Effects of Hydrocolloids on Processing and Qualities of Wheat Tortillas[1]

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ABSTRACT

Effects of hydrocolloids were evaluated in hot-press wheat tortillas. Natural (arabic, guar, and xanthan), modified cellulose (carboxymethylcellulose [CMC], hydroxypropyl methylcellulose, and methylcellulose), and commercial blends (mixtures of natural and modified cellulose gums) were utilized. Farinograph values, mixing characteristics, dough machinability, tortilla characteristics (diameter, weight, moisture content, and appearance), rollability over time, and freeze-thaw stability were determined. Increased levels of gums resulted in doughs that were more sticky and less cohesive throughout mixing. Doughs prepared with commercial blends containing cellulose gum exhibited characteristics similar to CMC, such as lower initial dough viscosity and longer dough development times compared with those of the control. Hot-press wheat tortillas containing natural gums, modified cellulose gums, or commercial blends were consistently round, puffed, slightly browned, and of good quality. Tortilla diameters (159 mm), weights (41.4 g), and moisture content (30.8%) were similar for all tortillas. Water absorption of dough increased when more gums were added. The rollability of tortillas was retained longer with CMC and cellulose-based commercial blends. Rollability of all tortillas decreased during freezing and thawing, and tortillas containing CMC were significantly more rollable than control tortillas after five freeze-thaw cycles. Proper gluten development appears to be essential for good dough machinability, tortilla qualities, and tortilla shelf stability.

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Wheat tortillas have been produced in Mexico for centuries and have become popular in the United States (Serna-Saldivar et al 1988). Traditionally, tortillas have been consumed on the day of baking. However, to meet increased demand for tortillas and to accommodate modern distribution methods, new processing technologies have been developed (Gorton 1984, Waniska and Clements, *unpublished data*). Most tortillas are now manufactured by hot-press, die-cut, or hand-stretch procedures (Serna-Saldivar et al 1988). Hot-press tortillas are smoother in surface texture and more elastic and rollable than other tortillas. Different processing conditions require different flour specifications (e.g., protein content and quality), dough preparations, and baking conditions.

The traditional wheat tortilla is a chemically leavened flat bread consisting of flour, water, shortening or oil, baking powder, and salt. Recent changes to formulations include the addition of antimicrobial agents, acidulants, leavening agents, emulsifiers, yeast, nonfat dry milk, and hydrocolloids to improve production efficiency, product uniformity, and shelf stability (Waniska and Clements, *unpublished data*, Friend et al 1992, Suhendro et al 1993).

Hydrocolloids are normally added to bakery products to improve shelf stability by retaining more moisture and retarding staling (Twillman and White 1988, Bell 1990). However, adding hydrocolloids to bakery products to reduce staling also affects processing and product qualities (Slaney 1979, Glicksman 1983). Hence, the balance between improved shelf stability, good processing efficiency, and good product qualities must be targeted (Skarra and Evans 1988). The ability of commercial hydrocolloids to improve shelf stability of wheat tortillas, while maintaining processing and tortilla qualities, was investigated. However, this study did not exhaust all of the possible applications of hydrocolloids in tortillas.

MATERIALS AND METHODS

Tortilla Formulation

Enriched, bleached bread flour (GM-44, General Mills; 11.50% protein) was used to prepare all tortillas. Hot-press wheat flour tortillas were prepared from a standard formula including: 1.0 kg of flour, 120 g of shortening (Tri-co, Bunge Foods, Bradley, IL), 15 g of salt (United Salt Corp., Houston, TX), 12 g of baking powder (ADM Arkady, Decatur, IL), 2.5 g of potassium sorbate (Sorbistat-K, Pfizer, New York, NY), 2.5 g of sodium stearoyl-2-lactylate (Breddo, Kansas City, KS), and 2.4 g of fumaric acid (Denka Chem. Co., Houston, TX). Hydrocolloid materials included were: natural (arabic, guar, xanthan); modified cellulose (carboxymethylcellulose [CMC] [7H4F, Dow Chemical Co., Midland, MI], and methylcellulose and hydroxypropyl methylcellulose [MO83 and MP874, respectively, Aqualon Gum Co., Wilmington, DE]); and commercial hydrocolloid blends. The commercial blends used were: natural and modified cellulose gums (Tic 1023T, Tic Gums, Belcamp, MD); cellulose gum, guar gum, and dextrose (Alimento, Germantown Gum Co., Germantown, PA); cellulose gum, gum arabic, and mono- and diglycerides (Ventura, Germantown Gum Co.); cellulose and sweet whey protein (Microquick, FMC, Philadelphia, PA); and xanthan and guar gum (KOB87, Kelco, Chicago, IL).

