



Effect of different polyols on wheat and maize starches paste and gel properties



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ABSTRACT

The use of polyols as sugar replacers in bakery products is a common practice. In these products, pasting and gelation properties of starches have a strong influence on the process and on the quality of final products. In this study, the influence of different polyols (maltitol, sorbitol, xylitol and mannitol) on pasting properties of two starches (wheat and maize) was analysed and compared to those made only from native starches and their combinations with sucrose. Rheological properties of gels as well as their texture and colour were also analysed. Even though differences among the different studied polyols and the interactions among them and among starches were observed, in general polyols showed an influence on starch properties similar to those of sucrose. Thereby, in general peak viscosity and setback as well as gel hardness were increased and L^* was reduced with the use of polyols. In all cases, the polyol which showed more similar results to those made from sucrose was maltitol. Meanwhile, xylitol was the polyol which modified the native starch properties to a lesser extent, both in RVA curve, especially in the cooling stage, and in gel rheology and hardness.

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1. Introduction

Polyols or sugar alcohols are neither sugars nor alcohols; rather they are a group of, low-glycaemic, low energy, low-insulinaemic, low-digestible, and osmotic carbohydrates (Livesey, 2003). These compounds have garnered interest, not only as a result of the properties they have been shown to possess but on their ability to be used as sucrose replacers (Ghosh & Sudha, 2012). Interest now arises since they can be used as sucrose replacers (Ghosh & Sudha, 2012).

Polyols have been proposed as sugar replacements in bakery products, such as cakes, muffins (Martínez-Cervera, Salvador & Sanz, 2014; Ronda, Gómez, Blanco, & Caballero, 2005) and cookies (Lin, Lee, Mau, Lin, & Chiou, 2010; Zoulias, Oreopoulou, & Kounalaki, 2002; Zoulias, Piknis, & Oreopoulou, 2000). In these products, starch gelatinisation, is dependent on the moisture of the formulation and the temperature reached during the baking process. Furthermore its posterior retrogradation, which occurs when the final product is cooled after baking process, is carried out. These

starch modifications have an important influence on the volume and the texture of the final product (Kweon, Slade, Levine, & Souza, 2010; Nakamura, Taniguchi, Taira, & Hiroyuki, 2010). It is well known that the quantity and type of sugar employed during a process influences not only the starch reactions (Deffenbaugh & Walker, 1989; Gunaratne, Ranaweera, & Corke, 2007; Hirashima, Takahashi, & Nishinari, 2005; Kim & Walker, 1992; Sopade, Halley, & Junming, 2004) but also the characteristics of the resulting gels (Katsuta, Miura, & Nishimura, 1992; Prokopowich & Biliaderis, 1995). Therefore, when sugars are replaced by polyols, the pasting properties of starch and the characteristics of its pastes or gels will be modified and will have an influence on the quality of the products obtained. Sun, Nan, Dai, Ji, and Xiong (2014) studied the effect of polyols (maltitol, xylitol and erythritol) on the physicochemical properties of wheat starch in several ratios. However, neither possible interactions of those polyols with different starches nor their comparison with those made from sucrose were studied. In general, studies about starch–polyol interactions are scarce and based on calorimetric studies with polyol/starch ratios much lower than those often used in bakery products (Baek, Yoo, & Lim, 2004).

The objective of the present study was to investigate the influence of different polyols (maltitol, xylitol, mannitol and sorbitol) on the pasting and rheological properties of the most common used starches in bakery products (maize and wheat) in 1:1 ratio, and to

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compare them with the effect of sucrose, one of the most customary used sugars in the food industry. The characteristics of sugar/polyol–starch gels (texture and colour) were also studied.

2. Materials and methods

2.1. Materials

Wheat starch (SP), maize starch (ST), sorbitol (neosorb P100T), mannitol (mannitol 60), xylitol (xilixorb 300) and maltitol (sweetpearl P200) were supplied by Roquette Laisa (Lestrem, France). Sucrose (AB Azucarera Iberia, Madrid, Spain) was also used.

2.2. Methods

2.2.1. Pasting properties

Pasting properties of starch in presence and absence of sucrose or of polyols were determined using a Rapid Visco Analyser (RVA, Model RVA-4C, Newport Scientific Pty. Ltd., Warriewood, Australia).

Polyol–starch–water and sucrose–starch–water combinations used in the different tests were made up by adding the polyol or sucrose water solution, prepared dissolving 3.5 g (± 0.001 g) of polyol or sucrose in 25 g (± 0.01 g) of distilled water, to 3.5 g (± 0.001 g) of starch. Control sample was prepared following the same process but without the addition of polyol or sucrose to the 25 g (± 0.01 g) of distilled water. Slurries were prepared in aluminium canisters and shaken manually prior to measurement. The heating and cooling cycles were programmed following the general pasting method 61.02.01 (AACC, 2012) with slight modifications, ending the measurement at 30 °C instead of 50 °C. The slurry was held at 50 °C for 1 min, then heated to 95 °C and held at that temperature for 2 min 30 s. It was subsequently cooled to 30 °C and held at that temperature for 4 min. All measurements were performed in duplicate.

