

# Characteristics of Noodle Flours from Japan<sup>1</sup>

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## ABSTRACT

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The compositions and physical properties of Japanese salt and alkaline noodle flours were contrasted and compared to those of flours from U.S. hard white and soft white wheats (HWW and SWW) and from Australian SWW wheats often segregated for salt noodles. The alkaline noodle flours averaged 11.5% protein, which was 3% higher than the salt noodle flours, and they had lower ash content (0.35 vs. 0.41%). Granulation of the salt noodle flours showed the same proportion of small particles (<38  $\mu\text{m}$ ) as in soft wheat flours but different levels of intermediate and large particles. The level of small particles was  $\approx 10\%$  greater in salt noodle flours than in the alkaline noodle flours. The alkaline noodle flours had  $\approx 8\%$  more fine particles and 2.5% more damaged starch than the HWW flours, which is consistent with fine grinding of hard wheat flour in the noodle flour. Starch damage also was higher in the salt noodle flours (5.3%) than in the SWW flours. The salt noodle flours had a higher

sodium dodecyl sulfate (SDS) sedimentation volume and a higher gluten index than the SWW flours from the United States. The SDS volume and gluten index were lower for the alkaline noodle flours than for the HWW flours, showing the preference for a mellow gluten of low-intermediate strength in alkaline noodle flour. Mixograph data also supported the conclusions of mellow gluten in alkaline noodle flour. The swelling powers (1.7% at 92.5°C) for Australian SWW, salt noodle, U.S. HWW, U.S. SWW, and alkaline noodle flours, were 19.4, 18.1, 17.0, 16.1, and 15.8 g/g, respectively, showing the preferences for high- and low-swelling starch, respectively, in the salt noodle and the alkaline noodle flour. A similar order of flour swelling was indicated by peak viscosity of flours heated at 12% solids in starch paste viscosity analysis. Water holding capacity of flour was correlated highly ( $r = 0.95$ ,  $P < 0.01$ ) with swelling power, both measured at 1.7% flour solids at 92.5°C.

Both protein and starch in wheat flour are known to have important effects on the eating quality of Asian noodles. Baik et al (1994a) prepared salt noodles from 10 U.S. flours and two commercial noodle flours. They found high correlations of the chewiness of cooked noodles to protein content ( $r = 0.92$ ) and also to sodium dodecyl sulfate (SDS) sedimentation volume ( $r = 0.93$ ), which is known to be associated positively with protein quantity and "strength" (Axford et al 1979). Those workers noted that both protein quantity and quality were involved in the eating quality of Japanese salt noodles. Oh et al (1985) compared the properties of salt noodles made from a soft and a hard wheat at a similar protein content. The hard wheat gave noodles with a darker color, higher cutting stress, and lower surface firmness, confirming differences beyond protein content. Flour for alkaline noodles contained more protein (10.5–12%) than that for Japanese salt noodles (8–10%), and protein quantity and quality were correlated highly with noodle quality (Huang and Morrison 1988, Baik et al 1994a, Nagao 1996).

The preferred texture of cooked salt noodles in Japan and Korea is associated with starch swelling and gelling properties (Seib 1997). Konik et al (1992) measured the pasting properties of starches isolated from 42 Australian wheat flours in relation to the eating texture of Japanese salt noodles. Significant positive correlations were found between the eating quality of noodles (softness and elasticity) and pasting temperature, pasting peak, and breakdown of starch pastes in the amylograph. Those findings confirmed previous observations that a high hot-paste peak (Moss 1980, Crosbie et al 1990, Crosbie 1991); a low pasting temperature (Nagao et al 1977, Endo et al 1988); and a high hot-paste breakdown (Oda et al 1980)

were associated with superior eating quality of Japanese salt noodles. The Rapid Visco-Analyser (RVA) (Newport Scientific Ltd., Warriewood, Australia) also has been employed to test the pasting properties of starch or flour, and the RVA pasting peak of flour or starch was correlated positively with overall texture score of cooked noodles (Panozzo and McCormick 1993, Batey et al 1997, Morris et al 1997a). Konik et al (1994) examined the relationships of starch properties, RVA paste viscosity, or swelling power (SP) from 23 Australian wheats to the eating parameters (smoothness and firmness) of alkaline noodles measured by a sensory panel. The smoothness of cooked noodles was correlated positively, but firmness correlated negatively, with RVA breakdown and SP.

