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RESEARCH ON CHANGE IN PROTEIN COMPOSITION DURING DOUGH PROCESSING

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Abstract: *The ability of wheat flour to be processed into different foods is largely determined by the gluten proteins. Therefore, the gluten proteins have been the subject of intensive studies and this has revealed that having unusual structures and properties, made gluten proteins of special interest for studies. The objectives of this paper were to increase the understanding about the protein in wheat flour and to investigate formation of gluten protein in dough system during dough mixing.*

Key words: *wheat flour, protein, gluten, dough, viscoelasticity.*

1. Introduction to Bread Dough

Rheology is the science concerned with the study of viscosity and deformation of a plastic substance. Elasticity and viscosity are the most familiar rheological concepts in this area and the measure of these properties becomes a significantly concerned topic. Currently, rheological measurements are extensively used in the baking industry for testing flour quality and adherence to specifications [2].

Empirical dough rheological instruments such as the Farinograph, Mixograph, Alveograph, and Extensograph, are used to measure the physical response of doughs to external forces. The basic parameters from the devices measure the dough stress and strain properties and quantify the elastic and viscous properties.

2. Viscoelastic Properties of Dough

Dough is viscoelastic, which means that it has both viscous and elastic characteristics and combines the properties of both solids and liquids. For ideal elastic solids, the strain is always proportional to the stress. For ideal viscous liquids, the strain is always proportional to the rate of stress. When both types of simple ideal behaviour coexist, the ratio stress-strain is a function of the stress or strain as well as time, and material shows nonlinear viscoelasticity [5].

The mechanical properties of dough show both kinds of behaviour, so that it is classified as a nonlinear viscoelastic material. If dough is too viscous and flows too much during sheeting, the dough does not maintain the desired final shape. If the dough lacks in its elastic properties, it is difficult to form into the desired shape with the result that the final products are not desired by the customers. If it is not sticky enough, the dough will not be sufficiently cohesive to be formed by sheeting, and the final product does not have the desired crumb structure.

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Therefore, a correct balance of viscoelastic properties is very important to a successful sheeting process. On the one hand it is necessary to control the extensibility of the dough, and on the other hand it is important to control the elasticity. It is necessary to have an appropriate extent of stickiness to hold the folded layers of dough together and to prevent large holes in the final baked food.

In addition, the rheological properties of dough help determine bread loaf shape during proofing before baking. The dough should expand to fill the pan but flow to keep a good product shape. If the viscous dough is too weak, it flows to fill the corners of the pan. It will cause a problem with sharp edges and a flat top [2].

Conversely, if the dough is too strong, it does not expand sufficiently during the proofing or baking, resulting in a low volume.

3. Factors Affecting Dough Rheology

The rheological properties of flour-water dough are affected by ingredient interactions during dough mixing. Most of the properties result from the interactions with flour, water, and air. Other factors such as salt, yeast, oxidizers, and emulsifiers are widely known to have effects also.

3.1. Dough Rheology Affected by Wheat Flour Protein Content

All gluten proteins are synthesised on the endosplasmic reticulum and they all contain a signal peptide. Flour proteins are classified into four categories. Osborne was the first to classify wheat grain proteins on the basis of their solubility: *albumins* (soluble in water), *globulins* (salt), *gliadins* (aqueous water) and *glutenins* (dilute acid or alkali).

Glutenins and gliadins, when wetted and mixed, form gluten, which is unique to wheat. Gliadins contain intra-molecular disulfide bonds, the breaking of which causes unfolding of the protein molecule (Figure 2). They are apparently responsible for the cohesive property of gluten [2].

The glutenin proteins are multi-chained and appear to be mainly polymerized by disulfide bonds and not cross-linked [4]. These proteins appear to give the gluten its elastic properties.

The currently used protein classifying system is based on biological characteristics of the proteins together with their chemical and genetic relationship, leading to different states of aggregation in dissociating solutions [13].

Thus, gliadins are a mixture of monomeric polypeptides and glutenins consist of polypeptides aggregated by disulphide bonds (Figure 1).

