Effects of Wheat Protein Fractions on Flour Tortilla Quality

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ABSTRACT

Commercial wheat protein fractions (10) were evaluated during processing for quality of tortillas prepared using pastry, tortilla, and bread flours. Protein fractions that separately modify dough resistance and extensibility were evaluated in tortillas to determine whether the proteins could increase diameter, opacity, and shelf stability. Tortillas were prepared using laboratory-scale, commercial equipment with fixed processing parameters. Dough and tortilla properties were evaluated using analytical methods, a texture analyzer, and subjective methods. Tortillas were stored in plastic bags at 22°C for up to 20 days. Adjustments in water absorption and level of reducing agent were made to normalize differences in functionality of 3% added proteins on dough properties. Tortilla weight, moisture, pH, opacity, and specific volume were not affected by added proteins, except for glutenin and vital wheat gluten treatments, which had decreased opacity in tortillas prepared from pastry flour. Increased insoluble polymeric protein content corresponded to decreased tortilla diameter and improved shelf stability. Treatments yielding tortillas with improved shelf stability and similar tortilla properties were produced when commercially processed vital wheat gluten products, FP600, FP6000, FP5000, or gliadin were added to pastry or tortilla flour. These wheat protein fractions improved processing and tortilla quality of wheat flours, especially pastry flour, by modifying protein content and quality.

Tortillas (corn and wheat flour) were ranked as the fastest growing segment of the U.S. baking industry (http://www.tortilla-info.com). Seven billion pounds of corn and wheat flour tortillas or almost one tortilla per person each day were consumed in United States. Good quality flour tortillas should be soft, opaque, flexible without cracking when folded, light color, and well puffed (Waniska 1999). When tortillas become stale, the texture is firmer; they are less extensible and less rollable. Cracking and breaking of tortillas during rolling can be delayed by using flour with higher protein quality or by adding vital wheat gluten (VWgluten) (Suhendro et al 1993; Friend et al 1995). These tortillas had smaller diameter, medium-to-good puffing, similar weights, and higher moisture contents. Good quality tortillas have large diameter (17–18 cm), are opaque (90–100%), and have long shelf stability (more than two weeks). To be able to achieve these attributes, the type of wheat flour, the protein content, and quality are important (Waniska 1999). Fractionation and reconstitution studies have revealed the functionality of wheat proteins in yeast-leavened breads (MacRitchie et al 1987; Toufeili et al 1999). Fractions rich in monomeric proteins (gliadins) decreased dough strength and slightly depressed loaf volume in optimized bake tests for bread quality. Fractions rich in polymeric proteins (glutenins), by contrast, increased dough strength and enhanced loaf volume. Arabic bread became more leathery after the addition of 1% glutenin, while 2% gliadin increased its resilience (Toufeili et al 1999). Commercially available tortilla flours are mostly milled from hard red winter wheat developed for bread quality with moderate to strong protein quality and dough strength. Wheat protein fractions with different functionality could improve weak protein strength flours for use in tortilla production.

The high molecular weight subfraction of glutenin corresponds to improved bread quality (Orth et al 1972, 1976; Payne et al 1979; Gupta et al 1993; Ciaffi et al 1996). These proteins are insoluble in polar organic solvents like 1-propanol. The amount and proportion of insoluble polymeric proteins are related to dough and mixing strength (Gupta et al 1993). Rapid methods to quantify proteins insoluble in 1-propanol and other solvents have been developed and used to predict bread quality of lines in wheat breeding programs worldwide (MacRitchie 1973, 1978; Huebner et al 1976, 1985; Field et al 1983; Chakraborty and Khan 1988; Bean et al 1998).

The relationship between insoluble polymeric proteins and tortilla quality has not been established. The commercially available wheat protein fractions could modify the amount and proportion of insoluble proteins in flour and thereby determine the functionality during processing on tortilla quality prepared using flours with different protein strengths. Hence, the functionality of unique wheat protein fractions on processing, quality, and shelf stability of wheat flour tortillas made from wheat flours varying in protein strength were investigated.

MATERIALS AND METHODS

Wheat Flour and Protein Fraction Samples

Three wheat flour samples were used: a pastry flour (Pollyana, General Mills Operation, Minneapolis, MN; unbleached flour); a tortilla flour (ADM Milling Co., Enid, OK; bleached, enriched, and malted flour), and a bread flour (GM44, General Mills; bleached, bakers enriched flour with malted barley flour, niacin, iron, thiamin mononitrate, riboflavin, and folic acid).