The objectives of this research were to contrast the composition and physical properties of salt and alkaline noodle flours from Japan and to compare the flours to selected soft white wheats (SWW) from Australia and the United States and of hard white wheat (HWW) flours from the United States. When considering end-use properties, wheat breeders select hard wheats based on breadmaking quality. But if they wish to develop a dual purpose wheat for bread and Asian noodles, breeders then select wheats based on quality factors for both foods. Quality factors for noodles include the level and strength of protein, hardness of kernels, granulation of flour, and hot-water swelling properties of starch. Another important factor, the level of browning enzymes in noodle flours, was not addressed in this investigation.

## MATERIALS AND METHODS

### Flour Samples and Chemicals

A total of 28 flours was examined. Fifteen commercial flours came from two milling companies in Japan; nine were salt noodle flours, and six were alkaline noodle flours. Three laboratory flours were milled from Australian (SWW) cultivars Eradu, Gamenya, and Cadoux, all three of which have been segregated in Australian noodle wheats. The Australian wheats were milled in Perth on a Buhler pilot mill to 60% extraction rate by combining the three break flour streams with the three middling flours. Four flours were milled from SWW U.S. cultivars Blue Mountain, White Spear, Franken Muth, and a blend of Geneva and Houser (4:1, w/w) on a Buhler laboratory mill to 70% extraction rate at the USDA-ARS, Soft Wheat Quality Laboratory, Wooster, OH. Another SWW flour was milled (63% extraction rate) from an Idaho wheat at the Wheat Marketing Center, Portland, OR. Two HWW flours were milled from Arlin and Rio Blanco cultivars on a Brabender Quadrumat Sr. experimental mill to 73 and 61% extraction rates, respectively, at the

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Grain Marketing and Production Research Center, USDA-ARS, Manhattan, KS. Three HWW flours were milled ( $\approx 63\%$  extraction rate) from three samples of Klasic from different harvest years at the Wheat Marketing Center.

Lactic acid (98% in purity) and SDS (99% in purity) were obtained from Sigma Chemical Co. (St. Louis, Mo). All other chemicals were analytical reagent-grade.

### General Methods

Protein ( $N \times 5.7$ ) was determined by a nitrogen determinator (Leco Corp., St. Joseph, MI). Ash, moisture, flour color, damaged

starch, and falling number were measured by Approved Methods 08-01, 44-15A, 14-30, 76-31, and 56-81B (AACC 1995). All assays were duplicated.

Particle size distribution of flour (50 g) was determined with an air jet (model A200LS, Alpine Co., Augsburg, Germany) on sieves with openings of 38, 53, 75, 106, and 125  $\mu\text{m}$ . The percentages of the fractions were determined from the weights of the overs on the sieves. This analysis was performed in duplicate.

A mixogram for each flour sample (10 g, 14% mb) was obtained on a 10-g bowl mixograph (National Manufacturing Co., Lincoln, NE) at optimum water absorption using Approved Method 54-

