NOTE

Functionality of Bicarbonate Leaveners in Wheat Flour Tortillas

Feliciano P. Bejosano[1] and Ralph D. Waniska[1,2]

Cereal Chem. 81(1):77–79

Tortilla processors are constantly finding ways to improve their products while cereal science-oriented research institutions are also carrying out similar efforts. Serna-Saldivar et al (1988) described the basic procedure, ingredient functionalities, and processing technologies for flour tortillas. Bello et al (1991) further described the important processing parameters and tortilla qualities at each stage of processing. The effectiveness of using additives such as acidulants, antimicrobial agents, reducing agents, and emulsifiers had also been studied (Friend et al 1995). The effects of leavening systems, particularly leavening acids, on tortilla quality and storage stability have been investigated (Cepeda et al 2000; Adams and Waniska 2002; Book et al 2002).

Most consumers prefer fluffy, thick, opaque tortillas (Waniska 1999), hence the use of the right chemical leavening system is critical. Good quality tortillas were obtained with the use of leavening acids such as sodium aluminum phosphate or sodium aluminum sulfate, individually or in combination with fumaric acid (Cepeda et al 2000; Adams and Waniska 2002; Book et al 2002). Increasing the amount of leavening (mixture of leavening acid and base) did not consistently improve tortilla quality. Hence, the type of base and the proportion of the acid to base in the leavening system need to be investigated to improve tortilla properties.

The most common leavening bases used in baked cereal products are sodium bicarbonate (SBC), potassium bicarbonate (KBC), and ammonium bicarbonate (ABC). Leavening action results when bicarbonate reacts with the leavening acid, thereby producing carbon dioxide gas. Therefore, manipulating the types or amounts of leavening acid or base could translate into changes in tortilla attributes. Lajoie and Thomas (1991) observed the level and type of bicarbonate used in the leavening process affected cookie spread, height, pH, and other characteristics. The effects of different types (sodium and ammonium) and grades (coarse, regular, and fine) of bicarbonates on wheat flour tortilla quality were determined in this study. Several proportions of acid to base in the leavening system were also evaluated.

MATERIALS AND METHODS

Formula

Enriched, unbleached wheat flour with 10.5% protein was used to prepare hot-pressed wheat flour tortillas. The base tortilla formula is 1,000 g of wheat flour, 1.7% salt, 0.2% sodium stearoyl-2-lactate, 0.1% succinylated monoglycerides, 0.5% sodium propionate, 0.4% potassium sorbate, and 5.0% shortening. Leavening ingredients used were sodium bicarbonate (Church and Dwight Co., Inc) (grades based on granule size: regular SBC G1, 66% [retained in 325 mesh screen]; coarse SBC G2, 98%; fine SBC G3, 25%), ammonium bicarbonate (ABC) (Church and Dwight Co., Inc), fumaric acid (Bartek Ingredients Inc.), sodium aluminum sulfate (SAS) (Ashland Distribution Co.) and distilled water.

[1] Texas A&M University, College Station, TX 77843-2474.
[2] Corresponding author. Phone: 979-845-2925. Fax: 979-845-0456. E-mail: waniska@tamu.edu

Publication no. C-2003-1215-02R.

Processing

Tortillas were processed using the procedure described by Bello et al (1991) with modifications. Shortening was mixed at low speed for 6 min, dough temperature (32 ± 1°C) was controlled using 38°C water and heated coils wrapped around the mixing bowl. Dough balls (36 balls; 43 ± 1 g) were formed in a Duchess divider-rounder. The dough balls were allowed to rest for 10 min in a proof chamber (32–35°C; 70–75% rh) and transferred to the processing line. Each dough ball was hot-pressed between warm platens (1.4 sec, 1,150 psi, 201°C) covered with Teflon sheets (1 mm thick). The pressed dough was passed through and baked in a three-tier oven at 180°C for 30 sec. Baked tortillas were allowed to cool (3–4 min, ambient conditions) and then packed in polyethylene bags.

Experimental Design

The first part (I) of the study was designed to compare bicarbonates. The effects of different grades (based on granular size coarse, regular, and fine) of sodium bicarbonate; and types (sodium and ammonium bicarbonate) on tortilla properties were determined. The second part (II) of the study determined combined effects of proportion and amount of leaveners on tortilla properties. Specifically, the proportion between the leavening base (sodium bicarbonate) and acids (sodium aluminum sulfate + fumaric acid) and the amount (sum of acid+base) of the leavening system were studied. The acid-to-base ratio (1.24; 7.45 g of acid and 6.00 g of base) and amount of acid+base (13.45 g/kg) of the leavening system used in Adams and Waniska (2002) were adopted as reference points. Higher and lower ratios and amounts were evaluated. In part I, the acid-to-base ratio (1.24) and amount (9.00 g/kg) were used, which limited amount of bicarbonate to emphasize its functionality during processing.

