

Relationship Between Protein Characteristics and Instant Noodle Making Quality of Wheat Flour

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ABSTRACT

Cereal Chem. 81(2):159–164

We investigated the relationship between the protein content and quality of wheat flours and characteristics of noodle dough and instant noodles using 14 hard and soft wheat flours with various protein contents and three commercial flours for making noodles. Protein content of wheat flours exhibited negative relationships with the optimum water absorption of noodle dough and lightness (L^*) of the instant noodle dough sheet. Protein quality, as determined by SDS sedimentation volume and proportion of alcohol- and salt-soluble protein of flour, also influenced optimum water absorption and yellow-blueness (b^*) of the noodle dough sheet. Wheat flours with high protein content ($>13.6\%$) produced instant noodles with lower fat absorption, higher L^* , lower b^* , and firmer and more elastic texture than wheat flours with low protein content ($<12.2\%$). L^* and free lipid content of instant noodles were >76.8 and $<20.8\%$ in

hard wheat flours of high SDS sedimentation volume (>36 mL) and low proportion of salt-soluble protein ($<12.5\%$), and <75.7 and $>21.5\%$ in soft wheat flours with low SDS sedimentation volume (<35 mL) and a high proportion of salt-soluble protein ($>15.0\%$). L^* of instant noodles positively correlated with SDS sedimentation volume and negatively correlated with proportion of alcohol- and salt-soluble protein of flour. These protein quality parameters also exhibited a significant relationship with b^* of instant noodles. SDS sedimentation volume and proportion of salt-soluble protein of flours also exhibited a significant relationship with free lipid content of instant noodles ($P < 0.01$ and $P < 0.001$, respectively). Protein quality parameters of wheat flour, as well as protein content, showed significant relationship with texture properties of cooked instant noodles.

Instant noodles have a distinctive flavor and texture due to unique processing, steaming, and frying, and to the residual oil in the noodles (Rho et al 1986). Instant noodles should have a porous spongy structure as well as pregelatinized starch through the steaming process (Wu et al 1998). During the frying process, many tiny holes are created as water is quickly dehydrated and replaced by oil on the surface of the noodles, serving as channel for water during cooking (Hou 2001). Frying and steaming processes can enable quick serving compared with other types of noodles, and the processes are important in governing the quality of instant noodles (Kim 1996).

Cooked instant noodles should have a relatively strong bite with a firm, smooth surface and good mouthfeel (Hou 2001). Because bright and light yellow color is usually popular with consumers, blended wheat flours, including dark northern spring, hard red winter, and Australian standard white wheats, are commercially used for making instant noodles in Korea and Japan (Kim 1996; Kubomura 1998). Instant noodles prepared from the flour of low protein content have exhibited higher fat absorption compared with instant noodles prepared from high protein content flours (Moss et al 1987). Although instant noodles have developed into a distinct category and are growing in demand, the influences of protein content and quality of flour on instant noodle characteristics, including color, fat absorption, and texture, have not been well documented. This study was conducted to investigate the effects of protein content and quality, as determined by SDS sedimentation volume based on constant protein weight and the proportion of alcohol- and salt-soluble protein, on instant noodle making quality of wheat flour.

MATERIALS AND METHODS

Materials

Fourteen wheat flours, including three club, three soft white spring (SWS), two soft white winter (SWW), four hard white (HW), and two hard red spring (HRS) wheats were obtained from the

Western Wheat Quality Laboratory (Pullman, WA). Wheat was milled using a Bühler experimental mill, and flour of 60% extraction was prepared by blending the millstreams. Two commercial wheat flours suitable for making udon noodles were obtained from Nissin Flour Milling (Tokyo, Japan). One commercial wheat flour suitable for making Korean dry noodles was provided by W. J. Park, U.S. Wheat Associates Seoul, Korea, through the Wheat Marketing Center (Portland, OR).

