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Different approaches for increasing the shelf life of partially baked bread: Low temperatures and hydrocolloid addition

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Abstract

Partially baked bread is a product with short shelf life that requires sub-zero temperatures for extending it. The storage of par-baked bread at low temperatures and the addition of bread improvers with antistaling effects, such as hydroxypropylmethylcellulose (HPMC), are very attractive alternatives for extending the shelf life of these products. In this study, staling during storage of partially baked bread (in the presence and absence of HPMC) at low temperatures (2 °C) is studied in terms of hardness increase and amylopectin retrogradation. Simultaneously, the staling of the derived full baked breads when stored at 25 °C is assessed. During the storage of par-baked bread at low temperatures, progressive crumb hardening and rapid crystallization of the amylopectin chains were produced. However, heat applied during full baking reversed those processes, and the extent of that improvement was dependent on the time of par-baked bread storage. Concerning the staling of the derived full baked bread, the time of par-baked bread storage did not significantly ($P < 0.05$) affect the staling process of the resulting full baked breads. The addition of HPMC decreased the crumb hardness in both par-baked and full baked breads, and also promoted a reduction of the amylopectin retrogradation. Overall results indicate that HPMC addition significantly retards the staling of par-baked bread during its storage at low temperatures and, moreover, the same effect is observed in the full baked bread.

Keywords: Partially baked bread; Staling; Low temperatures storage; HPMC; Amylopectin retrogradation; Hardness

1. Introduction

Consumer habits have undergone great changes, motivated by the new social lifestyles. Those changes have promoted the increase in the consumption of wheat bread from partially baked bread due to its availability at any time of the day with the quality characteristics of the fresh bread (Leuschner, O'Callaghan, & Arendt, 1997). That is only possible because this bread is made in two stages. The first one is identical to the conventional breadmaking process, with the exception that baking is interrupted when the crumb is completely formed, and just before the crust colour development. Then, this partially baked bread is packaged and, for retarding microbial growth, it can be stored at sub-zero temperatures or under modified atmosphere. In the second stage, the partially baked bread or par-baked bread is baked again, acquiring the crust colour and crumb texture properties of the just baked bread (Leuschner et al., 1997).

The quality of the bread from par-baked bread after its storage at subzero or low temperatures or under modified atmospheres has already been evaluated (Bárcenas, Benedito, & Rosell, 2004; Bárcenas & Rosell, 2006; Fik & Surowka, 2002; Leuschner et al., 1997; Leuschner, O'Callaghan, & Arendt, 1999). However, no information is available about the changes of the par-baked bread during storage, despite its influence on the characteristics of

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the final full baked bread. A better knowledge of those changes would help in defining the most convenient procedure for obtaining good quality full baked bread.

Hydroxypropylmethylcellulose (HPMC) is a useful bread improver that increases bread volume, improves crumb texture and retards bread staling when used in both conventional breadmaking (Armero & Collar, 1996; Guarda, Rosell, Benedito, & Galotto, 2004; Rosell, Rojas, & Benedito de Barber, 2001), and par-baked bread (Bárcenas et al., 2004; Bárcenas, Haros, & Rosell, 2003; Bárcenas & Rosell, 2006). The ability of HPMC to act as a bread improver has been attributed to its hydrophilic structure, that allows its interaction with water (Sarkar & Walker, 1995; Schiraldi, Piazza, & Riva, 1996). In addition, HPMC is able to increase the interface activity between water and the non-aqueous phases of the bread dough, favouring the formation of emulsions and strong and uniform films (Bell, 1990). Moreover, HPMC has the ability to change from solution to gel during heating, forming a thermostable network that shields the bread dough from volume and moisture content losses during baking (Bell, 1990; Dziezak, 1991). HPMC also increases the viscosity of aqueous systems, interfering with the diffusion phenomena (Caldwell, Goff, & Stanley, 1992).

The aim of this work was to study the effect of HPMC on the shelf life of par-baked bread during its storage at low temperatures and also on the staling of the resulting full baked bread. With this purpose, the crumb hardness increase and the amylopectin retrogradation were evaluated on the par-baked and full baked bread.

