Effects of Polyols on the Processing and Qualities of Wheat Tortillas[1]

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ABSTRACT

Effects of polyols on processing of hot-press wheat tortillas were evaluated. Hot-press wheat tortillas with 0, 2, 4, or 6% glycerol were prepared from wheat flour of 10.2, 11.0, or 11.5% protein content. Tortillas with 2, 4, or 6% propylene glycol, sorbitol, or maltitol were prepared from the 11.0% protein flour. Farinograph and alveograph values, dough mixing characteristics and machinability, rollability over time, sensory evaluation, water holding capacity, total liquid content, and water activity were determined. Low protein (10.2%) flour required less water, shorter mixing time, and yielded tortilla doughs that were less machinable compared to other flours. Water absorption decreased with increasing polyol level. Doughs containing 6% polyols, except maltitol, were stickier and less machinable than control doughs. Tortillas prepared from 10.2% protein flour with or without polyols were less rollable during storage compared to those prepared from higher protein flours. Tortillas containing glycerol had less moisture, higher liquid content, and improved shelf-stability, except when prepared from low protein flour. Water activity decreased with increasing polyol level. Propylene glycol and glycerol were more effective in decreasing water activity than sorbitol and maltitol. Formulas containing 4% polyols and ≥11.0% protein flour had good machinability and yielded acceptable tortillas with improved rollability during storage.

The increased production of wheat tortillas in the United States necessitates better shelf life and storage stability of wheat tortillas to accommodate their wider distribution. Longer shelf life of tortillas can be achieved with propionates and sorbates and sufficient acidulant (fumaric, citric, phosphoric, etc.) to lower the pH (Friend et al 1992).

Freshness, flexibility, and rollability (shelf stability) of tortillas during storage have become increasingly problematic in tortillas that resist molding. Shelf stability, or the retention of "fresh" tortilla characteristics, of wheat tortillas has been improved by using flour with higher protein quality or addition of wheat gluten or some hydrocolloids (Friend et al 1993, Suhendro et al 1993).

Glycerol was reported to increase both shelf life and shelf stability of wheat and corn tortillas (Skarra et al 1988). Glycerol (2–10% by dough weight) increased the shelf stability by promoting softness and flexibility of tortillas. By decreasing water activity, glycerol extends tortilla shelf life.

Effects of polyols on processing and qualities of wheat tortillas need to be more thoroughly investigated. The effectiveness of glycerol was evaluated using three wheat flours. The effectiveness of four polyols was evaluated using a flour commonly used to prepare wheat tortillas.

MATERIALS AND METHODS

Materials

Hard wheat flour with different protein contents (10.2, 11.0, and 11.5%) (donated by ConAgra, Omaha, NE) were used to prepare hot-press wheat tortillas. Flour quality was characterized using farinographic and alveographic methods (AACC 1983).

Hot-press wheat tortillas were prepared from: 1.0 kg of wheat flour; 120 g of shortening (Tri-Co, Bunge Foods, Bradley, IL); 15.0 g of salt (United Salt Corp., Houston, TX); 7.0 g of baking powder (Rexal double-acting, Real Commerce Corp., Houston, TX); 4.0 g of baking soda (Kroger, College Station, TX); 4.5 g of sodium aluminum phosphate (Levn-lite leavening agent, Monsanto Company, St. Louis, MO); 3.8 g of potassium sorbate (Sorbitat-K, Pfizer, New York, NY); 2.3 g of fumaric acid (Denka Chem. Co., Houston, TX); and 5.0 g of sodium stearoyl-2-lactylate (SSL)(American Ingredients Co., Kansas City, KS). Treatments were replicated at least twice on separate days.

Propylene glycol (J.T. Baker Chemical Co., Phillipsburg, NJ), glycerol (Superol glycerin USP, Proctor and Gamble Co., Cincinnati, OH), sorbitol (Neosorb, 70% solids content, Roquette Corporation, Gurnee, IL), and maltitol (Lycasin, 75% solids content, Roquette) were used at 2, 4, and 6% (baker's percent). Results of preliminary trials indicated that addition of <2% glycerol did not yield significant effects, while addition of >6% glycerol produced sticky doughs and poorly shaped tortillas.