Chemical and physical properties of 10 wheat protein fractions (MGP Inc., Atchison, KS) are listed in Table I. The properties of wheat protein fractions were collected from technical data sheets and the company web site (http://www.midwestgrain.com, Midwest Grain Products, Atchison, KS). The FP300, FP500, FP600, FP5000, and FP6000 samples were VWgluten-based protein fractions. The FP400 and FP1000 samples were slightly hydrolyzed VWgluten-based protein fractions. The gliadin and glutenin samples were subfractions obtained from the VWgluten.

Tortilla Formulation

Control tortillas were made from pastry, tortilla, or bread flour (1 kg of flour/batch). Tortillas were prepared using a standard formula (Srinivasan et al 2000): 1,000 g of flour, 15 g of salt (United Salt Corporation, Houston, TX), 6 g of sodium bicarbonate (Grade 1, Arm and Hammer, Church & Dwight Co., St. Louis, MO), 5 g of sodium stearoyl lactylate (American Ingredients, Grandview, MO), 4 g of potassium sorbate and 5 g of sodium propionate (ADM Arkady, Olathe, KS), 5.8 g of sodium aluminum sulfate (Eqisa, Cfb Budenheim Gallard Schlesinger Ind. Inc, Garden City, NY), 2.4 g of fumaric acid (type FT, Balchem Corp. Stale Hill, NY), and 60 g of shortening (Sysco Corporation, Houston, TX). The wheat proteins (30 g) were evaluated by replacing an equal weight of wheat flour.

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Evaluation of Dough Properties

The mixograph (National Mfg.) was used to estimate the dough mixing properties of wheat protein fractions added to flours (Approved Methods 54-40A and 82-23, AACC 2000). Using a continuous scale, we evaluated the tortilla dough properties for smoothness, softness, and toughness after the dough was mixed, and for press rating as dough was placed on metal plate before dividing and rounding. We attempted to normalize dough properties to the ideal dough ratings of 1.5–2.0 by varying moisture absorption and mixing time. Smoothness refers to the appearance and texture of the dough surface and was rated from one to five: 1 = smooth, 5 = very rough. Softness refers to the

TABLE I
Physical and Chemical Properties of Wheat Protein Fractions[a]

Protein Type	Protein[b] (% db)	Insoluble Protein Proportion [b,c] (% db)	Ash (% db)	pH	Water Solubility (%)	Particle Size (<75 μm)[d] (% wt)
FP1000	80.7	21.7c	1.0	4.0	70.3	99.9
FP400	81.9	26.3c	0.8	6.4	67.8	99.2
FP500	81.5	38.9b	1.0	4.4	· · ·	99.5
FP600	81.2	41.6b	0.8	5.8	· · ·	98.0
FP300	80.7	42.9b	0.9	6.0	· · ·	99.5
VWgluten	81.6	45.7b	1.0	5.5	· · ·	95.6
Glutenin	80.6	56.5b	0.8	4.6	· · ·	99.8
FP5000	86.0	89.1a	1.0	3.9	· · ·	99.2
Gliadin	83.9	91.6a	4.9	6.6	· · ·	98.9
FP6000	84.3	92.1a	4.2	6.6	· · ·	97.7
LSD[e]	0.6	12.9	· · ·	· · ·	· · ·	· · ·

[a] Information from technical data sheets (Midwest Grain Products, Atchison, KS); moisture content 3.2–5.2%.
[b] N × 5.7 conversion factor (db); Dumas method.
[c] Sample extracted with 50% 1-propanol; Dumas method; insoluble protein quantified and reported on a flour sample basis and as a proportion of insoluble protein to total protein.
[d] Through 200-mesh sieve.
[e] Least significant difference ($P < 0.05$).

