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Evaluation of Hard White Winter Wheat Breeder Lines for Alkaline Asian Noodles

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Rationale/Background

About 40 percent of wheat products consumed in Asian countries are in the form of noodles (1). As the largest wheat exporter country in the world, the United States needs to maintain its competitiveness in producing the wheat quality that is wanted by more sophisticated buyers. When Asian consumers choose wheat for noodle manufacturing, buying decisions are based on the final color and texture characteristics (1).

The interest in hard white winter wheat (HWWW) has been generated by competition of Australian Standard White wheat from western Australia, which has been tailored for white salted Asian noodles (2).

The interest in HWWW has grown in wheat producing states in the U.S. and overseas markets. White Winter varieties may not only produce brighter and whiter flour than the red winter wheat varieties, but they also lack the bitter aftertaste given by polyphenols present in the red wheat varieties.

The objective of this research was to compare the quality of Alkaline Asian noodles made from HWWW advanced breeder lines and commercial white varieties grown in different locations in Oklahoma.

Materials and Methods

Wheat Lines/Varieties

Eight HWWW advanced breeder lines and two commercial varieties grown in three locations (Altus, Fort Cobb and Sweetwater, Okla.) were donated by Brett Carver, wheat breeder at Oklahoma State University. Eltan (Soft White Winter) and Nu-West (Hard White Winter) varieties from Washington and Montana, respectively, were used for comparison. All samples were milled in a Quadromat Sr. mill (C.W. Brabender, Hackensack, N.J.).

The table below shows the counties to which the locations belong and their annual wheat production in million bushels in the crop years 1998 and 1999.

Location	County	1998	1999
Altus	Jackson	5.9	3.75
Fort Cobb	Caddo	7.4	6.6
Sweetwater	Roger Mills	2.0	6.6

* Source: - Oklahoma Agricultural Statistics 1998-1999.

Protein Analysis

Flour protein content was measured using a near infrared (NIR) spectrometer (Perten Instruments, Reno, Nev.) and the percent protein was calculated on a 14 percent moisture basis.

Noodle Preparation

Alkaline noodles were prepared from 200 grams of flour and 10 milliliters alkaline solution containing 0.5 percent Na2CO3 and 2 percent NaCl. Water absorption levels were adjusted to obtain an optimum sandy dough. Noodles were processed in a laboratory scale noodle machine (H. H. Kejentaraan, Malaysia) adjusting the reducing roll gap from 4.0 to 1.0 millimeters in seven steps. Pieces (6 square centimeters) of the dough were saved for color evaluation. The L*, a* and b* color space

was measured in a Minolta colorimeter (Minolta Ltd., Osaka, Japan) using a double layer of the raw dough at two and 24 hours after preparation. The dough pieces were stored in plastic bags at room temperature (26oC).

Peak viscosity was measured in a flour-water slurry at a 4 to 25 ratio (w/w) using a Rapid Visco Analyzer (Newport Scientific, Sydney, Australia). Objective textural properties were measured with a Texture Analyzer, TA-XT2i (Texture Technologies Corp., N.Y.). The test consisted of two compressions using a standard cylindrical plunger (probe) descending to a preset distance in the noodle with a constant load increase over the time it was used. Five independent observations were made on five, cooked noodle strands (two centimeters long) placed side by side. Due to the limited amount of wheat from the breeder program, all analyses were completed in a single experimental unit with sub samplings.

Results

Protein Content

The flour protein content ranged from 8.3 to 13.0 percent (Figure 1). Wheat lines and varieties grown in Altus showed a higher percentage of protein than Fort Cobb and Sweetwater. The percent protein of wheat line OK97G611 showed the largest variability while OK98G504W was less variable between locations. Averaging the three locations, OK98G505W contained the highest percent protein (10.5 percent) among the breeder lines tested. Comparing the average protein of the commercial varieties, Betty had a higher (12.5 percent) and more consistent protein content compared to Oro Blanco and wheat lines in all locations. Oro Blanco had similar average protein content compared to all the wheat lines tested.