Tortilla formulas contained natural gums at 0.2 and 0.5% and modified cellulose and commercial blends at 0.3 and 1.0%. Usage levels were based on preliminary trials that determined acceptable levels of gum addition based on dough characteristics, machinability, and tortilla acceptability.

Processing

The dry ingredients, except for the shortening, acidulant, and antimicrobial agent, were mixed with a paddle in a 20-qt mixer (model A-200, Hobart, Troy, OH) at low speed for 2 min. Shortening was then added to the dry ingredients and mixed for 8 min at low speed. Distilled water containing fumaric acid and potassium sorbate was heated to 49°C and added to the mixture at levels determined subjectively in preliminary trials. This mixture was mixed with a hook attachment for 1.5 min at slow speed and then at medium speed until the dough developed into a cohesive mass with a smooth surface (Bello et al 1991).

The dough mass was placed in a proof chamber (80% rh, 29°C) for 5 min. After 5 min of proofing, the dough mass was divided and rounded into 36 units using a rounder-divider (Dutchess, Bakery Equipment and Supply Co., San Antonio, TX). The resulting dough balls (42 g) were proofed for an additional 30 min and pressed to approximately 2.0 mm thickness in a hot-press (Bakery Equipment and Supply Co.). The top and bottom platens were heated to 195°C. The pressed dough was baked on a three-tier, gas-fired oven (model C-041, Superior Food Machinery, Pico Rivera, CA) for 45 sec at an average temperature of 195°C. Tortillas were cooled on a three-tier conveyor (model 3106, Superior Food Machinery) for 2 min and placed individually on a table (25°C) for 10 min more. Tortillas were packaged in 1-mil polyethylene bags.

Evaluation of Dough Mixing Properties

The effect of each hydrocolloid on mixing properties was evaluated subjectively on mixing characteristics and machinability (Bello et al 1991), as well as objectively with a Brabender Farinograph (model 3550, C. W. Brabender, Hackensack, NJ). A modified farinograph procedure with the curve centered at 750 farino-

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graph units was used to evaluate water absorption, dough development, and dough stability (AACC 1983, Bello et al 1991). Water was added to the tortilla formula (50 g of flour [14% moisture], salt, shortening, baking powder, hydrocolloid, and sodium stearoyl lactylate), and the farinograph was centered on the 750 farinograph unit line.

Evaluation of Tortilla Properties and Quality

Evaluation of tortillas. Baked tortillas were evaluated for weight (g) by stacking and measuring 10 cooled tortillas. The diameters (mm) of the tortillas were measured at two places on each of five baked tortillas per treatment, and the means calculated. Tortilla pH was also determined (Tellez-Giron et al 1988). Tortilla moisture content was determined on the day of baking and again after 10 days (AACC 1983).

Tortilla textural quality measurements. Shelf stability was determined by wrapping a tortilla around a dowel and evaluating the extent of cracking and breaking (i.e., the rollability-dowel test). Two tortillas per treatment were wrapped around a 1.0-cm dowel every other day for 16 days and subjectively rated for cracking and breakage. The rollability scale was: 1 = no cracking (best); 2 = signs of cracking, but no breaking; 3 = cracking and breaking beginning on one surface; 4 = cracking and breaking imminent on both sides; and 5 = unrollable, breaks easily.

Freeze-thaw stability. Tortillas were evaluated for freeze-thaw stability by using the rollability-dowel test after two and five freeze-thaw cycles. Each cycle consisted of a minimum of 10 hr at −4.0°C and 10 hr at 20°C. Rollability scores were determined on tortillas at 20°C.

Statistical analysis. Data were evaluated by the analysis of variance and least significant difference methods (SAS 1987).

RESULTS AND DISCUSSION

Effects on Dough Absorption, Mixing, and Machinability

Water absorption and mixing times were affected by the amount and type of gum added to the tortilla formula (Table I). Water absorption increased with increased levels of gum addition. Mixing times decreased with the addition of all hydrocolloids except 0.3% CMC.

