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Research Note

Effect of calcium content in the corn flour on RVA profiles

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ABSTRACT

Corn flour was produced using the traditional nixtamalization process and different steeping times of 0, 1, 5, 6, 10, 13, and 24 h. The flour particle size distribution was then evaluated in terms of the particles retained by using a 40 US mesh screen. The lime content, the Rapid Visco Analyzer (RVA) profiles, maximum peak viscosity, breakdown and final viscosity (V) were measured as a function of the steeping time. It was found that the initial rate of increase in viscosity (dV/dt), maximum peak viscosity, breakdown and final viscosity of fractions depended on the amount of calcium incorporated in the corn kernels during the steeping time (T_s) of the nixtamalization process. The particles retained using a 40 mesh that were steeped for 0–5 h, do not have the characteristic points of an RVA profile, i.e., maximum peak viscosity and breakdown. However, the particles retained using a 40 mesh and steeped for 6–24 h developed peak viscosity, breakdown and final viscosity. The corn flours that are recommended for making tortillas are precisely the flours whose particle size distributions develop these three characteristic points in the RVA profile. Differences in RVA measurements of the size fractions can be explained on the basis of the calcium content of the course fractions of corn flours. It was concluded that RVA characteristics may be changed by the calcium content in the starch polymer structures created during the nixtamalization process. Consequently, the increased calcium content in starch particles should be reflected in RVA measurements as an increase in the peak viscosity, in the gelatinization rate and in the development of a noticeable breakdown.

1. Introduction

The physicochemical state of different fractions is considered to be an important criterion for nixtamalized maize flour applications in the production of tortillas or derived products (Bedolla and Rooney, 1984; Gomez et al., 1991). According to Palacios-Fonseca et al. (2009), the coarser particles size results in a lower peak viscosity, which is due to lower levels of water absorption. They also concluded that the viscosity profile can be thought of as a reflection of the granular changes that occur during gelatinization. During the initial heating phase, a rise in maximum viscosity is recorded as granules begin to swell. At this point, polymers with lower molecular weights (amylose) begin to leach from the granules. A viscosity peak is obtained during pasting when there is a majority of fully swollen intact granules, and the molecular alignment of any solubilized polymer has not occurred within the shear field of the instrument (Méndez-Montealvo et al., 2007). Nixtamalization produces noticeable changes in certain chemical, physicochemical and functional properties of the starch. For instance, the amylose content increases, showing that some linear chains are split off from the amylopectin structure, which are determined together with amylose. Furthermore, the nixtamalization process can cause annealing of starch molecules due to the increase in gelatinization temperatures. Starch granules of nixtamalized maize have longer major axes and larger areas than those found in native maize. These results can be helpful to understand the characteristics of starchy products made from nixtamalized maize during the processing and storage. Sahai et al. (2001) concluded that various corn flour fractions exhibit significantly different RVA pasting characteristics.

The analysis of the RVA profiles of fractions 40, 60, and 70 as well as unfractionated flour is complicated because a distinct breakdown is absent and it is difficult to obtain a value for peak viscosity. It is, however, obvious from the profiles that peak viscosity increased while particle size decreased. According to current literature there are no articles published about the effect of calcium content in coarse particles of corn flour in the form of the RVA profiles, which is the primary objective of this work.

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2. Materials and methods

2.1. Preparation of nixtamalized samples

In the initial cooking step of the nixtamalization process, each sample was prepared by cooking 1 kg of whole maize kernels in a suspension of 3 l of water and 20 g of calcium hydroxide (reagent powder, Fermont, Monterrey, NL, México) according to Rojas-Molina et al. (2007) methodology. In brief: calcium hydroxide at a weight of 2% in relation to the maize was used. The maize kernels were cooked for 40 min at 92 °C. After cooking, the maize was steeped for 0, 1, 5, 6, 10, 13, and 24 h. After steeping each sample, the cooking liquor (nejayote) was drained off and the nixtamal samples were washed twice in water. The kernels were then stirred in the wash water for 2 min. After washing and draining, each sample was ground to a corn masa and then dehydrated using a flash type dryer. The dryer conditions were adjusted to 250 °C for the inlet air temperature and 90 °C to the exhaust air to avoid burning the material. Then the samples were remilled using a hammer mill (PULVEX 200, México, DF, México) equipped with a 0.8 mm screen.

2.2. Particle size distribution

For fractionation, corn flour was sieved in a Ro-TAP RXZ9WH349 equipment for 15 min and US standard Sieve No. 40 was used to obtain two fractions. Each fraction trial was performed using 150 g of corn flour, and fraction yields as well as total recovery were calculated.

2.3. Atomic absorption spectroscopy

The calcium content of corn flour was obtained by mineralizing the sample using the dry-ashing method 968.08 (AOAC, 1998), following the calcium ion determination with a double-beam atomic absorption spectrometer (Analyst 300, Perkin–Elmer), equipped with a deuterium lamp, background corrector, and hollow cathode lamp, operated with 12 psi of dry air, 70 psi acetylene, 422.7 nm flame, and 10 mA lamp current, 0.7 nm slit width.

