Noodles. IV. Influence of Flour Protein, Extraction Rate, Particle Size, and Starch Damage on the Quality Characteristics of Dry Noodles[1]

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ABSTRACT

The optimum cooking time of oriental dry noodles increased linearly with protein content. High-protein noodles were darker and stronger, and were firmer internally when cooked than low-protein noodles. However, protein content was not correlated with surface firmness. At high rates of flour extraction, noodle color darkened, but the internal firmness of cooked noodles did not change. The optimum absorption of noodle dough increased with starch damage and fineness of granulation. Increasing starch damage reduced both internal and surface firmness of cooked noodles; decreasing particle size improved the strength of uncooked noodles but did not affect noodle color or firmness of cooked noodles.

In contrast to the extensive literature on quality of flour for breadmaking, little has been reported on the quality of flour for making noodles. Flour properties would be expected to influence the color, opaqueness, strength, and cooking quality of noodles, all of which have been found important in pasta (Dexter et al 1983). Cooking quality includes strength or firmness, elasticity, water gain, cooking loss, surface characteristics, and tolerance to overcooking. In other work on dry noodles, we measured the color and strength of uncooked noodles, internal strength, and surface firmness (Oh et al 1983, 1985a,b).

Noodle color originates from two main sources, fragments of bran and enzymatic browning products that accumulate during processing of noodle dough. Enzymatic browning in noodles increases with increasing extraction rate of flour, presumably caused by bran particles that contain a high concentration of oxidative enzymes, phenolics, and pigments (Reed and Thorn 1971). Moss (1971) reported more rapid browning of noodle dough upon addition of 0.08% tyrosine. In contrast to pasta, noodles contain salt, which would be expected to reduce oxidase activity.

An increase in flour protein and brown pigments decreased flour brightness and produced dull, dry noodles. However, the effects of protein and brown pigments were not significant once the noodles had been cooked (Miskelly 1984). The protein content of wheat flour has long been associated with the "bite" of cooked noodles (Bunta 1980, Nagao et al 1977b). However, no detailed reports have been published on that association.

Nagao et al (1977a) reported that selected Australian wheats and American soft white and white club wheats showed favorable characteristics for Japanese-type noodles. The starches in those flours were found to swell at a relatively low temperature in the amylograph compared to those of other flours. Starch in flour from sprouted soft wheats gave sticky noodle doughs, presumably because of amylase and protease activity (Bean et al 1974).

The objectives of this investigation were to determine the effects of flour protein, extraction rate, starch damage, and flour granulation on the quality of dry noodles.

MATERIALS AND METHODS

Flours of Different Protein Content

Soft wheat flour from a high-protein sample of Logan wheat (15.3% protein) was blended with flour from a low-protein Logan wheat (9.6% protein) to give four blends containing 8.6–14.3% protein. Both Logan wheats were grown in Ohio. In the same manner, high- and low-protein hard wheat flours from Scout 66 (grown in Nebraska) were blended to give three blends containing 8.9–12.5% protein.

Six varieties of hard red winter wheat (Newton, Larned, Vona, Centurk 78, Scout 66, and Eagle) were grown in 11 locations in Kansas. After harvest in 1983 the grains were composited by location and by variety to prepare single-location composites and pure-variety composites, respectively. The composite grains were milled into flours, with flour protein ranges of 8.5–14.9% for single-location composites and 11.1–12.8% for pure-variety composites. Fourteen experimental varieties of hard red wheat grown in the Great Plains also were tested for their noodle-making quality.

Flours of Different Extraction Rates

Two hard red winter (HRW) wheat cultivars and two soft white wheat cultivars were used in this phase of the investigation. The hard wheats, Newton and Centurk 78, were grown in Kansas in 1983, and the soft wheats, Stephens and Daws, were grown in Washington in 1981 and 1982 (Table I). The hard and soft wheats, which were tempered to 16.0 and 13.5% moisture, respectively, were milled in a laboratory Buhler mill (Buhler Brothers Engineering Works, Uzwil, Switzerland) to give flours with extraction rates from 62 to 80%.

Flours with Different Granulations and Amounts of Starch Damage

To investigate the effects of starch damage and flour granulation on noodle quality, two hard wheat flours, Arkan and OK 80268, and two soft wheat flours, Oasis and OH 185, were used. Flour protein and ash percentages are listed in Table I. To obtain the various levels of starch damage, flour (200 g) was ball-milled in a ceramic jar (2,000 ml) for 8, 16, or 24 hr, using 25 ceramic cylindrical grinding stones. Percent damaged starch was determined by AACC method 76-30A (1969). To produce flours

TABLE I
Protein and Ash in Wheat and Flour Samples[a]

Sample	Protein (%)	Ash (%)
Wheat		
Newton	12.2	1.55
Centurk 78	11.3	1.68
Stephens	9.8	1.60
Daws	9.4	1.70
Flour		
Arkan	11.3	0.42
OK 80268	13.0	0.47
Oasis	11.5	0.44
OH 185	9.2	0.41

[a] 14% mb.