The control dough developed slowly after the addition of water and formed a cohesive mass after mixing for 3 min. After 3 min more, the mass developed into a smooth, satiny dough that did not stick to the processing machinery.

Mixing characteristics were affected by the amount and type of gum added to doughs (Table I). The gums improved the doughs by making them more stable to overmixing and processing abuse. Doughs containing natural gums were less resistant to extension, formed a cohesive mass in less time, and had fair to poor mixing characteristics. Doughs containing 0.3% modified cellulose gums had mixing characteristics similar to, or better than, the control. Doughs containing 1.0% modified cellulose gum were stiff, sticky, and less cohesive; they appeared to have not developed completely during mixing. All doughs containing 0.3% commercial blends exhibited mixing characteristics similar to the control, except K0B87, which was slightly more viscous. Doughs containing 1.0% commercial blends were slightly more viscous, more sticky, and slightly less cohesive during mixing.

Dough machinability (i.e., the ease of rounding, dividing, and hot-pressing) was affected by the amount and type of gum added (Table I). Increasing the level of natural gum from 0.2 to 0.5% gave doughs that were more sticky with only fair machinability (i.e., the dough adhered to surfaces longer than desired). Doughs prepared using gum arabic and xanthan gum had better dough-handling properties than those prepared using guar gum. Doughs prepared with 0.3% modified cellulose gums had better machinability than doughs containing natural gums. Doughs containing 1.0% modified cellulose gums were slightly sticky and had fair machinability. All doughs containing 0.3% commercial blends were easily machined. All doughs containing 1.0% commercial blends exhibited inferior machinability (i.e., the doughs tended to be sticky and elastic).

Dough mixing and machinability of tortillas appear to be affected by the viscosity characteristics of the gums. Doughs pre-

TABLE I
Characteristics and Machinability of Doughs Containing Natural, Modified Cellulose, and Commercial Blends of Hydrocolloids

Treatment (% in Formula)	Mixing Time (min)	Water Absorption (%)	Mixing Characteristics	Dough Machinability	Comments
Control	6.0	47.0	Good	Good	
Natural					
Arabic (0.2%)	5.5	47.5	Good	Good	
Arabic (0.5%)	4.5	48.0	Fair	Fair	Slightly sticky
Guar (0.2%)	5.0	47.5	Fair	Fair	Slightly sticky
Guar (0.5%)	4.5	48.0	Poor	Poor	Viscous, sticky
Xanthan (0.2%)	5.5	47.5	Good	Good	Smooth
Xanthan (0.5%)	5.0	48.0	Fair	Fair	Firm, slightly sticky
Modified cellulose[a]					
CMC (0.3%)	6.0	48.0	Good	Good	
CMC (1.0%)	5.0	48.5	Poor	Fair	Ropey, slightly sticky
HPMC (0.3%)	5.5	47.5	Good	Good	
HPMC (1.0%)	4.5	48.5	Poor	Fair	Rough, slightly sticky
MC (0.3%)	5.5	48.0	Excellent	Excellent	Silky, pliable
MC (1.0%)	4.5	48.5	Fair	Fair	Slack, slightly sticky
Commercial blends[b]					
Tic 1023T (0.3%)	5.5	47.5	Good	Good	
Tic 1023T (1.0%)	5.0	48.5	Fair	Fair	Ropey, slightly sticky
Ventura (0.3%)	5.5	47.5	Good	Good	
Ventura (1.0%)	5.0	48.5	Poor	Fair	Viscous, stiff
Alimento (0.3%)	5.5	47.5	Good	Good	Smooth
Alimento (1.0%)	5.0	48.5	Fair	Fair	Viscous, slightly sticky
Microquick (0.3%)	5.5	47.5	Good	Good	Good
Microquick (1.0%)	5.0	48.5	Fair	Fair	Poor, firm, sticky
KOB87 (0.3%)	5.0	48.0	Fair	Good	Slightly viscous
KOB87 (1.0%)	4.5	48.5	Poor	Poor	Viscous, sticky