Analytical Methods

Moisture and protein content of wheat flour were determined according to Approved Methods 44-15A and 46-30 (AACC 2000). An SDS sedimentation test was performed according to the procedure of Axford et al (1979) with a constant protein (300 mg) basis. The proportion of salt-soluble and 50% 1-propanol-soluble protein of wheat flours were determined according to the procedures of Fu and Sapirstein (1996).

Making of Instant Noodles

Flour (100 g, 14% mb) was mixed with the optimum water absorption in a pin mixer (National Mfg. Co., Lincoln, NE) for 4 min. The optimum water absorption for noodle dough was determined by experienced personnel through trial and error, based on appearance of the dough and dough sheet, and handling properties of the dough sheet during the noodle-making process. The concentration of brine solution for making noodles with different absorption was adjusted to contain 1.71% sodium chloride, 0.09% sodium carbonate, and 0.09% potassium carbonate in the noodle dough. Dough was passed through the rollers of a noodle machine (Ohtake Noodle Machine Mfg. Co., Tokyo, Japan) at 8 rpm and a 3-mm gap. The noodle dough sheet was folded and put through the sheeting rollers. The folding and sheeting were repeated two more times. The dough sheet was rested for 1 hr and then put through the sheeting rollers six times at progressively decreasing gaps of 2.60, 2.33, 2.00, 1.75, 1.40, and 1.20 mm. After the last sheeting, the color of the noodle dough sheet was measured by a Minolta CM-2002 camera (Osaka, Japan) with an 11-mm measurement aperture. The color differences of noodle sheets were recorded as CIE-LAB L^* (lightness), a^* (redness-greenness), and b^* (yellowness-blueness) values. The noodle dough sheet was then cut through no. 20 cutting rolls with 1.50-mm grooves.

Fresh noodles were steamed at atmospheric pressure for 3 min and fried in vegetable oil at 148°C for 1 min. Thickness of instant noodle strands was measured by a micrometer dial thickness gauge

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(Peacock dial thickness gauge G, Ozaki Mfg. Co., Ozaki, Japan) in 10 replicates. An uneven surface condition of instant noodle strands presents a difficulty in color measurement using a color meter. To obtain a smooth surface for color measurement, instant noodle strands (15 g) were then ground with a mortar and pestle to pass through a sieve with 1.0-mm openings. Ground instant noodles were packed in a transparent plastic dish (35 mm diameter), covered with a lid, and inverted. The color of the ground instant noodles was measured through the transparent plastic dish using the Minolta CM-2002 spectrophotometer. Ground instant noodles were also used for determination of moisture and free lipid content. Free lipids were determined according to Approved Method 30-25 (AACC 2000).

Texture of Instant Noodles

Cooking time of instant noodles was determined by the method used for dry noodles, in which cooking time is usually determined by the point at which the white core disappears when cooked noodle strands are squeezed between a pair of glass plates (Oh et al 1983). Raw noodles (30 g) were cooked at the determined cooking time in 1,000 mL of boiling distilled water and then rinsed with cold water. Two replicates of cooked noodles were evaluated by texture profile analysis (TPA) using a TA-XT2 texture analyser (Stable Micro Systems, Haslemere, England) within 5 min after cooking. A set of five strands of cooked noodles was placed parallel on a flat metal plate and compressed crosswise twice to 70% of their original height, using a 3.175-mm metal blade at a speed of 1.0 mm/sec. From force-time curves of the TPA, hardness, springiness, and cohesiveness were determined according to the description of Park et al (2003).

Statistical Analysis

Statistical analysis of data was performed by SAS software (SAS Institute, Cary, NC) using Fisher's least significant difference procedure (LSD), analysis of variance (ANOVA), and Pearson's correlation coefficient. All data were determined at least in duplicate and all were averaged.