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TABLE II

Protein of 72% Extraction Flours Compared with Properties of Noodles from One Variety of a Soft and a Hard Wheat[a]

Wheat	Protein[b] (%)	Flour Absorption for Noodlemaking[b] (%)	Uncooked Noodle Color[c]	Uncooked Noodle Thickness (mm)	Uncooked Noodle Breaking[d] Stress (g/mm^2)	Uncooked Noodle Cooking Time (min)	Cooked Noodle Cutting[d] Stress (g/mm^2)	Cooked Noodle Surface[d] Firmness (g/mm)
Soft (Logan)	8.6	32.0	94	1.45	1,475	10	22.7	52.4
	10.8	29.5	91	1.48	1,624	12	27.5	38.4
	12.4	31.5	86	1.60	1,940	14	32.7	35.3
	14.3	29.0	81	1.62	2,328	16	39.5	33.6
Hard (Scout 66)	8.9	32.5	93	1.48	2,115	11	25.0	33.0
	10.6	31.0	88	1.52	2,435	12	32.2	33.0
	12.5	30.5	31	1.57	2,876	14	38.1	34.0
LSD[c] ($P = 0.05$)			1.3		124		1.5	2.2

[a] Values represent an average of three measurements.
[b] 14% mb.
[c] Low color values represent a dark noodle color or reduced reflection of light.
[d] High values of breaking stress, cutting stress, and surface firmness represent strong and firm noodles. Surface properties were measured on the rolled surface of the noodle.
[c] Least significant difference. Differences between two means exceeding this value are significant.

TABLE III

Noodle Properties of Pure-Variety Composites of HRW Wheats Grown in Eleven Locations in Kansas[a]

Variety	Flour Protein[b] (%)	Uncooked Noodle Color	Uncooked Noodle Breaking[d] Stress (g/mm^2)	Cooked Noodle[c] Cutting[d] Stress (g/mm^2)	Cooked Noodle[c] Surface[d] Firmness (g/mm)
Newton	11.1	75.5 B	2,741 A	33.9 B	28.1 C
Vona	11.3	80.5 A	2,526 C	33.2 B	27.2 C
Centurk 78	11.6	76.5 B	2,630 B	38.5 A	38.1 A
Larned	11.8	78.0 A	2,763 A	40.7 A	29.1 C
Scout 66	11.9	79.0 A	2,640 B	39.6 A	33.8 B

[a] $\alpha = 0.05$, DF = 10, $n = 15$. Values represent an average of three measurements. Values followed by different letters are significantly different at $P = 0.05$. The five wheat varieties grown in Kansas in 1984 ranked in the following order of production: Newton, Larned, Vona, Scout 66, and Centurk 78.
[b] Extraction rate of flour 72%. Protein content on 14% mb.
[c] Optimum cooking time was 13 min for all noodles.
[d] High values of breaking stress, cutting stress, and surface firmness represent strong and firm noodles.

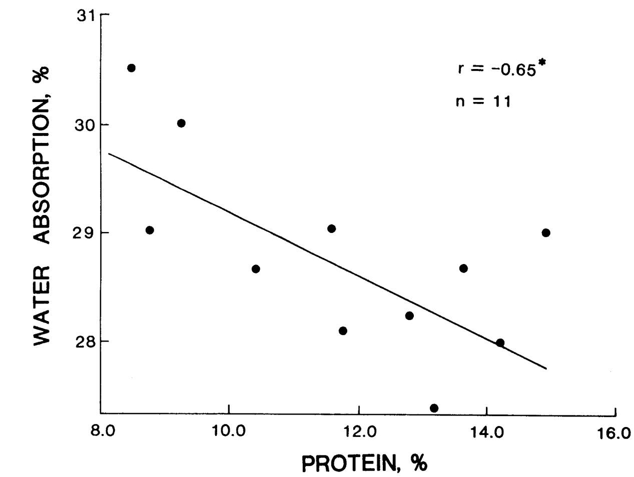

Fig. 1. Protein content of 11 location-composite flours from six Kansas hard red winter wheats and optimum absorption for noodle dough.

with different granulations, flours were passed through the Alpine Kolloplex pin mill (Alpine Ag., Augsburg, Germany) at either 7,100 rpm (one pass, medium granulation), 14,000 rpm (one pass, fine granulation), or 14,000 rpm (two passes, extra fine granulation).