[a]CMC = carboxymethylcellulose; HPMC = hydroxypropyl methylcellulose; MC = methylcellulose.
[b]Tic 1023T, blend of natural and modified cellulose gums (Tic Gums, city, NJ); Alimento, blend of cellulose gum, guar gum, and dextrose (Germantown Gum Co., Germantown, PA); Ventura, blend of cellulose gum, gum arabic, and mono- and diglycerides (Germantown Gum Co.); Microquick, blend of cellulose and sweet whey protein (FMC, Philadelphia, PA); KOB87, blend of xanthan and guar gum (Kelco, Chicago, IL).

pared with gums that produce low viscosity solutions at concentrations less than 30% (i.e., gum arabic and CMC) had improved mixing characteristics and good machinability. Doughs prepared from guar gum, which produces high viscosity solutions, displayed fair to poor mixing characteristics and compromised machinability. This suggests that wheat tortillas should not contain a hydrocolloid that produces high viscosity solutions at low concentrations. Gluten development appears to improve with hydrocolloids that produce low viscosity solutions at low concentrations.

TABLE II
Farinograph Analysis of Doughs Containing Natural, Modified Cellulose, and Commercial Blends of Hydrocolloids

Treatment (% in Formula)	Water Absorption (%)	Dough Development (min)	Mixing Stability (min)
Control	45.0	3.00	3.00
Natural gums			
Arabic (0.2%)	45.6	3.00	2.50
Arabic (0.5%)	46.8	3.50	1.75
Guar (0.2%)	45.8	3.25	2.00
Guar (0.5%)	46.5	3.50	2.25
Xanthan (0.2%)	48.6	4.00	1.75
Xanthan (0.5%)	47.0	4.00	2.50
Modified cellulose gums[a]			
CMC (0.3%)	44.6	4.50	2.25
CMC (1.0%)	46.2	5.25	3.00
HPMC (0.3%)	46.0	3.00	3.50
HPMC (1.0%)	49.0	1.75	3.75
MC (0.3%)	47.2	4.00	1.25
MC (1.0%)	48.4	3.50	2.00
Commercial blends[b]			
Tic 1023T (0.3%)	45.0	3.75	2.25
Tic 1023T (1.0%)	43.2	5.00	1.50
Alimento (0.3%)	48.0	3.50	3.25
Alimento (1.0%)	47.0	3.50	4.00
Ventura (0.3%)	46.2	3.75	2.75
Ventura (1.0%)	46.8	4.50	3.25
Microquick (0.3%)	46.8	3.50	1.75
Microquick (1.0%)	45.6	3.25	1.75
KOB87 (0.3%)	49.0	3.50	2.25
KOB87 (1.0%)	49.2	1.00	5.00
LSD[c]	...	0.14	0.52

[a]CMC = carboxymethylcellulose; HPMC = hydroxypropylmethylcellulose; MC = methylcellulose.
[b]See Table I for content of commercial blends.
[c]Least significant difference ($P = 0.05$).

Farinograph Analysis of Doughs

All treatments were evaluated for water absorption, dough development, and stability (Table II) using a modified Brabender Farinograph procedure (Bello et al 1991). Water absorption increased and mixing times were extended for most treatments containing hydrocolloids. Mixing stability measurements, however, showed no significant trends.

Farinograms of tortilla dough containing natural gums showed a slight increase in dough viscosity at 1–2 min, which was similar to the control dough. Dough containing guar at 0.2 and 0.5% (Figs. 1 and 2, respectively) also exhibit this initial rise in dough viscosity. Doughs containing CMC at 0.3 and 1.0% (Figs. 1 and 2, respectively) had lower initial viscosities than the control dough or the doughs containing hydroxypropyl methylcellulose, methylcellulose, or the natural gums. All doughs prepared with commercial blends of cellulose gum at 0.3 and 1.0% (Figs. 1 and 2, respectively) produced farinograms similar to doughs containing CMC. Adding natural gums (and mono- and diglycerides) to some commercial blends tended to maintain the slightly higher initial viscosity.

Modified farinograms were beneficial in showing differences in the development of dough viscosity and the duration of dough development. Doughs with lower initial viscosities and extended farinograph development times were also the doughs that exhibited the best mixing characteristics and machinability. Lower initial dough viscosity also permitted better, more complete dough (gluten) formation in bread (Faubion and Hoseney 1989).