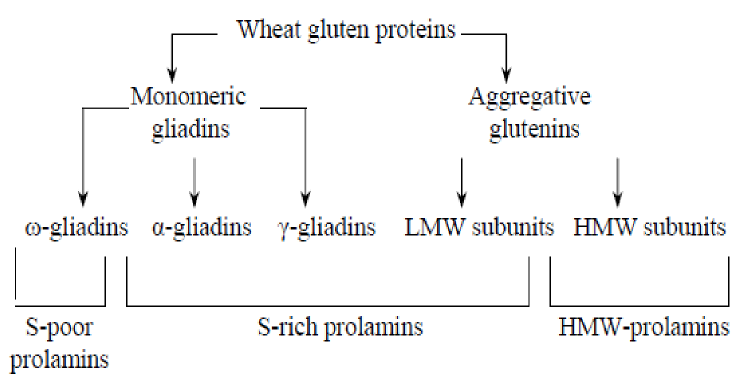

Fig. 1. *Traditional classification of gluten proteins* [*13*]

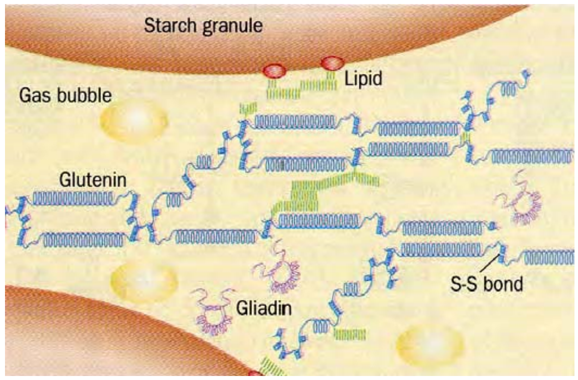

Fig. 2. *The disulphide-bonded polymeric structure of wheat glutenin: the protein matrix between the starch granules and gas bubbles in dough [14]*

Both types of wheat storage proteins, the gliadins and glutenins, are the main components, building the gluten polymer and determining bread-making properties [3].

Generally, albumins and globulins are not thought to play a critical role in flour quality, although, minor importance on bread-making quality has been reported. [8]. Protein fractions are important from a nutritional point of view, because of rather high amounts of essential amino acids.

Simple correlation between bread strength parameters and the proportion of each protein faction or combination of fractions shows that the proportions of both glutenin and residue protein have a direct effect on baking performance. The ratios of gliadin to glutenin and albumin to globulin are also significantly positively corrected with loaf volume per unit protein [14].

The relative quantity of glutenin is highly positively correlated with loaf volume, extensigraph dough resistance and extensibility, and mixograph peak development time of these flours.

3.2. Protein Behaviour during Dough Processing

Three factors are required to form dough - flour, water and energy. Dough are concentrated systems where shear and tensile forces imparted by mixing or sheeting cause gluten proteins join together and form a network in the dough [6].

During development, the dough acquires viscoelastic properties which become optimum at peak consistency. At a molecular level, the dough development involves the use of shear and tensile forces to extend the large glutenin molecules from their equilibrium conformations [9].

Extended molecules give rise to elastic restoring forces similar to what occurs in rubber elasticity. The high elasticity arising mainly from the entanglement coupling of glutenin molecules retards the molecular retraction and maintains the elasticity during resting. At a molecular level, during mixing glutenins retract from extended conformations. Mixing stresses produce orientation of molecules. Polymer molecules respond to the application of stress by three main processes, disentanglement, chain orientation and bond rupture. All three can occur during dough mixing. Scission of the largest glutenin molecules results from chains not being able to slip free at entanglements points quickly enough in response to the stress [12].

The covalent bonds that are broken are the disulphide bonds between glutenin subunits. Important is that the highest stresses occur at the centres of molecules where the probability of chain scission is the greatest.

The roles of the individual gluten components in dough functionality are complex [1]. When isolated gliadins are mixed with starch and water, a purely viscous material is formed and there is no development stage as in common dough. In contrast, pure glutenin forms a rubbery material with low extensibility. The elastic properties that appear in dough during mixing are due to glutenin [14].

