Kinetic Approach to Nixtamalization of Corn Pericarp

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ABSTRACT

The nixtamalization of the pericarp isolated from grains of corn was studied with 2, 5, 10, 20 and 40% $Ca(OH)_2$ based upon the mass of the pericarp. For 2 and 5% $Ca(OH)_2$ a small loss of the mass of the pericarp takes place quickly which is accompanied by an abrupt fall of the concentration of the OH^- ions. A suitable kinetic model for the decrease of the mass of the pericarp is a two phases exponential equation. The second phase is the slowest and it depends on the quantity of $Ca(OH)_2$ employed.

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The extent of removal of the pericarp is one of the factors that differentiates the techniques for the industrial production of tortillas made from corn. The quality of the processed corn flour is strongly influenced by the quantity of pericarp incorporated to it (Cruz-Orea et al 1999).

The conservation of the pericarp leads to the manufacture of a product similar to the traditional one, such as home-made yellow corn tortilla; while its elimination and other factors permit the preparation of a white dough which requires the use of additives to improve flexibility and mechanical and thermal resistance of tortilla. But, with the elimination of the pericarp, the health value that the dietary fibers have for consumers is lost.

The physicochemical changes that take place in corn during nixtamalization are not completely understood and are still under investigation (Rodriguez et al 1996). Some authors (Vaqueiro and Reyes 1986) consider that only the pericarp might be nixtamalized and mixture with grounded endosperm to prepare corn flour.

The pericarp is the main source of dietary fibers in the corn (Sugawara 1994). Its composition is similar to that of the dietary fibers coming from other cereals. It is formed by cellulose, hemicellulose, lignin and proteins (Doner and Hicks 1997).

The cellulose-hemicellulose-lignin combination is characteristic of phytomass products like wood, straw, sugar cane bagasse, corn cobs, and many others agriculture wastes, and it is considered a structural composite (Gandini 1992). Cellulose is a polymer with a well-defined chemical structure. On the other hand, the structure of the hemicellulose and of the lignin, as well as their proportion, depends on the vegetable type.

Wood is rich in cellulose (40–50%) and lignin (18–35%). The treatment with alkali causes the rupture of the cellulose-hemicellulose-lignin structure which, depending on its composition, allows the production of cellulose or hemicellulose. Thus, cellulose is obtained from wood but it is necessary to eliminate lignin. In its early stages, delignification in pulping processes consists of breaking the connecting bonds, thus allowing the separation of lignin from cellulose (Gandini 1992). Corn pericarp, which possesses a low content of lignin, releases mainly hemicellulose during cooking with lime, i.e., readily yields hemicellulose during nixtamalization. Mechanisms of wood delignification and corn pericarp nixtamalizaton are complex. The rate at which the first process takes place has been studied (Dolk et al 1989) but not the second process.

The objective of our work was to determine the nixtamalization rate of corn pericarp, i.e., the rate at which the isolated corn pericarp is degraded by $Ca(OH)_2$.

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MATERIALS AND METHODS

Materials

$Ca(OH)_2$ from Merck was used to degrade corn pericarp. Percentage of $Ca(OH)_2$ employed in this work is based upon the mass of pericarp. Corn grain (cultivar Toluca from Mexico, 1998) was soaked in water, and the pericarp was separated manually to prevent the endosperm from contaminating it.

Methods

To measure the mass change of pericarp and the pH level of the cook solution during nixtamalization, several Erlenmeyer flasks containing similar mixtures of 1–2 g of pericarp and 0.025–0.4 g of $Ca(OH)_2$ in 20–40 mL of water (Table I) were placed in a thermostatic bath at 80°C (t = 0). Flasks were removed from the bath at 5, 10, 15, 20, 30, 90, and 120 min, and nixtamalization was stopped abruptly by immersing each flask in an ice water bath. The pH level was measured at room temperature and the mixture was vacuum-filtered through a Whatman 40 filter paper. The pericarps were washed with 200 mL of water. The dry mass of pericarp was determined by placing the samples on filter paper in a forced-air oven at 130°C for 1 hr. They were allowed to cool down in a desiccator before weighing.

To measure viscosity, the pericarp was ground in a hammer mill and dry samples of milled pericarp (2 g) that passed through a 0.147-mm sieve, 10 mL of water, and either 5, 20, or 40% $Ca(OH)_2$ were employed in the assays. Measurements of viscosity (cP) were conducted in Rapid Visco Analyser instrument (RVA) (Newport Scientific) to detect the solubilization of hemicellulose in water during nixtamalization. Samples were heated at 15°C/min to 80°C, maintained at this temperature for 5 min, and finally cooled to 40°C.

The hemicellulose in solution was separated by precipitation in ethanol. NMR ^{13}C spectra were recorded using a Jeol Eclipse spectrometer at 270 MHz. Samples (100 mg) were dissolved in 0.7 mL of deuterated water.

RESULTS AND DISCUSSION

Nixtamalization of isolated pericarp produces the rupture of the cellulose-hemicellulose-lignin structure and the incorporation to the solution of hemicellulose and small quantities of lignin and proteins. The hemicellulose isolated from cooking liquor is mainly galacto glucurono arabinoxylans according to ^{13}C NMR spectrum, which agree with that reported and discussed by Saulnier et al (1993) in the studies of polysaccharides solubilized during nixtamalization of maize kernels.

The extraction of the hemicellulose during the nixtamalization depends markedly on the quantity of $Ca(OH)_2$ used. The variation of the pH level during the nixtamalization of the pericarp is shown in Fig. 1. Reproducibility of results is observed in the curves corresponding to 2 and 5% $Ca(OH)_2$, which were obtained from the data of two different experiments. Experimental points in the other