodama za određivanje količine i kakvoće glutena. Između vrijednosti glutenskog indeksa i ekstenzografskih pokazatelja kakvoće brašna uočena je značajna pozitivna linearna korelacija, i to: između glutenskog indeksa i maksimalnog otpora tijesta na rastezanje (r = 0,860); glutenskog indeksa i energije tijesta (r = 0,799); glutenskog indeksa i otpora tijesta na rastezanje od 50 mm (r = 0,788). To pokazuje da glutenski indeks zapravo definira tehnološku kakvoću brašna. Optimalne vrijednosti glutenskog indeksa u brašnima za proizvodnju kruha u hrvatskim su sortama pšenice od 75 do 90 %.