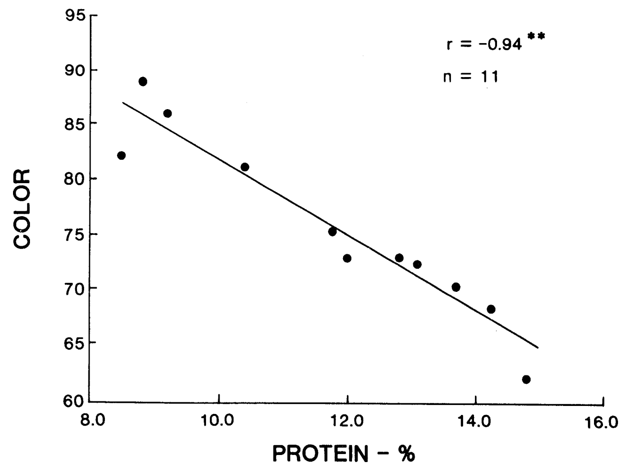

Fig. 2. Protein content of 11 location-composite flours from six Kansas hard red winter wheats and the color of uncooked dry noodles.

Particle-Size Analysis

Particle-size distribution of flours was determined with the Alpine Air Jet sieve (model A 200 LS, Alpine Ag., Augsburg, Germany) on sieves with openings of 15, 20, 38, 53, 75, and 106 μm. The percentage of each fraction was determined from the weight of the overs on each sieve.

Noodles and Noodle Quality

Flour (300 g) was mixed with an optimum amount of distilled water for 3 min after 1 min slow-speed mixing, and the dough was sheeted after resting 30 min. Optimum absorption was determined by the handling and sheeting characteristics of noodle dough (Oh et al 1985a). Four sheeting steps were used, starting at a roll gap of 5.4 mm and ending at 1.3 mm. A 30% reduction in roll gap and a roll speed (diameter 18 cm) of 8 rpm were used for each sheeting step. Other details of the noodle-making process are given in Oh et al (1983).

Color and breaking stress of uncooked dry noodles were measured as described by Oh et al (1985b). Noodles were cooked to optimum in tap water (pH ~9). Cutting stress (internal firmness), corrected to a constant thickness of 2.4 mm, and surface firmness of cooked noodles were measured as described by Oh et al (1983, 1985a). Scanning electron microscopy was done on cross sections of cooked noodle strands as in Oh et al (1985a).

RESULTS AND DISCUSSION

Effect of Protein Content

Table II summarizes the effect of increasing protein on the noodle-making quality of flour from one variety each of hard and soft wheats. The high-protein noodles were darker, stronger, and more resistant to fracture than the low-protein noodles from both flour types. High-protein noodles required longer cooking and gave a higher cutting stress than low-protein noodles. The surface of the soft wheat noodles decreased in firmness as protein increased (Table II), at least partly because of the increased cooking time used with higher protein content. By contrast the surface firmness of the hard wheat noodles varied little as protein increased.

In the past, the protein content of semolina has been shown to significantly influence the cooking quality of pasta (Dexter and Matsuo 1977). Thus, to compare the intrinsic value of the protein in pasta or noodles made from two varieties of wheat, the varieties must be tested at the same protein level. When hard wheat and soft wheat noodles of similar protein content were compared, the hard wheat noodles were generally darker and stronger but less firm at the surface (Table II). These differences may be due to protein quality or other factors. For example, Wasik (1978) found a linear relationship between the tenderness index and the residue protein in five varieties of durum; the internal strength of pasta increased with the amount of acetic acid-insoluble gluten. Surface firmness may vary with the degree of gluten development in the dry noodle (Oh et al 1985a).

To further examine the effect of protein on noodle properties, we prepared flours (70% extraction) from 11 single-location composites of six Kansas HRW wheat varieties. The flours from the composites ranged from 8.6 to 14.9% protein. Figure 1 shows that the optimum handling absorption of a noodle dough decreased as protein in the hard wheat flour increased. Perhaps a continuous phase of gluten is required for a dough sheet, and such a phase is formed quickly when the surface of flour particles is rich in protein. With low-protein flour, protein inside the HRW flour particles must be used for gluten development, and extra water is needed to disaggregate the flour particles. This phenomenon was reported by Irvine and co-workers (1961), who found high-protein semolina

TABLE IV
Noodle Properties of Straight-Grade Flours from Experimental Hard Red Winter Wheat Varieties[a]