Characteristics and Rollability of Tortillas

The hot-press control tortillas were round, well-puffed, slightly browned, and had smooth surface texture. All tortillas were acidified to pH 5.94 ± 0.03. Tortilla diameter (159 mm), weight (41.1 g), moisture content (30.8%), and moisture loss after 10 days (1.19%) were typical of hot-pressed tortillas (Serna-Saldivar et al 1988, Friend et al 1992). Tortillas containing gums had diameters (159 mm, LSD = 2.4 mm) and weights (41.4 g, LSD = 0.8 g) similar to control tortillas.

Tortillas containing lower levels (0.3–0.5%) of gums were fully baked with few translucent areas or streaks. However, tortillas containing higher levels (0.5–1.0%) of gums were fully baked but

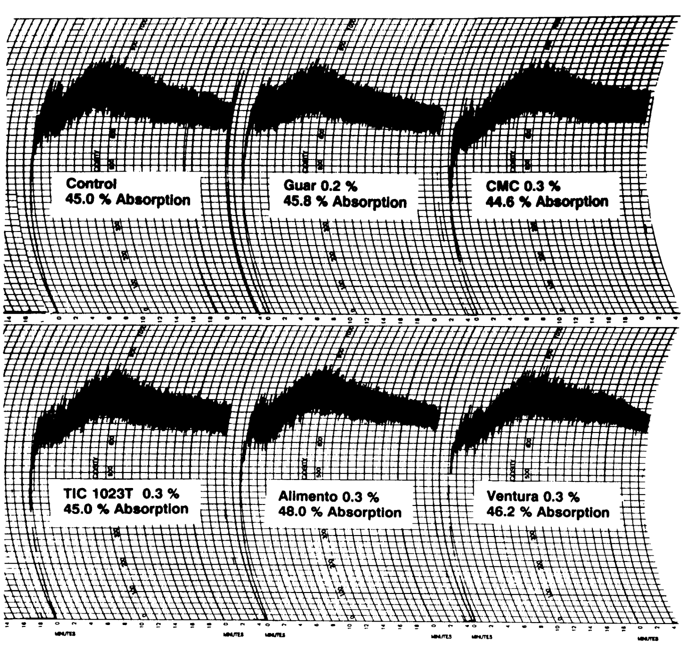

Fig. 1. Modified farinograms of tortilla doughs containing 0.2% guar or 0.3% carboxymethylcellulose (CMC), Tic 1023T, Alimento, or Ventura. Water absorptions indicated. See Table I for content of commercial blends.

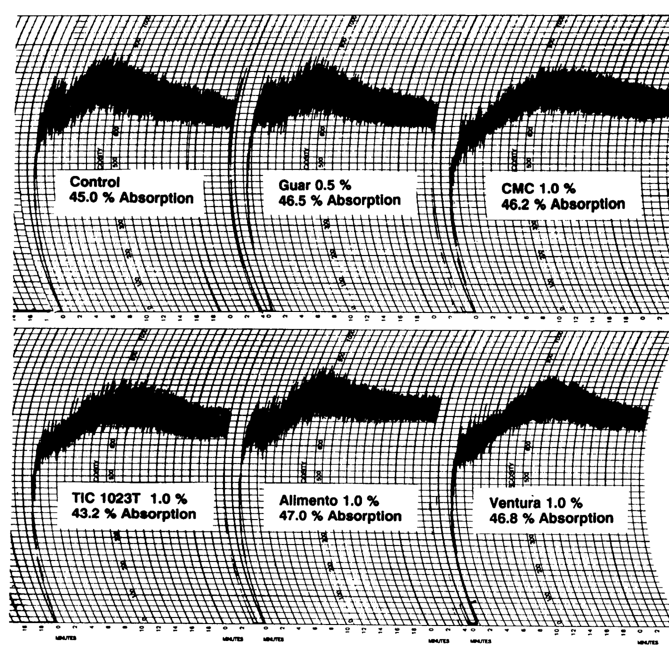

Fig. 2. Modified farinograms of tortilla doughs containing 0.5% guar or 1.0% carboxymethylcellulose (CMC), Tic 1023T, Alimento, or Ventura. Water absorptions indicated. See Table I for content of commercial blends.