Tortilla Properties

The height, diameter, weight, pH, and opacity of baked tortillas were determined after 24 hr (Bello et al 1991). Opacity was measured subjectively using a continuous scale with 100% being completely opaque (white) and 0% being completely translucent (not white). Tortillas packed in polyethylene bags were stored at room temperature (22°C).

Storage stability of tortillas was determined using the rollability test (Friend et al 1995). Rollability was evaluated by wrapping a tortilla around a dowel (1.0 cm diameter) and rating the cracking and breakage of the sample. A continuous scale of 1–5 was used, where 5 = no cracking; 4 = signs of cracking but no breaking; 3 = cracking and breaking beginning on the surface; 2 = cracking and breaking imminent on both sides; and 1 = unrollable, breaks easily. Tortilla stability was defined as the number of days the tortilla could be rolled without breaking (rollability score = 3.0).

Tortilla extensibility was measured using TA.XT2 texture analyzer (Texture Technologies Corp., Scarsdale NY) (Suhendro et al 1999). The modulus of deformation (initial linear slope, N/m) was measured.

Statistical Analysis

The effects of the leavening system on tortilla quality were evaluated with one-way analysis of variance in a completely randomized experimental design. Protected Fisher's LSD was used

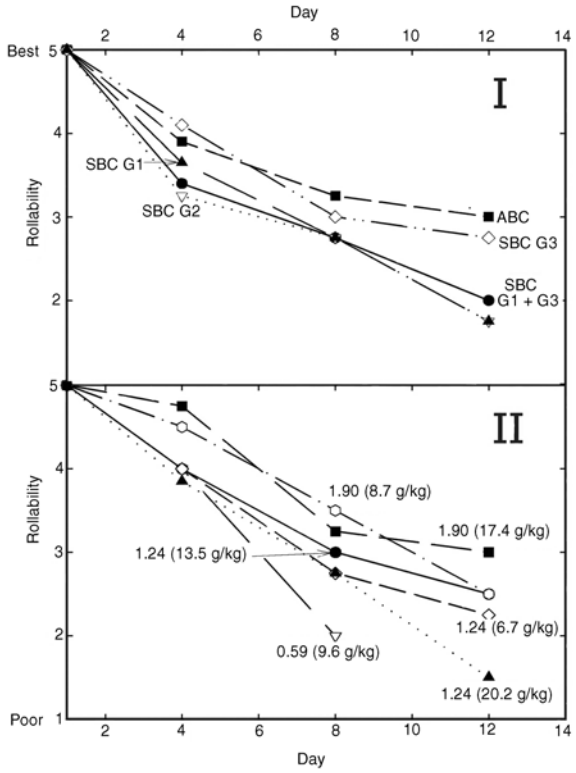

Fig. 1. Effects of type of leavening base (I) (SBC = sodium bicarbonate; ABC = ammonium bicarbonate); and acid-to-base ratio and amount (number in parenthesis) of leavening system (II) on storage stability based on tortilla rollability (see Table I for details).

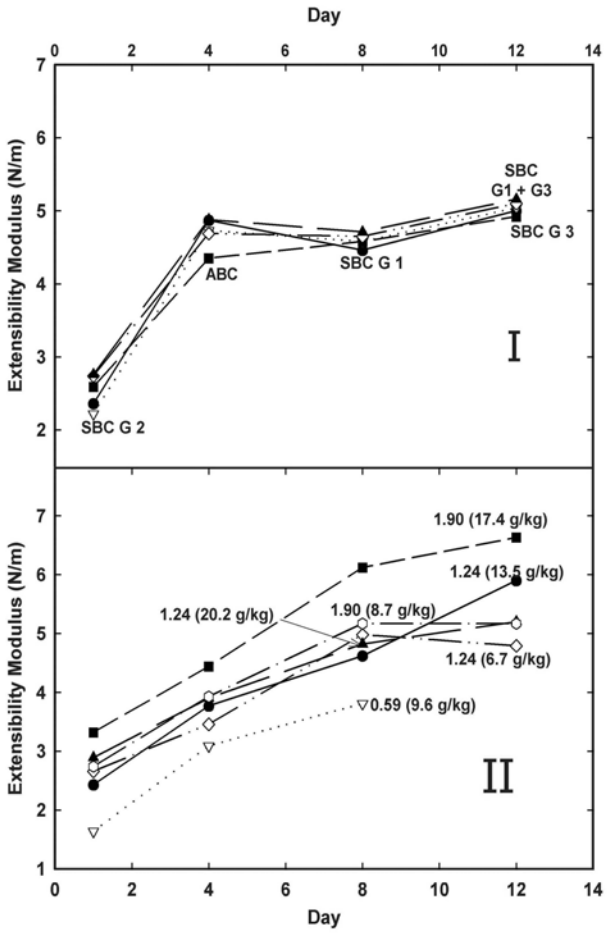

Fig. 2. Effects of type of leavening base (I) (SBC = sodium bicarbonate; ABC = ammonium bicarbonate); and acid-to-base ratio and amount (number in parenthesis) of leavening system (II) on tortilla extensibility (see Table I for details).

for multiple mean comparisons. SAS statistical software package was used for statistical analysis (SAS Institute, Cary, NC).