2.2.2. Rheological measurements

Dynamic viscoelastic properties of the freshly prepared pastes of sucrose/polyol–starch mixtures obtained from pasting in the RVA were performed using a rheometer (Haake RheoStress 1, Thermo Fischer Scientific, Scheverte, Germany) with a titanium parallel plate geometry sensor PP60 Ti (60 mm diameter, and 1 mm gap). The sample was placed into the rheometer, which was stabilized at 30 °C, and covered with Panreac vaseline oil (Panreac Química S.A., Castellar del Vallés, Spain) to avoid drying. The pastes were rested for 300s in both sweeps before the tests were started. Two dynamic viscoelastic measurements were made: (1) deformation sweeps over a range of 0.1–100 Pa at a constant frequency (1 Hz) to determine the deformation attainable by a sample in the linear viscoelastic range, and (2) frequency sweeps over a range of 0.1–10 Hz at a constant deformation, determined previously, within the linear viscoelastic range. The storage modulus (G'), loss modulus (G'') and loss tangent ($\tan \delta$) as a function of frequency (ω) were obtained. All measurements were performed in duplicated.

2.2.3. Gel preparation

Gels were made using a 1 L beaker, adding the sugar/polyol–starch water solution previously prepared, made up dissolving 42 g (± 0.01 g) of sugar or polyol in 300 g (± 0.01 g) of distilled water (14 g sugar or polyol/100 g of water), to 42 g (± 0.01 g) of starch (14 g starch/100 g of water). Sugar/polyol–starch dispersions were heated to boiling on a heater plate at a constant magnetic stirring speed in order to achieve sufficient hydration and homogenous dispersions. The samples were also kept at a consistent temperature (approximately 93 °C, at 8 min) for the duration of the preparation. For texture analysis, the pastes were then poured into three

cylindrical plastic containers (40 mm base and 64 mm height) until complete ≈ 40 mL and for colour analysis into two Petri dishes ≈ 60 g. After pouring, samples were left to rest at room temperature for 20 min and then covered and stored at 4 °C for 24 h to achieve gel stabilization. Prior to analysis all gels were rested at room temperature. Each gel was made in duplicate.

2.2.4. Gel texture and colour

Texture measurements of the prepared gels were performed at room temperature (≈ 25 °C) using a TA.XT2i Texture Analyser (Stable Micro Systems Ltd., Surrey, UK) equipped with Texture Exponent Lite 6.1,4,0 Lite software for Windows. A 2 kg load cell was used for force calibration. A penetration test was performed using a 25 mm-diameter cylindrical probe (P25p) at a constant crosshead velocity of 0.5 mm s^{-1} to a sample depth of 10 mm, followed by a return to the original position. The force–time curve thus obtained was used to calculate the values of the texture attributes: hardness (force corresponding to the breaking peak) and breaking time (time to reach the breaking peak). All texture measurements were performed in duplicate.

Gel colour was measured using a Minolta CN-508i spectrophotometer (Minolta Co., Ltd, Osaka, Japan). Results were expressed in the CIE $L^*a^*b^*$ colour space and were obtained using standard illuminant D65 with the 2° standard observer. L^* represents the value between light (where $L^* = 100$) and dark (where $L^* = 0$). a^* represents the value between green ($-a^*$) and red ($+a^*$), and b^* represents the value between yellow ($+b^*$) and blue ($-b^*$). All colour measurements were performed in duplicate.

2.2.5. Statistical analysis

Multiple analysis of variance was used to determine the individual effects of starchy source and the type of sugar/polyol. Fisher's least significant differences test was used to calculate the means with their 95% confidence intervals. The statistical analysis was performed using Statgraphics Centurion XVI V16.1.17 (Statpoint Technologies, Inc., Warrenton, USA).

3. Results and discussion

3.1. Pasting properties of sugar/polyol–starch pastes

The RVA curves of sucrose and polyol combinations with wheat and maize starches are shown in Fig. 1. It is observed how, in both cases, sugar and polyol incorporation increased peak viscosity and, in general setback or retrogradation. These results agree with those observed by other authors using RVA (Zhang, Tong, Zhu, & Ren, 2013), starch pasting cell of rheometer (Martinez-Cervera et al., 2014) or viscoamylograph and light microscopy (Bean & Yamazaki, 1978; Sun, Nan, et al., 2014) in sugar–starch combinations. Theories of these events are diverse and are correlated to the available water competence by starch and sugar, and the consequent reduction of the water activity (Spies & Hosney, 1982; Zhou, Wang, Li, Fang, & Sun, 2011); and with the decrease of the free volume of sugar–water solvent which appears to lead to a reduced plasticizing effect of the solvent (Chiotelli, Rolee, & Le Meste, 2000; Hansen, Setser, & Paukstelis, 1989; Wang et al., 2009). In addition, it was also suggested that sugars could form crosslinks (sugar bridges) between starch chains in the amorphous regions of starch granules, which would restrict starch swelling and thereby would stabilize these regions (Spies & Hosney, 1982; Zhou et al., 2011).

Only in the case of wheat starch, pastes made by sugars or polyols displayed a faster increase of the viscosity against pastes made only by starch. Starch source also had an influence on the shape of RVA curves, in such a way, sugar or polyol–maize starch combinations showed a faster increase of viscosity during the

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