RESULTS AND DISCUSSION

Protein Content and Quality

Table I shows protein content and protein quality parameters of flour used for making instant noodles. Protein content was >13.6%

in hard white (HW) and hard red spring (HRS) wheat, except in Nuwest (10.9%), <12.2% in club, soft white spring (SWS), and soft white winter (SWW) wheat, and 10.1–10.8% in three commercial noodle flours. Park et al (2003) proposed the use of SDS sedimentation volume based on constant protein weight and the proportion of alcohol- and salt-soluble protein for effective evaluation of protein quality needed for making white salted noodles, because they were relatively independent of protein content. SDS sedimentation volume performed on a constant protein weight (300 mg) basis was 22.0–44.5 mL in club, SWS, and SWW wheat flours, and 31.5–46.0 mL in HW and HRS wheat flours. Sedimentation volumes of SWS wheat cvs. Alpowa and Vanna were exceptionally higher, while the SDS sedimentation volume of HW cv. IDO377S was only 31.5 mL, lower than that of many soft wheat flours. The proportion of alcohol-soluble protein was 45.5–54.1% in club and soft wheat flours, and 44.1–47.1% in hard wheat flours. While the proportion of salt-soluble protein was 15.0–19.2% in club and soft wheat flours, it was <13.8% in hard wheat flours, except in HW wheat cv. Nuwest. Protein quality parameters of commercial noodle flours were similar to those of many hard wheat flours.

Color of Noodle Dough Sheet of Instant Noodles

Table II shows optimum water absorption of noodle dough and color of the noodle dough sheet for instant noodles. Commercial noodle flours required 35% absorption to make uniform, smooth, and nonsticky dough. Optimum water absorption of noodle dough was 34–37% in club and soft wheat flours. Optimum water absorption of noodle dough was <35% in hard wheat flours. The L* value of the noodle dough sheet was 76.1–81.1 in club, soft, HW wheat flours, and commercial noodle flours, and <73.4 in HRS wheat flours. Similar trends in L* values of white salted noodles prepared from hard and soft wheat flours were reported by Park and Baik (2002). The a* value of the noodle dough sheet ranged from 0.7 to 1.1 in HRS wheat flours, higher than that of soft, club, and HW wheat flours. The b* value of the noodle dough sheets was >20.8 in club and soft wheat flour, except for Alpowa (17.3), and <20.2 in hard wheat flours and commercial noodle flours, except for Nuwest (20.9).

There were distinctive differences in b* values of instant noodle dough sheets among different classes of wheat, although Park and Baik (2002) previously reported no differences in b* value of the dough sheet for making white salted noodles between samples.

TABLE I
Protein Characteristics of Wheat Flours for Making Noodles^a

Class	Cultivar ^b	Protein (%)	SDS Sedimentation Volume (mL)	Proportion of Protein Fraction	
				Alcohol Soluble (%)	Salt Soluble (%)
Club	Calorwa	11.4	31.5	45.5	15.7
	Bruehl	8.9	27.0	48.7	18.9
	Hiller	8.2	22.0	49.7	19.2
SWS	Treasure	10.3	33.5	48.4	16.7
	Vanna	11.7	40.5	50.9	17.7
	Alpowa	8.9	44.5	44.2	16.7
SWW	Stephens	12.2	34.0	49.4	15.0
	OR939526	11.9	35.0	54.1	15.6
HW	Winsome	14.3	36.0	44.9	12.7
	Nuwest	10.9	35.5	46.3	15.8
	Klasic	14.9	40.0	44.1	10.9
HRS	IDO377S	13.6	31.5	47.7	13.8
	WA7839	16.9	44.0	46.6	12.6
	WPB926	17.5	46.0	45.8	12.5
Commercial	Com1	10.1	39.0	44.6	13.3
	Com2	10.2	38.5	43.5	13.2
	Com3	10.8	40.0	45.2	13.8
LSD ^c		0.04	1.59	2.66	0.61

^a Club, soft white spring (SWS), soft white winter (SWW), hard white (HW), and hard red spring (HRS) wheat flours, and three commercial flours. Results expressed on a dry weight basis.

^b Com1 and 2, commercial noodle flours from Japan; Com3, commercial noodle flour from Korea.

^c Least significant difference ($P = 0.05$). Differences between two means exceeding this value are significant.

The influence of alkali used in formulation, as well as the influence of flour characteristics on the b^* value of the noodle dough sheet has been reported by Miskelly (1984).