**TABLE I**  
Properties of Wheat Flours<sup>a</sup>

Flour	Composition (%; 14% mb)			Falling Number (sec) <sup>b</sup>	Extraction Rate (%)	Color <sup>c</sup>
	Protein	Ash	Starch Damage			
Japanese salt noodle ( $n = 9$ )	8.8d <sup>d</sup>	0.41c	5.3b	428	...	97a
Japanese alkaline noodle ( $n = 6$ )	11.5a	0.35d	7.8a	422	...	93b
Australian soft white wheat						
Eradu	9.2	0.41	2.4	452	60	97
Gamenya	9.2	0.44	2.6	411	60	98
Cadoux	9.1	0.41	2.5	440		97
Mean	9.2c	0.42bc	2.5d	434		97a
U.S. soft white wheat						
Idaho	10.2	0.46	5.6	427	63	91
Blue Mountain	9.0	0.46	3.9	421	70	87
White Spear	9.1	0.46	3.7	435	70	93
Franken Muth	8.1	0.40	1.5	423	70	94
Geneva-Houser (4:1)	8.6	0.46	1.2	471	70	93
Mean	9.0cd	0.45a	3.2c	436		92b
U.S. hard white wheat						
Arlin	10.3	0.45	4.9	540	73	89
Rio Blanco	9.8	0.37	5.1	451	61	88
Klasic 1	10.9	0.47	4.4	436	$\approx 63$	88
Klasic 2	8.9	0.49	6.8	492	$\approx 63$	91
Klasic 3	12.1	0.44	5.5	463	$\approx 63$	90
Mean	10.4b	0.44ab	5.3b	476		89c
LSD <sup>e</sup>		0.03	0.2	33		1

<sup>a</sup> Data are averages of two replicates.

<sup>b</sup> Calculated on 14% mb.

<sup>c</sup> Brightness determined by Agtron.

<sup>d</sup> Values followed by different letters in the same column are significantly different ( $P < 0.01$ ).

<sup>e</sup> Least significant difference for 28 samples ( $P < 0.05$ ).

**TABLE II**  
Swelling Power, Water Holding Capacity, and Pasting Properties of Wheat Flours<sup>a</sup>

Flour	Swelling Power (g/g)	Water Holding Capacity (g/g)	Rapid Visco-Analyser Measurements (RVU)		
			Peak	Breakdown	Final
Japanese salt noodle ( $n = 9$ )	18.1b	12.8b <sup>b</sup>	188b	84b	191b
Japanese alkaline noodle ( $n = 6$ )	15.8d	10.7d	166d	75c	186c
Australian soft white wheat					
Eradu	19.2	14.3	209	78	202
Gamenya	19.4	14.3	201	90	194
Cadoux	19.6	14.5	202	84	197
Mean	19.4a	14.4a	204a	84b	198a
U.S. soft white wheat					
Idaho	16.8	12.1	190	84	193
Blue Mountain	15.0	10.6	123	35	184
White Spear	17.3	12.7	189	73	201
Franken Muth	16.7	12.0	190	72	202
Geneva-Houser (4:1)	14.9	11.1	180	60	204
Mean	16.1d	11.7c	174c	65d	197a
U.S. hard white wheat					
Arlin	14.2	10.4	191	62	206
Rio Blanco	17.5	11.9	156	106	107
Klasic 1	17.9	12.5	185	99	174
Klasic 2	17.8	12.5	192	93	189
Klasic 3	17.6	12.4	195	90	192
Mean	17.0c	11.9c	184b	90a	174d
LSD <sup>e</sup>	0.3	0.2	4	2	7

<sup>a</sup> Data are averages of two replicates.

<sup>b</sup> Values followed by different letters in the same column are significantly different ( $P < 0.01$ ).

<sup>c</sup> Least significant difference for 28 samples ( $P < 0.05$ ).