Modified Farinograph

A modified farinograph method (50-g bowl, type 3350, C. W. Brabender, South Hackensack, NJ) was used to measure optimum water absorption and mixing time for tortilla doughs (AACC 1983, Bello et al 1991). Optimum water absorption was designated as the amount of water needed to center the farinogram curve on the 750 FU line. Wheat flour (50 g) was mixed with: 0.74 g of salt; 3.94 g of fat; 0.35 g of baking powder; 0.20 g of baking soda; 0.22 g of sodium aluminum phosphate; 0.25 g of SSL; and 0.00, 0.10, 0.20, or 0.30 g of glycerol.

Preparation of Hot-Press Tortillas

Tortillas were prepared according to Bello et al (1991) using a hot-press method with modifications. Glycerol and other polyols were added to heated distilled water containing fumaric acid and potassium sorbate. The system was mixed at low speed for 1 min, then at medium speed until a soft and pliable dough developed.

Processing and Product Analyses

Dough was analyzed for mixing characteristics, machinability, and pH (Bello et al 1991). Tortillas were analyzed for baking characteristics, puffing, rollability, moisture content (AACC 1983), diameter, weight, and sensory properties (Bello et al 1991, Friend et al 1992).

Thirty untrained panelists evaluated the color, texture, flavor, acceptability, and overall ranking of preference of tortillas containing 4% polyol. Tortillas were evaluated using a scale of 1 (dislike) to 9 (like) and ranked using a scale of 1 (worst) to 5 (best) (Friend et al 1992). The tortillas were made one day before sensory evaluation. Flexibility and rollability of tortillas were evaluated every two days by wrapping a tortilla around a dowel (1.0 cm diam) and rating the cracking and breakage on both sides of the tortilla. The rollability scale was 1 (no cracking) to 5 (breaks easily) (Friend et al 1992).

Glycerol content of tortillas was determined by high-performance liquid chromatography (HPLC). Fresh tortillas were ground, weighed (0.075 g), extracted with 10 ml of HPLC-grade water at 50°C for 10 min, centrifuged (5,000 × g, 20 min). The supernatant was filtered through 0.45-μm nylon filter. Glycerol in the

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filtrate was separated using an ion-exchange column (Aminex HPX-87C, Bio-Rad, Richmond, CA) held at 85°C, using water as the mobile phase.

Glycerol concentration was corrected for moisture content of tortilla. Total liquid content of tortillas was determined by adding percent glycerol content and percent moisture content.

Water holding capacity (WHC) of tortillas was determined by the amount of water (on a dry basis) held by ground tortillas after being hydrated and centrifuged (Skarra et al 1988). Water activity of tortillas was determined (Psycrotherm, New Brunswick Scientific, Co., Inc., New Brunswick, NY) and calibrated using standard salts slushes (AOAC 1980).

Treatment effects were evaluated by analysis of variance using a completely randomized design of duplicated analyses. Treatment means were compared using least significant difference. SAS (ver 6.04) was used to carry out statistical analyses on a personal computer (SAS 1990).

RESULTS AND DISCUSSION

Flour Characteristics

Farinograph water absorption decreased as flour protein content decreased (Table I). Mixing times and mixing tolerance indices of flours B and C were similar, while those of flour A corresponded to a weaker protein flour.

Alveograph analysis revealed flour C had the strongest protein functionality: highest over pressure (related to elasticity) and energy to rupture (Table I). Flour B had intermediate quality protein: low pressure but the greatest longitude (related to viscosity). Flour A had poor quality protein. Flour B was expected to have better functionality because a dough with some elasticity and more viscous flow properties is better in tortilla manufacturing (Friend et al 1992, Suhendro 1993).

Effects of Glycerol

Modified farinograph. Dough prepared from 11% protein flour had a relatively slow continuous rise in viscosity to 750 FU, followed by a slow decrease in viscosity (Fig. 1). The initial rise in viscosity of doughs containing glycerol was similar to that of control dough (tortilla dough that does not contain polyols). However, the subsequent loss of mixing stability of the doughs containing glycerol were faster than that of the control dough.

Mixing time was not affected by glycerol content. However, water absorption and mixing stability decreased as glycerol content increased (Table II). Total liquid content of dough increased from 48.3% for control dough to 51.5% for dough containing 6% glycerol.

Glycerol is a liquid that contributes to dough fluidity, but glycerol is not as effective a plasticizer as water (Slade and Levine 1987, 1988). Therefore, doughs containing glycerol needed more liquid to center peak viscosity on the 750 FU line (Table II). The increased liquid content of dough, however, probably contributed to poorer mixing stability.