TABLE III
Characteristics of Tortillas Containing Natural, Modified Cellulose, and Commercial Blends of Hydrocolloids

Treatment (% in Formula)	Diameter (mm)	Weight (g)	Moisture (%)	Moisture Loss (%)[a]	Shelf Stability (day)[b]
Control	159	41.1	30.8	1.19	8.7
Natural gums					
Arabic (0.2%)	159	41.0	31.1	1.33	8.7
Arabic (0.5%)	158	41.2	31.0	1.19	11.2
Guar (0.2%)	158	41.5	31.2	0.97	11.0
Guar (0.5%)	158	41.6	31.8	1.08	11.6
Xanthan (0.2%)	159	41.0	30.9	1.09	12.8
Xanthan (0.5%)	157	41.6	31.4	0.32	11.6
Modified cellulose gums[c]					
CMC (0.3%)	160	41.1	31.1	1.13	11.1
CMC (1.0%)	158	41.8	31.2	1.31	12.9
HPMC (0.3%)	160	41.4	30.9	0.91	10.4
HPMC (1.0%)	158	41.9	31.4	1.29	8.6
MC (0.3%)	160	41.2	31.8	1.98	9.9
MC (1.0%)	160	41.6	32.5	1.77	9.3
Commercial blends[d]					
Tic 1023T (0.3%)	160	41.2	30.7	1.01	11.7
Tic 1023T (1.0%)	161	41.7	31.0	1.23	11.3
Alimento (0.3%)	161	40.9	30.8	1.35	10.8
Alimento (1.0%)	159	41.9	31.7	0.85	12.1
Ventura (0.3%)	160	41.0	30.3	0.58	10.6
Ventura (1.0%)	159	41.1	31.5	1.87	11.9
Microquick (0.3%)	160	41.3	30.8	1.45	11.3
Microquick (1.0%)	160	41.4	31.1	0.83	10.4
KOB87 (0.3%)	159	41.4	31.0	1.14	10.8
KOB87 (1.0%)	159	41.7	31.6	1.40	9.3
LSD[e]	2.4	0.8	0.98	0.97	2.4

[a] Moisture loss after 10 days.
[b] Days the tortilla could be rolled before breaking on one side (rollability score = 3.0).
[c] CMC = carboxymethylcellulose; HPMC = hydroxypropyl methylcellulose; MC = methylcellulose.
[d] See Table I for content of commercial blends.
[e] Least significant difference ($P = 0.05$).

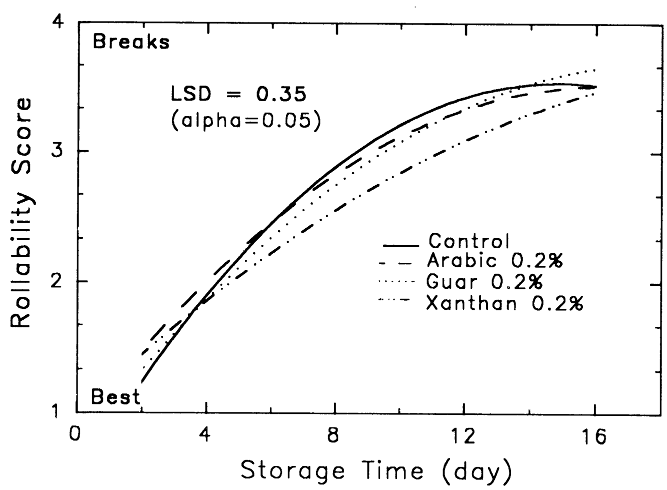

Fig. 3. Effect of 0.2% natural gums on the rollability of tortillas.

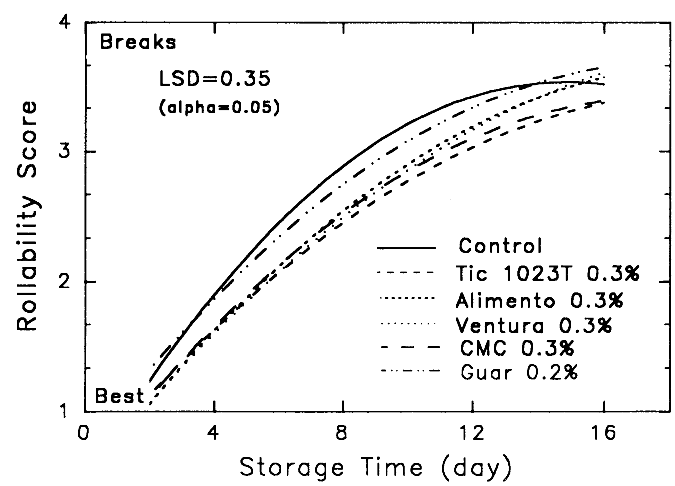

Fig. 4. Effects of 0.2% guar or 0.3% carboxymethylcellulose (CMC), Tic 1023T, Alimento, or Ventura on the rollability of tortillas. See Table I for content of commercial blends.

tended to have more translucent areas and less whiteness.