Variety	Uncooked Noodles		Cooked Noodles[b]	
	Color	Breaking Stress (g/mm^2)	Cutting Stress (g/mm^2)	Surface Firmness (g/mm)
Group I (11.3–11.4% protein)[c]				
NE 78696	89 B	1,901 B	35.7 B	34.4 A
NE 78698	92 A	1,977 B	38.9 A	28.1 C
CO 786741	86 C	2,102 A	35.6 B	35.3 A
CO 779274	89 B	1,965 B	35.9 B	34.4 A
Group II (12.1–12.2% protein)[c]				
TX 71A 562-6-28	77 C	2,276 A	37.9 B	38.5 A
NAPB 200	85 A	2,169 B	41.4 A	29.4 C
NAPB 201	83 A	2,189 B	39.0 B	38.8 A
SD 7279	79 C	2,255 A	43.2 A	28.8 C
Group III (13.5–13.6% protein)[c]				
NE 75424	80 A	2,346 B	44.5 B	33.1 B
TX 71A 916-3	78 A	2,152 C	41.1 C	32.5 B
KS 75721	73 C	2,474 A	43.7 B	38.8 A
NE 75424	80 A	2,306 B	48.6 A	31.3 B

[a] $\alpha = 0.05$, DF = 8, $n = 12$. Values represent an average of three measurements. Values with different letters are significantly different. The letters of different groups are not related to each other.
[b] The optimum cooking times for noodles in groups I, II, and III were 13, 14, and 15 min, respectively.
[c] 14% mb.

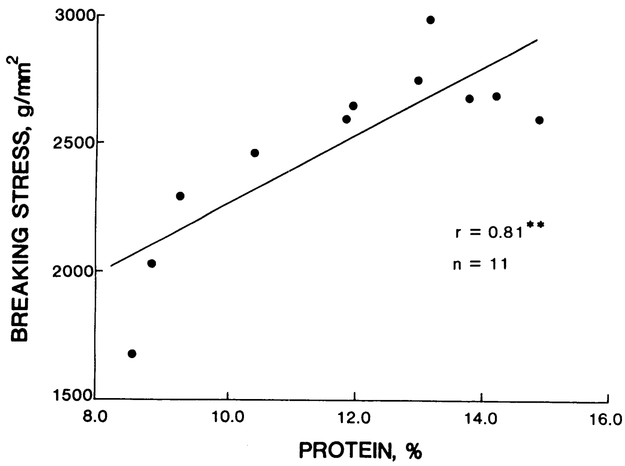

Fig. 3. Protein content of 11 location-composite flours from six Kansas hard red winter wheats and the breaking stress of uncooked dry noodles.

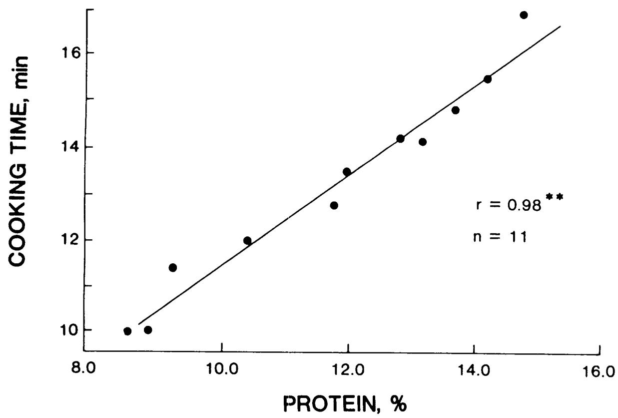

Fig. 4. Protein content of 11 location-composite flours from six Kansas hard red winter wheats and noodle cooking time.

TABLE V
Noodle Properties of Straight-Grade Flours from Selected Wheat Varieties

Variety	Flour Protein[a] (%)	Noodle-making Absorption[a] (%)	Uncooked Noodle		Cooked Noodle		
			Color	Breaking Stress (g/mm^2)	Cooking Time (min)	Cutting Stress (g/mm^2)	Surface Firmness (g/mm)
Hard wheat							
Newton	11.1	30.5	76	2,741	12	33.9	28.1
Centurk 78	11.6	32.0	77	2,630	13	38.5	38.1
NE 77682[b]	12.6	31.0	81	2,950	14	38.0	47.0
TX 79A2729	12.4	31.5	79	2,830	14	37.0	50.0
Soft wheat							
Oasis	11.5	25.5	95	2,188	13	32.8	47.0
OH 185	9.2	27.5	97	1,799	11	20.9	52.5

[a] 14% mb.
[b] Released under the name Centura.