Dough mixing and machinability. Mixing times of doughs prepared with flour A were 1.5 min less than those using flours B and C (the higher protein flours) (Table III). Addition of 2 or 4% glycerol did not affect mixing time of tortilla dough. Addition of 6% glycerol caused the mixing time to decrease from 6.0 to 5.5 min when prepared using flours B and C.

Characteristics of all doughs containing glycerol were similar to those of the control when ≤4% glycerol was incorporated (Table III). However, tortilla doughs containing 6% glycerol became stickier in the resting chamber and were less machinable compared to those containing less glycerol. Glycerol is hygroscopic, that is it has the ability to attract and retain moisture (Mellan 1962). Therefore, addition of >4% glycerol increased stickiness of the dough, especially during resting in a warm, moist chamber. To alleviate machinability problems, doughs containing >4% glycerol were rested for 25 min and placed in an open room at 22°C for 5 min to evaporate moisture on the surface of the dough balls.

Tortilla characteristics. Incorporation of glycerol into the dough yielded round, well-puffed tortillas with a smooth surface (Table IV). Tortillas containing 6% glycerol had more brown spots when

TABLE I
Farinographic and Alveographic Characteristics of Flour Used to Prepare Wheat Tortillas

	Flour		
Characteristics	**A**	**B**	**C**
Protein (%)[a]	10.2	11.0	11.5
Water absorption (%)[a,b]	53.8	59.3	61.3
Mixing time (min)[a,b]	5.5	8.5	8.0
MTI (min)[a,b,c]	50	20	30
p (m/m)[d,e]	96.8	68.0	135.9
Longitude (*L*) (m/m)[d]	51.7	70.0	68.0
Area (*S*) (cm^2)[d]	27.0	35.0	35.0
Rupture (*G*)[d]	14.6	20.6	16.9
Work (*W*) ($\times 10^{-4}$ *J*)[d,f]	176.6	230.0	289.4

[a] ConAgra certificate of analysis (ConAgra, Omaha, NE).
[b] Farinograph method (AACC 1983).
[c] Mixing tolerance index, the higher the number the weaker the flour.
[d] Alveograph method (AACC 1983).
[e] Pressure × coefficient manometer.
[f] Work = 6.54 × S.

TABLE II
Rheological Properties of Tortilla Doughs Prepared from Flour B (11.0% protein) Containing Added Glycerol Using the Modified Farinograph Procedure

Treatment	Water Absorption (%)	Mixing Time (min)	Mixing Stability (min)	Liquid Content (%)
Glycerol 0% (control)	48.3	4.38	5.25	48.3
Glycerol 2%	48.0	4.38	5.25	50.0
Glycerol 4%	45.8	4.25	4.75	49.8
Glycerol 6%	45.5	4.13	4.00	51.5
Least significant difference ($\alpha = 0.05$)	0.2	0.43	0.49	0.2

