

THE GENOTYPE EFFECT ON THE RATIO OF WET GLUTEN CONTENT TO TOTAL WHEAT GRAIN PROTEIN

UTJECAJ GENOTIPA NA OMJER VLAŽNOG GLUTENA I UKUPNIH BJELANČEVINA ZRNA PŠENICE

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ABSTRACT

Gluten proteins are primarily responsible for the end-use wheat quality and quite a number of methods for gluten quality evaluation was suggested and applied. The aim of the work presented here was to examine the genotype effect on the ratio of wet gluten to total protein content (WG/P), as measure of wet gluten production per protein unit. Ten winter wheat cultivars of Agricultural Institute Osijek were included in this study. Significant ($P<0.05$) difference in WG/P ratio was noticed among analyzed cultivars. The ratio of the wet gluten to protein content varied within a broad range depending on genotype. The data showed that, with regard to Gluten Index (GI) value, cultivars with WG/P ratio range from 2.7 to 3.0 had optimal baking characteristics of gluten (GI varied between 75 and 90), while cultivars with strong gluten characteristics ($GI>90$), known as improvers, had WG/P ratio between 2.3 and 2.4. Significant ($P<0.05$) negative correlation ($r=-0.622$) was determined between GI and WG/P ratio.

KEY WORDS: wheat, protein, wet gluten, ratio WG/P, Gluten Index

SAŽETAK

Bjelančevine glutena imaju ključan utjecaj na kakvoću pšenice i preradbenu vrijednost brašna. Cilj rada bio je ispitati u kojoj mjeri je omjer vlažnog glutena i ukupnih bjelančevina (WG/P), kao mjera dobivene količine glutena po jedinici ukupnih bjelančevina, karakteristika genotipa. U radu je analizirano 10 kultivara ozime pšenice Poljoprivrednog instituta Osijek. Kultivari se značajno razlikuju ($p<0,05$) po vrijednostima omjera WG/P. Kultivari S. Žitarka, Barbara, Žitarka i Golubica s omjerom WG/P između 2,7 i 3,0 pokazali su optimalna tehnološka svojstva. Gluten indeks ovih kultivara kreatao se od 75 do 90, dok su kultivari Srpanjka, Ana i Demetra, inače poznati kao poboljšivači obzirom na vrijednost $GI>90$, imali omjer WG/P između 2,3 i 2,4. Statistički značajna ($p<0,05$) negativna korelacija ($r=-0,622$) utvrđena je između GI i omjera WG/P.

KLJUČNE RIJEČI: pšenica, vlažni ljepak, omjer WG/P, gluten indeks

DETALJAN SAŽETAK

Bjelančevine glutena imaju ključan utjecaj na kakvoću pšenice i preradbenu vrijednost brašna. Mnogobrojne metode se koriste u procjeni kakvoće glutena. Gluten indeks metoda (ICC Standard No. 155) temelji se na automatiziranom ispiranju vlažnog glutena (Glutomatic 2200 Gluten System i Glutomatic Centrifuge 2015, Perten), te je kao objektivna metoda našla svoju široku primjenu. Ova metoda omogućuje istovremenu kvantitativnu i kvalitativnu analizu bjelančevina glutena. Vlažni gluten značajno korelira s količinom proteina, sa izraženim utjecajem okoline na njihovu količinu. Za razliku od količine, kakvoća glutena značajno je definirana utjecajem genotipa. Cilj rada bio je ispitati u kojoj mjeri je omjer vlažnog glutena i ukupnih bjelančevina (WG/P), kao mjera dobivene količine glutena po jedinici ukupnih bjelančevina, karakteristika genotipa. U radu je analizirano 10 kultivara ožime pšenice Poljoprivrednog instituta Osijek. Godina žetve značajno je utjecala na udio bjelančevina i količinu vlažnog glutena ($p < 0,05$), čak i kad je analizom varijance utvrđen i značajan utjecaj genotipa (Tablica 2). Međutim, utjecaj genotipa je dominantan kada govorimo o kvalitativnim karakteristikama glutena, uključujući Gluten indeks (GI), te omjer vlažnog glutena i ukupnih bjelančevina (WG/P). Iz dobivenih rezultata može se vidjeti da se kultivari značajno razlikuju ($p < 0,05$) prema vrijednostima omjera WG/P (Tablica 2). Kod kultivara s jakim glutenom ($GI > 90$), Srpanjke, Ane i Demetre, omjer WG/P u prosjeku je varirao od 2,3 do 2,4, za razliku od kultivara S. Žitarke, Barbare, Žitarke i Golubice s većim WG/P omjerom (2,7-3,0) (Slika 1) i vrijednošću GI od 75 do 90 (Tablica 1). Statistički značajna ($p < 0,05$) negativna korelacija ($r = -0,622$) utvrđena je između GI i omjera WG/P.