2. Materials and methods

2.1. Breadmaking process

A basic recipe was used in this study, which consisted of 6.5 kg commercial flour (14% moisture content, 12.5% proteins): the other ingredients, on flour basis, were 2% compressed yeast, 2% salt and the water amount necessary to reach the optimum consistency (500 Brabender Units). In breads containing hydrocolloid, 0.5% (w/w, flour basis) of HPMC (Methocel K4M from Dow Chemical, France) was added to the dough. All the ingredients were mixed for 21 min with a spiral kneader, after resting for 10 min, the dough was mechanically divided into 150 g portions, hand-moulded, and mechanically sheeted and rolled to obtain wheat dough rolls. Proofing was performed at 28 °C and 85% relative humidity until the dough reached three times its initial volume; then bread dough rolls were partially baked for 7 min at 165 °C in an electric oven. Par-baked loaves were cooled until; the core crumb centre reached 40 °C, before packaging in polypropylene bags, and stored at 2 °C. Loaves were taken after 0, 2, 4, 7, 10 and 15 days of storage and baked in the electric oven at 195 °C for 10 min and cooled for 60 min at 25 °C, giving the so-called full baked bread.

2.2. Hardness determination

Hardness was determined on the crumbs of par-baked bread and full baked bread. To assess bread staling, crumb hardness was determined in the full baked bread stored for 24 h at 25 °C. Bread slices (four replicates) of 2 cm height were compressed at a velocity of 100 mm/min to 50% strain, using a 25 mm plunger in a texture press (texture press, TA-XT2i Stable Microsystems, Surrey, UK).

2.3. DSC analysis

The interrupted breadmaking process was simulated in the oven of the differential scanning calorimeter (Perkin–Elmer DSC-7, USA) (Bárcenas & Rosell, 2005). Briefly, bread dough was prepared as has been described for the breadmaking process; 20 mg of bread dough were precisely weighed in stainless steel pans (Perkin–Elmer 0319-0218), and hermetically sealed by using a press (Perkin–Elmer 0990-8467). An empty pan was used as a reference. Pans were heated in the DSC from 25 °C to 90 °C – in order to simulate the partial baking – followed by cooling to 25 °C and, after different storage times (0, 1, 2, 4, 7 days) at 2 °C, pans were reheated from 25 °C to 110 °C, in order to simulate the full baking process. Full baked bread staling was followed after 24, 48 and 96 h at 25 °C, while par-baked bread staling was followed after 0, 1, 2, 4 and 7 days at 2 °C that corresponds to the storage at low temperature. Amylopectin retrogradation during the storage of both par-baked and full baked bread was determined by heating from 25 °C to 110 °C. All the heating and cooling processes were performed into the DSC oven at 10 °C/min. The endotherms were analyzed by the system programme (Pyris Toolbars Application, version 3.01), obtaining the onset (T_o), peak (T_p) and conclusion (T_c) temperatures (°C), besides the gelatinization (ΔH_g) or the retrogradation (ΔH_r) enthalpies, expressed as mJ/mg of dry matter. The retrogradation index was defined as the ratio between retrogradation and gelatinization enthalpy ($\Delta H_{retrogradation}/\Delta H_{gelatinization}$) (León, Durán, & Benedito de Barber, 1997). The melting temperature range for the retrograded material (ΔT_r) was the difference between the onset and the conclusion temperatures ($T_c - T_o$). Three replicates for each sample were run.

The amylopectin retrogradation index was analyzed by using the Avrami equation:

$$(A_L - A_t)/(A_L - A_0) = \exp(-kt^n)$$

A_0, A_t and A_L being the retrogradation index at time zero, t and infinite (or limited value), respectively; k was the constant rate, and n was the Avrami exponent.

2.4. Statistical analysis

Multiple sample comparison was used for the statistical analysis of the results (Statgraphics Plus 5.1, Statistical Graphics Corporation, UK). Fisher's least significant