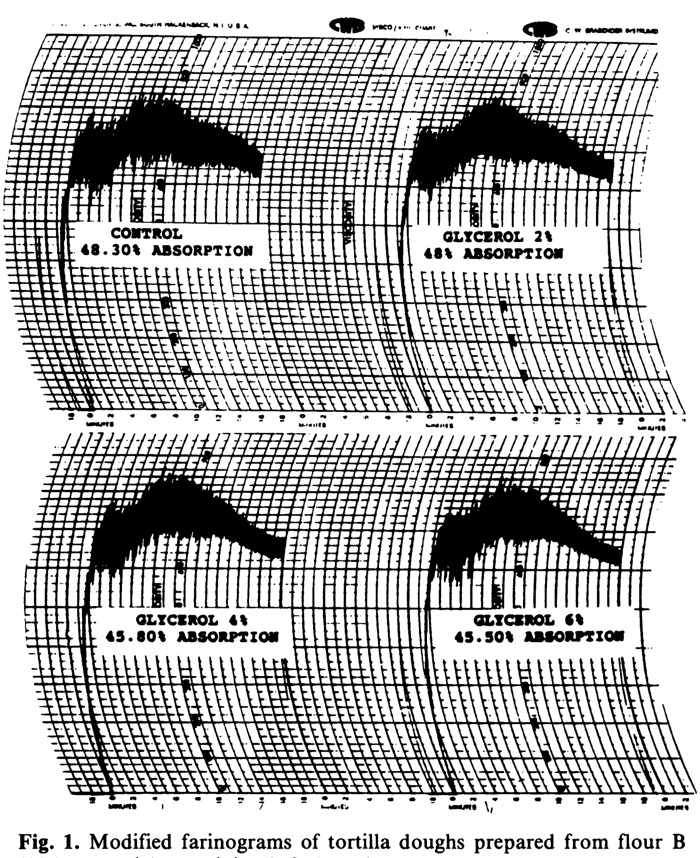

Fig. 1. Modified farinograms of tortilla doughs prepared from flour B (11.0% protein) containing 0, 2, 4, or 6% glycerol.

TABLE III
Effect of Added Glycerol and Other Polyols on Tortilla Dough Characteristics

Treatment	Mixing Time (min)	Water Absorption (%)	Liquid Content (%)	Mixing Characteristics	Dough Machinability	Comments
Flour A (10.2% protein)						
Glycerol						
0% (control)	4.5	44.5	44.5	Good/fair	Good/fair	Pliable
2%	4.5	44.5	46.5	Good/fair	Good/fair	Softer
4%	4.5	43.0	47.0	Good/fair	Fair	Soft, slightly (sl) sticky
6%	4.0	42.5	46.5	Fair/poor	Fair/poor	Soft, sticky
Flour B (11.0% protein)						
Glycerol						
0% (control)	6.0	47.0	47.0	Good	Good	Pliable
2%	6.0	47.0	49.0	Good	Good	Pliable
4%	6.0	45.5	49.5	Good	Good	Soft
6%	5.5	44.0	49.5	Fair	Fair	Soft, sl sticky
Propylene glycol						
2%	6.0	47.0	49.0	Good	Good	Pliable, softer
4%	5.5	45.0	49.0	Good	Fair	Softer, sticky
6%	5.5	44.0	49.5	Fair	Fair	Soft, sl sticky
Sorbitol						
2%	6.0	47.1	49.1	Good	Good	Pliable, soft
4%	6.0	46.2	50.2	Good	Good	Soft, sl sticky
6%	5.5	45.8	50.8	Fair	Fair	Soft, sl sticky
Maltitol						
2%	6.0	47.0	49.0	Good	Good	Pliable, dry
4%	6.0	46.0	50.0	Good	Good	Pliable, dry
6%	5.5	45.8	51.5	Good	Good	sl stiff
Flour C (11.5% protein)						
Glycerol						
0% (control)	6.0	47.0	47.0	Good	Good	Pliable
2%	6.0	47.0	49.0	Good	Good	Pliable
4%	6.0	45.5	49.5	Good	Good	Softer
6%	5.5	44.0	49.5	Fair	Fair	Softer

TABLE IV
Effect of Added Glycerol and Other Polyols on Tortilla Characteristics

Treatment	Diameter (mm)	Weight (g)	Moisture (%)	Appearance	Puffing	Brown Spots[a]
Flour A (10.2% protein)						
Glycerol						
0% (control)	170	37.0	28.2	Rough, round	High	Light, few
2%	170	36.9	27.7	Rough, off-round	Medium	Light, few
4%	170	38.2	27.3	Rough, off-round	Medium	Light, more
6%	169	37.5	26.7	Rough, off-round	Medium	Darker, more
Flour B (11.0% protein)						
Glycerol						
0% (control)	163	39.6	30.5	Smooth, round	High	Light, few
2%	164	39.7	29.6	Smooth, round	High	Light, few
4%	165	39.9	29.3	Smooth, round	High	Light, few
6%	166	41.0	27.7	Smooth, round	High	Darker, more
Propylene glycol						
2%	168	39.3	29.8	Smooth, round	High	Light, few
4%	175	38.9	28.8	Smooth, round	High	Light, more
6%	176	40.1	27.3	Less smooth, off-round	Medium	Darker, more
Sorbitol						
2%	165	40.1	30.3	Smooth, round	High	Light, few
4%	169	40.4	29.9	Smooth, round	High	Light, more
6%	169	40.2	28.7	Smooth, round	High	Light, more
Maltitol						
2%	165	39.3	29.7	Smooth, round	High	Light, few
4%	164	40.5	29.8	Smooth, round	High	Light, few
6%	164	40.2	28.8	Smooth, round	High	Light, few
Flour C (11.5% protein)						
Glycerol						
0% (control)	158	40.2	30.7	Smooth, round	High	Light, few
2%	155	40.6	29.0	Smooth, round	High	Light, few
4%	160	41.4	29.1	Smooth, round	High	Light, few
6%	160	41.3	27.9	Smooth, round	High	Darker, more
Least significant difference ($\alpha = 0.05$)	5.0	2.0	1.0			

[a]List of adjectives describing the colored spots on baked tortillas.

compared to control tortillas.

