

# Effects of Wheat Starch and Gluten on Tortilla Texture<sup>1</sup>

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## ABSTRACT

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Wheat starches were isolated from three wheat flours. Two vital wheat glutes, one from a commercial source and another one isolated from straight-grade flour, were combined with wheat starches to form reconstituted flours with a protein level of 10%. Several characteristics of tortillas made with the hot-press method were measured. No significant difference ( $P < 0.05$ ) occurred in texture of tortillas made with hard wheat

gluten and soft wheat gluten. Wheat starches did not have any significant ( $P < 0.05$ ) effect on tortilla stretchability or foldability. Analysis of variance confirmed that wheat starch and gluten had limited effects on tortilla texture. The possible reasons were that the solubles of wheat flour were not included, and the shortening in the tortilla formula interfered with the interaction of gluten and starch.

Starch and protein are the two major components of wheat flour. The effects of wheat starch and gluten on baking quality of bread have been investigated by many researchers (Harris and Sibbitt 1941, 1942; Harris 1942; Finney 1943; Sandsted 1961; Medcalf and Gilles 1968; Hosoney et al 1969b, 1971). However, this has not been the case for baking quality of flour tortilla.

Fractionation and reconstitution techniques are used commonly to evaluate the baking quality of gluten and starch. Harris and Sibbitt (1941, 1942), Harris (1942), and Sanstedt (1961) fractionated wheat flour into gluten and starch fractions and studied effects of the reconstituted flour on breadbaking quality. Their results showed that starches from the same cultivar grown in different years and in different places yielded different loaf volumes. This indicated that starch properties were affected by both inherited and environmental factors. Their results also showed that more variability in loaf volume occurred with the various glutes combined with the same starch than with the various starches combined with the same gluten. In their studies, the water-solubles were eliminated.

Finney (1943) and Hosoney et al (1969b, 1971) combined water-solubles in their reconstituted flours. Their data indicated that starches from various wheat cultivars had similar baking quality, but starches from different sources such as wheat, rye, corn, oats, rice, potato, and barley behaved differently. Hosoney et al (1971) tried to explain those differences by the variations in gelatinization temperature and particle size of starch. However, their results showed that neither of these factors related to the breadmaking potential of the starches. Ponte et al (1963) suggested that protein and starch from different air-classified bread flour fractions affected breadmaking quality. Their data indicated that wheat starch and gluten isolated from the coarse fractions were superior to those from the fine fractions. Lelievre et al (1987) also reported the effects of starch particle size and protein concentration on breadmaking performance. They tested different starch particle sizes and ratios of starch to protein. Their results showed that the toughness of the bread increased remarkably with an increase in protein content of reconstituted flour with coarse starch. The interaction of starch granules with protein was important in breadmaking.

During dough-washing, part of the flour becomes soluble in water. Water-solubles include albumin, globulin, glucoproteins, and pentosans, and the amount of gliadin depends on the ratio of flour to water. Hosoney (1969a) reported that at a 1:3 flour-to-water ratio,

gliadin was not in the water-solubles, and these water-solubles did not affect baking performance. The amount of gliadin in water-solubles increased with the water used in the fractionation process. They also found that water-solubles were not responsible for the difference in loaf volume; however, they were essential to produce a normal bread with optimum volume. An excess amount of water-solubles added in reconstituted flours did not increase loaf volume. The albumin or globulin proteins did not contribute to breadmaking. Hosoney (1969a) stated that water-solubles contributed to gas production and gas retention because of the content of sugar, pentosans, and glucoprotein.

We did not find any report on the issue of using reconstituted flour to study the effects of gluten and starch on flour tortilla making. The purpose of this study was to investigate the effect of wheat starch and gluten from various wheat classes on tortilla texture using fractionation and reconstitution techniques.

## MATERIALS AND METHODS

### Starch Preparation

Straight-grade wheat flours were milled from hard red winter (HRW) wheat, Jagger, from Kansas; hard white winter (HWW) wheat, 4AT-9900, from Kansas; and soft red winter (SRW) wheat, Ernie, from Missouri, harvested in 1997, on the experimental Miag Multomat mill with extraction rates of 68.9, 68.3, and 64.7%, respectively.

The protein contents of the three flours were 11.25, 10.90, and 7.44%, respectively (Wang 1999, Wang and Flores 1999). Wheat starches were washed from doughs of HRW, HWW, and SRW wheat straight-grade flours using the procedure of Wolf (1964). Starch was air-dried at room temperature ( $25 \pm 2^\circ\text{C}$ ) for 24 hr and ground with a mortar and pestle. The ground starch then was passed through a 10xx silk sieve with openings of 132  $\mu\text{m}$ .

