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THE IMPACT OF GLIADIN ON THE RHEOLOGICAL PROPERTIES OF WHEAT GLUTEN

Ruska-Banda Laszlo*

*University of Oradea, Faculty of Environmental Protection, 26 Gen. Magheru St., 410048, Oradea, Romania, e-mail: ruska_laszlo@yahoo.com;
**Food engineeringl Oradea

Abstract

Were studied the effects on the technological potential of wheat gluten of a purified gliadin addition of α, β, γ and ω gliadine subgroups. The gluten viscosity with the addition of α, β, γ and ω2-gliadine showed considerable increases in the magnitude of G 'and G ", suggesting the existence of native gluten. On the contrary, a reduction in the size of G 'and G ", occurred upon the addition of the total fraction of gliadin and 1-gliadin, involving the softening of gluten.

Key words: gliadin, gliadin subgroups, dynamic rheological properties, quality bread.

INTRODUCTION

It is known that gluten proteins play an important role in the technological potential of wheat flour. The two gluten proteins gliadin and glutenin during dough processing form gluten. Its importance in the manufacture of bread is primarily due to its unique viscoelastic properties. Thus, the correct determination of the rheological properties of gluten in different wheat varieties is very important in terms of its use in obtaining different finished products. For a better view of the factors influencing the viscoelastic properties of gluten it was studied the ratio of the two gluten proteins gliadin and glutenin and to how it affects the gluten viscoelasticity.

The dynamic rheological parameters (G′, G″ and tan) of gluten doughs are reported to depend on wheat cultivar. According to these reports, the glutens from poor quality wheats are rheological characterised as less elastic and more viscous than glutens from good quality wheats. It has been suggested that quantitative and compositional variation in the glutenin polypeptide, gliadin/glutenin ratio and high/low M_r glutenin subunit ratio have important effects on viscoelasticities of glutens (Khatkar *et al.*[7]). Differences among gluten systems have also been reported in terms of the molecular size range and molecular size distribution of the glutenin polymers (Cornec *et al.*[9]; Popineau *et al.*[10]). To study the effect of molecular weight distribution on gluten rheology, Cornec and co-wokers[9]

prepared a series of gluten sub-fractions by sequential extractions with increasing concentrations of dilute HCl(0·3–5 mM) as described by MacRitchie[11,12] .

The results obtained by dynamic measurements in shear suggested that the viscoelasticity of sub- fractions correlate strongly with the proportion of the high M_r proteins (i.e. glutenin polymers) as determined by SE-HPLC.

Seemingly some progress has been made in understanding the contribution of glutenin poly- peptides to gluten rheology. However, limited attempts have been made to understand the relative contributions of purified gliadin subgroups to gluten viscoelasticity. Recently, some research has been done to evaluate the contribution of gliadin components to dough strength using empirical rheological instruments such as the Mixograf and Extensograph. These instruments are not a possibility to study the viscoelastic behavior of materials in terms of mechanical spectra, i.e. plots of storage modulus (G′) and loss modulus (G″) vs frequency. It is well established that mechanical spectra are basic elements for analyzing the viscoelastic behavior of materials and for understanding their underlying structures and / or interactions. In the present study, therefore, a controlled voltage viscoelastic rheometer was used to elucidate the precise effects of purified total gliadin and its subgroups, α, β, γ and ω on the dynamic rheological properties of gluten and the potential for the production of bread from wheat flour.

MATERIAL AND METHOD

The gliadin and purified gliadin subgroups of α-, β-, γ-,slow ω (ω1) - and fast ω (ω2) -gliadins) from Partizanca flour were extracted and purified. The parameters of the mixture were determined as described Khatkar *et al.*[17]. The water absorption value of Partizanca flour was determined using Farinograph. The Partizanca flour made the water absorption value at Farinograph to be 60%. Additional 1.5 ml water / g gluten / gliadin fraction was added to Partizanca flour and the dough samples were grown to the maximum consistency using 2 g Mixograph.