TABLE II
Effects of Added 3% Wheat Protein Fractions to Pastry, Tortilla, or Bread Flours on Dough Mixing and Tortilla Characteristics[a]

Flour Type/ Protein Type	Mixing Time[b] (min)	Mixing Resistance[b] (MU)	Tortilla Water Abs. (%)	Diameter (mm)	Opacity (%)	Specific Vol. (cm^3/g)	Shelf Stability (days)	Insoluble Protein[c,d] (% db)
Pastry Flour	5.0	2.5	53.5	182.5	94.0	1.42	10	0.87
FP1000	2.8	3.5	52.5	186.8	94.0	1.45	12	1.37
FP400	2.2	3.5	52.5	190.3	95.0	1.45	14	1.49
FP500	2.5	4.8	54.0	177.0	91.0	1.40	24	1.79
FP600	2.8	4.8	54.0	178.8	93.0	1.41	24	1.85
FP300	4.5	4.8	54.0	177.1	94.0	1.47	26	1.88
VWgluten	4.0	4.8	54.0	173.0	88.0	1.42	26	1.96
Glutenin	5.5	3.5	54.0	168.7	87.0	1.25	22	2.21
FP5000	2.5	4.8	54.0	181.4	94.0	1.47	22	3.14
Gliadin	3.4	4.8	54.0	181.8	94.0	1.43	20	3.15
FP6000	3.2	4.5	54.0	184.2	95.0	1.52	20	3.17
LSD	0.5	0.4	0.5	4.6	6.0	0.20	8	0.25
Tortilla Flour	4.8	4.2	53.0	185.4	95.0	1.46	12	0.94
FP1000	2.3	4.3	52.0	187.3	94.5	1.65	12	1.44
FP400	2.2	4.8	50.0	173.7	90.0	1.59	16	1.56
FP500	2.3	5.8	52.5	172.4	88.3	1.30	26	1.87
FP600	2.5	5.9	52.5	176.0	94.5	1.37	26	1.93
FP300	3.0	6.2	53.0	171.4	88.5	1.31	26	1.95
VWgluten	3.0	5.8	53.0	172.3	91.3	1.32	28	2.03
Glutenin	4.0	4.8	53.0	167.5	87.5	1.21	26	2.28
FP5000	2.0	5.5	51.5	183.3	94.5	1.60	26	3.21
Gliadin	2.5	5.5	52.5	178.6	92.5	1.33	22	3.22
FP6000	2.0	5.8	52.5	183.6	92.5	1.39	24	3.24
LSD	0.6	0.5	0.5	7.0	6.5	0.25	7	0.25
Bread Flour	4.0	4.8	52.5	185.9	91.3	1.54	18	0.94
FP1000	2.5	3.8	49.6	184.0	94.5	1.48	16	1.44
FP400	2.5	3.8	49.6	185.2	94.0	1.40	14	1.56
FP500	2.5	4.8	51.0	178.0	94.5	1.44	28	1.86
FP600	3.1	4.8	51.0	181.2	90.5	1.49	26	1.93
FP300	4.0	4.8	52.0	180.6	93.0	1.50	28	1.95
VWguten	4.5	4.8	52.5	180.5	93.0	1.52	24	2.03
Glutenin	5.0	5.0	52.5	178.3	92.3	1.45	28	2.28
VWgluten	2.5	4.5	51.0	182.6	91.3	1.50	26	3.21
Gliadin	2.5	4.8	52.0	183.6	95.0	1.48	24	3.22
FP6000	2.5	5.0	51.0	183.6	94.3	1.46	26	3.24
LSD	0.6	0.5	0.5	3.8	4.0	0.15	7	0.25

[a] Least significant difference ($P < 0.05$).
[b] Mixograph water absorption was 60.2% for pastry flour, 60.6% for tortilla flour, 61.8% for bread flour; Water absorption remained the same for each protein evaluated except for FP400 and FP1000, which required 1% unit less water absorption.
[c] N × 5.7 conversion factor (db); Dumas method.
[d] Values calculated based on 3% addition of wheat protein fractions to flours.

viscosity or firmness of the dough when is compressed by pressing the dough with the fingers in a fixed point and was rated from one to five: 1 = soft, less viscous, 5 = soft, more viscous. Toughness refers to the elasticity of the dough when it is pulled apart and was obtained by pulling the dough at the same point where softness was ranked. Toughness was rated from one to five: 1 = less tough, less elastic , 5 = excessively elastic. Press rating refers to the force required to press the dough on the stainless steel round plate before dividing and rounding and was rated from one to five: 1 = very easy to press, 5 = very hard to press.

Tortilla Processing

Tortillas were prepared according to the method of Bello et al (1991) as modified by Srinivasan et al (2000). Change in tortilla dough water absorption due to added protein was estimated from mixograph results. Tortilla dough water absorption was confirmed or adjusted empirically to yield similar dough properties. Uniform dough properties are required during processing using fixed processing parameters to yield comparable tortillas. Reducing agents, cysteine or metabisulfite, are normally added to tortilla formula to facilitate and improve dough machinability and tortilla quality. The cysteine level of 0.03 g/kg was used for pastry and tortilla flour formulas, while 0.04 g/kg was used for bread flour. The increased level of cysteine in bread flour made the dough softer and yielded tortillas with significantly larger diameter and improved tortilla quality.