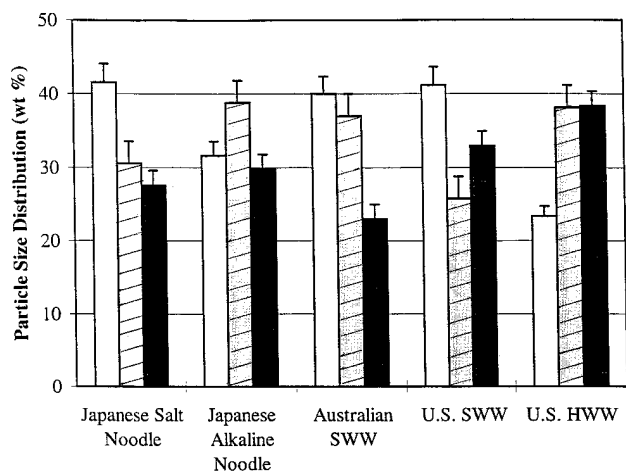
40A(Finney and Shogren 1972) (AACC 1995). Optimum absorption was determined by narrowing of the mixogram curve for a slack dough or wild swings for a stiff dough, mixing tolerance, and dough strength by the stability and width of a mixogram. A strong elastic dough was rated 6 on a scale of 0–6.

### Swelling Power and Water Holding Capacity (WHC) of Flour

Swelling power (SP) was assessed on flour in water (30 mL) at 92.5°C by the method of Crosbie (1991), except the sample size was 0.5 g (db) and the quenching step in an ice bath was eliminated. After centrifugation, SP was calculated as the weight of gel divided by the original dry weight of flour less soluble dry matter. Water holding capacity (WHC) was determined by the same method as flour SP, without correcting for solubles in the supernatant. All tests were duplicated.

### Pasting of Flour in an RVA

Pasting properties of flour (3.5 g, 14% mb) in water (25.0 mL) were measured in RVA units (RVU) according to the method of Panozzo and McCormick (1993) with some modifications. The

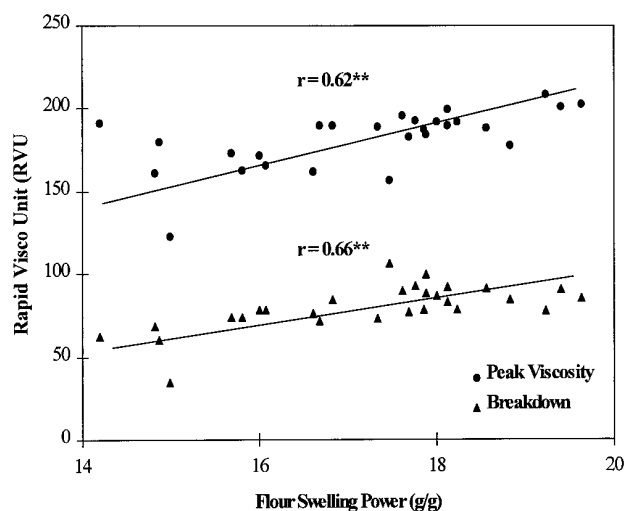


**Fig. 1.** Particle size distributions (wt %) of flours averaged for nine Japanese salt noodle flours, six Japanese noodle flours, three Australian soft white wheat (SWW) flours, five U.S. SWW flours, and five U.S. hard white wheat (HWW) flours (small <38 μm and large >75 μm). Small, medium and large indicated by white, striped, and black bars, respectively.

flour suspension was held at 50°C for 2 min and heated to 95°C at the rate of 5.6°C/min. The hot paste was held at 95°C for 4 min, cooled to 50°C at the rate of 9°C/min, and then held at 50°C for 4 min. Parameters read from RVA curves were peak viscosity, breakdown, final viscosity, and pasting temperature. Breakdown was defined as the difference in consistency from the peak to the lowest value occurring after the peak. This analysis was replicated twice.

### Sedimentation Volume and Gluten Tests

The SDS-sedimentation volume of flour was measured as described by Axford et al (1979), except that flour was weighed on a constant protein (0.3 g) basis (Baik et al 1994b). Wet and dry gluten contents of flour were determined by method 137 of the International Association for Cereal Science and Technology (ICC 1986) using the Glutomatic 2200 system (Falling Number Co., Huddinge, Sweden). After the wet gluten was centrifuged, the percentage of wet gluten remaining on the sieve to the total wet gluten was defined as gluten index. The amount of gluten protein recovered from flour was expressed as the percentage of dry gluten, divided by the protein content on a dry basis. All tests were done in duplicate.



