Milling and Processing Parameters for Corn Tortillas from Extruded Instant Dry Masa Flour

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ABSTRACT

A continuous extrusion process to provide instant corn flour for tortillas was evaluated. Variables investigated included two types of mill (knives and hammer) with screens with two diameters (0.5 and 0.8 mm), two types of corn (hard endosperm or normal and soft endosperm or cacahuazintle), lime concentration (0.15 and 0.25% w/w), processing moisture (45 and 48% w/w) and temperature (70, 80 and 90°C). The water absorption capacity, water solubility index, color of instant corn flour, adhesiveness of masa, tensile strength, cutting force, rollability and puffing of tortillas, were compared. Based on textural data the hammer mill with 0.8 mm sieve, normal corn type, 0.15% lime, 48% moisture and 90°C processing temperature, produced the highest quality tortillas.

Key Words: corn tortilla, corn flour, extrusion, milling

INTRODUCTION

Traditional nixtamalization process to make masa and corn tortillas includes batch cooking and soaking in water of whole corn kernels with addition of calcium hydroxide (lime) in a process that requires 8 to 12 h. Industrial production of instant corn flour for tortillas depends upon an adaptation of the traditional nixtamalization process and includes nutrient losses, high cost and space disadvantages (Serna-Saldivar et al., 1990). This process requires long processing time and intensive labor, as well as producing alkaline waste water disposal problems. Investigations to overcome these problems have been reported (Figueroa et al., 1993).

Some studies have focused on alternative methods to produce corn tortillas. The use of cooker extruders as continuous reactors to convert corn to masa or instant corn flour has been reported (Irvin et al., 1991; Bázua et al., 1979; Gómez and Aguilar, 1983; Menah-Agyapong and Horner, 1992). In general, experimental extrusion processes have yielded corn tortillas with lower sensorial quality compared with those from the traditional process.

Martínez-Bustos et al. (1996), patented a continuous extrusion process, and an experimental low shear extruder with specific characteristics for making corn masa and instant corn flour suitable to form tortillas of good quality. Whole corn grain was ground and the corn meal was mixed with lime and water. The mixture was extruded to produce fresh masa in pellet form. The fresh masa was dehydrated in an experimental infrared (IR) tunnel dryer, to provide a moisture content of 8–10% (w/w). The dry masa was reground to prepare instant masa flour. The fresh masa was dehydrated in an experimental infrared (IR) tunnel dryer, to provide a moisture content of 8–10% (w/w). The dry masa was reground to prepare instant masa flour.

The aim of our work was to select the type of mill and screen hole diameter based on textural properties of tortilla, and to evaluate the effects of processing parameters on some properties of flour, masa and tortillas produced from the extrusion process. The processing objective was to produce tortillas with similar or better quality and functional characteristics than those produced with commercial instant corn flour.

MATERIALS & METHODS

Materials

Commercial samples of food grade white corn, hard endosperm (normal) and soft endosperm (cacahuazintle) were used and the physical and chemical characteristics were compared (Table 1). Powdered hydrated lime (El topo, Monterrey, N.L., México) was used as alkali.

Methods

The proximate composition, 1000 kernel weight and test weight of corn samples were determined using procedures described by the AACC (1983) approved methods. The pearled index (Buendía, 1981), apparent density (Koeppke et al., 1987), water absorption capacity (Bedolla, 1983) and water solubility index (Anderson et al., 1969) were also determined.

Mean particle size

Samples (50 g each) were used to determine the mean particle size (MPS) of corn raw flour using screens (MONT-INOX) # 30, 40, 60, 80, 100 (595, 420, 250, 175 and 149 μm respectively) and pan. The screens were placed in a RO-TAP-shaker for 10 min. The flour retained on the screen was weighed and the MPS was determined as follows:

\[
\text{MPS} = \frac{(W_1d_1+W_2d_2+...+W_n d_n)/R}{(W_1+W_2+...+W_n)}
\]

where \(W_{1,2,3} = \text{weight of product through each sieve; } d_{1,2} = \text{diameter of mesh for each sieve; } R = \text{total recovery.}