Evaluation of Tortilla Properties

Ten tortillas were selected randomly; weight, diameter, height, opacity, moisture, and pH were determined on the first day after processing (Bello et al 1991). Ten tortillas were weighed and averaged. Diameter of 10 tortillas was measured using a ruler at two points across the tortilla: the large and the smaller diameter were recorded and averaged. The large to small diameter ratio (oval character) of tortillas was ≤1.03. Height of a stack of 10 tortillas was measured using a 12" Chicago electronic digital caliper and averaged. Opacity (%) was subjectively evaluated using a scale where opaque tortillas were rated as 100% and completely translucent tortillas were rated as 0%. Moisture content and pH of tortillas were determined (Approved Methods 44-15A and 02-52, AACC 2000). Specific volume was calculated: $\pi \times (\text{diameter}/2)^2 \times \text{height/weight}$ (Cepeda et al 2000).

Subjective rollability test. Two tortillas from each trial were evaluated subjectively by rolling around a dowel (1.0 cm diameter) on one side of the tortilla after 4, 8, 12, 16, and 20 days of storage. Cepeda et al (2000) used a continuous scale for rollability score: 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. Shelf stability was determined as the number of days until the rollability score reached 3.0 (several cracks and breaks on the surface).

Several critical quality parameters for tortillas are opacity, rollability score, diameter, and height. We decided to combine these parameters into one number to use as a quality index. Specifically, the tortilla quality index was calculated as TQI = opacity × rollability score at 12 days storage × specific volume. The applicability of the TQI to tortilla quality will be determined with use.

Objective rheological test. Rheological measurements were conducted using a texture analyzer (model TA-XT2i, Texture Technologies Corp., Scardale, NY; Stable Micro Systems, Godalming, Survey, UK). Extensibility was tested on tortillas stored after 4, 8, 12, 16, and 20 days of storage. Tortillas were evaluated by extending a strip (35 × 75 mm). Two tortilla strips from two tortillas from each trial were cut using an acrylic template in such a way to avoid the puffed portions (to maintain sample uniformity) (Joseph 1999). Force, work, distance required to rupture, and modulus were recorded.

TABLE III
Significance Levels of Regression Terms for Flour Type (FT), Protein Fraction (PF), and Their Interaction on Dough, Tortilla, and Protein Properties[a]

Dependent Variable	FT	PF	FT × PF
Dough properties			
Press rating	0.0162	ns	ns
Tortilla properties			
Moisture	<0.001	ns	ns
Diameter	<0.001	<0.001	0.002
pH	0.025	ns	ns
Shelf stability	0.010	<0.001	0.018
Rollability score			
4 day	0.040	ns	ns
8 day	0.05	0.015	ns
12day	0.01	<0.001	ns
16 day	0.001	<0.001	ns
20 day	0.005	<0.001	ns
Rupture force			
4 day	0.005	ns	ns
8 day	0.003	0.004	ns
12 day	0.013	ns	ns
Rupture distance			
4 day	ns	0.021	0.017
8 day	0.021	0.002	ns
12 day	0.003	<0.001	ns
16 day	0.004	<0.001	ns
20 day	0.003	0.003	ns
Protein (%)	<0.001	<0.001	ns
Insoluble protein amount	<0.001	<0.001	ns
Insoluble protein proportion	<0.001	<0.001	ns

[a] Probability values are significant (α = 0.05); ns, nonsignificant.