The diameters and weights of tortillas were not affected by glycerol addition. Moisture content of tortillas decreased as more glycerol was incorporated (Table IV). Tortillas prepared with flour A had the largest diameter and lower moisture content when compared to tortillas prepared from flours B and C.

As expected, addition of glycerol increased total liquid content of tortillas, from 30.5% for control tortillas (11.0% protein flour) to 32.1% for tortillas containing 4% glycerol (Fig. 2). The amount of glycerol added to the dough remained in the tortilla after baking. A 100% recovery of glycerol was observed. Addition of 6% glycerol on a flour basis calculates to be 4.2% glycerol in tortillas.

Shelf stability, measured by maintenance of rollability during storage, of tortillas was prolonged by the addition of glycerol when the tortillas were prepared using 11.0 and 11.5% protein flour (Fig. 3). Tortillas containing 4% glycerol could easily be rolled two to four days longer than control tortillas. Addition of glycerol (2–6%) tended to prolong tortilla rollability, but the change was not significantly different when tortillas were prepared from higher protein flours. Apparently, glycerol interacted with gluten, as suggested by Levine and Slade (1988), to stabilize the polymer structure during processing (mixing, pressing, baking, etc.).

Tortillas prepared from 10.2% protein flour had significantly worse shelf stability or rollability than tortillas prepared from 11.0% protein flour. Addition of glycerol did not prolong shelf stability of tortillas prepared from 10.2 % protein flour. Friend et al (1992) and Suhendro et al (1993) also observed that more gluten content corresponded to longer shelf stability. Apparently, the 10.2% protein flour did not have enough gluten to interact with glycerol to improve shelf stability as did the other flours evaluated.

Addition of glycerol increased liquid content and shelf stability of tortillas prepared from flours B and C but did not increase the shelf stability of tortillas prepared from flour A. Therefore, the 11.0% protein flour was selected to be an appropriate flour for further investigations of polyol effects.

Effects of Other Polyols

Dough characteristics and machinability. Doughs containing polyols, except maltitol, tended to be softer (less viscous and less elastic) than control doughs (Table III). Doughs containing propylene glycol were the softest. Addition of 6% polyols decreased mixing times of tortilla doughs from 6 min for the control to 5 min for propylene glycol or 5.5 min for other polyol treatments.

Incorporation of ≥4% polyols yielded doughs that were less machinable than the control dough (Table III). However, doughs containing maltitol had handling properties similar to those of the control dough. Doughs containing propylene glycol were the stickiest. The lower viscosity of propylene glycol (Mellan 1962) probably contributed to the softness and stickiness of tortilla doughs.

Tortilla characteristics and rollability. Tortillas prepared with 2% polyols (propylene glycol, glycerol, sorbitol, or maltitol) were round, well-puffed, and had a smooth surface texture similar to that of control tortillas (Table IV). Tortillas containing 2% polyols had better shelf stability (retained rollability) from 5–13 days of storage than did control tortillas (Fig. 4).

Addition of 4 and 6% polyols yielded tortillas that contained less moisture but had shelf stability two to four days longer than those of control tortillas (Fig. 4).

Sensory evaluation. Tortillas containing 0 and 4% polyols were evaluated for organoleptic properties because these treatments had good dough characteristics, machinability, and improved