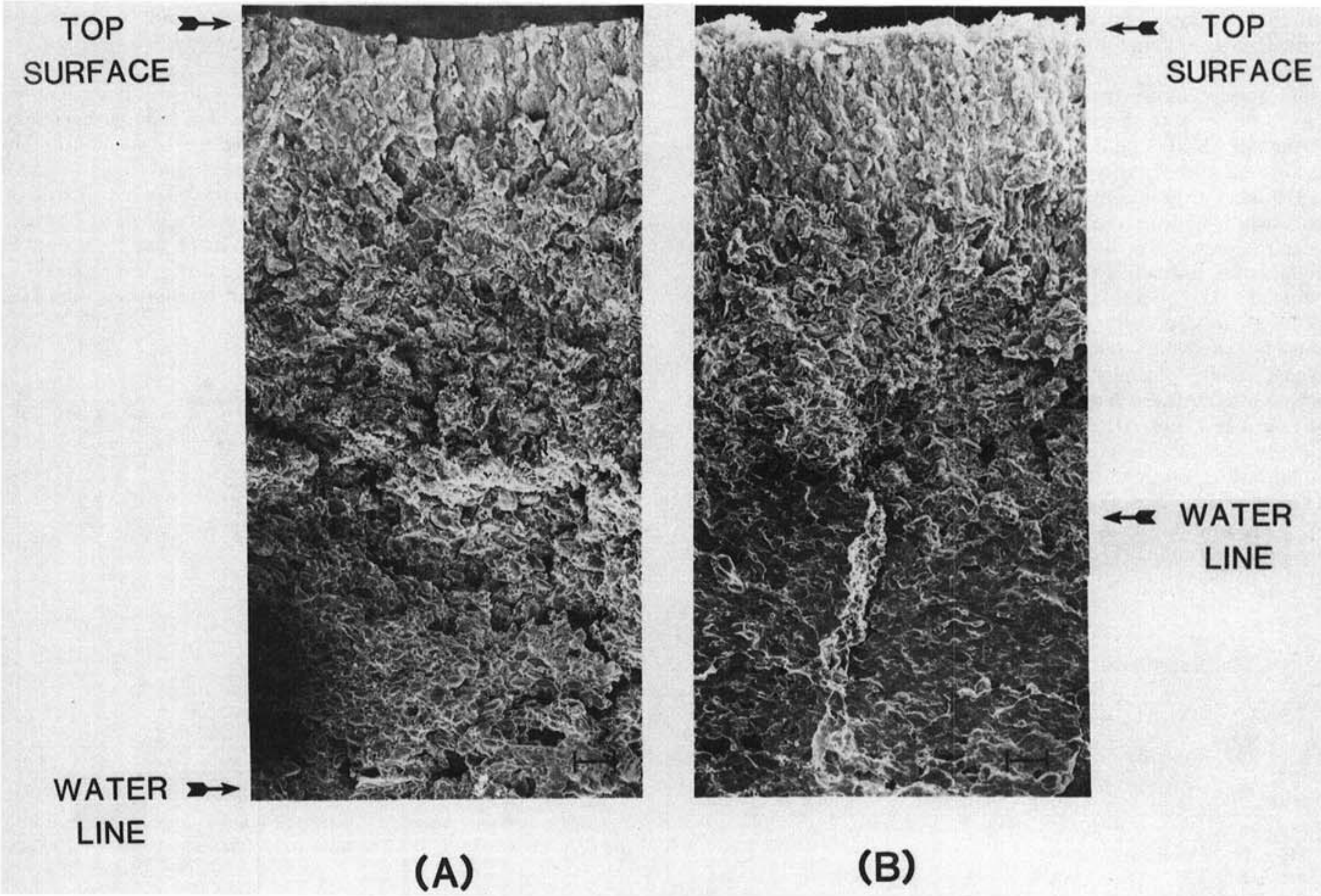

Fig. 5. Scanning electron micrographs of the cross sections of noodle strands cooked for 3 min. (**A**) Noodle from hard red winter flour containing 11.5% protein, and (**B**) from flour containing 14.3% protein. Scale bar indicates 20 μm.

TABLE VI
Effect of Flour Extraction on Noodle Properties[a]

Cultivar	Extraction (%)	Flour Protein[c] (%)	Uncooked Noodle Color	Uncooked Noodle Breaking Stress (g/mm^2)	Cooked Noodle[b] Cutting Stress (g/mm^2)	Cooked Noodle[b] Surface Firmness (g/mm)
Newton[d]	62.3	10.8	93.5	2,411	37.8	30.0
	66.0	11.0	90.5	2,485	35.4	26.3
	70.3	11.2	85.5	2,579	36.4	26.0
	73.9	11.2	83.0	2,509	34.6	28.1
	78.0	11.5	78.0	2,410	35.0	30.5
Centurk 78[d]	64.0	10.0	95.0	2,523	28.5	30.5
	66.5	10.0	93.5	2,442	27.7	32.5
	70.3	10.2	89.0	2,667	26.8	33.8
	74.9	10.6	83.0	2,442	28.9	35.6
	79.0	10.9	81.0	2,410	29.1	32.5
Stephens[d]	63.0	7.8	100.0	1,970	22.9	37.5
	66.5	7.9	99.0	2,080	22.8	30.9
	71.0	8.4	97.5	1,962	22.8	36.2
	75.0	8.5	96.0	2,015	23.8	37.5
	80.0	8.9	88.0	1,952	22.5	40.0
Daws[d]	62.8	7.8	98.0	2,100	29.1	45.0
	67.0	8.1	97.0	1,965	27.2	43.1
	71.6	8.5	94.0	2,056	26.8	42.5
	75.5	8.6	88.5	2,087	26.2	43.7
	79.5	8.9	86.0	2,041	29.1	46.9

