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The influence of changes in gluten complex structure on technological quality of wheat (*Triticum aestivum* L.)

A. Torbica [a,*], M. Antov [b], J. Mastilović [a], D. Knežević [c]

[a] *Institute for Food Technology, University of Novi Sad, Novi Sad, Blvd. Cara Lazara 1, Serbia*
[b] *Faculty of Technology, University of Novi Sad, Novi Sad, Blvd. Cara Lazara 1, Serbia*
[c] *Faculty of Agriculture Priština-Lešak, University of Priština, Priština, Serbia*

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Abstract

The influence of changes in glutenin–gliadin complex of grain on technological quality of the wheat variety (*Triticum aestivum* L.) was studied. It was shown that wheat-bug attack caused differences in electrophoregram pattern of glutenins and gliadins concerning their number, intensities and molecular weights. The environmental influence had detrimental effect on rheological properties of dough. Expected heat-stress effect – the increase of gliadin–glutenin ratio was not detected. The modified method for gluten index was introduced and it was proven as superior to the standard method in predicting technological quality of wheat.

Keywords: Glutenins; Gliadins; Technological quality; Wheat variety; Gluten index

1. Introduction

Gluten can be defined as the rubbery mass that remains when wheat dough is washed to remove starch granules and water-soluble constituents. In practice, the term 'gluten' refers to the proteins, because they play a key role in determining the unique baking quality of wheat by conferring water absorption capacity, cohesivity, viscosity and elasticity on dough. Traditionally, gluten proteins have been divided into roughly equal fractions according to their solubility in alcohol–water solutions of gluten (e.g. 60% ethanol): the soluble gliadins and the insoluble glutenins. The glutenin fraction comprises aggregated proteins linked by interchain disulphide bonds; they have varying size ranging from about 500,000 to more than 10 million (Wieser, 2007). When glutenin is treated with reducing agents and analyzed by electrophoresis, two groups of proteins are obtained based on molecular weight: high molecular weight glutenin subunits (HMW-GS) and low molecular weight glutenin subunits (LMW-GS) (Wang, Khan, Hareland, & Nygard, 2006). The molecular weight distribution of glutenins has been recognized as one of the main determinants of dough properties and baking performance. Most gliadins are present as monomers; they were initially classified into four groups on the basis of mobility at low pH in gel electrophoresis: α-, β-, γ-, ω-gliadins in order of their descending mobility (Wieser, 2007).

Both glutenins and gliadins are important contributors to the reologhical properties of dough, but their functions are divergent. Hydrated gliadins have little elasticity and are less cohesive than glutenins; they contribute mainly to the viscosity and extensibility of dough system. In contrast, hydrated glutenins are both cohesive and elastic and are responsible for dough strength and elasticity (Wang et al., 2006; Wieser, 2007). Some reports suggest that the overall function of wheat proteins derives mainly from the glutenin, and that gliadin is only as a diluent. Others, however, suggest that gliadin is an important direct contributor to gluten's properties (Xu, Bietz, & Carriere, 2007).

* Corresponding author. Tel.: +381 (0) 21 485 3779; fax: +381 (0) 21 6350 20.
E-mail address: torbica@tehnol.ns.ac.yu (Aleksandra Torbica).

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Although the appearance of glutenin and gliadin electrophoregrams with respect to number and band positions depends exclusively on wheat genotype, the intensities of the present bands that refer to protein fractions quantities may reflect also the environmental conditions (Lookhart, Menkovska, & Pomeranz, 1989; Sivri, Köksel, & Bushuk, 1998). Many factors can produce environmental modifications of grain quality including soil type and fertilizer level (particularly nitrogen, phosphorus and sulphur), climate fluctuations (especially influence of drought and heat-stress during grain filling) and finally the attack of insects and field pests (Altenbach, Kothari, & Lieu, 2002; Daniel & Triboi, 2000; Dupont & Altenbach, 2003; Lookhart et al., 1989).

A number of researchers confirmed that some of factors mentioned above affect particularly glutenin–gliadin complex in a way that, e.g. enzyme hydrolysis occurs or rate of gliadins synthesis is higher comparatively to glutenins, what causes change of optimal ratio between glutenins and gliadins 1:1 (Fido, Bekes, Gras, & Tatham, 1997; Goesaert et al., 2005; Peña, 2002; Radovanovic, Cloutier, Brown, Humphreys, & Lukow, 2002).

Because of that, the necessity of investigation on essences of changes in glutenin–gliadin complex of wheat, that induces appearance of differences in technological quality, is imposed, and that was the aim of our study. This could be the most objectively investigated by comparing the characteristics of glutenin–gliadin complex of chosen wheat variety grown during the two production years in which it showed high and low technological quality.

2. Materials and methods

2.1. Material

Winter wheat variety which analyzed was created in a breeding centre of Institute of Field and Vegetable Crops, Novi Sad, Serbia. In previous decade this variety showed relatively stable high technological quality. The samples were collected from several locations of province of Vojvodina. Locations were chosen with respect to the high variations of infestation of insect damage attack and heat-stress. Analyzed samples originated from two wheat production years: year 1 was characterized by absence of insect attack and heat-stress, while year 2, in contrary, was characterized by heat-stress and presence of high level of wheat-bug damaged kernels, especially in locations B and C (see Tables 1 and 2).

2.2. Standard methods of evaluation of technological quality of wheat

Chosen samples have been tested by all Standard methods for the determination of trading and technological wheat quality: determination of Besatz of wheat (ICC Standard No. 102/1), protein content (NIT analyzer "Infratec 1241"), sedimentation according Zeleny (ICC Standard No. 116/1), rheological examinations with farinograph and extensograph (ICC Standard No. 114/1 and ICC Standard No. 115/1), wet gluten content (ICC Standard No. 106/2), gluten index (ICC Standard No. 155)

Table 1
Wheat-bug damaged kernels content and values of indirect and direct gluten quality parameters of wheat samples from the production year 1

Locations	Wheat-bug damaged kernels (%)	Content of protein (% on dry base)	Zeleny sedimentation value (ml)	Zeleny sedimentation value 6 months after harvest (ml)	Wet gluten content (%)	Dry gluten content (%)	Gluten index (%)	Gluten index at 37 °C (%)
Year 1								
A	0.60	13.2	47	40	34	12	88.86	65.85
B	0.60	11.5	31	32	31	10	91.64	51.08
C	0.70	11.8	43	36	30	10	96.61	66.57
D	1.10	12.3	40	33	32	9	91.90	46.88
E	0.60	12.5	40	35	30	11	89.83	72.81
F	1.00	12.3	38	29	31	10	91.59	67.46
G	1.10	12.1	41	39	29	10	94.81	73.75

Table 2
Wheat-bug damaged kernels content and values of indirect and direct gluten quality parameters of wheat samples from the production year 2

Locations	Wheat-bug damaged kernels (%)	Content of protein (% on dry base)	Zeleny sedimentation value (ml)	Zeleny sedimentation value 6 months after harvest (ml)	Wet gluten content (%)	Dry gluten content (%)	Gluten index (%)	Gluten index at 37 °C (%)
Year 2								
A	3.70	11.7	40	34	37	12	75.68	31.99
B	4.40	13.9	58	38	43	14	46.51	0.00
C	7.10	16.1	60	36	42	13	52.38	0.00
D	2.50	10.3	32	33	30	10	93.33	36.96
E	1.30	13.9	52	38	34	11	94.12	53.08
F	1.40	12.1	38	32	33	11	96.97	67.52
G	1.30	12.2	61	36	36	12	86.11	40.49