INTRODUCTION

Gluten forming proteins are primarily responsible for the functional properties of wheat flour [1]. The Gluten Index Method (Glutomatic 2200, Perten) provides information on both quantity and quality of wet gluten [2]. Wet gluten content is a frequently sought-after specification. It is highly correlated to the grain protein content, which is strongly influenced by growing environment [3,4]. However, genotype influence is generally considered to be dominant for qualitative characteristics of gluten [5]. 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 [6, 7, 8]. The aim of the work presented here was to examine the genotype effect on the ratio of WG/P, as indicator of wet gluten production per protein unit.

MATERIALS AND METHODS

Ten wheat cultivars (Žitarka, S. Žitarka, Barbara, Ana, Demetra, Srpanjka, Golubica, Monika, Klara and Hana) of Agricultural Institute Osijek were included in this study. The field trials were set up on eutric cambisol soil at location Osijek as RCB design in 4 repetitions during 7 growing seasons. Annual data were available from 1997 – 2004, with the exception of 2003 because that year's data were incomplete. The crude protein content on dry matter basis was measured by NIT technology (Infratec 1241, Foss Tecator). Wet gluten and Gluten Index were determined according to ICC standard method No 155 using a Glutomatic 2200 Gluten System and Glutomatic Centrifuge 2015, Perten. Wet gluten in wheat flour is a plastic-elastic substance consisting of the proteins gliadin and glutenin, obtained after washing out the starch from wheat flour dough. Gluten separated from wheat flour is centrifuged to force wet gluten through a specially constructed sieve under standardized conditions. The percentage of wet gluten remaining on the sieve after centrifugation is defined as the Gluten Index. Statistical analysis of data was carried out with Statistica 6.0 (StatSoft software).

RESULT AND DISCUSSION

The mean total protein content in the wheat samples for the six years period (1997-2002) varied between 12.4% (cv. Ana) and 14.3% (cv. Golubica) (Table 1). In 2004 protein content varied from 13.8% (cv. Ana) to 15.9% (cv. Golubica). The 1997-2002 mean value for wet gluten content varied between 29.3% (cv. Ana) and 41.5% (cv. Golubica), and in 2004 it ranged from 31.4% (cv. Ana) to 47.9% (cv. Golubica).

Environmental factors strongly influenced the grain protein content and wet gluten content ($P < 0.05$), even though there was also a significant genotype effect shown by analysis of variance (Table 2). This strong influence of environment on quality traits of wheat is in agreement with results of many authors [9, 10, 11, 12]. However, genotype effect was dominant for qualitative characteristics of gluten, including ratio of WG/P and Gluten Index (GI) (Table 2). The results of analysis of the ratio between wet gluten content and grain protein content showed that WG/P ratio varied within a broad range. The WG/P ratio during six years period varied from 2.27 (cv. Srpanjka) to 2.90 (cv. Golubica), and results from 2004 showed that WG/P ranged from 2.28 (cv. Ana) to 3.01 (cv. Golubica) (Figure 1).