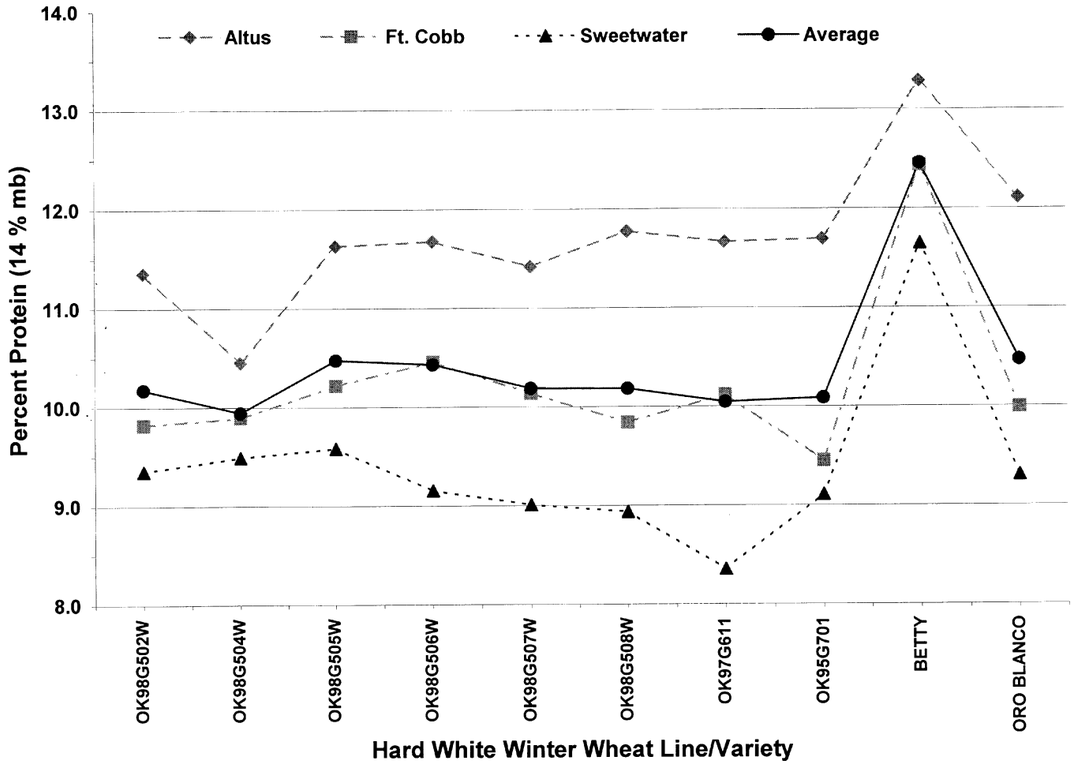

Figure 1. Percent protein (14% mb) of flour from hard white winter wheat breeder lines and commercial varieties grown in three Oklahoma locations (1998-1999 crop year). Standard deviation for Altus = ± 0.7, Fort Cobb = ± 0.8, Sweetwater = ± 0.8, and average = ± 0.7. Protein content (14%mb) for the comparison varieties Eltan and Nu-West were 7.3% and 10.9%, respectively.

Gain Weight

Noodles (35 grams) were cooked in boiling water for two minutes, rinsed with tap water, drained by tapping 10 times, stored in water and immediately analyzed. Gain weight was calculated as a percentage using initial and final weights. A higher value of gain weight will produce higher yields and thus more profits for the processor. Breeder line OK98G502W gave the highest (116.4 percent) and less variable gain weight among the lines and varieties in all three locations (Figure two). Wheat line OK97G611 had the lowest gain weight (94.1 percent) among the lines and varieties in all the locations. Breeder lines OK98G506W and OK98G507W exhibited the greatest variation of gain weight between locations. The commercial varieties, Betty (110.5 percent) and Oro Blanco (114.0 percent), showed higher and less variable gain weight in all locations.On average, Oro Blanco was similar to breeder line OK98G502W (116.4 percent).

Color

Asian customers prefer bright and yellow alkaline noodles with a stable color after 24 hours of preparation. Objective measurement of color is conducted by a colorimeter that gives values of brightness (L*), yellowness (b*) and redness (a*). Desirable values for L* are higher than 60 with a maximum value of 100 for bright noodles and a value of 50 for a gray, dull color. Lower values, less than 50, indicate a general darkness of the noodles. The a* and b* are the color coordinates: +a* and –a* are the red and green directions and +b* and –b* are the yellow and blue directions, respectively. The +a* and +b* values range from 10 to 60 and between 0 and < 10 results on gray and dull color. In alkaline Asian noodles, the basic pH enhances the xanthophylls or yellow pigments in the flour. Redness +a* values are an undesirable hue in alkaline noodles, the lower the value the better but too low will produce a dull gray color.

Brightness (L*)

Table 1a shows the change in brightness of the alkaline Asian noodles from two to 24 hours. Delta (Δ) L* is an estimate of the stability of the noodle brightness. Lower ΔL* values (2.7) of noodles made from breeder line OK97G611 were observed (Table 1a) and ranked first among the lines and varieties in all locations. The ΔL* was lower than Betty (7.2) and Oro Blanco (5.1) which