RESULTS AND DISCUSSION

Effects of Type and Grade of Bicarbonate (I)

The use of different types or grades of leavening base (Table I) did not significantly affect tortilla pH. Thus, all the bicarbonates completely dissolve and react during processing of tortillas, although the amount released varies at specific stages of processing varies as indicated by tortilla properties.

Critical tortilla quality attributes such as height, specific volume, and opacity increased using coarse (G2) and regular (G1) grades of SBC compared with those with fine granular size (Table I). The activity of the fine grade (G3) predominates when mixed in equal proportions (G3 + G1) and negatively affected tortilla quality. The quality of tortillas obtained with ABC was between those with coarse and fine SBC grades.

The greater proportion of SBC granules retained on a 325-mesh screen in the coarse and regular grades of SBC corresponds to tortillas with greater heights, specific volumes, and opacities, i.e., better quality tortillas. Because smaller SBC granules dissolve faster than larger SBC granules (Lajoie and Thomas 1994), more leavening reactions probably occurred before baking using smaller SBC granules. The gas generated by the reaction of SBC in the dough either modified dough properties or did not contribute as much to the height, specific volume, and opacity as does the gas generated during heating. Hence, timing of leavening reactions during processing affects tortilla quality. Specifically, more SBC must dissolve or react during baking (hot-press and oven) for improved tortilla quality.

Shelf-stability of tortillas was improved using ABC (Table I, Fig. 1) compared with those of tortillas prepared with SBC. Tortillas prepared with the fine SBC had a slightly higher stability than those prepared using other grades. The type and grades of leavening base did not significantly affect tortilla extensibility (Fig. 2).

Although SBC is routinely used to leaven tortillas, ABC is an acceptable leavening base for tortillas. Unlike SBC, ABC does not compromise storage stability. Additional studies should be conducted to validate the advantages of ABC in flour tortillas.

Effects of Acid-to-Base Ratio and Amount of Leavening (II)

Tortilla pH was dependent on the acid-to-base ratio of the leavening system (Table I). The highest acid-to-base ratio (1.90) produced thinner tortillas with decreased opacity and pH than those with lower acid-to-base ratios. The lowest acid-to-base ratio (0.59) produced thicker tortillas with increased specific volume, opacity and pH (Table I). The pH of these tortillas (pH 7.24), however, was much higher than the target range of pH 5.9–6.1. Tortillas with pH values within or lower than the target range lasted >20 days before mold colonies were visible; but those with high pH (≥ 7.0) were moldy after eight days.

The amount of leavening had some effect on tortilla quality but less than that of the acid-to-base ratio (Table I). Only the opacity of tortilla improved as the amount of leavening consistently increased using the same acid-to-base ratio (1.24) (Table I). The pH, height, diameter, and specific volume of these tortillas were not affected by the amount of leavening, except for thinner, larger diameter tortillas produced using 6.7 g of leavening/ kg of flour, a level half that normally recommended for baking powder. A larger diameter tortillas was also observed in tortillas prepared using 1.90 ratio and 8.7 g of leavening/kg of flour.

TABLE I
Effects of Type and Amount of Leavening Base on Tortilla Properties[a]

Treatment	pH	Height (cm)	Diameter (cm)	Specific Vol. (cm^3/g)	Opacity (%)	Stability (days)
(I) Leavening base (bicarbonate)						
SBC G1 (regular)	5.80a	0.27a	17.6a	1.65a	81a	6.2b
SBC G2 (coarse)	5.88a	0.27a	17.9a	1.65a	80a	6.2b
SBC G3 (fine)	5.86a	0.24b,c	18.0a	1.44c	70b	8.0b
SBC G1 + G3 (1:1)	5.82a	0.23c	17.2a	1.32d	66b	6.8b
ABC	5.82a	0.26a	18.0a	1.59b	73a,b	12.0a
(II) Acid-to-base ratio and amount of leavening						
1.90 (17.4 g/kg)	5.32d	0.24b	17.3b	1.42c	68d	12.0a
1.90 (8.7 g/kg)	5.52d	0.24b	18.1a	1.60b	67d	10.0a
1.24 (20.2 g/kg)	5.83c	0.27a	17.6b	1.62b	91b	8.0ab
1.24 (13.5 g/kg)	5.89c	0.26a	17.5b	1.61b	88b,c	8.0ab
1.24 (6.7 g/kg)	5.99b,c	0.24b	18.2a	1.61b	80c	7.5b
0.59 (9.6 g/kg)	7.24a	0.28a	18.2a	1.86a	100a	6.0b

