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Effect of HPMC addition on the microstructure, quality and aging of wheat bread

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Abstract

The effect of hydroxypropylmethylcellulose (HPMC) addition on a basic bread formulation is described. The effect of HPMC as bread improver and antistaling agent was analysed in terms of microstructure. Bread quality was assessed by physical parameters (volume, width/height ratio, moisture content and hardness), crumb grain structure (number of air cells, cells area and the ratio between cells area and total area) and sensory evaluation (appearance, aroma, taste and texture). Bread staling was determined by following both the hardness increase and the starch retrogradation during storage. The microstructure was analyzed by cryo scanning electron microscopy (cryo-SEM). The results confirm the ability of the HPMC for improving fresh bread quality and for delaying staling. The presence of HPMC decreased the hardening rate of the bread crumb and also retarded the amylopectin retrogradation. The microstructure analysis revealed the possible interaction between the HPMC and the bread constituents, which could partially explain the antistaling effect of this hydrocolloid.

Keywords: HPMC; Hydrocolloid; Bread quality; Staling; Sensory analysis; Microstructure

1. Introduction

Bread is still a widely consumed product, and moreover the wheat bread. In opposition to other food products, bread quality is not spoiled by the microorganism or the endogenous enzyme activity present in the food products. Bread quality is rapidly lost due to staling that begins just when loaves are taken out from the oven. The staling of bread is a very complex process that has been extensively studied (Chinachoti & Vodovotz, 2001; D'Appolonia & Morand, 1981; Kulp & Ponte, 1981; Maga, 1975; Zobel & Kulp, 1996), although the mechanism still remains unknown. The staling involves several physical and chemical phenomena, being the recrystallization of the amylose and amylopectin (Hug-Iten, Escher, & Conde-Petit, 2003; Krog, Olesen, Toenaes, & Joensson, 1988; Schoch & French, 1947; Zobel & Kulp, 1996), both the loss and redistribution of water (Biliaderis, 1992; Czuchajowska & Pomeranz, 1989; He & Hoseney, 1990; Zeleznak & Hoseney, 1986), and the protein-starch interactions (Every, Gerrard, Gilpin, Ross, & Newberry, 1998; Martin, Zeleznak, & Hoseney, 1991), the most important ones. There have been a lot of studies focussed on the search of methods for retarding the staleness. Among the most successful ones are the use of additives and technological aids as emulsifiers and enzymes, respectively (Armero & Collar, 1996; Davidou, Le Meste, Debever, & Bekaert, 1996; Guarda, Rosell, Benedito, & Galotto, 2004; Martínez-Anaya, Devesa, Andreu, Escrivá, & Collar, 1999; Rosell, Haros, Escrivá, & Benedito de Barber, 2001; Twillman & White, 1988).

The hydrocolloids are water soluble polysaccharides with a range of functional properties that make them very useful in food technology. In baked goods, hydrocolloids have been used for retarding the staling and for improving the quality of the fresh products. In fact, guar, xanthan, arabic and locust bean gums, carrageenans, alginates, pectins and cellulose derivatives have been used to improve bread quality (Guarda et al., 2004; Rosell, Rojas, & Benedito de Barber, 2001; Sharadanant & Khan, 2003). The cellulose derivatives (methylcellulose, carboxymethylcellulose and hydroxypropylmethylcellulose) are obtained

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by chemical modification of cellulose, which ensures their uniform properties, in opposition to the hydrocolloids from natural sources that have a high variability (Guarda et al., 2004). Hydroxypropylmethylcellulose (HPMC) is obtained by the addition of methyl and hydroxypropyl groups to the cellulose chain, leading to a polymer with a high surface activity and unique properties regarding its hydration–dehydration characteristics in the solution state and during temperature changes. In addition, despite the presence of hydrophobic groups in the HPMC chain, this polymer partially maintains the hydrophilic properties of the cellulose (Sarkar & Walker, 1995). Those properties allow the HPMC acting as emulsifier, strengthener of the crumb grain and increase the moisture content of the crumb (Bell, 1990; Dziezak, 1991). In addition, Rosell et al. (2001) found better bread volume when added 0.5% HPMC to wheat flour. An improved volume and a reduction on the crumb hardening rate of the typical Chilean bread were obtained by adding up to 0.5% of HPMC (Guarda et al., 2004). Recently, a protecting effect of the HPMC has been also described on the partially baked bread stored at frozen temperature, leading to better volume and softer crumb of the full baked bread (Bárcenas, Benedito, & Rosell, 2004; Bárcenas & Rosell, 2005). However, although the improving effect of the HPMC has been described, there is scarce information trying to explain the acting mechanism of this polymer. The aim of this study was to analyse the possible interaction of the HPMC with the bread constituents in order establish an understanding about the effect of the HPMC as a bread improver and antistaling agent. The microstructure of the bread in the presence of HPMC and its relationship with the bread quality and behaviour during storage was studied.