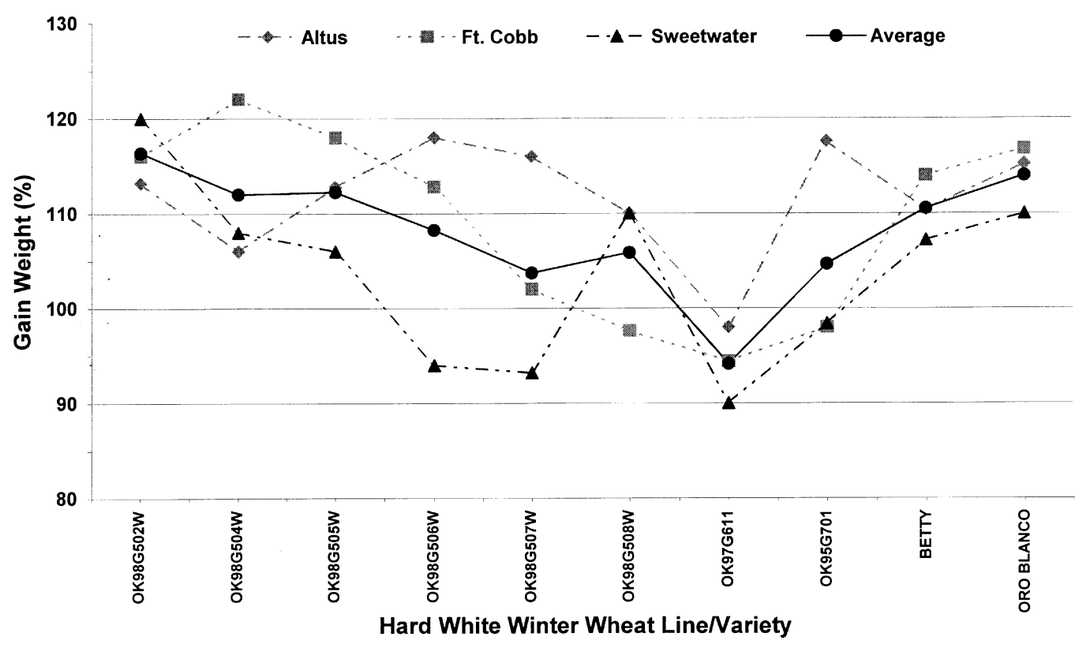

Figure 2. Gain in weight of Asian alkaline noodles made from hard white winter wheat breeder lines and commercial varieties grown in three Oklahoma locations (1998-1999 crop year). Standard deviation for Altus = ± 6.09, Fort Cobb = ± 10.07, Sweetwater = ± 9.44, and average = ± 6.44. Gained weight for the comparison varieties Eltan and Nu-West were 94.8% and 92.0%, respectively.

ranked seven and four, respectively. Only breeder line OK97G611 gave a comparable ΔL* value to Eltan (3.0) and Nu-West (2.3) while the other samples gave higher ΔL* values indicating a larger decrease in brightness.

Yellowness (b)*

The majority of the change in yellow (Δb*) values in the samples tested were relatively small and negative, average b*, -3.0 (Table 1b). In comparison to Eltan (1.1) and Nu-West (1.7), the breeder and variety samples grown in Oklahoma indicate a marked deterioration from the original yellowness of the dough.

Redness (a)*

All the dough samples of Oklahoma-grown wheat showed small but negative Δa* values ranging from – 0.1 to – 0.7 (Table 1c). These values are at the center of the color space (map) where gray color resides. Wheat lines OK98G504W and OK98G506W ranked as number one while the commercial varieties ranked nine (Betty) and five (Oro Blanco). The Δa* values from the breeder lines and varieties in this study demonstrated a shift to a grayish hue, which is undesirable in alkaline noodle.

Starch Peak Viscosity

Overall, the Sweetwater location showed the highest peak viscosity of flour while Altus had the lowest. High peak viscosities are associated with desirable texture characteristics in white noodles (5).

Texture

Objective evaluation of textural properties that are reproducible and not subject to regional taste and evaluator's fatigue is valuable in breeding programs for screening purposes. There are a number of literature reports on textural properties of Asian noodles using sensory (subjective method) evaluation with trained panelist from particular regions in Asia (5, 2, 7). However, it is more challenging to find native Asian evaluators from several regions and their commitment of time for constant noodle evaluation sessions.

Hardness is a measure of the firmness of the noodles and probably the most important texture parameter. Hardness was measured as the maximum peak of the first compression. Smooth surface and higher elasticity (springy) properties are preferred in cooked Chinese wet alkaline noodles (5). In this study, the average score for hardness was 1551 ± 132 (Table 2a) from all samples and locations. The majority of the breeder lines and varieties were comparable to the firmness score of Nu-West (1567) and higher than Eltan (1147). The firmest noodles were obtained from breeder line OK98G508W (1791) and the softest was line OK97G611 (1402). Nevertheless, the softest among the wheat lines and varieties scored higher than Eltan. However, Eltan showed the highest resilience value (Table 2c), meaning it produces a soft but resilient noodle structure.

Springiness is a measure of the ability of the noodle to bounce back after a pressure is applied. In the TPA analysis, springiness is calculated as the length (X axis) of the two compression peaks, from the baseline to each peak. Springiness correlates with how rubbery noodles are perceived. Average springiness scores ranged from 0.95 to 1.04 ± 0.02 in all locations (Table 2a). The majority of the samples had springiness values similar to Nu-West except for OK97G611 (0.97), OK95G701 (0.95), and Oro Blanco (0.95), which had similar values to the comparison variety Eltan (0.95).