### Vital Wheat Gluten

The HRW vital wheat gluten (gluten) was procured from Heartland Wheat Growers, L. P., Russell, KS. The gluten of SRW wheat was isolated from the dough-washing of SRW wheat flour (Wolf 1964). Wet gluten was put in a wide-mouth glass bottle; frozen for 24 hr in a freezer ( $-15 \pm 2^\circ\text{C}$ ) and freeze-dried for 48 hr using a freeze-dryer (Dura-Dry, FTS Systems, Stone Ridge, NY). The dried gluten was ground for 2 min with an analytical mill (Tekmar, IKA-Labortechnik, Staufen, Br., Germany) that was cooled with tap water.

### Analyses

The contents of moisture, protein, ash, and damaged starch of the flour samples were determined using Approved Methods 44-15A, 46-30, 08-03, and 76-31, respectively (AACC 1995). The color of

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the flour was measured using an Agtron color meter (Filper Industries, Reno, NV). Starch particle distribution was analyzed with an air-jet sieve (model A 200 LS, Alpine Ag., Augsburg, Germany). Starch (50 g) was sieved using a No. 400 U.S. standard sieve with openings of 38  $\mu$ m for 5 min. The amount of starch passing the sieve was calculated.

### Tortilla Making

Reconstituted flours with 10% protein content were made with the ratios of vital wheat gluten to starch. Starch-to-HRW gluten ratio was 85.1:14.9, and starch-to-SRW gluten ratio was 85.3:14.7 on 14% moisture basis. Optimum water absorption was 15% less than the farinograph water absorption centered at 500 BU according to the best performance of the dough. Wheat gluten was hydrated for 30 min at room temperature and mixed with wheat starch for 1 min at low speed and 2 min at medium speed in a mixer (KitchenAid K45SS, St. Joseph, MI). Salt, baking powder, and partially hydrogenized vegetable shortening were added and mixed for 3 min at medium speed. Other steps were the same as described in the method of Wang and Flores (1999). Tortillas were stored at room temperature for 18–20 hr before evaluation.

### Tortilla Characteristics

The moisture content of tortillas was measured using Approved Method 44-15A (AACC 1995). The diameter of the tortillas was the average of two diagonal measurements, and the weight was the average of three tortillas. The lightness of tortilla color was measured in triplicate using a chromameter (Minolta CR-300, Minolta Corporation, Ramsey, NJ) and avoiding burned areas. The three measurements were averaged.

### Firmness and Stretchability

The firmness of flour tortillas was determined with a texture analyzer (TA-XT2, Texture Technologies Corp., Scarsdale, NY) equipped with a rounded-end probe 1.90 cm (0.75-in.) in diameter (TA-108). The settings were the same as described by Wang and Flores (1999). The firmness was measured as the force (grams) required

for a compression of 30% strain of the tortillas. The force-deformation curve was obtained, and the peak force, distance, modulus of elasticity, and area under the curve were recorded. Three measurements were made for each tortilla on different spots. Based on the maximum distance (30% strain), the thickness of tortillas was determined as maximum compression distance  $\times$  10/3.

The stretchability of flour tortillas was determined according to the manufacturer's instructions with the texture analyzer equipped with a TA-108 tortilla film fixture and the rounded-end probe. The distance was 25.0 mm at speed of 2.0 mm/sec. For each test, measurements were taken of the force-deformation curve, maximum peak force value and the distance to rupture the tortilla (rupture distance), the area under the curve of force (load) versus deformation as absorbed energy, and the modulus of elasticity (Young's modulus).

### Subjective Test

The foldability of tortillas was determined through a subjective test. One tortilla was folded firmly and then unfolded, and cracks on the surface of the tortilla were evaluated. A hedonic rating scale of 1–10 was used. Ten points were given to tortillas without any cracks on the surface after they were folded, and 1 point to tortillas showing a broken surface along the folding line. The values were the averages of three tests for each sample.

### Experimental Design and Statistical Analyses

To study the effect of different wheat starches and glutes on tortilla texture, a 2<sup>3</sup> factorial experimental design was employed. The results were analyzed with the SAS System (SAS Institute, Cary, NC). Least significant difference of the results was conducted at the 95% confidence interval.