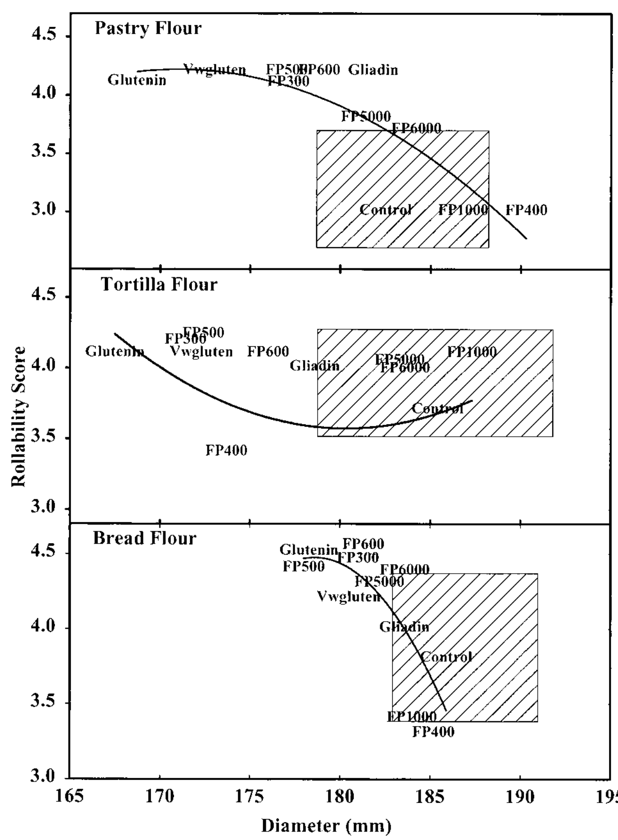

Fig. 1. Effects of wheat protein fractions on tortilla diameter and rollability score after 12 days of storage at 22°C for pastry, tortilla, and bread flours. Least significant differences (α = 0.05) are 4.6, 7.0, and 3.8 for diameter and 0.5, 0.3, and 0.4 for rollability score, respectively, for pastry, tortilla, and bread flours.

Insoluble Protein Analysis

Insoluble polymeric proteins were determined using the procedure of Bean et al (1998) with modifications to improve quantification. Wheat protein samples (≈1.000 g) were mixed for 5 min by vortex stirrer (Vortex Genie 2, Scientific Industries Inc., Bohemia, NY) with 4 mL of 50% 1-propanol solvent in 10-mL plastic tubes with caps. Samples were centrifuged (model Sorvall SS-3 automatic super speed, Du Pont Instruments, Wilmington, DE) at 8,160 × *g* for 5 min. After the supernatant was discarded, the extraction procedure was repeated three times. The pellets were mixed with 4 mL of acetone to remove residual solvent and facilitate drying. Samples were centrifuged at 8,160 × *g* and the supernatant was discarded. Tubes were dried in the oven at 50°C for 24 hr. Dried pellets were weighed and analyzed for moisture and nitrogen content (Approved Method 44-19, AACC 2000) by the Dumas method (FP-428, Leco Corporation, St. Joseph, MI) (Approved Method 46-30, AACC 2000). Duplicate samples were extracted and subsequently each pellet was analyzed in duplicate. The amount of insoluble protein in tortillas with 3% added wheat proteins was calculated.

The protein content was calculated by multiplying nitrogen content by 5.7% N/g (Approved Method 46-30, AACC 2000). The amount of insoluble protein was calculated by dividing the product of the dry pellet weight and nitrogen content of the dry pellet to dry weight of sample and multiplied by 5.7% N/g. The proportion of insoluble protein was calculated by dividing the amount of insoluble protein by amount of protein in the sample and multiplied by 100.

Statistical Analysis

Each treatment was prepared randomly on different days in at least two replicates. The SAS statistical software package (v. 8, SAS Institute, Cary, NC) was used for statistical analysis. The least significant difference (LSD) using α = 0.05 of level of significance was calculated using the General Linear Models procedure. A regression model was used to determine the effect of flour, protein fraction types, and their interaction term.

RESULTS AND DISCUSSION

Dough Properties

Mixograph characteristics of pastry, tortilla, and bread flours were modified by the addition of protein fractions (Table II). Mixograph shapes were typical, except for FP400 and FP1000 treatments, where water absorption was lowered one or more percentage units to reduce dough stickiness. This is probably due to the increased water solubility and decreased water holding capacity of these partially hydrolyzed gluten proteins (Table I). Dough mixing time decreased for most protein treatments, especially when added to pastry or tortilla flours. The glutenin treatment increased mixing times in pastry and bread flours. Mixing resistance increased for most protein treatments added to pastry or tortilla flour but it did not change for most added protein treatments when added to bread flour. The water absorption increased for pastry flour but decreased for most treatments when added to tortilla or bread flour.

The subjective dough properties were not affected by the 3% addition of wheat protein fractions, flour type, or their interaction (Table III). Adjustments to the tortilla water absorption (Table II) and reducing agent normalized differences in functionality of added wheat proteins and made doughs appropriate for tortilla processing. Dough ratings averaged 1.7 ± 0.13 for smoothness, 1.9 ± 0.14 for softness, and 2.0 ± 0.13 for toughness. Only press rating was affected by flour type but not by added protein fractions.