To investigate the effects of total gliadin and its subgroups α-, β-, γ, slow ω (ω 1) - and rapid ω (ω 2) –gliadine, on the rheology of gluten, purified gliadin and total gliadin subgroups were first added on Partizanca flour on a 1% (w / w) basis and mixed until a top dough in the 2 g mixture was obtained to achieve homogeneous mixing and desired interactions of gliadins added with basic flour proteins. Optimally the mixed doughs were then hand washed using distilled water for the recovery of gluten with the incorporated gliadins. The washing process hydrates the gluten samples thoroughly. The gluten was then placed in a sealed cup for 1 hour at room

temperature before loading onto the rheometer. Reference gluten samples (Partizanca) were also prepared in the same way as gluten with added gliadin samples. Dynamic oscillatory measurements of optimal mixing and fully hydrated samples were determined using RTI (Rheo-Tech International Ltd, London, U.K.), a viscoelastic rheometer. Samples prepared using the Mixograph were placed carefully between plates on the rheometer and the space between plates (sample thickness) was adjusted to 1 · 0 mm. A top plate with a radius of 10 mm was used. Excessive dough has been thoroughly cleaned with a razor blade and a thin layer of low viscosity (<0.1% of the test material viscosity), the silicone lubricant has been applied to the surfaces exposed to the dough to prevent loss of moisture. The sample was left to rest for 30 minutes on the rheometer to allow the stresses induced during sample manipulation to relax. Tests were performed at 25 ° C. The linear viscoelastic region of Partizanca gluten and Partizanca gluten with the addition of gliadin sample was determined by performing a stress amplitude maturity, the sample under investigation was subjected to a range of stress values and the dynamic moduli. Weighing experiments were carried out in the linear viscoelastic region. The effects of total gliadin and its sub-fractions on the performance of Partizanca flour were determined using optimized micro-baking tests.

RESULTS AND DISCUSSION

The effects of total gliadin addition on the dynamic rheology of gluten. Figure 1 shows a comparison of the results obtained during a stress sweep performed at a constant oscillation frequency of 1 Hz on native gluten (Partizanca) and native gluten with total gliadin added fraction.

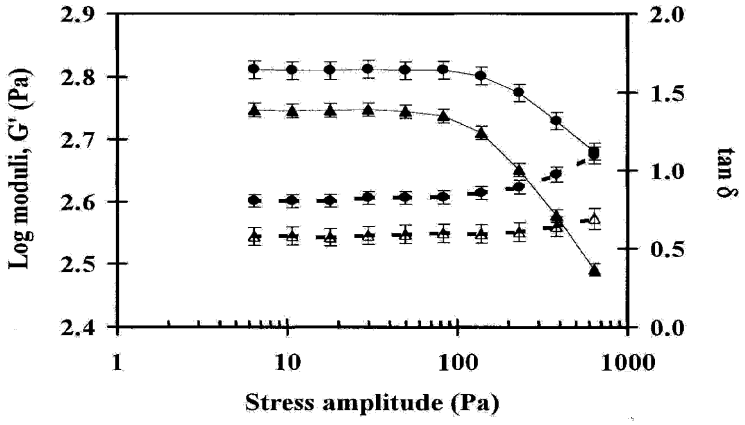

Figure 1 Stress dependence of G′ (—) and tan (. . .) profiles for Partizanca gluten (circles) and Partizanca gluten plus total gliadin (1%, w/w, flour basis) (triangles). Frequency, 1 Hz.

From the analysis of G 'and tan (figure 1), it was possible to detect a linearity region for the two systems examined. It is of interest that, at higher stress amplitudes (> 100 Pa), it was observed that there was a relatively lower deviation from linearity in the case of native gluten, whereas a pronounced deviation in linearity was demonstrated by gluten contains the total added giadin, G' and tan. However, it should be noted that both systems meet the linearity conditions at a stress amplitude of less than 50 Pa. Addition of individual groups of purified gliadin to Partizanca gluten has also illustrated the linear responses of G 'and G" in this stress amplitude region (the results presented). Thus, a stress amplitude of 25 Pa was chosen to perform the frequency measurement experiments (the study of the effect of the oscillatory frequency of the sample on the measured values of G ', G" and tan).