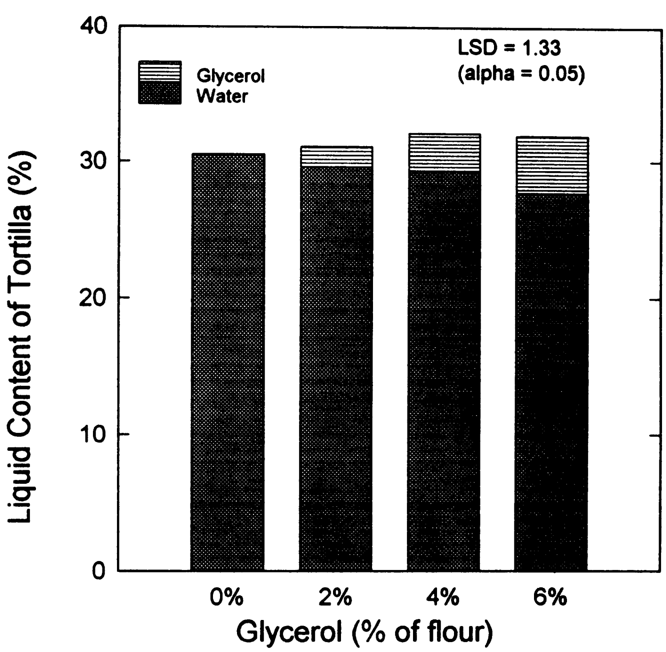

Fig. 2. Effect of glycerol addition on liquid content of tortillas prepared from flour B (11.0% protein).

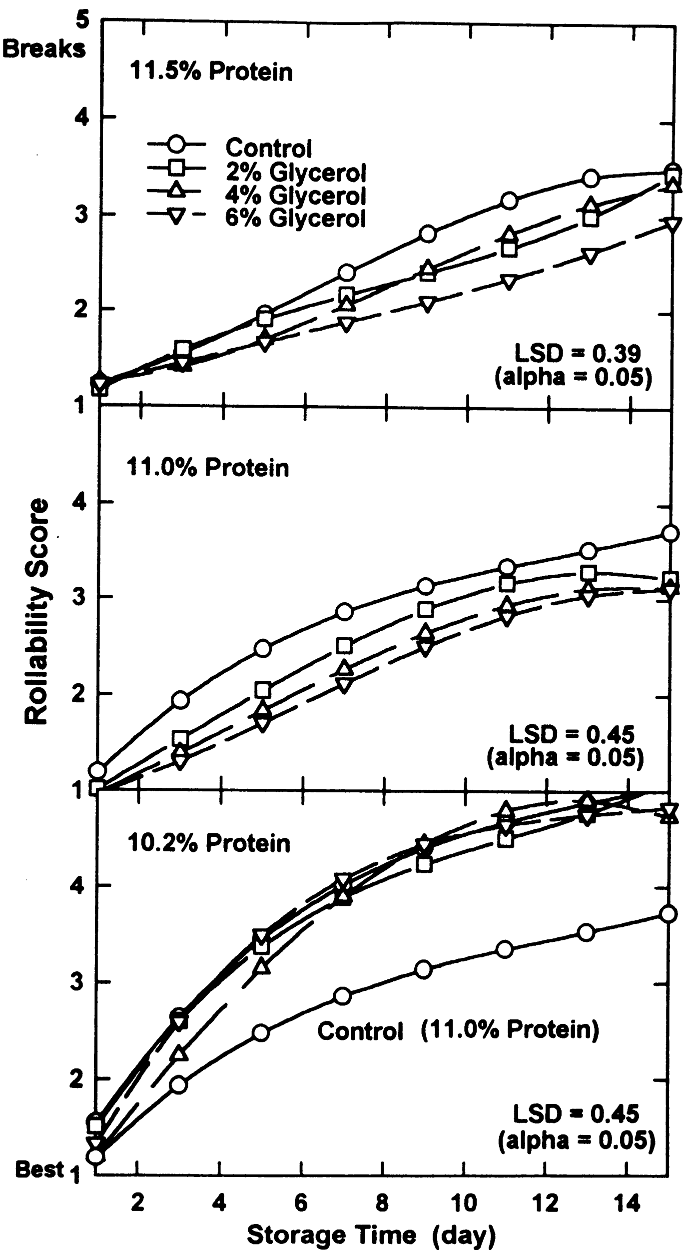

Fig. 3. Rollability of tortillas containing 2, 4, or 6% glycerol prepared from flours with different protein contents.

rollability during storage. Control tortillas and tortillas prepared with 4% propylene glycol, glycerol, sorbitol, or maltitol had similar color (7.1 ± 1.5), texture (6.8 ± 1.7), flavor (6.6 ± 1.9), and acceptability (6.7 ± 1.9) (data not shown). Some panelists noted that tortillas with 4% polyols were more chewy when compared to control tortillas.