In this study we have noticed that average coefficient of variation for WG/P ratio (9.03%) in 2004 was not much larger than during 6 years period ($CV = 8.60\%$).

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Table 1. Quality parameters of wheat cultivars
 Tablica 1. Parametri kakvoće analiziranih kultivara

Cultivar	P* (%)		WG (%)		GI	
	1997-2002	2004	1997-2002	2004	1997-2002	2004
Žitarka	13.8	15.6	38.7	45.1	71	77
S. Žitarka	13.2	14.2	36.0	37.0	75	71
Barbara	13.6	14.8	37.5	39.8	84	89
Ana	12.4	13.8	29.3	31.4	98	98
Demetra	12.7	14.2	29.2	33.9	98	98
Srpanjka	13.5	15.8	30.6	36.7	96	96
Golubica	14.3	15.9	41.5	47.9	75	79
Monika	14.2	14.5	34.5	35.2	75	66
Klara	13.4	14.5	34.4	37.9	87	92
Hana	12.9	14.2	32.5	35.2	92	97
CV%	8.60**	5.10***	15.93	13.31	18.43	13.97

*P= protein content (%); WG= wet gluten content (%); GI=Gluten Index
 P= udio bjelančevina (%); WG= količina vlažnog glutena (%); GI=gluten indeks
 ** Coefficient of variation (n=60), *** Coefficient of variation (n=10)

Table 2. Analysis of variance*
 Tablica 2. Analiza varijance

Quality	Factors	SS	df	MS	F
P**	Cultivars	23.1385	9	2.5709	2.2101*
	Years	46.6672	6	7.7779	12.9319*
WG	Cultivars	1013.185	9	112.5761	6.8272*
	Years	715.3682	6	143.0736	6.7722*
WG/P	Cultivars	2.8004	9	0.3112	11.6835*
	Years	0.7589	6	0.1518	2.3230 ^{ns}
GI	Cultivars	4812.829	9	534.759	5.8035*
	Years	1824.583	6	304.097	2.0896 ^{ns}

*(P<0.05)
 **P= protein content (%); WG= wet gluten content (%); GI=gluten index
 P= udio bjelančevina (%); WG= količina vlažnog glutena (%); GI=gluten indeks

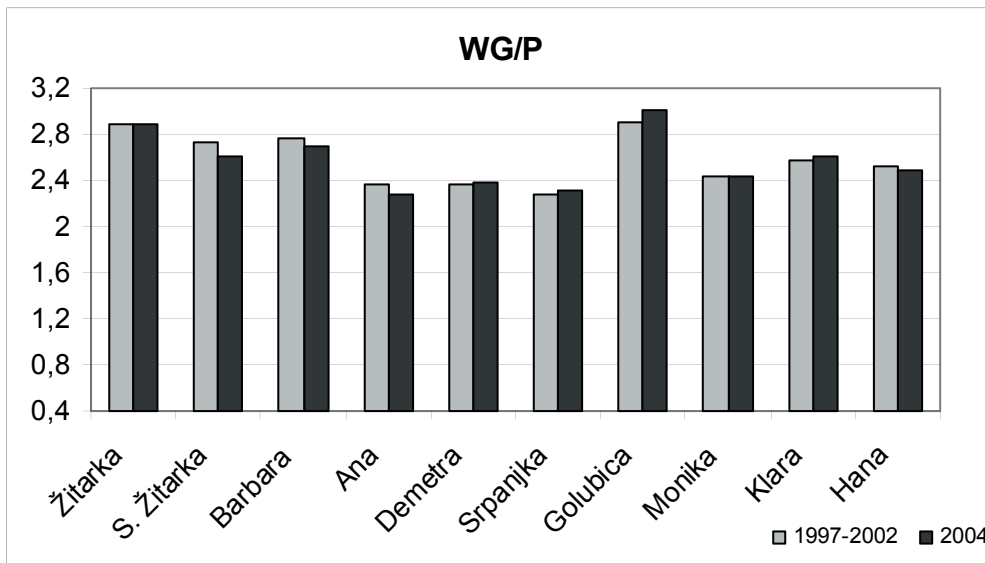


Figure 1. The ratio of wet gluten to total protein content (WG/P)
Slika 1. Omjer vlažnog glutena i ukupnih bjelančevina (WG/P)