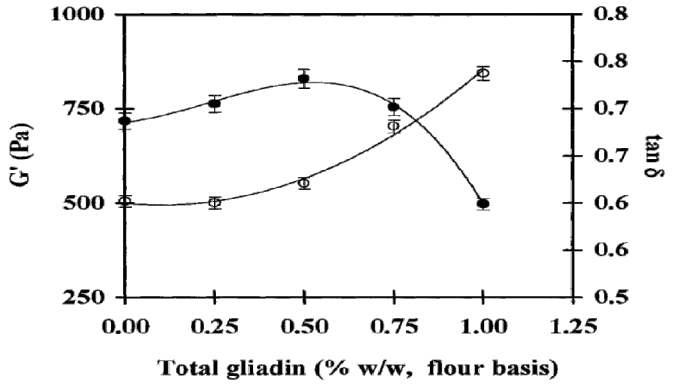

Figure 2 Effect of addition of total gliadin on G′ (X) and tan (B) profiles of Partizanca gluten. Stress amplitude, 25Pa.Frequency, 1 Hz

The effects of total gliadin addition on dynamic gluten measurements are illustrated in Figure 2. The storage modulus, G' from Partizanca gluten first increased to 0.5% total gliadin, then decreased substantially.Tan δ values increased as the total gliadin addition increased, however. This is due to the differential rate of G' and G" as a result of the total addition of gliadin; clearly, the decline rate beyond the 0.05% addition was higher for G' than G" values.The effects of addition of individual gliadin groups on the frequency of cleaning native gluten (Partizanca) are shown in Figure 3.

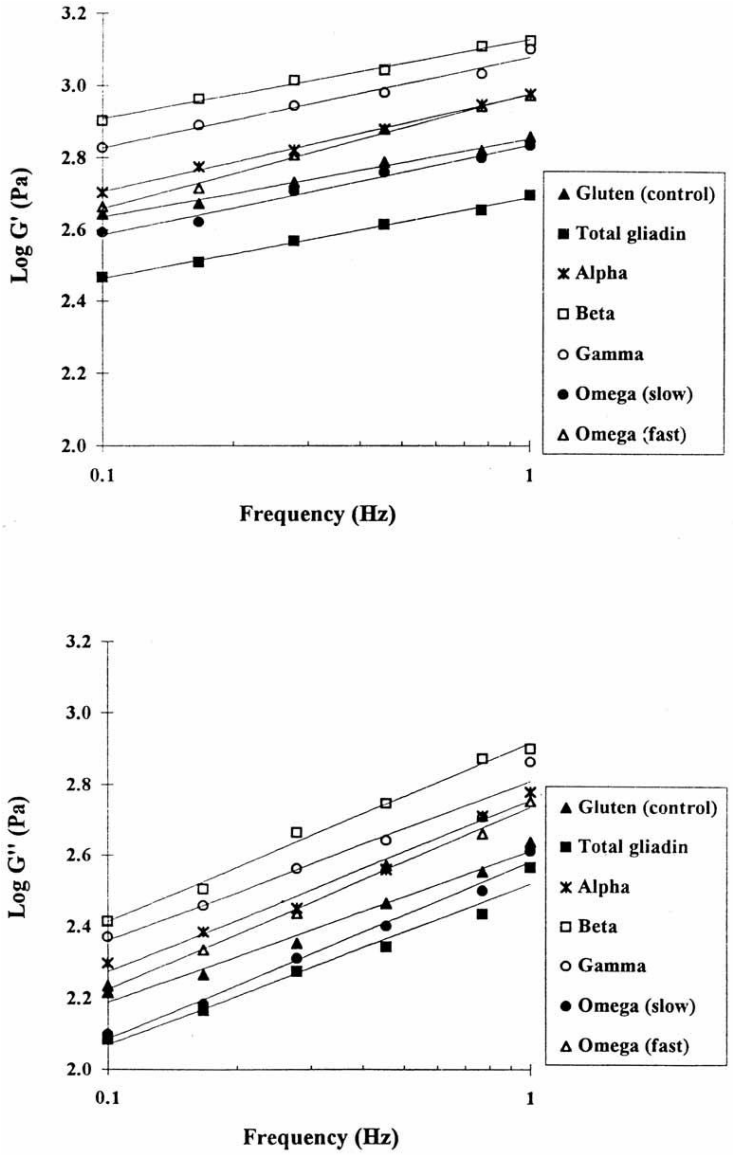

Figure 3 Effects of addition of different gliadin subgroups on the mechanical spectra of Partizanca gluten. Stress amplitude ($_0$), 25 Pa.