**Fig. 2.** Relationship between swelling powers (1.7% flour at 92.5°C) and peak viscosities or breakdowns of 28 wheat flours measured in Rapid Visco-Analyser units.

**TABLE III**  
Mixograph Data on Wheat Flours<sup>a</sup>

Flour	Absorption (%)	Mix Time (min)	Tolerance <sup>b</sup>
Japanese salt noodle ( <i>n</i> = 9)	61.4	4.0	3
Japanese alkaline noodle ( <i>n</i> = 6)	68.1	4.1	4
Australian soft white wheat			
Eradu	61.4	3.8	2
Gamenya	60.8	2.8	2
Cadoux	61.3	3.4	2
Mean	61.2	3.3	2
U.S. soft white wheat			
Idaho	62.8	3.1	2
Blue Mountain	60.5	2.4	1
White Spear	61.5	2.6	1
Franken Muth	56.2	3.4	1
Geneva-Houser (4:1)	58.9	2.3	1
Mean	60.0	2.8	1
U.S. hard white wheat			
Arlin	62.7	5.6	5
Rio Blanco	67.6	4.5	4
Klasic 1	62.9	6.1	5
Klasic 2	62.6	6.8	6
Klasic 3	64.1	5.6	5
Mean	64.0	5.7	5

<sup>a</sup> Mixograph water absorption is expressed as % flour weight on 14% mb.

<sup>b</sup> Scale ranged from 0 (weakest) to 6 (strongest or most elastic) with 4 considered satisfactory for hard winter wheat flours.

## Statistical Analysis

Data were analyzed with statistical software (SAS Institute, Cary, NC) using analysis of variance (ANOVA), Fisher's least significant difference (LSD), Pearson correlation coefficient ( $r$ ), and general linear model (GLM).

## RESULTS AND DISCUSSION

### Flour Protein, Ash, and Color

The salt noodle flours contained 8.5–9.0% protein with a mean of 8.8%, which was similar to or slightly lower than the mean protein levels in flours from the SWW (Table I). On the other hand, the alkaline noodle flours had a higher mean protein level (11.5%) than all the flours except for one sample of Klasic (12.1%). Salt noodles in Japan often are made of flours with 8–10% protein content (Nagao 1996), whereas alkaline noodles are made from flours with 10–13% protein (Moss 1982, Miskelly 1996). Miskelly and Moss (1985) reported that flour with protein <9.5% gave Cantonese (alkaline) noodles with unsatisfactory eating quality. All the flours in the present investigation showed a falling number >350 sec (Table I), indicating that they were from sound wheats.

The average ash content of salt noodle flours (0.41%) was similar to that of the Australian flours (0.42%) but was higher than that of the alkaline noodle flours (0.35%) (Table I). Nagao (1995) reported that flours for alkaline noodles are selected to a low extraction rate ( $\approx 60\%$ ) giving 0.33–0.38% ash, whereas flours for salt noodles are selected at a slightly higher rate ( $\approx 65\%$ ) with 0.36–0.40% ash. Color and eating texture are the two most important quality factors for Asian noodles. Low ash flours are needed to achieve bright color in noodles. The three flours from Australian SWW exhibited higher Agron brightness values than the U.S. SWW flours (Table I), perhaps in part because of the lower extraction rate. Nemeth et al (1994) previously reported that flours from Australian soft wheats had higher brightness than those from the U.S. and from Canadian soft wheats. On average, the salt noodle flours showed similar brightness to the Australian flours, whereas the alkaline noodle flours had lower brightness (Table I). According to Miskelly (1984), soft wheats produced brighter flour than hard wheats, which agrees with the alkaline noodle flours being milled from predominantly hard wheats. Color appeared to be influenced more by protein than by ash content

for the flours used in this investigation, because color displayed a better correlation with protein content than ash content ( $r = -0.49$  vs.  $r = -0.21$ ). Miskelly (1984) found that high protein levels in hard wheat flours gave dark flour color.