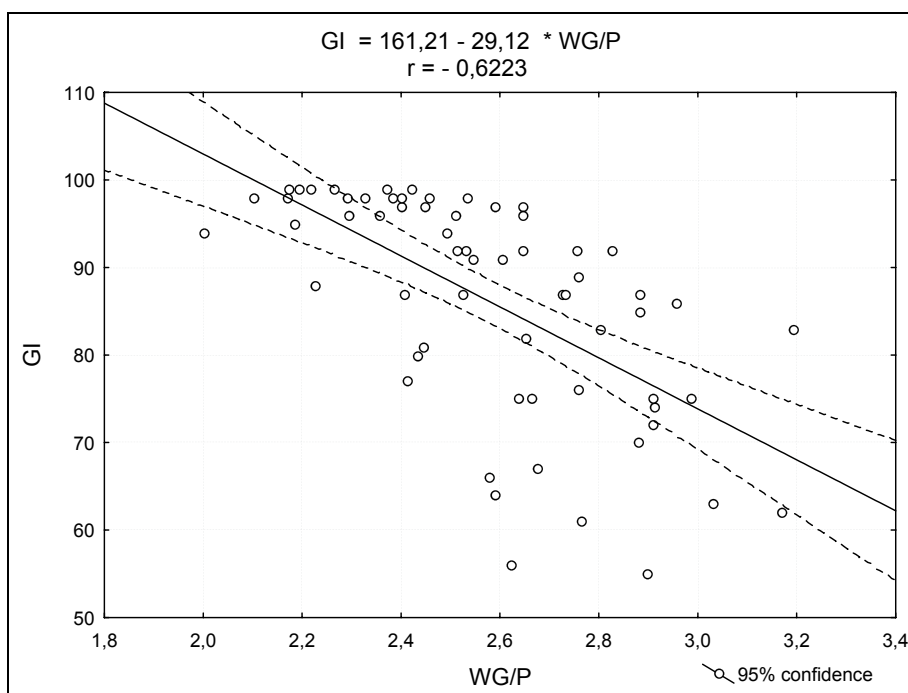


Figure 2. Relationship between Gluten Index and the ratio of wet gluten to total protein content (WG/P)
Slika 2. Povezanost gluten indeksa i omjera vlažnog glutena i ukupnih bjelančevina (WG/P)

Comparing the last harvest year results of WG/P ratio to average value obtained during six years, the genotype effect on this feature was emphasized (Table 2). Cultivars Srpnjka, Ana and Demetra, with strong gluten ($GI > 90$), had average WG/P values from 2.27 to 2.43 in contrast to cultivars S. Žitarka, Barbara, Žitarka and Golubica with higher average WG/P ratio (2.73-3.01) and GI values between 75-90 (Table 1). According to this results, significant ($P < 0.05$) negative correlation ($r = -0.622$) was found between Gluten Index and WG/P (Figure 2). It has been shown by O. K. Chung et al. [3] and Williams [5] that wet gluten content is highly correlated to protein content, and the ratio of wet gluten to protein content for Canadian wheats is about 2.8 for Canada Western Red Spring flours (CWRS). However, this ratio differs among Canadian wheat classes. For Western Extra Strong wheat the ratio is about 2.6, while for Western Soft White Spring wheat the ratio is closer to 3.0.

CONCLUSION

The ratio of the wet gluten to protein content varied within a broad range depending on genotype. Cultivars with WG/P ratio between 2.7 and 3.0 have shown optimal baking characteristics of gluten, while cultivars with strong gluten characteristics, known as improvers, have shown WG/P ratio closer to 2.3.

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