The gluten sweeps frequencies with α-, β-, γ- and ω 2-gliadines showed unexpected increases in the size of G 'and G ", suggesting the existence of native gluten.

On the contrary, a reduction in the size of G 'and G "occurred upon the addition of the global gliadin and ω 1-gliadin fraction, implying the softening of gluten. Non-destructive rheological measurements have

indicated differential interactions behavior of gliadin subgroups with gluten proteins. It seems that α, β and γ-gliadins have a greater tendency to interact with gluten than ω-gliadins.

The relative sizes of G 'and G "provide important information to define and distinguish between biopolymer systems. In a tangled biopolymer system, the magnitude of G 'and G "is expected to be relatively close.

The size of the slope of log G ' vs log frequency also provides other useful information, that , in the case of a three-dimensional network, the slope is expected to be close to zero, which is a characteristic of a highly cross-linked material.

This implies that increasing the concentration of uncross-linked material would cause the slope to increase and vice versa.

The relationships between dynamic rheological measurements, baking results and Mixograph parameters were determined for the different subgroups of gliadin added to Partizanca flour 1%, w / w.

As shown earlier, dynamic measurements were recorded on wet gluten containing different gliadins. The dynamic moduli G 'and G "from Partizanca gluten showed significant relationships (r = 0 · 74 and, respectively,77) with the bread volume for the gliadin subgroups added to the Partizanca flour (Figure 4).

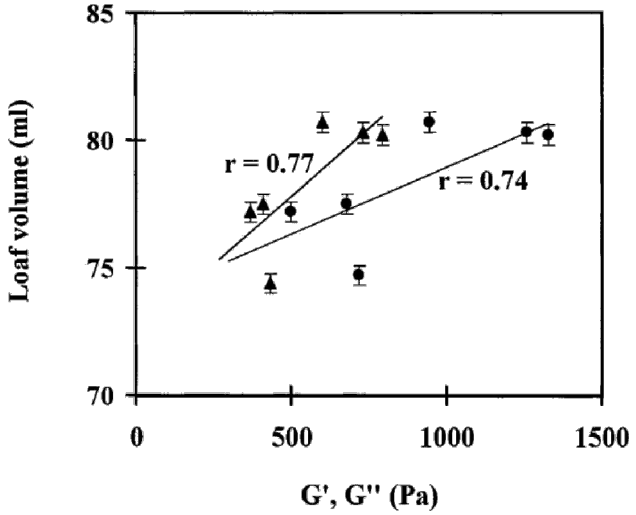

Figure 4 Relationships of G′ (circles) and G″ (triangles) of Partizanca gluten with loaf volume for adding different gliadin subgroups

The correlations of dynamic measurements with the Mixograph parameters are shown in Table II.

As indicated in table II, G 'and G " were significantly correlated with maximum dough resistance (PDR) and resistance breakdown (RBD).

However, none of the dynamic measurements were significantly correlated with the mixing time, but showed insignificant negative relationships. Additionally, the relationships between dynamic measurements and bread volume and the Mixograph PDR parameter were almost similar.

Thus, the rheological dynamic results and the PDR Mixograph parameter were consistent in highlighting the positive role of gliadins in the bread making process.

CONCLUSIONS

Dynamic rheological analysis of gluten with the addition of gliadin subfractions indicated that α-, β- and γ-gliadinyls tend to interact with gluten rather than ω-gliadins.

This can be attributed to the presence of cysteine residues in gliadins rich in sulfur. Non-destructive rheological analysis of gluten with added gliadins also indicated that ω- and α-gliadins are relatively less inter-related than β- and γ-gliadins.

Additionally, rheological dynamic measurements, PDR Mixer parameter and baking results were consistent in highlighting the positive role of gliadins in the bread making process.

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