Many approaches have attempted to explain the molecular basis of interactions of dough proteins [10].

Undeveloped dough is defined as wheat flour that has become fully hydrated without being deformed (i.e. subjected to nomechanical action). Developed dough is described as a transformation of undeveloped dough through some appropriate deformational energy input, to form the developed protein matrix [3].

The molecular models used to describe the gluten development involve glutenin proteins and crosslinks between them.

Schematic mechanisms involved in dough formation are shown in Figure 3.

Variation in the composition of polymeric proteins between wheat cultivars during dough mixing has been demonstrated [11]. The relative amount of polymeric protein increases with increasing gluten strength.

However, protein composition explains only a small proportion of the variation in quality. The effects of the glutenin polymer function in dough and flour end-use quality have also been investigated.

Specific changes in molecular weight and composition of polymeric glutenin occur during dough development and breakdown [11].

Many protein structural studies, as well as mixing and baking studies, have postulated that disulphide bonds contribute to the process of dough formation through the disulphide-sulphydryl exchange (Figure 3).

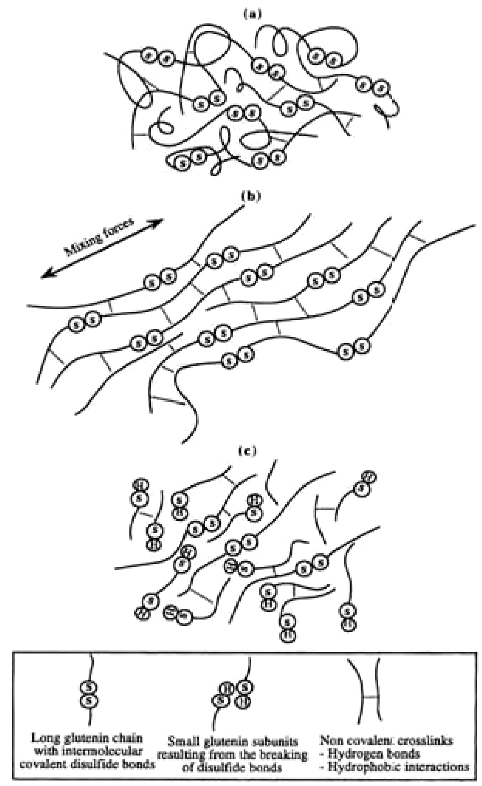

Fig. 3. *Molecular interpretation of the gluten development: a*) *beginning of the mixing; b*) *optimum development; c*) *overmixing* [*10*]

However, a full understanding of the structure of the gluten polymer during dough processing, as well as of the changes in molecular associations, is still far from being reached.

3.3. Viscoelasticity of Gluten

By measuring the rheological properties of dough not much information about the structure of gluten proteins can be obtained, since the rheological properties of gluten are masked by the large amount of starch and water content of dough.

Gliadins are responsible for the viscous and extensible properties, while glutenins confer elastic properties and resistance to expansion to the system. A balance between the two protein fractions is important for the rheological behaviour of gluten [7].

The viscoelastic properties of the glutenins have been postulated to govern the good mixing properties of dough and the quality of the final bread.

However, an appropriate relationship between rheological properties and baking performance is difficult to find. A great number of studies showed that there are a lot of factors influencing rheological properties of dough and baking quality.

Water content and flour type have a significant effect on storage modulus and phase angle measured by an oscillatory test both in linear viscoelastic region and as a function of stress [1].

In a study of the effect of granule size on dough extension it was found that small starch granules increase extensibility of the dough, whereas large granules increase resistance to extension.

4. Conclusion

A number of studies have been performed on gluten behaviour and indicating the importance of intramolecular disulphide bonds in dough/gluten rheological behaviour.

Viscoelasticity of gluten influence rheological properties of dough. By measuring the rheological properties of dough not much information about the structure of gluten proteins can be obtained, because the rheological properties of gluten are masked by the large amount of starch and water content of dough.

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