2.4. Relative viscosity

The relative viscosities of the water suspensions of corn flour dough were determined using a pasting viscometer (Rapid Visco Analyser (RVA), Newport Scientific, Narabee, NSW, Australia). Dough samples were adjusted to 14% moisture content, and distilled water was added to keep the total weight of water and sample constant at 28 g. Dry base material (4 g) retained on the mesh 40 was suspended in 24 mL of water. The sample was heated over 5 min from 50 °C to 90 °C at a rate of 5.6 °C/min, and then held at a constant temperature of 90 °C for 5 min, the sample was then cooled down to 50 °C over 5 min, the total time for the text was 15 min at 160 RPM.

2.5. Statistical analysis

All treatments were performed randomly and the data of calcium content and RVA profiles were statistically analyzed using the SAS Systems for Windows software, version 6.12 TS020 (SAS, Statistical Analysis System, Institute Inc., Cary, NC, 1996). Analysis of variance and *F*-tests were used to determine significant differences between the treatment means at $P \leqslant 0.05$. Multiple of mean comparisons were made by using the least significant difference (LSD).

3. Results and discussion

Fig. 1 shows the calcium content as a function of the steeping time in the coarse particles for 40 US mesh. As can be seen in this figure, the calcium content does not increase in a linearly manner with T_s, as expected; a tendency to saturation regime was observed. These results corroborate the research published by Fernández-Muñoz et al. (2006) which demonstrated that the incorporation of calcium into the maize kernel during nixtamalization follows a nonlinear process as a function of the steeping time. Fig. 2 shows the pasting profiles of corn flour of fraction 40 obtained at different steeping times, these were spread out for enhance visual purposes. Sahai et al. (2001) undertook RVA profiles of fraction 40, 60, 70, and greater and an un-fractionated corn flour; however, the analysis was complicated because a distinct breakdown was absent, and it was difficult to obtain values of peak, breakdown and through viscosity. Then, in our case, the distinct breakdown was not observed for T_s values of 0, 1 and 5 h. This is probably because the size of particles have not reached the critical value (≈100 mesh) as was noted by Sahai et al. (2001). The development of peak viscosity, breakdown, and final viscosity are evident in samples subjected to steeping times of 6, 10, 13 and 24 h. The differences in pasting characteristics observed in these samples herein can be attributed to calcium content. The increase in calcium content in particle distribution is reflected in RVA measurements as an increase in peak viscosity, with the development of a noticeable breakdown. Therefore, the calcium content contributes with the water diffusion into coarse particles and improved swelling of starch granules in such a way that when $T_s = 6$ h the distinct breakdown has already been observed. Calcium content is responsible for the rapid viscosity development in the coarse fractions.

Fig. 3 shows the slope of the first derivate of the apparent viscosity ($M = \mathrm{d}V/\mathrm{d}t$) as a function of the steeping time for the time window between 200 and 260 s. On the right side of the axe the calcium content as a function of time for comparative purposes is presented. The inset of this figure shows the first derivate of the complete pasting profile where it is clear that there is a

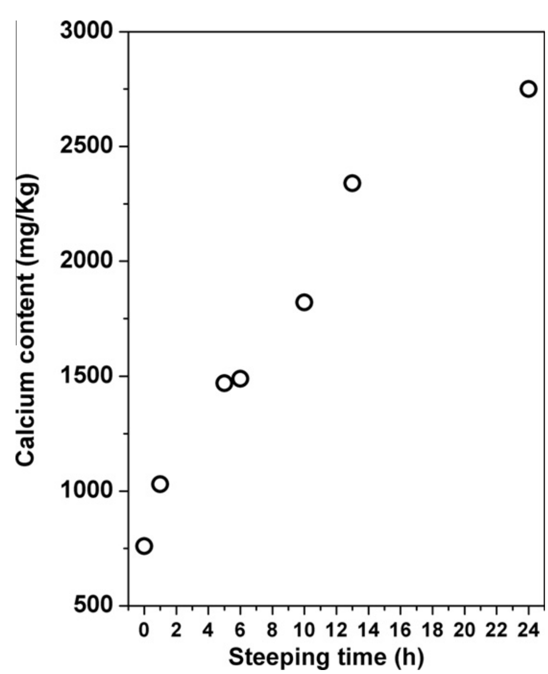

Fig. 1. The calcium content as a function of the steeping time in the coarse particles for 40 US mesh.