[a] Optimum water absorption of each flour was independent of extraction rate; 30–32% for all flours.
[b] Optimum cooking time for noodles from each variety was: Newton, 12–13 min; Centurk 78, 11–12 min; Stephens and Daws, 9–10 min.
[c] 14% mb.
[d] Ash range for each variety was: Newton, 0.37–0.62; Centurk 78, 0.40–0.80; Stephens, 0.40–0.62; and Daws, 0.40–0.66.

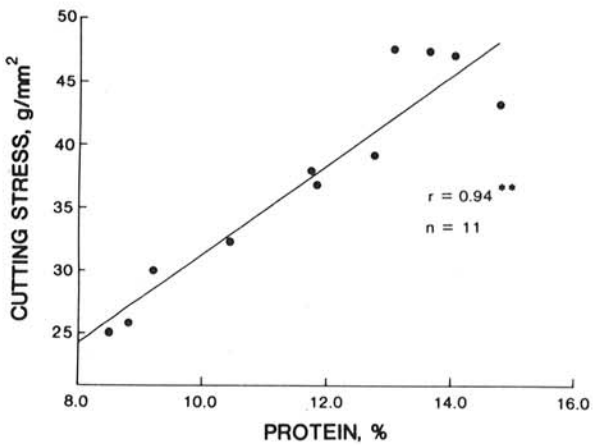

Fig. 6. Protein content of 11 location-composite flours from six Kansas hard red winter wheats and the cutting stress of cooked noodles.

developed more quickly at constant absorption than low-protein semolina. Although the correlation coefficient ($r = -0.65$) between protein and optimum water absorption in noodles was significant at the 5% level, much of the variation in absorption was not caused by the difference in protein content. Other variables that probably influence absorption include protein quality, starch damage, granulation, and pentosans.

The color of dry noodles darkened as protein content increased (Fig. 2). Moss (1971) and Miskelly (1984) have reported that flours with high protein give noodles that tend to be dark. Dexter and Matsuo (1978) used reconstitution studies to show that 90% of the protein in durum wheat has no effect on the brownness of pasta.

The dark color in pasta is associated with the fraction of protein insoluble in 0.005M acetic acid.

Flour protein may produce a tight noodle structure resulting from a strong adherence between starch and protein. Such a tight structure would cause uncooked noodles to appear translucent, resulting in less reflected light in high-protein noodles. This explanation was supported by the data on increased strength of the high-protein, uncooked noodles (Fig. 3).

The cooking time of hard wheat noodles increased linearly with protein content (Fig. 4). The thickness of noodles also varied with protein, but not linearly. Dry noodles with 8.5% protein were 1.4 mm thick; those with 15% protein were 1.7 mm. Apparently, the tight structure of a high-protein noodle retards moisture penetration into its core during cooking. Figure 5 shows two scanning electron micrographs of partially cooked hard wheat noodles containing 11.5 and 14.3% protein. After 3 min of boiling, the moisture has penetrated 40% farther into the low-protein noodle than the high-protein noodle. Low- and high-protein noodles had optimum cooking times of 13 and 16 min, respectively.

The internal firmness (cutting stress) of cooked, hard wheat noodles increased linearly with protein content. Figure 6 shows that protein content dominated the variation in internal firmness, and the correlation was highly significant. The same correlation is well known for cooked pasta (Dexter and Matsuo 1977, Matsuo et al 1972), using a "tenderness index" as the measure of force required to cut through spaghetti.