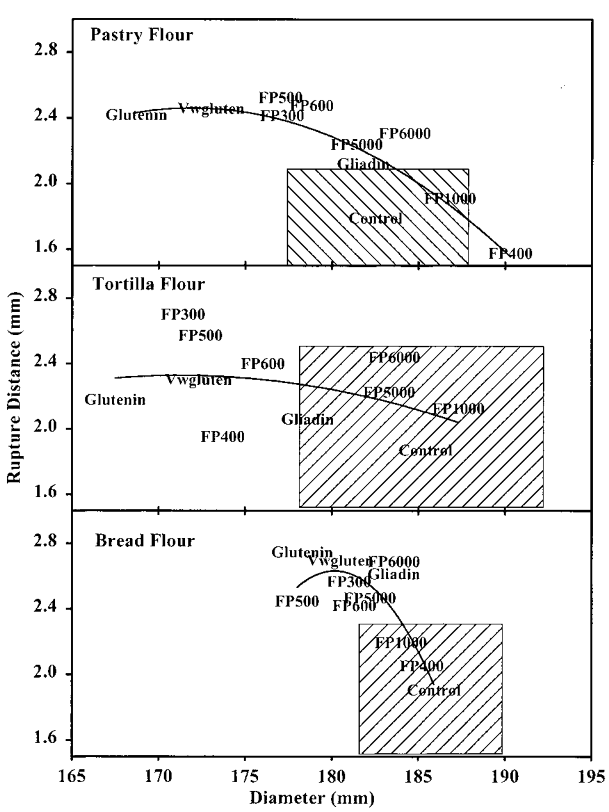

Fig. 2. Effects of wheat protein fractions on tortilla diameter and rupture distance after 12 days of storage at 22°C for pastry, tortilla, and bread flours. Least significant differences (α = 0.05) are 4.6, 7.0, and 3.8 for diameter, and 0.3, 0.6, and 0.5 for rupture distance, respectively, for pastry, tortilla, and bread flours.

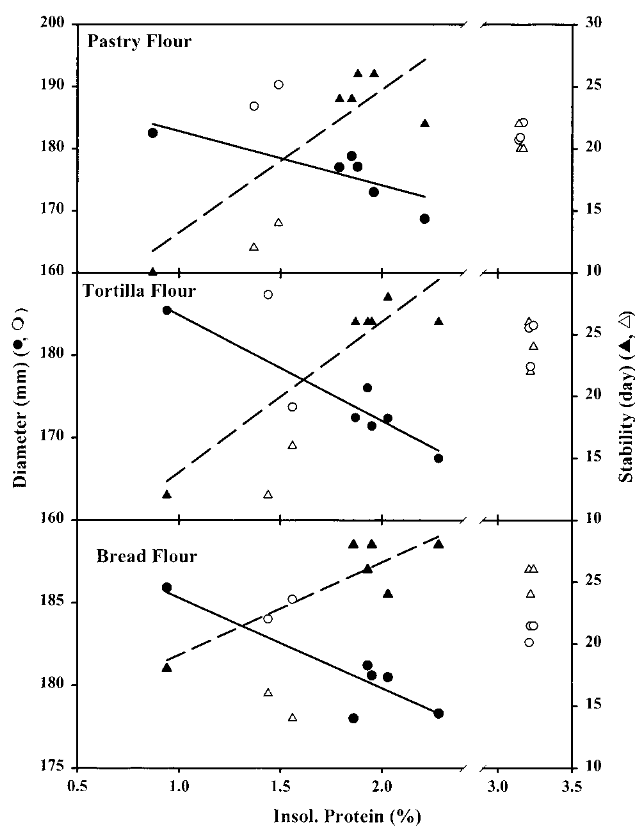

Fig. 3. Effects of insoluble protein in tortillas on diameter and shelf stability of tortillas prepared using pastry, tortilla or bread flours. Least significant differences (α = 0.05) are 4.6, 7.0, and 3.8 for diameter, 8, 7, and 7 for shelf stability, and 0.25, 0.25, and 0.25 for insoluble protein in flour, respectively, for pastry, tortilla, and bread flours.

Press ratings were 2.1 ± 0.16 for pastry flour, 2.1 ± 0.15 for tortilla flour, and 2.0 ± 0.05 for bread doughs.

