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Thermal properties of gluten proteins of two soft wheat varieties

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Abstract

The thermal properties of gluten proteins from two soft wheat varieties showing different rheological properties, ''Amazonas'' and ''Sorraia'', were studied by differential scanning calorimetry. Three endothermic peaks were found in all gluten proteins fractions, exception to ''Amazonas'' gliadins. In this case, the third endotherm is absent. Transition temperature, transition enthalpy and activation energy of the transition reaction were determined. Since gluten development is caused by the breakage and reformulation of sulphur bridges, the higher the energy needed to perform denaturation the more difficult will be the interaction between gliadins and glutenins. ''Amazonas'' wheat needs more energy to onset and to develop the transition. So, it is to be expected that the interactions among the protein fractions will become more difficult and consequently the gluten will appear as a weaker one. Multivariate analysis of the results indicates that the gliadin fraction seems to be the most responsible for the lower bread baking ability shown by ''Amazonas'' wheat.

Keywords: DSC; Gluten protein; Gliadins; Glutenins; Soft wheats

1. Introduction

The knowledge of the conformational changes that occurred in cereal macromolecules, namely proteins, is important for understanding their functionality. Proteins are known to form three dimensional structures mainly stabilized by non-covalent interactions. Gluten proteins (glutenins and gliadins) are the major storage wheat proteins. The unique functional properties of wheat among cereals are due to its ability to form gluten, a protein network showing viscoelastic properties and leading to a desirable texture after baking. These properties are mainly related to insoluble storage proteins. In particular, the glutenin polymer appears to determine dough strength, by forming an elastic network, which interacts with the gliadins by non-covalent forces, mainly hydrogen bonds (Lamacchia et al., 2000). Several research studies showed that the impact of glutenins on bread making quality is more important than the one of gliadins (Odintsova et al., 2000).

Gliadins are present as monomers and are responsible for gluten extensibility and cohesiveness, while the glutenins form high molecular weight polymers and contribute to the elasticity of gluten.

Both the gliadins and glutenins are mixtures of proteins that can be divided into groups. One of such groups of glutenin proteins, called the high molecular weight subunits of glutenin, appears to be particularly important in determining the viscoelastic properties of gluten and differences in this property among cultivars of good and poor bread making performance (Payne, 1987).

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The transitions occurring in protein affect the physical state and textural characteristics of various foods. The thermal behaviour of dough is very important to the quality of the final bakery product which results from two thermally induced phenomena: starch galatinization and protein denaturation. Denaturation is the most important transition occurring in proteins during the baking process, and contributes significantly to the characteristics of the baked products. Protein denaturation is defined as a process or a sequence of processes in which spatial arrangement of the polypeptide chain within the protein molecule is changed from the typical form of the native protein to a more disordered arrangement.

Most proteins denature at temperatures from 50 to 80 °C, being range of protein transition temperature specific for each protein (Slade & Levine, 1995). The denaturation of proteins has been extensively studied by differential scanning calorimetry (DSC), where denaturation is observed as an endothermic peak (Privalov & Khechinashvili, 1974).

The protein fraction of food materials is often composed of several proteins. Therefore, thermograms of a particular food material may exhibit several denaturation endotherms (Donovan, Mapes, Davis, & Garibaldi, 1975).

Wheat protein transition is of major importance in establishing bread structure. Another functional feature of wheat protein is its hydration during dough formation and the transfer of water from gluten to the starch component during baking, to support the swelling of the starch granules. The transition of gluten is accompanied by decreased solubility and proceeds to a point where the gas vesicle walls are fixed and expansion ends. The glass transition temperature (T_g) has been the main studied parameter to understand the mechanical properties of gluten proteins (Kalichevsky & Blanshard, 1992). The glass transition of glutenin and its depression due to water plasticization were observed from studies using thermal and mechanical behaviours of the glutenin fraction by DSC and mechanical spectroscopy (Cocero & Kokini, 1991). Other authors Kalichevsky, Jaroszkiewicz, and Blanshard (1993) confirmed this statement.

In spite of the current knowledge about glass transition of wheat proteins, little is known about other thermal properties of those proteins. However, one can assume that dough constituents react on heating to give rise to intermolecular and intramolecular cleavages which produce highly crosslinked macromolecular structure. These phenomena modify the reological properties of dough and are responsible for the solid-like properties of baked products (Schiraldi, Piazza, Fessas, & Riva, 1999, chap. 16). The lack of knowledge of those thermal properties has been explained by the small or no calorimetric response of wheat proteins (gliadins and glutenins) (Ma, 1990). Arntfield and Murray (1981) did not found a characteristic endotherm of denaturation for gluten proteins. Meanwhile, other authors reported the presence of two or four small peaks on isolated globulins from wheat (Eliasson & Hegg, 1980). The peaks at 88 and 101 °C were attributed to gluten protein transitions but the apparent enthalpies of the protein transition were very small. There is no consistent explanation for the absence of gluten denaturation endotherms. Eliasson and Larsson (1993) proposed different hypotheses: (i) no ordered structure exits in the gluten proteins; (ii) they have an unusual thermostability; (iii) or the DSC technique requires considerable cooperativity to produce a detectable heat flow, which may not be possible with gluten proteins. Nevertheless recently Léon, Rosell, and Barber (2003) concluded that DSC conditions used in previous works for the detection of the thermal properties of wheat proteins were not the most suitable. The same authors also concluded that when thermal properties of wheat proteins are assessed in samples with low water content, peak endotherms are found at temperatures ranging from 50 to 85 °C. The albumins and globulins are the most heat sensitive, followed by the gliadins and finally the glutenins. Based on the encountered high enthalpy values, this effect seems to be related to the most ordered structure of those proteins.

The present study intends to contribute to explain the differences between technological ability of two portuguese soft wheat varieties presenting similar protein content, on the basis of the thermal properties of the gliadins and glutenins fractions (soluble and insoluble in an acid solution).

2. Materials and methods

2.1. Materials

Two portuguese soft wheat varieties – "Amazonas" and "Sorraia" – were supplied by a national germplasm bank (Estação Nacional de Melhoramento de Plantas – Portugal). Those were previously characterized for protein content and rheological properties (Brites & Bagulho, 1999).

Flours were fractionated into three main fractions according to a previously reported method (Czuchajowska & Pomeranz, 1993). The obtained gluten fractions were further fractionated and purified according to Fig. 1.

2.2. Methods

2.2.1. DSC analysis

DSC analysis was performed in a Shimadzu DSC 50 equipped with a TA 50 SI thermal analyser. Helium (99.95% purity) was the purge gas and flowed at approximately 20 mL min^{-1}. The calorimeter was calibrated according to a standard procedure established in the manufacturer user manual. The DSC instrument was