TABLE VII
Effect of Ball-Milling of Flour on Noodle Properties

Ball Milling (hr)	Starch Damage[a] (%)	Noodle-making Absorption[a] (%)	Uncooked Noodle: Color	Uncooked Noodle: Breaking Stress (g/mm²)	Cooked Noodle[b]: Cutting Stress (g/mm²)	Cooked Noodle[b]: Surface Firmness (g/mm)
Arkan						
0	9/1	29.0	87.0	2,511	32.4	37.2
8	11.2	30.0	87.0	2,850	31.4	34.5
16	13.1	30.5	87.0	2,571	27.1	31.6
24	16.0	32.0	87.0	3,000	27.9	30.4
OK 80268						
0	8.3	29.5	83.5	3,027	39.2	42.0
8	10.7	30.5	83.0	3,251	37.6	40.5
16	14.7	31.5	82.0	3,323	36.3	35.6
24	16.3	32.5	80.5	3,435	36.3	33.1
Oasis						
0	2.8	25.5	95.0	2,188	32.8	47.0
8	5.4	27.5	93.5	2,222	32.0	46.0
16	9.9	29.5	88.5	2,434	27.1	42.5
24	15.6	31.0	86.5	2,434	26.3	38.8
OH 185						
0	3.3	27.5	97.0	1,799	20.9	52.5
8	5.7	28.5	95.0	1,697	20.3	44.3
16	10.0	31.0	92.0	2,072	19.8	44.0
24	16.3	33.5	89.0	2,222	18.5	38.7

[a] 14% mb.
[b] Optimum cooking time for noodles from each variety was independent of ball-mill treatment: Arkan, 13 min; OK 80268, 15 min; Oasis, 13 min; and OH 185, 11 min.

TABLE VIII
Particle Size Distribution (Weight %) of Ball-Milled Flour Samples

Ball Milling (hr)	<15 (%)	15–20 (%)	20–38 (%)	38–53 (%)	53–75 (%)	75–106 (%)	>106 (%)
Arkan							
0	5.8	12.2	20.5	18.0	19.3	23.3	0.4
8	15.6	18.2	41.2	15.7	8.3	···	···
16	18.0	28.5	45.2	8.3	···	···	···
24	20.2	38.0	39.1	2.7	···	···	···
OK 80268							
0	3.3	5.7	23.5	18.2	20.1	28.6	0.6
8	10.7	19.3	34.2	24.0	8.8	3.0	···
16	15.5	26.5	35.1	12.5	10.4	···	···
24	19.7	32.3	44.2	3.8	···	···	···
Oasis							
0	2.3	18.5	27.9	10.1	9.0	27.8	4.4
8	11.7	42.3	37.5	8.5	···	···	···
16	17.5	44.5	38.0	···	···	···	···
24	20.0	52.3	29.7	···	···	···	···
OH 185							
0	2.0	20.5	35.2	8.4	7.4	22.0	4.5
8	7.1	27.0	30.6	7.9	6.8	17.6	3.0
16	14.5	40.5	40.9	4.1	···	···	···
24	21.0	39.9	39.1	···	···	···	···

TABLE IX
Particle Size Distribution (Weight %) of Pin-Milled Flour Samples

Granulation	<15 (%)	15–20 (%)	20–38 (%)	28–53 (%)	53–75 (%)	75–106 (%)	>106 (%)
Arkan							
Coarse[a]	5.8	12.2	20.5	18.0	19.8	23.3	0.4
Medium	10.3	16.0	25.1	19.0	16.5	12.9	0.2
Fine	15.7	27.3	38.4	11.9	6.7	···	···
Extra fine	22.5	30.5	41.6	6.4	···	···	···
OK 80268							
Coarse[a]	3.3	5.7	23.5	18.2	20.1	28.6	0.6
Medium	7.0	12.5	26.0	21.4	18.0	14.9	0.2
Fine	14.2	25.8	36.1	15.4	8.5	···	···
Extra Fine	19.6	34.3	36.3	9.8	···	···	···
Oasis							
Coarse[a]	2.3	18.5	27.9	10.1	9.0	27.8	4.4
Medium	4.5	31.0	37.7	9.5	8.5	8.6	0.2
Fine	5.0	53.0	37.5	4.5	···	···	···
Extra Fine	8.3	61.0	30.7	···	···	···	···
OH 185							
Coarse[a]	2.0	20.5	35.2	8.4	7.4	22.0	4.5
Medium	4.4	30.6	42.4	7.5	6.5	8.6	···
Fine	6.3	42.7	45.5	5.5	···	···	···
Extra fine	8.5	49.4	35.6	6.5	···	···	···

[a] Flour without pin-mill treatment.