Flour color

The flour color was determined by the Hunter \(L, a, b\) method. A colorimeter (Minolta, CR-210) was used. A 100g sample was placed on a petri plate of 16 cm dia and 1 cm deep. Readings on four posi-
tions, 90° apart, were obtained. The L, a, and b values were determined, and \( \Delta E \) was calculated as follows:

\[
\Delta E = \sqrt{(\Delta L)^2 + (\Delta a)^2 + (\Delta b)^2}
\]

where \( L \) = brightness or lightness (100 = perfect white, to 0 = black); \( a \) = greenness/redness (negative (green) to positive (red)); \( b \) = yellowness/blueness (negative (blue) to positive (yellow)); \( \Delta L \), \( \Delta a \), and \( \Delta b \) = absolute differences of the values between the reference tile (white porcelain) and sample values were also recorded; \( \Delta E \) = total difference between reference and sample color.

The reference values (calibration) were: \( L = 97.63 \), \( a = 0.78 \) and \( b = 2.85 \).

**Apparent viscosity with RVA**

A Rapid Visco Analyzer (RVA-3D) (Newport Scientific Pty, Australia) was used to measure apparent viscosity of samples as a function of temperature. All corn flour samples were passed through a #60 screen; sample moisture was determined and sample weight adjusted (320.001g) to 14% (m. b.). For example, if a flour sample was 12.5% (w/w.) moisture, 3g × (100-14) / (100-12.5) = 2.95g was used. After that, distilled water was added to keep the total weight (water plus sample) constant at 28 g. Rotating paddles were held at 50°C for 2 min to stabilize the temperature and ensure uniform dispersion and wetting of samples, then it was heated to 92°C at a constant rate of 5.6°C/min. The sample was held at this temperature for 5 min and then cooled to 50°C in 7.5 min at the same rate.

**Production of experimental instant corn flour**

Whole corn kernels were ground with a mill (Pulvex-200) using knives and hammer head, and the corn flour was mixed with lime and water at different concentrations (see experimental design), with a domestic blender (Kitchen Aid, K5SS). An experimental single screw extruder with a low shear was used. All samples were extruded at 35 rpm with 1.8 min residence time to produce fresh masa in pellet form. The corn masa was dehydrated in an experimental IR tunnel dryer, to obtain fresh masa with adequate consistency to make tortillas. Contrary to the normal corn, when the hammer mill was used, finer flour was obtained than with the knives mill. The apparent density of normal corn (Table 2) was affected by the type mill (knives and hammer) and screen hole diameter (0.5 and 0.8 mm). The effects of processing parameters were determined by a factorial experimental varying type of corn (normal and cacahuazintle), lime concentration (0.15 and 0.25% w/w), processing moisture (45 and 48% w/w) and temperature (70, 80 and 90°C). The Statistical Analysis Method (SAS Institute, Inc., 1991) to analyze data, and Duncan means comparisons were used. Significance was defined at p<0.05.

**RESULTS & DISCUSSION**

**Evaluation and selection of milling type**

The normal corn was denser (Table 1) than the cacahuazintle corn (test weight 75.1 vs. 56.8 kg/L, respectively). The pearled index of cacahuazintle corn was higher than normal corn mainly because of its higher proportion of floury endosperm and higher amylose content (Trejo-González et al., 1982; Bedolla and Rooney, 1982). Those characteristics are related to grain breakage, grain density and overall dry milling performance (Peplinsky et al., 1992). The chemical composition (Table 1) of the experimental corn kernel was in the range reported by others (Robles et al., 1988; Bedolla et al., 1983). The mean particle sizes (MPS) of raw corn flour from the two types of corn were compared (Table 2). When the knives mill was used, a finer flour was obtained than with the hammer mill, for normal corn. For both types of corn and mill finer particles were obtained when the 0.5 mm sieve was used, compared with the 0.8 mm sieve. The type mill affected significantly the MPS for cacahuazintle corn contrary to the normal corn. When the hammer mill was used, finer flour was obtained than with the knives mill. The apparent density of normal corn (Table 2) was affected by the
type of mill and sieve. The knives mill produced a flour with lower density than the hammer mill because of the different grinding form. The knives mill cuts and rubs the material producing fine particles and the hammer mill hits and breaks the material producing coarser particles. Also the 0.5 mm sieve flour was lower density than that from the 0.8 mm sieve, probably because of the higher hardness of the normal corn (Table 1) and high resistance in dry milling.