Cohesiveness is measured by the ratio of the two compression areas. It is related to the extent to which noodle structure is disrupted during the two compressions by the testing probe. This measurement is associated with sensory evaluation of the noodle bite and springiness. The more cohesive noodles in the group were obtained from lines OK98G504W and OK98G506W (0.70) (Table 2b). These noodles have similar cohesiveness score to Nu-West (0.71) but lower than Eltan (0.78). In contrast, the less cohesive noodle was made from OK97G611 (0.56). Overall, wheat lines and varieties tested had cohesiveness score of 0.65 comparable to Nu-West (0.71).

Gumminess is the energy required to disintegrate a semisolid food to a state ready for swallowing and is a combination of hardness and cohesiveness (6). The overall gumminess score for all the samples in the three locations was 856 ± 126 which is within the range of Eltan (812) and Nu-West (961). Wheat line OK98G504W demonstrated the highest score (1050) for gumminess compared to all the wheat lines and varieties Eltan and Nu-West (Table 2b). In contrast, OK97G611 conferred the lowest score (620).

Chewiness is a combination of hardness, cohesiveness and elasticity (6). Subjectively, chewiness is measured by "tooth packing", where the evaluator uses molar compression on the noodles and then assesses how much the noodle's structure springs back. In this study, the average score for chewiness of all the samples across the locations was 846 ± 136 (Table 2c). Wheat line OK98G504W gave the highest score for chewiness (1060) while OK97G611 had the lowest score (598). Three lines OK98G506W, OK98G507W, and OK98G508W had similar chewiness score (938) to the Nu-West variety.

Resilience is the ability of the noodles to regain their shape after being compressed. In theory, this measure is positively correlated with elasticity. The overall score for resilience was 0.35 ± 0.05 (Table 2c). This score is similar to Nu-West (0.35) but lower than Eltan (0.50). The most resilient noodle was obtained from OK98G506W (0.43) and the least resilient from OK95G701 (0.28).

Adhesiveness is a negative force after the first compression cycle and is a measure of how sticky, tacky or gooey the noodles are (6). All samples adhered to the probe with an overall score of -52.76 ± 14.57. This value is similar to Eltan (-50.0) but higher than Nu-West (-34.5). Wheat lines and varieties with higher adhesiveness than Eltan (-50.0) were OK98G504W (-73.0), OK98G505W (-60.4), OK98G506W (-67.1), OK98G504W (-66.5), and Oro Blanco (-58.2). Only wheat line OK98G507W (-29.1) had lower adhesiveness than Nu-West (-34.5), and was the top ranking sample in this property.

Conclusion

The texture of alkaline noodles has been reported to be influenced by quality and content of protein and starch characteristics (5, 4). Functionality of the protein and starch control the quality of the end product. In white salted noodles, a negative correlation of high protein content with brightness of noodles has been reported (4). In this report, the variety Betty and location Altus that produced the highest protein content also produced the darkest noodle. Eltan exhibited a lower value for the textural properties of firmness/hardness but it was the most resilient and cohesive sample.

Among the breeder lines, OK97G11 demonstrated a promising noodle color stability having the brightest color after 24 hr. However, this line also showed the lowest rank in all textural properties except for adhesiveness and had the lowest gain weight. Compared to the commercial varieties Eltan and Nu-West, OK97G11 line is short in three out of seven textural properties (cohesiveness, gumminess and chewiness). A promising breeder line in terms of texture characteristics is OK98G504W, which shows top values for hardness, springiness, cohesiveness, chewiness, gumminess and resilience values. The textural property that is deterrent in this line is the highest adhesiveness value. It also had the least stable color with the highest decrease in brightness ΔL* after 24 hr. Overall, the Sweetwater location showed a trend to higher L* values translated into brighter noodles. The weight gained by the noodles after cooking showed large variation with no distinguishable trend at any specific location.

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Table 1a. Color lightness values (L*)[1] at 2 and 24 hr of Asian alkaline noodles made from hard white winter wheat breeder lines and commercial varieties. 1998 -99 crop year.