TABLE X
Effect of Pin-Milling on Noodle Properties

Granulation	Starch Damage[a] (%)	Noodle-making Absorption[a] (%)	Uncooked Noodle: Color	Uncooked Noodle: Breaking Stress (g/mm²)	Cooked Noodle[b]: Cutting Stress (g/mm²)	Cooked Noodle[b]: Surface Firmness (g/mm)
Arkan (HRW)[c]						
Coarse[d]	8.1	29.0	87.0	2,511	32.4	37.2
Medium	8.5	30.0	88.0	2,635	32.5	37.5
Fine	11.4	30.0	87.5	2,892	31.1	36.2
Extra fine	13.0	32.5	85.0	2,997	29.0	36.2
OK 80268 (HRW)[c]						
Coarse[d]	8.3	29.5	83.5	3,027	39.2	42.0
Medium	8.5	30.0	83.5	3,254	40.6	40.6
Fine	11.3	30.5	81.0	3,330	38.5	45.6
Extra fine	13.3	32.0	82.5	3,386	37.7	45.6
Oasis (SRW)[c]						
Coarse[d]	2.8	25.5	95.0	2,188	32.8	47.0
Medium	3.0	25.5	93.7	2,250	33.3	43.1
Fine	3.9	26.0	93.5	2,330	34.7	45.4
Extra fine	4.7	27.5	95.0	2,201	35.1	44.4
OH 185 (SRW)[c]						
Coarse[d]	3.3	27.5	97.0	1,799	20.9	52.5
Medium	3.5	27.8	93.0	2,003	20.0	47.5
Fine	3.9	28.0	99.5	2,150	21.6	49.4
Extra fine	5.1	29.5	97.0	2,188	22.3	48.1

[a] 14% mb.
[b] The optimum cooking time for noodles from each variety was independent of flour granulation: Arkan, 13 min; OK 80268, 15 min; Oasis, 13 min; OH 185, 11 min.
[c] HRW = Hard red winter wheat, SRW = soft red winter wheat.
[d] Flours without pin-mill treatment.

The surface firmness of hard wheat noodles was not influenced significantly by protein content. Furthermore, 10 samples of soft wheat noodles with protein contents of 8.5–9.8% displayed considerable variability in surface firmness after cooking (data not shown). Dexter et al (1983) reported surface stickiness of spaghetti was weakly related to semolina protein content. The factors controlling surface firmness of noodles remain to be defined.

Pure varieties of five leading Kansas wheats were composited from 11 locations, and the composites were milled into straight-grade flours of 72% extraction. Protein contents of noodles prepared from the five flours ranged from 11.1 to 11.9%. The data in Table III show that noodles from Centurk 78 gave the best overall quality. Noodles differed significantly in color, breaking stress, and strength of uncooked and cooked noodles. Newton, the most popular variety grown in Kansas, produced noodles with a relatively poor surface after cooking as compared to Centurk 78, the least popular of the five varieties.

Noodles also were made from straight-grade flour milled from 12 experimental varieties of HRW wheats grown throughout the Great Plains (Table IV). The data in Table IV also show that the differences in protein of the flours could not always account for the differences in noodle quality.

Even though, in our laboratory, most hard wheat noodles had a soft and mushy surface when cooked, two samples of HRW wheat flours gave cooked noodles with a smooth and firm surface. These two exceptions were the experimental varieties of hard wheats (NE 77682 and TX 79A2729) listed in Table V. Noodles from these two varieties gave high values of cutting stress, which is typical of hard wheats, and their cooked surfaces were as smooth and firm as the surfaces of the soft wheat noodles (OH 185 and Oasis, Table V) and unlike those of the hard wheat noodles (Centurk 78 and Newton, Table V).

Flour Extraction Rate Effects on Noodle Quality

Two hard wheats and two soft white wheats were milled to flour extraction rates between 62–80%, and the flours were made into noodles. With the exception of a decline in brightness (color), increasing extraction rate up to 80% did not have a detrimental effect on the breaking strength or firmness of the noodles (Table VI).

Effect of Ball-Milling and Pin-Milling of Flour on Noodle Quality

Prolonged ball-milling of flour increased starch damage (Table VII) and reduced the particle size for both hard and soft wheat flours (Table VIII). Pin-milling reduced the particle size for both types of wheat flour (Table IX). However, the level of starch damage increased only slightly for the two soft wheats but much more for the two hard wheats (Table X).

During noodle making, flours with high starch damage and small particle size required more absorption, and the uncooked noodles from those flours gave increased breaking stress. Starch damage, which increased fivefold in the ball-milled, soft wheat flours, was correlated with dark color in the soft wheat noodles (Table VII). Greater starch damage in ball-milled flours gave less firm noodles, as seen by their low values for cutting stress and surface firmness in Table VII. Starch damage probably caused higher swelling and softening in the cooked noodles.

Pin-milling soft wheat flour reduced particle size with a slight increase in starch damage (Table V). Noodles prepared from the pin-milled soft wheat flours showed some increase in internal firmness of the cooked noodles. However, the finely ground hard wheat flours, when cooked, gave weak noodles because of their high levels of starch damage. The effect of starch damage overshadowed the expected increase in strength due to fine grinding.

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