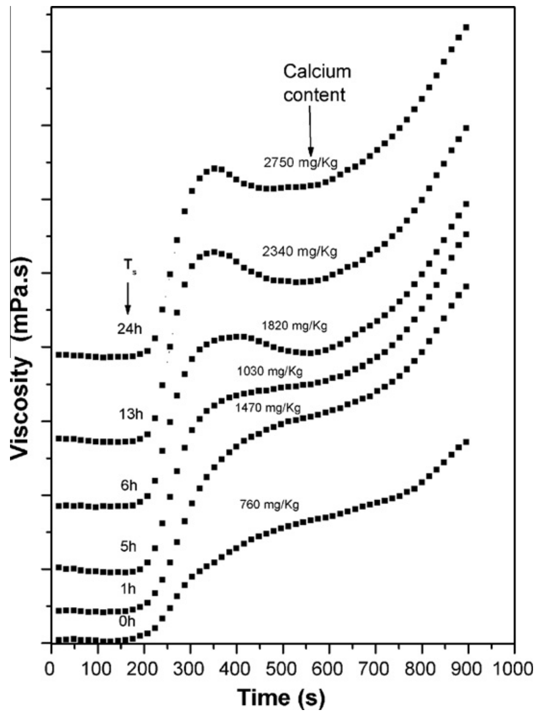

Fig. 2. The pasting properties of corn flour of fraction 40 obtained at different steeping times.

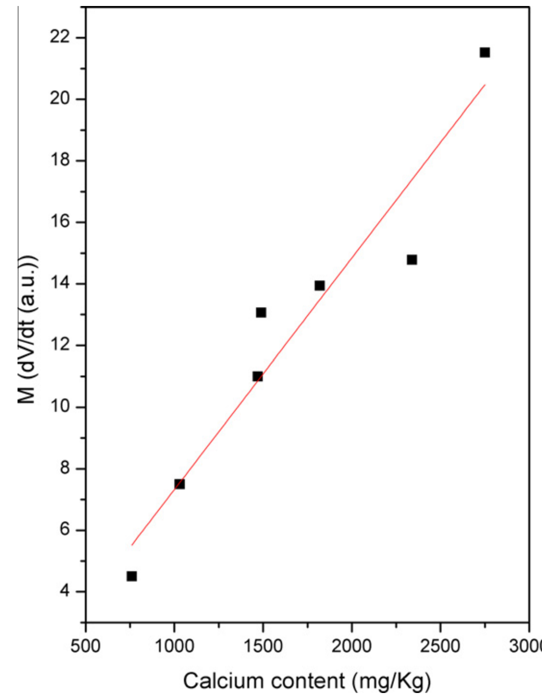

Fig. 4. The $M(\mathrm{d}V/\mathrm{d}t)$ as a function of the calcium content. Each point represents the average of three measurements per sample.

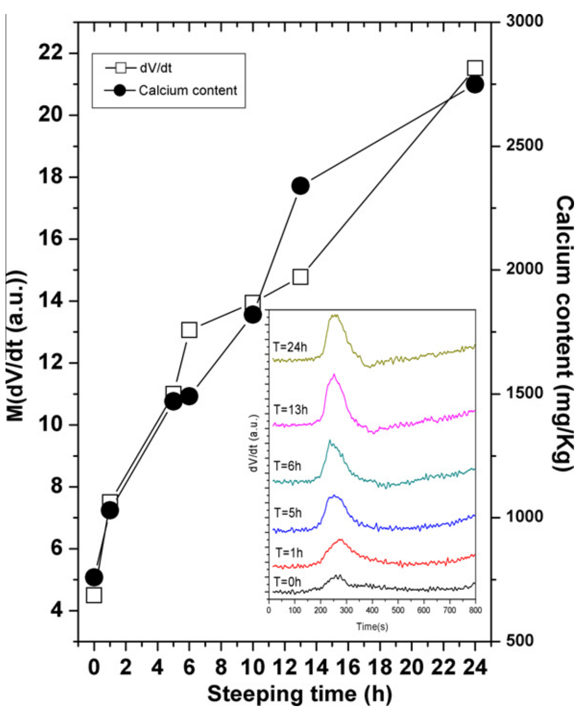

Fig. 3. The derivative of viscosity as a function of the steeping time. On left axis; the calcium content (same data of Fig. 1, added for comparison). The inset shows the complete first derivate as a function of the time.

significant change in dV/dt at approximately the 200 s. According to this figure it is evident that at approximately 6 h there is a change in the slope of dV/dt. These values represent the average of three measurements per sample. The increase in dV/dt when T_s increases are due to the increases of the calcium that is related to the increases in the cross linking. Utilizing direct inspection of the dV/dt behaviors and calcium content; it is clear that there is a direct correlation between these parameters.

Fig. 4 shows $M = \mathrm{d}V/\mathrm{d}t$ as a function of the calcium content, where each point represents the average of three measurements per sample. It can be observed that the first derivate of viscoamilograms (40 US mesh) increases when calcium content increases, this result is significantly different ($P \leqslant 0.05$) for samples. As can be seen in this figure, the first derivate of viscoamilograms of the coarse fractions of the corn flours increases linearly with the calcium content.

4. Conclusions

The shape of RVA profiles depend on calcium content in coarse particles, In general, it was observed that the smallest particles contain a greater percentage of calcium for the different steeping times. The increase in calcium content in the coarse fractions of corn flours increases the viscosity peak and develops a breakdown point. Thus, the pasting properties of coarse particles depend on calcium content. Therefore, it can be assumed that calcium inhibits gelatinization during the nixtamalization process, promotes aggregation and possible crosslink connections, which increases viscosity.

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