	2 hr					24 hr					ΔL 2-24 hr[2]				
Variety/Location	Altus	Ft. Cobb	Sweetwater	**Ave**	**Rank**	Altus	Ft. Cobb	Sweetwater	**Ave**	**Rank**	Altus	Ft. Cobb	Sweetwater	**Ave**	**Rank**
OK98G502W	78.4	80.9	80.2	**79.8**	**(9)**	68.5	76.7	72.6	**72.6**	**(9)**	9.9	4.3	7.6	**7.2**	**(7)**
OK98G504W	77.4	80.5	84.7	**80.9**	**(5)**	70.7	69.3	79.6	**73.2**	**(7)**	6.6	11.2	5.1	**7.7**	**(10)**
OK98G505W	78.5	85.0	80.8	**81.4**	**(2)**	71.6	77.7	78.8	**76.1**	**(4)**	6.9	7.3	2.0	**5.4**	**(4)**
OK98G506W	79.8	84.9	84.2	**83.0**	**(1)**	73.2	77.0	79.0	**76.4**	**(3)**	6.6	7.9	5.2	**6.6**	**(5)**
OK98G507W	77.2	80.5	84.3	**80.7**	**(7)**	70.7	76.2	79.8	**75.6**	**(6)**	6.5	4.3	4.5	**5.1**	**(3)**
OK98G508W	79.0	80.2	82.8	**80.7**	**(7)**	69.9	74.9	74.7	**73.2**	**(7)**	9.1	5.3	8.1	**7.5**	**(9)**
OK97G611	78.2	81.3	83.0	**80.9**	**(5)**	75.1	78.0	81.4	**78.1**	**(1)**	3.1	3.3	1.7	**2.7**	**(1)**
OK95G701	82.6	78.5	82.9	**81.3**	**(3)**	74.9	75.3	80.4	**76.9**	**(2)**	7.7	3.2	2.6	**4.5**	**(2)**
Betty	67.3	80.8	79.7	**75.9**	**(10)**	58.1	72.7	75.3	**68.7**	**(10)**	9.3	8.1	4.4	**7.2**	**(7)**
Oro Blanco	82.8	79.3	81.4	**81.2**	**(4)**	75.5	74.8	77.8	**76.1**	**(4)**	7.3	4.5	3.6	**5.1**	**(3)**
Average	**78.1**	**81.2**	**82.4**	**82.4**		**70.8**	**75.3**	**77.9**	**77.9**		**7.3**	**5.9**	**4.5**	**4.5**	
SD[3]	4.3	2.1	1.8	1.8		5.1	2.6	2.8	2.8		1.9	2.6	2.2	2.2	
Eltan (WA)[4]	-	-	-	84.2		-	-	-	81.2		-	-	-	3.0	
Nu-West (MT)[4]	-	-	-	75.5		-	-	-	73.2		-	-	-	2.3	

Table 1b. Color (b*) values[1] at 2 and 24 hr of Asian alkaline noodles made from hard white winter wheat breeder lines and commercial varieties. 1998-99 crop year.

	2 hr					24 hr					Δb 2-24 hr[2]				
Variety/Location	Altus	Ft. Cobb	Sweetwater	**Ave**	**Rank**	Altus	Ft. Cobb	Sweetwater	**Ave**	**Rank**	Altus	Ft. Cobb	Sweetwater	**Ave**	**Rank**
Sweetwater	**Ave**	**Rank**													
OK98G502W	14.4	11.0	10.6	**12.0**	**(8)**	15.8	16.0	10.3	**14.0**	**(10)**	-1.4	-5.0	0.3	**-2.0**	**(6)**
OK98G504W	14.0	12.5	14.6	**13.7**	**(6)**	14.3	13.1	15.0	**14.2**	**(9)**	-0.3	-0.5	-0.4	**-0.4**	**(2)**
OK98G505W	17.4	13.4	10.7	**13.8**	**(4)**	16.7	13.7	15.5	**15.3**	**(7)**	0.6	-0.3	-4.8	**-1.5**	**(3)**
OK98G506W	21.3	13.6	14.0	**16.3**	**(1)**	20.4	14.3	14.8	**16.5**	**(4)**	0.9	-0.6	-0.7	**-0.2**	**(1)**
OK98G507W	15.1	12.3	14.4	**14.0**	**(3)**	15.3	19.1	14.6	**16.3**	**(5)**	-0.1	-6.7	-0.1	**-2.3**	**(7)**
OK98G508W	15.6	13.1	12.8	**13.8**	**(4)**	16.8	15.9	13.2	**15.3**	**(7)**	-1.2	-2.8	-0.4	**-1.5**	**(3)**
OK97G611	12.3	11.2	11.2	**11.5**	**(10)**	19.1	18.1	17.1	**18.1**	**(1)**	-6.8	-6.9	-5.9	**-6.6**	**(10)**
OK95G701	12.7	12.3	10.8	**11.9**	**(9)**	13.6	18.9	17.2	**16.6**	**(3)**	-0.9	-6.6	-6.5	**-4.6**	**(9)**
Betty	18.4	13.4	10.4	**14.1**	**(2)**	19.0	12.6	15.9	**15.8**	**(6)**	-0.6	0.8	-5.5	**-1.8**	**(5)**
Oro Blanco	12.7	12.9	12.0	**12.6**	**(7)**	12.9	19.2	18.0	**16.7**	**(2)**	-0.2	-6.2	-6.0	**-4.1**	**(8)**
Average	**15.4**	**12.6**	**12.2**	**12.2**		**16.4**	**16.1**	**15.2**	**15.2**		**-1.0**	**-3.5**	**-3.0**	**-3.0**	
SD[3]	2.9	0.9	1.7	1.7		2.5	2.6	2.2	2.2		2.2	3.1	2.9	2.9	
Eltan (WA)[4]	-	-	-	17.3		-	-	-	16.2		-	-	-	1.1	
Nu-West (MT)[4]	-	-	-	13.1		-	-	-	11.4		-	-	-	1.7	