Water-holding capacity. Addition of 4% polyols did not affect WHC of fresh or stored tortillas, but the WHC of all treatments decreased with increasing storage time (Fig. 5). We did not expect this result because Skarra and coworkers (1988) observed greater retention of WHC of tortillas containing 2–10% glycerol. During storage however, starch and proteins lose their ability to hold water (Kim and D'Appolonia 1977). In another experiment, initial WHC of tortillas containing 6% propylene glycol was similar to that of control tortillas, while initial WHC of tortillas containing 6% maltitol was lower than that of control tortillas (Fig. 6). Tortillas containing 6% propylene glycol did not lose as much WHC after one or nine days of storage as the control tortillas or tortillas containing maltitol. Apparently, polyols vary in their ability to retain moisture in baked products.

Water activity. Control tortillas had a water activity of 0.93 ± 0.01 (Table V). The amount of glycerol added to tortillas was negatively correlated to water activity ($R^2 = 0.98$; water activity $= 0.93 - (0.01)$ (% glycerol); $\alpha = 0.05$; $n = 19$). Propylene glycol and glycerol were more effective in decreasing water activity than were the other polyols. Addition of 4% propylene glycol or glycerol significantly decreased water activity of tortillas to 0.90 (Table V). Propylene glycol and glycerol have lower molecular weights than sorbitol and maltitol; thus, they more effectively increased osmotic pressure and decreased water activity.

SUMMARY

Dough-mixing characteristics (mixing time and water absorption) decreased using flour with a lower protein level. Increased

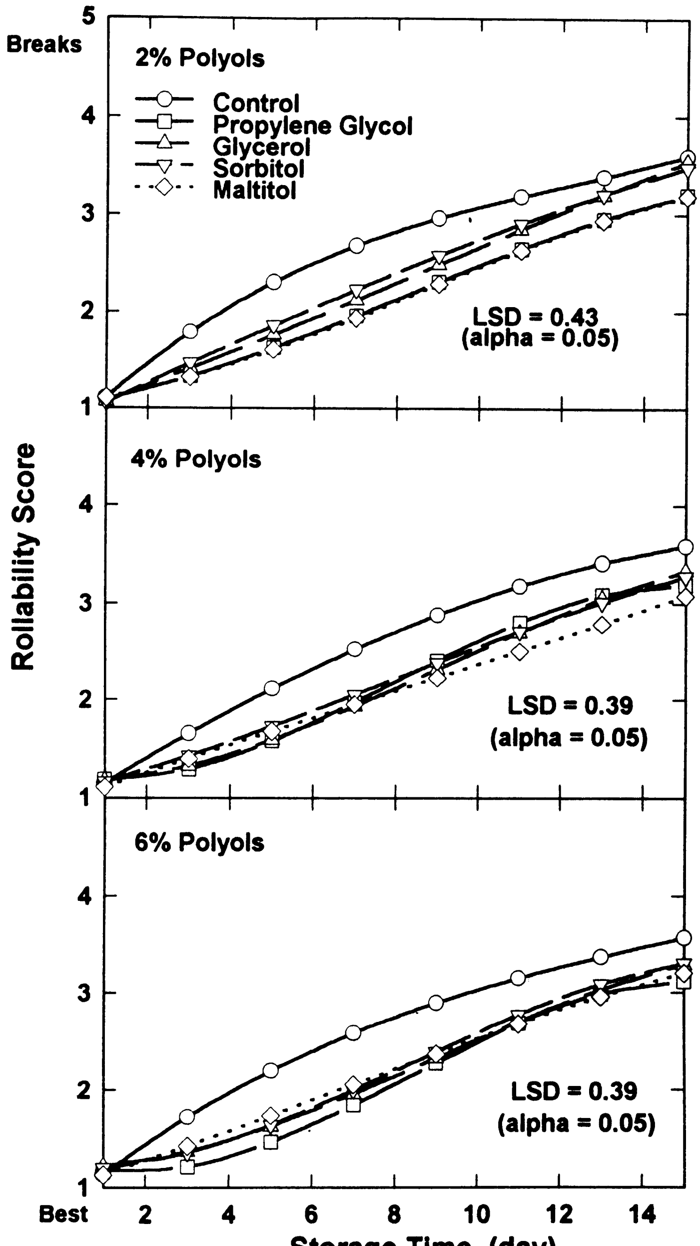

Fig. 4. Rollability of tortillas containing 2, 4, or 6% polyols prepared from flour B (11.0% protein).