Tortilla Properties

Added wheat protein fractions did not affect moisture content, weight, height, specific volume or pH of tortillas prepared using pastry, tortilla or bread flours (Table II). The weight, height, and specific volume of tortillas with added wheat proteins were not significantly different from control tortillas regardless of flour type or protein fraction (Table III). Average tortilla properties were: 40.5 ± 0.62 g, 2.3 ± 0.12 mm, and 1.4 ± 0.1 cm^3/g specific volume. Tortilla moisture and pH were affected only by flour type. Tortilla moisture contents were 32.9% ± 0.54, 33.4% ± 0.37, and 32.2% ± 0.77 for tortillas prepared from pastry, tortilla, and bread flours, respectively. Tortilla pH was 5.2 ± 0.05, 5.3 ± 0.09, and 5.3 ± 0.04 for tortillas prepared from pastry, tortilla, and bread flours, respectively. Opacity decreased in tortillas prepared from pastry flour with added glutenin or VWgluten and in tortillas prepared from tortilla flour with added glutenin.

Diameter and shelf stability were the most important properties of tortillas that were affected by the addition of protein fractions, flour type or their regression interaction term (Table III). Addition of FP400 yielded larger diameter tortillas using pastry flour but smaller diameter tortillas using tortilla flour. These protein-fortified tortillas had similar shelf stabilities compared with control tortillas. Several proteins (FP300, FP500, FP600, VWgluten, and glutenin) yielded tortillas with smaller diameters, except for FP300 and FP600 treatments using pastry flour, but with significantly improved shelf stability using all flours. However, three proteins (FP5000, FP6000, and gliadin) yielded tortillas with similar diameters and significantly improved shelf stability using all flours.

VWgluten improves dough strength, gas retention, and loaf expansion during proofing and baking that result in uniformly shaped yeast-leavened bakery products (Magnuson 1985). The water absorption capacity and other properties of VWgluten improve baked product yield, softness, and shelf life. When VWgluten was added to bread flour, increased water-absorption, dough strength, and tortilla elasticity, and decreased tortilla diameter were observed (Suhendro et al 1993). More extensibility appears to be needed in the dough for tortilla production. The elastic properties of VWgluten are due to the glutenin components, while the viscous properties are due to the gliadins (MacRitchie et al 1987; Khatkar and Schofield 1997). Increased dough extensibility may be derived from less glutenin and more gliadin functionality in the dough. Tortillas prepared with glutenin in this study had smaller diameters, less opacity, and improved shelf stabilities when prepared using pastry or tortilla flour but only smaller diameters when prepared using bread flour. On the other hand, tortillas prepared with gliadin had similar properties to control tortillas and improved shelf stability when prepared using all flours.

Rheological Properties During Storage

Textural changes during storage were affected by added wheat proteins and by flour type; their regression interaction term was not significant (Table III). Rollability score and rupture distance had more regression terms that were significant for flour type and protein fraction than did rupture force, modulus, and work (data not included for modulus and work). Hence, rollability score and rupture distance were graphed versus diameter to illustrate the magnitude of rheological changes due to added proteins and flour type (Figs. 1 and 2). Similar graphs were observed after 12, 16, and 20 days of storage. Boxes with LSD dimensions were drawn on the graph to indicate that treatments within the box were similar to control tortillas. Most added proteins, except FP1000 and FP400, improved rollability scores and rupture distances compared with pastry flour tortillas. Of these treatments, FP300, FP600, FP6000, FP5000, and gliadin yielded tortillas with similar diameters and good opacities compared with pastry flour tortillas.

Improved rollability scores were observed in most tortillas prepared with tortilla flour containing added protein fractions (Fig. 1). However, only the FP1000 treatment yielded improved rollability score and a similar diameter compared with control tortillas. The FP300 and FP500 treatments yielded tortillas with improved rupture distance but smaller tortilla diameter and less opacity.