## RESULTS AND DISCUSSION

The protein contents of the starches were quite uniform and ranged from 0.16 to 0.19%. The ash content of HWW wheat starch (0.39%) was higher than that of HRW and SRW wheat starches

TABLE I  
Characteristics of Baked Tortillas

Flour	Water Absorption (%) <sup>a</sup>	Moisture Content (%)	Diameter (cm)	Thickness (mm)	Lightness (L)
HRW straight-grade	67.3a	28.36a	16.7b	1.7a	81.86bc
Gluten-to-starch ratio					
HRW:HRW	56.5b	25.59b	17.8a	1.5b	80.69c
HRW:HWW	53.9c	24.19c	17.7a	1.5b	82.43b
HRW:SRW	52.6d	26.10b	17.1ab	1.6ab	83.62a
SRW straight-grade	52.0d	22.54d	18.1a	1.7a	84.52a
Gluten-to-starch ratio					
SRW:HRW	54.2c	24.96c	17.7ab	1.5b	80.80c
SRW:HWW	52.0d	23.20d	18.0a	1.5b	82.83b
SRW:SRW	53.6c	26.28b	18.0a	1.6ab	83.93a

<sup>a</sup> Defined by the farinograph absorption centered at 500 BU.

TABLE II  
Texture Characteristics of Tortillas Made from Reconstituted Flours

Flour	Firmness			Stretchability			Rupture Distance (mm)	Foldability
	Peak Force (kg)	Absorbed Energy (kg·mm)	Young's Modulus (kg/mm)	Peak Force (kg)	Absorbed Energy (kg·mm)	Young's Modulus (g/mm)		
HRW straight-grade	10.34a <sup>a</sup>	2.26a	21.03a	1.12ab	7.49ab	117.2cd	14.3a	6.0a
Gluten-to-starch ratio								
HRW:HRW	7.52b	1.81b	19.94ab	1.18ab	8.24ab	133.3abc	12.1b	3.0b
HRW:HWW	7.52b	1.51b	16.68c	1.17ab	8.71a	120.9cd	13.0ab	2.0b
HRW:SRW	10.64a	2.36a	21.62a	1.27a	7.75ab	146.4ab	11.8b	1.5b
SRW straight-grade	6.80b	1.59b	12.39d	1.03b	7.49ab	100.0d	13.3ab	2.3b
Gluten-to-starch ratio								
SRW:HRW	8.40b	1.74b	18.53bc	1.05b	7.29ab	128.1bc	11.1b	2.3b
SRW:HWW	7.39b	1.49b	16.29c	1.08ab	7.86ab	115.1cd	13.0ab	1.7b
SRW:SRW	10.30a	2.21a	21.84a	1.17ab	6.92b	152.8a	11.1b	1.0b

<sup>a</sup> Values followed by the same letter in the same column are not significantly different ( $P < 0.05$ );  $n = 3$ .

(0.23 and 0.20%, respectively). HRW and HWW wheat isolated starches contained 2.1 and 2.5% damaged starch, which were higher than SRW wheat isolated starch with 0.7%. In the original straight-grade flours of HRW, HWW, and SRW wheats, the levels of damaged starch were 7.6, 5.2, and 3.0%, respectively. The starch damage levels were much lower in isolated starches, indicating that damaged starch was lost during the dough-washing process. Also, the water-solubles were lost at the same time.

The amount of starch particles that passed through No. 400 sieve were 82.3% for HRW, 82.8% for HWW, and 98.1% for SRW wheat starch. It was not clear why almost all of the SRW wheat starch particles passed the sieve. The protein in the starches probably bound with starch granules, and the bonds of HRW and HWW wheat proteins might be stronger than that of SRW wheat. The color of the SRW wheat starch was much whiter than that of HRW and HWW wheat starches. The small particle size of the starch may increase its whiteness.

Vital wheat glutes were light yellow and gray with plain flavor. Glutes of HRW and SRW wheats had very high protein contents, 65.95 and 67.00%, respectively. The ash contents also were high, 0.80% for HRW and 0.57% for SRW wheat gluten.