### Starch Damage and Granulation

High levels of damaged starch were found in the alkaline noodle flours with a mean of 7.8% (Table I), which was much above the starch damage level in the U.S. hard wheat flours (5.3%). These results indicate that the alkaline noodle flours had been subjected to fine grinding. It is also conceivable that the flours had been milled from extra hard kernels, or that the flours had been heat-treated to destroy enzymes. Figure 1 shows that the alkaline noodle flours indeed contained more fine particles ( $\approx 32\%$ ) compared to U.S. HWW flours ( $\approx 23\%$ ). Flours milled from the Australian and U.S. SWW contained the least damaged starch, as expected. Moss et al (1994) pointed out that a hard wheat flour with a high level of damaged starch was not acceptable for the production of alkaline noodles, because excess starch damage ( $\approx 11\%$  measured by Ap-

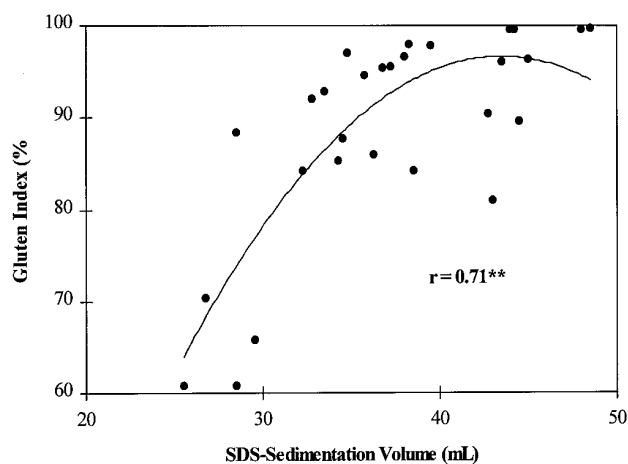


Fig. 3. Second-order correlation curve between SDS-sedimentation volumes and gluten indices of 28 wheat flours.

TABLE IV  
Sedimentation Volume, Gluten Content, and Gluten Index of Wheat Flours<sup>a</sup>

Flour	SDS Sedimentation Vol (mL)	Wet Gluten (%)	Dry Gluten (%)	Protein Recovered as Gluten (%)	Gluten Index (%)
Japanese salt noodle ( $n = 9$ )	36.3c <sup>b</sup>	25.4e	8.3d	81.1c	94.0b
Japanese alkaline noodle ( $n = 6$ )	32.7d	32.1	10.7a	80.5c	88.4c
Australian soft white wheat					
Eradu	44.5	27.5	9.8	91.6	89.6
Gamenya	42.8	29.7	10.0	93.0	90.4
Cadoux	43.5	28.0	9.3	87.7	96.2
Mean	43.6b	28.4b	9.7b	90.8a	92.1b
U.S. soft white wheat					
Idaho	43.0	32.8	10.3	87.3	81.0
Blue Mountain	25.5	26.9	8.9	85.6	60.9
White Spear	29.5	26.9	9.1	85.8	65.8
Franken Muth	26.8	25.4	8.6	91.5	70.4
Geneva-Houser (4:1)	28.5	25.2	8.6	86.0	60.8
Mean	30.7e	27.4c	9.1c	87.2b	67.8d
U.S. hard white wheat					
Arlin	44.3	26.1	9.7	80.8	99.6
Rio Blanco	45.0	24.8	8.4	73.7	96.4
Klasic 1	48.0	28.7	10.0	78.8	99.7
Klasic 2	44.0	20.8	7.2	69.2	99.5
Klasic 3	48.5	30.4	10.8	76.6	99.7
Mean	46.0a	26.2d	9.2c	75.8d	99.0a
LSD <sup>c</sup>	2.0	0.3	0.2	2.1	1.6

<sup>a</sup> Data are averages of two replicates.