Effects of type of mill and sieve size were compared (Fig. 1) on the apparent viscosity profiles of two types of corn. The initial temperature of gelatinization (Ti) was lower for cacahuazintle raw corn flour than for normal raw corn flour (68°C vs 73°C). The larger starch granules (cacahuazintle corn) gelatinize at lower temperatures than small starch granules (normal corn) (Shuey and Tipples, 1980; Rooney and Serna-Saldívar, 1987). The apparent viscosity peaks (Vp) of the two corn types were affected by type of mill and size of sieve. For the two types of corn the Vp was higher when the hammer mill was used (174 and 74 RVU). That was probably due to the low breakage of starch granules produced by the action of the hammer mill. In general a higher gelatinization peak was observed for the cacahuazintle corn than for the normal corn.

The tensile strength, cutting force and rollability were affected by type of corn (Table 3). The cutting force and rollability values of tortillas made with instant corn flour formed from normal corn were similar to those for tortillas made with commercial instant corn flour. Regarding type of mill and sieve size, the textural quality of tortillas did not show significant differences but values for tortilla obtained with the hammer mill and the 0.8 mm sieve were closer to those values for commercial tortillas. Based on these results, the hammer mill and 0.8 mm sieve were selected as the best performance type of mill.

Evaluation of processing parameters

The corn type affected the color, water absorption capacity and water solubility index of instant corn flour (Table 4). The water absorption capacity of cacahuazintle corn was high, probably because the corn with soft endosperm absorbs more water when gelatinized, than the normal corn with hard endosperm (Bedolla and Rooney, 1982). The cacahuazintle corn showed higher amounts of soluble solids than normal corn. The adhesiveness of masa; tensile strength, cutting force, rollability and puffing of tortillas were affected significantly by corn type (Table 4 and 5). The normal corn showed higher values than the other corn and the hard corn endosperm had produced better tortillas than soft corn endosperm types (González et al., 1991).

The color of instant corn flour and adhesiveness of masas (Table 4) were improved when the lime concentration was increased. Thus the instant corn flour, masa and tortillas showed a yellow color. However, the lime concentration showed adverse effects on water solubility index of instant corn flour and tensile strength of the tortillas.

The tensile strength and cutting force of tortillas decreased when
high moisture and high processing temperature were used (Table 5). The increment of moisture in whole corn flour and processing temperature produced a significant increase in color, water absorption capacity, water absorption index and water solubility index of instant corn flours. In addition, the adhesiveness of masas and puffing were improved (Table 4 and 5).

The most important changes were found when moisture and the extrusion temperature were increased. When processing moisture and temperature increased (Fig. 2), the apparent viscosity of instant corn flour decreased. All such changes were related to the degree of starch gelatinization of the samples. Results confirmed those reported by Mensah-Agyapong and Horner (1992) for lime-treated corn grits processed in a single cook-extruder.

Textural properties of tortillas from instant corn flour using the low shear extrusion process were compared with tortillas formed with commercial instant corn flour used as control. The optimal processing conditions were: normal corn type, 0.15% lime, 48% moisture of whole corn flour and 90°C processing temperature.

CONCLUSIONS

EXPERIMENTAL INSTANT CORN FLOURS WITH DIFFERENT FUNCTIONAL PROPERTIES AND FORMED WITH DIFFERENT TECHNIQUES WERE INFLUENCED BY TYPE OF CORN AND PROCESSING PARAMETERS SUCH AS LIME CONCENTRATION, PROCESSING MOISTURE AND TEMPERATURE. TORTILLAS MADE WITH INSTANT CORN FLOUR OF NORMAL CORN, PROCESSED WITH HAMMER MILL AND 0.8 mm SIEVE, 0.15% LIME, 48% MOISTURE OF WHOLE CORN FLOUR AND 90°C PROCESSING TEMPERATURE, HAD GOOD PERFORMANCE CHARACTERISTICS WITH QUALITY SIMILAR TO TORTILLAS FROM COMMERCIAL INSTANT CORN FLOUR.

REFERENCES

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