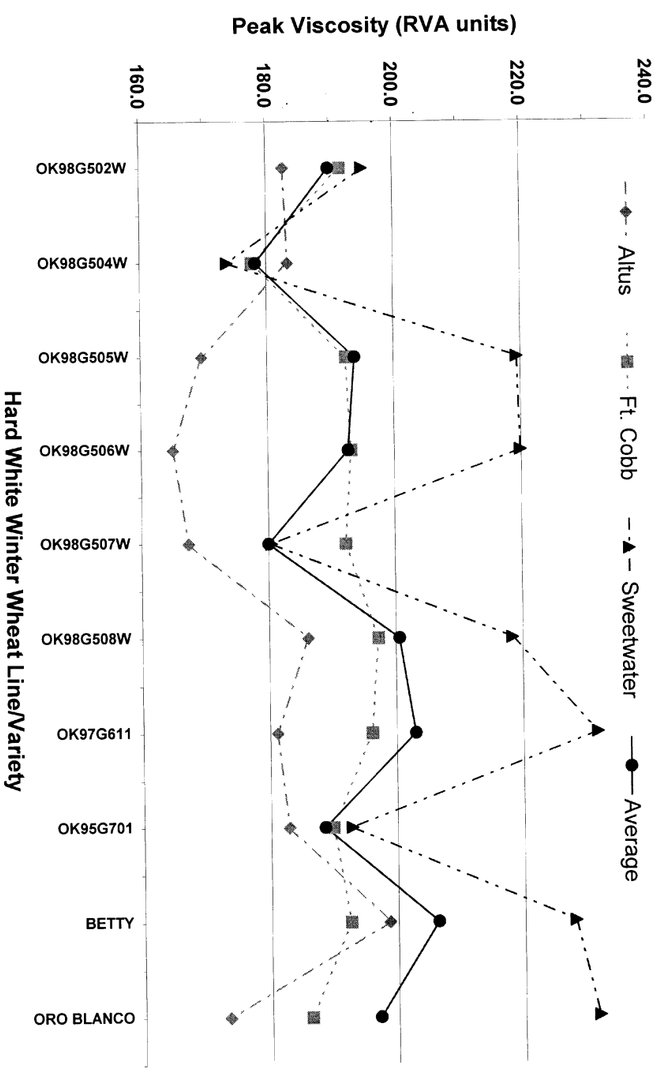

Figure 3. Peak viscosity of flour made from hard white winter wheat breeder lines and commercial varieties grown in three Oklahoma locations (1998-1999 crop year). Standard deviation for Altus = ±10.21, Fort Cobb = ±5.54, Sweetwater = ±21.65, and average = ±9.24. Peak viscosity for the comparison samples Betty and Oro Blanco were 206.4 and 197.1, respectively.

Table 2c. Evaluation of chewiness and resilience of Asian alkaline noodles made from hard white winter wheat breeder lines and commercial varieties. 1998-1999 crop year.

	Chewiness					Resilience				
Variety/Location	Altus	Ft. Cobb	Sweetwater	**Ave**	**Rank**	Altus	Ft. Cobb	Sweetwater	**Ave**	**Rank**
OK98G502W	1103	667	713	828	**(6)**	0.36	0.37	0.41	0.38	**(3)**
OK98G504W	728	1397	1053	1060	**(1)**	0.35	0.33	0.45	0.38	**(3)**
OK98G505W	846	989	825	887	**(5)**	0.42	0.40	0.39	0.40	**(2)**
OK98G506W	1247	806	780	944	**(3)**	0.47	0.44	0.38	0.43	**(1)**
OK98G507W	1262	758	732	917	**(4)**	0.39	0.37	0.34	0.37	**(5)**
OK98G508W	1180	855	830	955	**(2)**	0.35	0.37	0.26	0.32	**(7)**
OK97G611	806	519	470	598	**(10)**	0.36	0.30	0.25	0.31	**(8)**
OK95G701	656	904	590	717	**(9)**	0.26	0.31	0.27	0.28	**(10)**
Betty	712	996	754	821	**(7)**	0.29	0.35	0.37	0.34	**(6)**
Oro Blanco	743	987	472	734	**(8)**	0.27	0.37	0.25	0.30	**(9)**
Average	**928**	**888**	**722**	**846**		**0.35**	**0.36**	**0.34**	**0.35**	
SD[1]	241	236	176	136		0.07	0.04	0.07	0.05	
Eltan (WA)[2]	-	-	-	775		-	-	-	0.50	
Nu-West (MT)[2]	-	-	-	938		-	-	-	0.35	