Improved rollability scores and rupture distances were observed in most tortillas that were prepared with bread flour containing

TABLE IV
Pearson Correlation Coefficients Between Protein, Dough, and Tortilla Properties (% db)[a]

Pastry Flour	All Protein Fractions: Protein	All Protein Fractions: Insoluble Protein Amount	All Protein Fractions: Insoluble Protein Proportion	Selected Protein Fractions[b]: Protein	Selected Protein Fractions[b]: Insoluble Protein Amount	Selected Protein Fractions[b]: Insoluble Protein Proportion
Pastry flout						
Mixing resistance	0.72*	0.63*	0.62*	0.85*	0.65*	0.61*
Diameter	–0.10	–0.10	–0.12	–0.64*	–0.84*	–0.86*
Stability	0.57*	0.41	0.40	0.97*	0.88*	0.85*
Rollability score						
4 days	0.69*	0.55*	0.54*	0.69*	0.71*	0.70*
8 days	0.73*	0.51*	0.50*	0.99*	0.93*	0.90*
12 days	0.56*	0.07	0.05	0.71*	0.74*	0.73*
Tortilla flour						
Mixing resistance	0.55*	0.56*	0.56*	0.78*	0.72*	0.71*
Diameter	–0.36	0.06	0.07	–0.90*	–0.88*	–0.86*
Stability	0.57*	0.58*	0.58*	0.99*	0.98*	0.97*
Rollability score						
4 days	0.62*	0.04	0.02	1.00*	0.93*	0.95*
8 days	0.71*	0.17	0.15	0.98*	0.93*	0.90*
12 days	0.35	0.11	0.13	0.27	0.35	0.34
Bread flour						
Mixing resistance	–0.30	–0.31	–0.29	–0.08	0.14	0.17
Diameter	–0.45	–0.10	–0.10b`	–0.89*	–0.80*	–0.78*
Stability	0.37	0.52*	0.53*	0.92*	0.73*	0.77*
Rollability score						
4 days	0.16	0.41	0.43	0.19	0.16	0.15
8 days	0.19	0.54*	0.56*	0.20	0.15	0.13
12 days	0.19	0.23	0.23	0.30	0.34	0.35

[a] *, Significant at $r \geq 0.444$ ($\alpha = 0.05$).
[b] Selected protein fractions are FP300, FP500, FP600, glutenin, and VWgluten.

added protein fractions (Figs. 1 and 2). Only FP5000 and FP6000 treatments yielded tortillas with improved rollability scores and rupture distances and similar tortilla diameter with good opacity.

Insoluble Protein

All wheat protein fractions had ≈80% protein but had variable proportions of insoluble protein (Table I). Because all protein fractions were derived from VWgluten, the expected proportion of insoluble protein in these samples should be comparable to previously published values (Gupta et al 1993; Ciaffi et al 1996; Bean et al 1998). Insoluble polymeric protein accounts for 0.7–4.0% of wheat flour and 22–60% of the proteins. Most protein fractions (FP300, FP500, FP600, glutenin, and VWgluten) had the expected insoluble protein values (38–56%). The partially hydrolyzed samples (FP1000 and FP400) had the lowest insoluble protein values (22–26%), while FP5000, FP6000, and gliadin had the highest insoluble protein values (89–92%). Processing of some commercial protein samples apparently affected the proportion of insoluble proteins. The high amount of insoluble protein of gliadin protein isolate was unexpected because the SDS-PAGE separation revealed the sample contained mostly gliadin (Waniska 2002; *personal communications*).

Significant Pearson correlation coefficients of protein measurements with tortilla properties indicated that tortilla diameter, rollability score, and shelf stability were affected by the amount and type of proteins in the flour (Table IV). The scatter plots of the amounts of insoluble protein versus tortilla diameter (and versus stability) of the added proteins to the three flour types are illustrated in Fig. 3. The protein content and the amount of insoluble protein were affected by flour type and wheat protein fractions but not by the regression interaction term (Table III). Tortillas with more insoluble protein had a smaller diameter (r = –0.84) and a longer shelf stability (r = 0.88) (Fig. 3). The commercial samples with typical insoluble protein values for VWgluten were included in this statistical analysis, while the commercial samples that were partially hydrolyzed or that had very high insoluble protein values were not included. The FP400 and FP1000 treatments (1.4–1.6% insoluble protein) had similar or larger diameters and similar shelf stability values compared with control tortillas, which are not consistent with other wheat gluten isolate treatments. The FP5000, FP6000, and gliadin treatments (3–3.5% insoluble protein) had similar diameters and improved shelf stability compared with control tortillas, which are also not consistent with other wheat gluten isolate treatments.

Unique commercial protein fractions contributed to the development of tortillas with unique combinations of diameter and shelf stability. Many added protein fractions doubled the shelf stabilities of tortillas prepared from pastry and tortilla flour. Research continues on determining cost-effective levels of protein addition to improve flour tortillas.

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