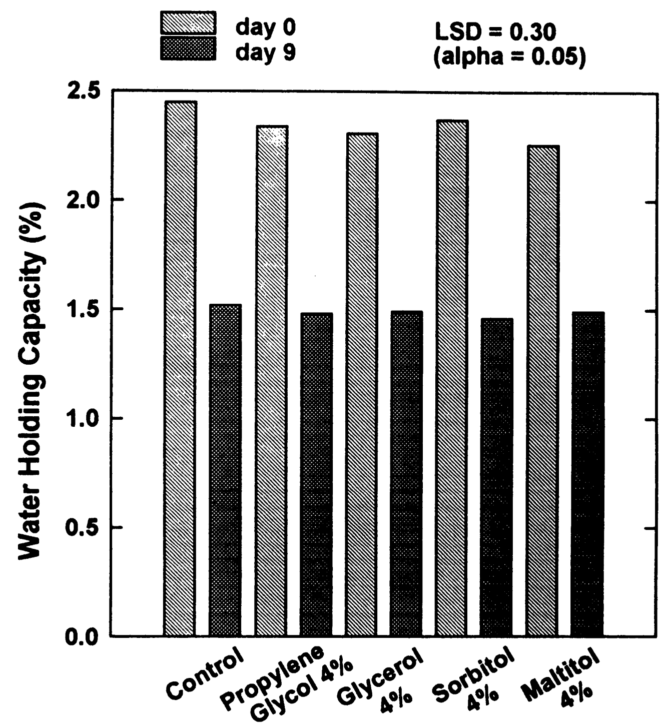

Fig. 5. Water-holding capacity of tortillas prepared from flour B (11.0% protein) containing 4% polyols.

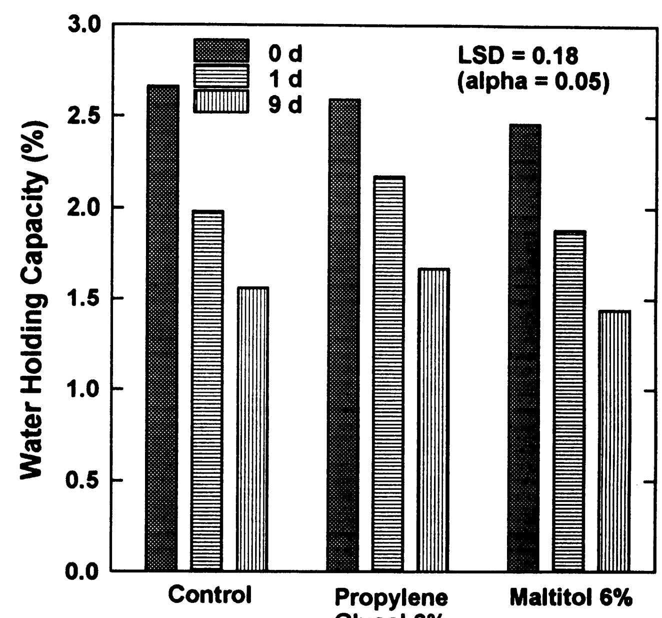

Fig. 6. Water-holding capacity of tortillas prepared from flour B (11.0% protein) containing 6% propylene glycol or maltitol.

TABLE V
Water Activity of Tortillas Containing Polyols

Treatment	Water Activity (%)
Control[a]	0.93
Propylene glycol 4%	0.90
Glycerol 2%	0.91
Glycerol 4%	0.90
Glycerol 6%	0.90
Sorbitol 4%	0.92
Maltitol 4%	0.92
Least significant difference ($\alpha = 0.05$)	0.01

[a]Prepared from flour B (11.0% protein).

polyol content also decreased water absorption but increased total liquid content in dough. Doughs containing 6% polyol were stickier and less machinable than control doughs, except for the dough containing 6% maltitol, which had good machinability. Increased polyol content decreased water activity of tortillas. Propylene glycol and glycerol were more effective than other polyols.

The shelf stability of tortillas was retained when glycerol was incorporated only when tortillas were prepared from flours with ≥11.0% protein content. Tortillas prepared from 10.2 % protein flour, with or without addition of glycerol, become brittle more rapidly than those prepared from flours with ≥11.0% protein flours. Formulas containing 4% polyols and ≥11.0% protein flour had good machinability and yielded acceptable tortillas with improved rollability during storage.

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