<sup>b</sup> Values followed by different letters in the same column are significantly different ( $P < 0.01$ ).

<sup>c</sup> Least significant difference for 28 samples ( $P < 0.05$ ).

proved Method) produced noodles with a sticky surface or poor eating quality. The high starch damage may be an unfortunate consequence of the need for fine flour particles to facilitate hydration to form a smooth sheet of dough at low water addition to flour.

The starch damage levels of the salt noodle flours (mean = 5.3%) were elevated compared to the damage (2.5–3.2%) in the SWW flours, indicating that the salt noodle flour either had been subjected to fine grinding or that it contained finely ground hard wheat flour. Fine grinding would be expected to produce an increased level of fine particles, which was not found (Fig. 1). Salt noodle flour may contain club wheat flour, but damaged starch in club wheat flour equaled that in soft white wheat, at least for those from the U.S. Northwest (Lin and Czuchajowska 1996). Yet, adding hard wheat flour to the Australian SWW flour should reduce brightness, which was not found either (Table I). A significantly positive correlation ( $r = 0.67$ ,  $P < 0.01$ ) was found between the level of fine particles in all flours and brightness (data not shown), which is in agreement with previous work by Miskelly (1984). A fine granulation in a flour may increase the brightness and strength of dry noodles.

### Swelling and Pasting Properties of Flours

Many investigators have reported a relationship between the quality of Japanese salt noodles and hot-water swelling of wheat flour or starch (Endo et al 1989, Crosbie et al 1990, Crosbie 1991, McCormick et al 1991, Crosbie and Lambe 1993, Morris et al 1997b). As presented in Table II, SP and RVA data showed that the salt noodle flours swelled more than the alkaline noodle flours, which produced a high pasting consistency and increased breakdown in the RVA, as expected (Miskelly and Moss 1985, Konik et al 1992). The SP values of three Australian flours (19.2–19.6 g/g) were the highest among all the flours, and RVA peak viscosities, breakdowns, and final viscosities also were the highest. The average salt noodle flour displayed  $\approx 7$ –8% lower SP and RVA peak viscosity than the average Australian flour, whereas RVA breakdowns and final viscosities were similar. On the other hand, the average SP and RVA peak viscosity and breakdown of average alkaline noodle flour were lower than those of U.S. HWW flours (Table II). Other researchers (Baik et al 1994a, Wang and Seib 1996) have observed that some U.S. HWW flours had elevated SP, although the values were below those of Australian SWW flours.

Flour WHC differs from SP because it is calculated by not correcting for the water-solubles in the separated liquid phase. Flour SP was correlated highly ( $r = 0.95$ ,  $P < 0.01$ ) with WHC of flour, indicating that the solubles leached out of the starch granules did not differ between flours, in agreement with Crosbie et al (1992). Because WHC is a simple determination, it can replace SP to indicate starch swelling in noodle flours. Flour SP also had a negative correlation ( $r = -0.45$ ,  $P < 0.05$ ) with protein level, probably because of the inverse relationship between the protein and starch levels in flour. A significantly positive correlation ( $r = 0.62$ ,  $P < 0.01$ ) was found between the RVA peak viscosity and SP in various flours, and a slightly better correlation ( $r = 0.66$ ,  $P < 0.01$ ) was observed between the breakdown and SP (Fig. 2).

### Mixograph Characteristics

In mixograph studies, the average water absorption of the alkaline noodle flours was the highest among the flours examined (Table III). The mean of U.S. HWW flours was slightly below that of the alkaline noodle flours, but above that of all SWW flours. Water absorption of all flours was correlated positively with protein level ( $r = 0.77$ ,  $P < 0.01$ ) or positively with damaged starch level ( $r = 0.68$ ,  $P < 0.01$ ). Oh et al (1985) reported that salt noodle flours with high amounts of damaged starch absorbed more water during dough mixing, which caused uncooked noodles to break easily and cooked noodles to soften greatly. Mixing times for both types of noodle doughs were intermediate between hard and soft wheat doughs.