	Adhesiveness, g				
Variety/Location	Altus	Ft. Cobb	Sweetwater	**Ave**	**Rank**
OK98G502W	-60.8	-27.1	-54.1	-47.3	**(4)**
OK98G504W	-41.2	-81.8	-95.9	-72.9	**(10)**
OK98G505W	-63.3	-64.8	-53.0	-60.4	**(7)**
OK98G506W	-75.0	-57.0	-69.2	-67.1	**(9)**
OK98G507W	-21.3	-30.8	-35.1	-29.1	**(1)**
OK98G508W	-69.2	-25.2	-105.1	-66.5	**(8)**
OK97G611	-44.4	-33.6	-29.8	-35.9	**(2)**
OK95G701	-63.7	-39.8	-43.1	-48.9	**(5)**
Betty	-41.3	-46.2	-36.0	-41.2	**(3)**
Oro Blanco	-88.2	-48.0	-38.4	-58.2	**(6)**
Average	**-56.9**	**-45.4**	**-56.0**	**-52.8**	
SD[1]	19.63	18.15	26.24	14.6	
Eltan (WA)[2]	-	-	-	-50.0	
Nu-West (MT)[2]	-	-	-	-34.5	

[1] SD = Standard deviation

[2] Eltan and Nu-West = commercial varieties used for comparison

Table 1c. Color (a*) values[1] at 2 and 24 hr of Asian noodles made from hard white winter wheat breeder lines and commercial varieties. 1998-99 crop year.

	2 hr					24 hr					Δa 2-24 hr[2]				
Variety/Location	Altus	Ft. Cobb	Sweetwater	**Ave**	**Rank**	Altus	Ft. Cobb	Sweetwater	**Ave**	**Rank**	Altus	Ft. Cobb	Sweetwater	**Ave**	**Rank**
OK98G502W	-0.99	-0.75	-0.72	**-0.82**	**(3)**	-0.84	0.18	-0.61	**-0.42**	**(3)**	-0.15	-0.93	-0.11	**-0.40**	**(5)**
OK98G504W	-0.69	-0.71	-0.79	**-0.73**	**(2)**	-0.42	-0.67	-0.82	**-0.64**	**(9)**	-0.28	-0.03	0.03	**-0.09**	**(1)**
OK98G505W	-1.24	-0.90	-0.67	**-0.93**	**(5)**	-1.14	-0.83	0.17	**-0.60**	**(7)**	-0.10	-0.07	-0.83	**-0.33**	**(3)**
OK98G506W	-1.75	-0.82	-0.85	**-1.14**	**(10)**	-1.48	-0.79	-0.91	**-1.06**	**(10)**	-0.27	-0.03	0.06	**-0.08**	**(1)**
OK98G507W	-0.88	-0.90	-0.84	**-0.87**	**(4)**	-0.73	-0.23	-0.85	**-0.60**	**(7)**	-0.16	-0.67	0.01	**-0.27**	**(3)**
OK98G508W	-0.91	-0.92	-0.98	**-0.94**	**(6)**	-0.77	0.23	-1.03	**-0.52**	**(4)**	-0.13	-1.15	0.05	**-0.41**	**(5)**
OK97G611	-1.02	-1.14	-0.95	**-1.04**	**(9)**	-0.29	-0.53	-0.23	**-0.35**	**(2)**	-0.73	-0.61	-0.72	**-0.69**	**(10)**
OK95G701	-0.98	-0.95	-0.94	**-0.95**	**(7)**	-1.02	-0.37	-0.39	**-0.59**	**(6)**	0.05	-0.58	-0.55	**-0.36**	**(5)**
Betty	1.80	-0.73	-0.86	**0.07**	**(1)**	2.59	-0.56	0.05	**0.69**	**(1)**	-0.80	-0.18	-0.91	**-0.63**	**(9)**
Oro Blanco	-0.96	-0.88	-1.03	**-0.96**	**(8)**	-0.96	-0.02	-0.63	**-0.54**	**(5)**	0.00	-0.86	-0.40	**-0.42**	**(5)**
Average	**-0.76**	**-0.87**	**-0.86**	**-0.86**		**-0.51**	**-0.36**	**-0.52**	**-0.52**		**-0.26**	**-0.51**	**-0.34**	**-0.34**	
SD[3]	0.94	0.13	0.11	0.11		1.14	0.39	0.41	0.41		0.29	0.41	0.39	0.39	
Eltan (WA)[4]	-	-	-	-1.98		-	-	-	-2.14		-	-	-	0.20	
Nu-West (MT)[4]	-	-	-	-1.02		-	-	-	-1.02		-	-	-	0.00	

[1]Lightness or brightness (L*), b* - high values desired, and a* - small values desired

[2]ΔL, Δa, Δb, - difference between 2 and 24 hr of raw noodles, small values desired

[3]SD - standard deviation

[4]Eltan and Nu-West - commercial varieties used for comparison

Notes:

Hatcher, DW; Kruger, JE; Anderson, MJ; 1999, Cereal Chem 76(4), 566-572.

Alkaline noodle should be bright (high L*) and display good yellow color (high b*).

Higher negative a* value means more green noodle.

Higher positive a* value means more red noodle.

Table 2a. Evaluation of hardness and springiness of Asian alkaline noodles made from hard white winter wheat breeder lines and commercial varieties. 1998-1999 crop year.