2. Materials and methods

Commercial wheat flour (14% moisture content, 12.5% protein) was purchased from local market. Compressed yeast (purchased in the local bakery) was used as a starter. HPMC (Methocel K4M) was provided by Dow Chemical (France).

2.1. Breadmaking process

A basic recipe consisted in wheat flour (6.5 kg), compressed yeast (2%, flour basis), salt (2%, flour basis) and water (up to optimum consistency of 500 Brabender units) was used in this study. When HPMC was tested 0.5% (w/w, flour basis) concentration was used. Ingredients were mixed, rested for 10 min, divided (150 g), kneaded and mechanically sheeted and rolled. Dough was proofed at 28 °C and 85% relative humidity for 90 min. Baking was performed at 195 °C for 16 min and finally bread was cooled at room temperature for 60 min. For the aging study, bread was packed in polypropylene bags and stored at 25 °C. Since this type of bread is for daily consumption, the hardness increase was only followed during the first 24 h.

2.2. Technological evaluation of the bread

The technological parameters for determining bread quality included volume (rapeseed displacement), weight, specific volume and width/height ratio of the central slice. The water content was measured following the standard method (44-15A AACC, 1995). The crumb hardness was carried out in a texturometer TA-XT2i (Stable Microsystems, Surrey, UK). A 2 cm thick slice was compressed with a 25 mm aluminium probe up to 50% at 100 mm/min speed.

2.3. Image acquisition and analysis

The crumb grain of the loaves was assessed using a digital image analysis system (Crowley, Grau, & Arendt, 2000). Images were taken from the centre of the bread slice and were captured using a Hewlett Packard flatbed scanner (HP ScanJet 4400c, Hewlett Packard, USA) supporting HP Precisionscan Pro 3.1 software (Hewlett Packard, USA). A single 40 mm × 40 mm square field of view was evaluated for each image. The clear colours were adjusted to 160 units and the dark ones to 120 units, while the middle colours to 2.2. Images were scanned fullscale in 256 grey levels at 150 dots per inch (dpi). Data were processed using SigmaScan Pro 5 software (Jandel Corporation, USA). The crumb grain features chosen were: number of cells, mean cell area and cell to total area ratio.

2.4. Retrogradation index detemination

A differential scanning calorimeter (Perkin–Elmer DSC-7, USA) was used as an oven to simulate the baking process (León, Durán, & Benedito de Barber, 1997). Bread dough samples (18–20 mg) were weighed in stainless steel pans (PE 0319-0218). An empty capsule was used as a reference. After sealing, capsules were heated from 25 to 100 °C at 10 °C/min and hold at 100 °C for 5 min. Capsules were stored at 4 °C for accelerating the amylopectin retrogradation during bread staling. Samples after 2, 4 and 7 days of storage were scanned in the DSC from 25 to 110 °C at 10 °C/min. The parameters measured were the onset temperature (T_o), peak temperature (T_p) and conclusion temperature (T_c). Straight lines were drawn between the T_o and T_c and the enthalpy associated to the amylopectin retrogradation (ΔH_r) was calculated as the area enclosed by the straight lines and endotherm curves; and it was expressed in joules per gram of dry sample. The retrogradation index was defined as the ratio between retrogradation and gelatinization enthalpy ($\Delta H_{retrogradation}/\Delta H_{gelatinization}$) (León et al., 1997). Three replicates for each sample were carried out.