Mixograms indicated that the salt noodle flours gave weak doughs compared to the alkaline noodle flours, but they seemed somewhat stronger than those from the Australian flours (Table III). Flours milled from U.S. SWW and U.S. HWW wheats had the weakest and strongest dough mixing properties, respectively.

### Gluten Quality and Quantity in Flours

The SDS-sedimentation test was performed on a constant protein (0.3 g) in the flour samples. The sedimentation volume measured on wheat starches from three hard and three soft wheats, including one of the Australian white wheats showed no difference (data not shown). The alkaline noodle flours averaged 32.7 mL of sedimentation volume, which was below that of the salt noodle flours with a mean of 36.3 mL (Table IV). Apparently the strong bite of an alkaline noodle is caused not so much by the inherent strength of the protein in its flour as by its high level of protein plus the strengthening effect of sodium carbonate and bicarbonate (Terada et al 1978, Hosney and Brown 1983, Shelke et al 1990). The average sedimentation volume of salt noodle flours (36.3 mL) was higher than that of U.S. SWW flours (30.7 mL), except for the Idaho flour, but lower than that of the Australian flours (43.6 mL). Those results also indicate that salt noodle flour was not entirely from segregated Australian-SWW noodle wheat, and that mellow protein was chosen for alkaline noodle flour. As expected, the sedimentation volume was not correlated with protein content but with mixograph dough-mixing time ( $r = 0.60$ ,  $P < 0.01$ ). Similar results were obtained by Baik et al (1994b), who found a positive correlation ( $r = 0.61$ ,  $P < 0.01$ ) between the two parameters.

Australian SWW flours contained more wet and dry gluten than did the salt noodle flours but less than the alkaline noodle flours (Table IV). On average, the gluten fraction as a percent of total protein was greater in the Australian SWW flours (90.8%) than in the various flours, in agreement with elevated SDS sedimentation volume. A significantly positive correlation was observed between flour protein content and wet gluten content ( $r = 0.80$ ,  $P < 0.01$ ) or dry gluten content ( $r = 0.86$ ,  $P < 0.01$ ) in various flours.

Gluten index also estimates gluten strength. The average gluten index of the salt noodle flours (94.0%) was similar to that of Australian SWW flours (92.1%) but significantly higher than that of other soft wheat flours (67.8%) milled from U.S. SWW (Table IV). Interestingly, the mean of gluten index in the salt noodle flours was clearly higher than that in the alkaline noodle flours (88.4%), indicating again the inherent strength of the protein in the salt noodle flour and the mellowness of the gluten in alkaline noodle flour. According to Nagao (1995), flour with high protein (10.5–12%) but mellow gluten is suitable for alkaline noodles. Gluten index was correlated well with mixograph dough-mixing time ( $r = 0.68$ ,  $P < 0.01$ ), but no relationship was found with protein level. Also, gluten index had a highly positive correlation ( $r = 0.71$ ,  $P < 0.01$ ) with SDS-sedimentation volume (Fig. 3), suggesting that the sedimentation test indicated the differences in gluten quality.

## CONCLUSIONS

Japanese salt noodle flour contained 2–3% lower protein and somewhat higher ash content than Japanese alkaline noodle flour. Also, it had more fine particles, higher hot-temperature swelling starch, and higher SDS sedimentation volume per unit protein. The salt noodle flour appeared to be a mixture of mostly high-swelling soft wheat flour plus perhaps 10–20% of another flour as suggested by gluten strength data and elevated starch damage. The Australian soft white wheats gave high SDS sedimentation values compared to most U.S. soft wheats. Alkaline noodle flour may have been milled, with some fine grinding, from hard wheat that contained mellow gluten and low swelling starch. The sodium carbonate used to make alkaline noodles is known to strengthen dough and to increase its tolerance to overmixing. Apparently strong wheat flours give alkaline noodle doughs with poor sheeting properties.

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