	Hardness, g					Springiness				
Variety/Location	Altus	Ft. Cobb	Sweetwater	**Ave**	**Rank**	Altus	Ft. Cobb	Sweetwater	**Ave**	**Rank**
OK98G502W	1750	1187	1526	1488	**(6)**	1.01	0.99	0.98	0.99	**(3)**
OK98G504W	1338	2123	1794	1752	**(2)**	0.98	1.07	0.96	1.00	**(2)**
OK98G505W	1599	1347	1619	1522	**(5)**	0.98	1.16	0.98	1.04	**(1)**
OK98G506W	2103	1278	1489	1623	**(3)**	0.99	1.00	0.97	0.98	**(5)**
OK98G507W	1880	1425	1358	1554	**(4)**	0.99	1.01	0.98	0.99	**(3)**
OK98G508W	1925	1539	1910	1791	**(1)**	1.01	0.97	0.96	0.98	**(5)**
OK97G611	1610	1337	1257	1402	**(10)**	0.96	0.97	0.97	0.97	**(8)**
OK95G701	1434	1517	1369	1440	**(9)**	0.94	0.96	0.95	0.95	**(10)**
Betty	1486	1575	1352	1471	**(7)**	0.97	0.98	0.98	0.98	**(5)**
Oro Blanco	1622	1547	1239	1470	**(8)**	0.98	0.96	0.95	0.96	**(9)**
Average	**1675**	**1488**	**1491**	**1551**		**0.98**	**1.01**	**0.97**	**0.99**	
SD[1]	239	258	225	132		0.02	0.06	0.01	0.02	
Eltan (WA)[2]	-	-	-	1147		-	-	-	0.95	
Nu-West (MT)[2]	-	-	-	1567		-	-	-	0.98	

Table 2b. Evaluation of cohesiveness and gumminess of Asian alkaline noodles made from hard white winter wheat breeder lines and commercial varieties. 1998-1999 crop year.

	Cohesiveness					Gumminess				
Variety/Location	Altus	Ft. Cobb	Sweetwater	**Ave**	**Rank**	Altus	Ft. Cobb	Sweetwater	**Ave**	**Rank**
OK98G502W	0.73	0.67	0.62	0.67	**(5)**	1095	672	729	832	**(7)**
OK98G504W	0.66	0.72	0.73	0.70	**(1)**	743	1305	1100	1050	**(1)**
OK98G505W	0.66	0.73	0.65	0.68	**(4)**	867	856	846	857	**(5)**
OK98G506W	0.72	0.74	0.65	0.70	**(1)**	1264	808	803	959	**(3)**
OK98G507W	0.77	0.65	0.65	0.69	**(3)**	1271	752	748	924	**(4)**
OK98G508W	0.71	0.68	0.54	0.64	**(7)**	1163	883	861	969	**(2)**
OK97G611	0.64	0.53	0.50	0.56	**(10)**	842	534	484	620	**(10)**
OK95G701	0.57	0.68	0.58	0.61	**(8)**	698	936	618	751	**(9)**
Betty	0.60	0.74	0.68	0.67	**(5)**	733	1021	768	840	**(6)**
Oro Blanco	0.55	0.74	0.51	0.60	**(9)**	759	1027	497	761	**(8)**
Average	**0.66**	**0.69**	**0.61**	**0.65**		**944**	**880**	**745**	**856**	
SD[1]	0.07	0.06	0.08	0.05		230	214	182	126	
Eltan (WA)[2]	-	-	-	0.79		-	-	-	812	
Nu-West (MT)[2]	-	-	-	0.71		-	-	-	961	

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Bringing the University to You!

The Cooperative Extension Service is the largest, most successful informal educational organization in the world. It is a nationwide system funded and guided by a partnership of federal, state, and local governments that delivers information to help people help themselves through the land-grant university system.

Extension carries out programs in the broad categories of agriculture, natural resources and environment; home economics; 4-H and other youth; and community resource development. Extension staff members live and work among the people they serve to help stimulate and educate Americans to plan ahead and cope with their problems.

Some characteristics of Cooperative Extension are:

- The federal, state, and local governments cooperatively share in its financial support and program direction.
- It is administered by the land-grant university as designated by the state legislature through an Extension director.
- Extension programs are nonpolitical, objective, and based on factual information.
- It provides practical, problem-oriented education for people of all ages. It is designated to take the knowledge of the university to those persons who do not or cannot participate in the formal classroom instruction of the university.
- It utilizes research from university, government, and other sources to help people make their own decisions.
- More than a million volunteers help multiply the impact of the Extension professional staff.
- It dispenses no funds to the public.
- It is not a regulatory agency, but it does inform people of regulations and of their options in meeting them.
- Local programs are developed and carried out in full recognition of national problems and goals.
- The Extension staff educates people through personal contacts, meetings, demonstrations, and the mass media.
- Extension has the built-in flexibility to adjust its programs and subject matter to meet new needs. Activities shift from year to year as citizen groups and Extension workers close to the problems advise changes.