The farinograph curves of the reconstituted flours in the experiment showed that the curves of the reconstituted flours of HRW wheat gluten with HRW and HWW wheat starches had shorter peak time and mixing stability than the straight-grade flour of HRW wheat. The curves reached the peak consistency very quickly and then lowered. The consistency stayed between 300 and 400 BU, which indicated that HRW vital wheat gluten was stronger. However, the HRW wheat gluten combined with SRW wheat starch gave different results. Peak time and mixing stability were longer, which may have been due to the smaller particle size of SRW wheat starches. Small particles absorbed water faster and caused the consistency of the farinograph to increase. The curves of reconstituted flours with SRW wheat gluten and various starches were quite similar, but consistency of the SRW wheat starch curve decreased faster than the consistencies of other two. The major difference observed was that the farinograph curves of reconstituted flours with SRW wheat gluten lowered faster than those of the reconstituted flours with HRW wheat gluten. This indicates the effects of gluten as well as the starch particle size.

Water absorption of reconstituted flours of various starches with HRW wheat gluten was lower than that of HRW wheat flour, and the water absorption of reconstituted flours of various starches with SRW wheat gluten was higher than that of SRW wheat flour (Table I). The protein contents of straight-grade flours of HRW and SRW were 11.25 and 7.44%, respectively. The protein of the reconstituted flours was controlled at 10.0%. The water absorption of reconstituted flour with HRW wheat gluten and HRW wheat starch was 56.5%, which was higher than absorptions of flours with HWW wheat starch (53.9%) and SRW wheat starch (52.6%). SRW wheat gluten had lower absorption when reconstituted with HWW wheat starch than with HRW and SRW wheat starches.

The moisture content of tortillas made with HRW wheat gluten and various starches was lower than that of tortillas made from straight-grade HRW flour, and the reconstituted flours with SRW wheat gluten and various starches resulted in tortillas with higher moisture content than straight-grade SRW wheat flour. Tortillas made from SRW wheat starch and HRW or SRW wheat gluten had higher moisture content, but the reason is not clear.

Tortillas made from reconstituted flours were larger in diameter and thinner than those made from HRW wheat flour, even though all tortillas made had the same initial dough weight (45 g). SRW wheat starch combined with HRW wheat gluten produced tortillas with smaller diameter compared with those made with HRW and HWW wheat starches. No difference occurred in diameters of tortillas made from SRW wheat gluten and various starches. The lightness of the tortillas increased in the order HRW < HWW < SRW starches (Table I).

The firmness and stretchability data of the tortillas are listed in Table II. The tortillas made from SRW wheat starch with HRW or SRW wheat gluten had higher peak values of compression compared with other tortillas. They also had higher values of absorbed energy and Young's modulus, which indicated that they were firmer and more elastic than others. The analysis of variance (ANOVA) showed that the gluten did not affect the firmness of tortillas, but the starch significantly affected the peak value, absorbed energy, and Young's modulus ( $P < 0.001$ ). The values of stretchability of the tortillas were different. Young's modulus was higher for tortillas made from reconstituted flours of SRW wheat starch and various glutes than for tortillas made from other starches. The ANOVA showed that wheat gluten significantly affected the absorbed energy of the stretchability ( $P < 0.04$ ), and starch significantly affected Young's modulus of the stretchability ( $P < 0.007$ ).

Rupture distance and foldability of tortillas are listed in Table II. Rupture distance was longer for tortillas made with reconstituted flour from HWW wheat starch than for those made with flours from other starches. The ANOVA showed that wheat gluten and starch significantly affected rupture distance ( $P < 0.006$  and  $0.0001$ , respectively). Starches from different classes affected foldability of tortillas. The average values of the foldability of the tortillas made from reconstituted flours were lower than those of tortillas made from HRW wheat flours. Tortillas made from reconstituted flours with HRW and HWW wheat starches and glutes had better foldability than those made from flours with SRW wheat starches. Caution must be taken when considering the use of starch as a diluting agent to mellow the strong flour in tortillas because it might greatly dilute the gluten and affect tortilla texture.

## CONCLUSIONS

The investigation on the effects of wheat starch and protein on tortilla texture led to the conclusion that flour reconstitution did not fully recover the properties of original flours. Flour fractionation techniques may alter the natural bonds between protein and starch granules. Starches of various cultivars performed differently; SRW wheat starch produced tortillas that were firmer than others, and HWW wheat starch produced tortillas with longer rupture distance. There was no explanation for these differences. Glutes of HRW and SRW wheats affected only the rupture distance and not other texture parameters. The foldability of the tortillas made from the reconstituted flours was low, so tortillas were very easy to break. All these results indicated that the water-solubles in the flour are important in tortilla making. To study the effects of starch and protein, the water-solubles should be included in the formula. Shortening used in this study diluted the interaction between gluten and starch. The reconstitution method was not suitable for a high-fat tortilla formula.

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