[a] Means within column and treatment group (I and II) with same letter are not significantly different ($P \leq 0.05$). Sum of leavening (group I treatments) = 9.0 g/kg; with 1.24 acid-to-base ratio and 2.48 SAS-to-fumaric acid ratio. In group II, the first number denotes acid-to-base ratio; the number in parenthesis denotes amount of leavening agents (acids+base)/kg of flour; all treatments contained SBC-G1, SAS, and fumaric acid; the SAS-to-fumaric acid ratio was 2.48:1.

TABLE II
Correlations of Tortilla Properties with Amounts of Leavening Acid and Base (multiple regression) and Acid-to-Base Ratio

Tortilla Property	Multiple Regression[a]	Acid-to-Base Ratio	Acid+Base Sum
pH	0.97*	–0.92*	–0.34
Height	1.00*	–0.92*	0.13
Diameter	0.88	–0.45	–0.79
Specific volume	0.96*	–0.88*	–0.33
Opacity	0.99*	–0.94*	0.28

[a] Equation: pH = 6.04 + (0.317) (base) – (0.259) (acid); height = 0.24 + (0.010) (base) – (0.005) (acid); specific vol. = 1.64 + (0.065) (base) – (0.053) (acid); opacity = 69.6 + (7.75) (base) – (4.21) (acid).
[b] *, Significant at $P = 0.05$.

Tortilla properties correlated significantly with leavening compounds, i.e., the amounts of acids and base, the sum of acids and base, and the acid-to-base ratio (Table II). Multiple regression equations using the individual amounts of acid and base in the leavening system yielded higher correlation coefficients for tortilla pH, height, specific volume, and opacity.

Tortillas with high acid-to-base ratio (lower pH) retained rollability longer than those with low acid-to-base ratio (higher pH) (Fig. 1, Table I). Shelf-stability also has inverse relationships with opacity ($r = –0.83$) and specific volume ($r = –0.72$). Tortilla extensibility was significantly affected by the acid-to-base ratio in the leavening system but not by the total amount of leavening used (Fig. 2). High acid-to-base ratio (low pH) resulted in tougher tortillas while the opposite effect resulted with low acid-to-base ratio (high pH).

The reduced tortilla stability may be due to the lower pH or to the disruption of the gluten network of the tortilla. More research needs to be conducted, especially on the structural aspects of tortillas. It is obvious that the structure of the dough is modified when air bubbles expand during heating. The integrity of the less leavened tortillas (less height, specific volume, and opacity) was not compromised as much when it was stretched after storage compared with the more leavened tortillas. Air bubbles disrupt and expand the gluten network during baking. After baking and during storage, the air bubbles apparently weaken the remaining gluten network in the tortilla, as indicated by the shorter shelf-stability.

LITERATURE CITED

Adams, J. L., and Waniska, R. D. 2002. Effects of the amount and solubility of leavening compounds on flour tortilla characteristics. Cereal Foods World 47:60-64.

Bello, A. B., Serna-Saldivar, S. O., Waniska, R. D., and Rooney, L. W. 1981. Methods to prepare and evaluate wheat tortillas. Cereal Foods World 36:315-322.

Book, S. L., Brill, R. V., and Heidolph, B. B. 2002. Effects of leavening acids on characteristics of fresh and 30-day-old tortillas. Cereal Foods World 47:390-393.

Cepeda, M., Waniska, R. D., Rooney, L. W., and Bejosano, F. 2000. Effects of leavening acids and dough temperature in wheat flour tortillas. Cereal Chem. 77:489-494.

Friend, C. P., Ross, R. G., Waniska, R. D., and Rooney, L. W. 1995. Effects of additives in wheat flour tortillas. Cereal Foods World 40:494.

Lajoie, M., and Thomas, M. 1994. Sodium bicarbonate particle size and neutralization in sponge-dough systems. Cereal Foods World 39:684-687.

Serna-Saldivar, S. O., Rooney, L. W., and Waniska, R. D. 1988. Wheat flour tortilla production. Cereal Foods World 33:855.

Suhendro, E. L., Almeida-Dominguez, H. D., Rooney, L. W., Waniska, R. D., and Moreira. R. G. 1999. Use of extensibility to measure corn tortilla texture. Cereal Chem. 76:536-540.

Waniska, R. D. 1999. Perspectives on flour tortillas. Cereal Foods World 44:471-473.

[Received June 5, 2003. Accepted July 22, 2003.]