Shelf stability of tortillas was affected by the amount and type of gum in the tortilla (Table III, Fig. 3). Xanthan gum was the only natural gum at the 0.2% level to significantly improve tortilla rollability over time. Shelf stability of wheat tortillas was not affected by 0.2% arabic or guar gum (Fig. 3), but it was significantly extended with 0.5% arabic, guar, or xanthan gum.

Tortillas containing 0.3% CMC or commercial blends containing cellulose gum had improved rollability during storage compared to the control (Fig. 4). The other modified cellulose gums and the commercial gum containing xanthan and guar were less effective in extending the shelf stability of wheat tortillas (Table III). Tortillas with higher levels of hydrocolloids tended to maintain rollability longer during storage (Fig. 5, Table III).

Tortillas containing 0.3% CMC had improved rollability over time. Tortilla rollability was also improved by preparation with flour with more protein or by incorporating vital gluten (Suhendro et al 1993). Apparently, 0.3% CMC either contributed to the flexibility of the tortilla or permitted more complete gluten development.

Freeze-Thaw Stability

Wheat tortillas became less rollable after two and five freeze-thaw cycles; the rollability scale (RS) was 1.6 and 2.6, respectively. Tortillas containing natural gums (all types, both levels) exhibited rollabilities similar to those of control tortillas. After five freeze-thaw cycles, tortillas containing 0.3% CMC were significantly more rollable (RS = 2.2, LSD = 0.37, $\alpha = 0.05$) than control tortillas. Tortillas containing other modified cellulose gums and commercial blends exhibited rollabilities similar to those of control tortillas.

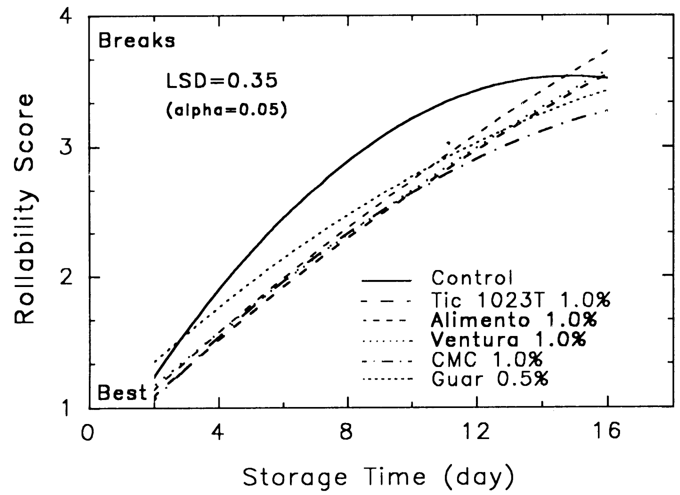

Fig. 5. Effects of 0.5% guar or 1.0% carboxymethylcellulose (CMC), Tic 1023T, Alimento, or Ventura on the rollability of tortillas. See Table I for content of commercial blends.

SUMMARY

Hot-press wheat tortillas containing natural gums, modified cellulose gums, or commercial blends were consistently round, puffed, slightly browned, and were of good quality. Water absorption of tortilla dough increased when more gums were added. Increased levels of gums resulted in doughs that were more sticky and less cohesive throughout mixing. Doughs containing commercial blends of cellulose gum exhibited characteristics similar to CMC, such as lower initial dough viscosity and longer dough development times compared to those of the control.

Tortilla diameters and weights were similar for all treatments. All tortillas prepared with 0.2 and 0.3% hydrocolloids exhibited few translucent areas; however, tortillas prepared with higher levels of hydrocolloids had more translucent areas.

The rollability of tortillas with CMC and cellulose-based commercial blends was retained longer. Rollability of all tortillas decreased during freezing and thawing, and tortillas containing CMC were significantly more rollable than control after five freeze-thaw cycles.

Proper gluten development appears to be essential for good dough machinability, tortilla qualities, and tortilla shelf stability.

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