Optimum water absorption of noodle dough negatively correlated with protein content ($r = -0.913$, $P < 0.001$) and SDS sedimentation volume ($r = -0.596$, $P < 0.05$). The proportion of salt soluble protein showed a positive correlation with optimum water absorption of noodle dough ($r = 0.802$, $P < 0.001$). The influence of protein content and quality on the optimum water absorption of flours for making white salted noodles has also been reported by Oh et al (1986) and Park and Baik (2002). Optimum water absorption of noodle dough showed a significant relationship with b^* values of noodle dough sheets ($r = 0.588$, $P < 0.05$). The L^* value of noodle dough sheets generally decreased with an increase in water absorption in white salted noodles (Park and Baik 2002) and yellow alkaline noodles (Hatcher et al 1999; Morris et al 2000). However, there was no significant relationship between optimum water absorption and L^* value of the dough sheet of instant noodles. Optimum water absorption for making instant noodles for HW wheat cv. Klasic was much lower than for other flours. Klasic showed a lower proportion of alcohol- and salt-soluble protein than other hard wheat flours, although the protein content and SDS sedimentation volume of Klasic were lower than those of HRS wheat flours. This result indicates that protein quality also significantly affects the water absorption of dough for making instant noodles.

The L^* value of the noodle dough sheet exhibited a negative relationship with protein content ($r = -0.689$, $P < 0.01$), but no significant relationship between L^* value of noodle dough and protein quality parameters was found. SDS sedimentation volumes based on constant protein weight negatively correlated with b^* value of the noodle dough sheet ($r = -0.561$, $P < 0.05$). The proportion of alcohol- and salt-soluble protein exhibited a positive relationship with b^* value of the instant noodle dough sheet ($r = 0.747$, $P < 0.001$, and $r = 0.696$, $P < 0.01$, respectively), while no significant relationship between b^* value of noodle dough and protein content of flour was found. These relationships between protein characteristics of flour and color of dough sheet indicate that the L^* value of noodle dough may be mainly influenced by protein content, and that protein quality influences the b^* value of the noodle dough sheet. The relationship between color of noodle dough and protein content and quality of flours has also been

reported in white salted noodles (Oh et al 1985; Baik et al 1995; Yun et al 1996) and yellow alkaline noodles (Miskelly 1984; Miskelly and Moss 1985; Baik et al 1995).

Free Lipid Content and Color of Instant Noodles

Moisture content, free lipid content, and color parameters of instant noodles are summarized in Table III. Moisture content of instant noodles prepared from soft and hard wheat flours was 5.1–7.4%, lower than the moisture content (8–10%) of commercial instant noodles consumed in Korea and Japan (Kim 1996; Kubomura 1998). Thickness of instant noodle strands was 1.7–1.9 mm. Thickness of commercial instant noodle strands is generally ≈ 1.7 mm in Japan, and varies from 1.2 to 2.1 mm in Korea (Kim 1996; Kubomura 1998).

Free lipid content of instant noodles was 20.4–23.6% in club, SWS, and SWW wheat flours. SWS wheat cv. Vanna and two SWW wheat cultivars were relatively higher in protein content (Table I) and exhibited lower free lipid content than other soft wheat flours. Hard wheat flours generally showed lower free lipid content of instant noodles (<20.8%) than club and soft wheat flours, except for Nuwest and IDO377S. Free lipid content of instant noodles was 21.6% in Nuwest and 21.4% in IDO377S, higher than other hard wheat flours, probably due to their low protein content and quality (Table I). Nuwest had the lowest flour protein content, while IDO377S was lowest in SDS sedimentation volume among hard wheat flours. Three commercial noodle flours exhibited similar free lipid content of instant noodles (20.6–20.8%) to hard wheat flours, despite their low protein content (Table I). Comparable SDS sedimentation volume of commercial noodle flours to hard wheat flours (Table I) may be responsible for low free lipid content of instant noodles prepared from commercial noodle flours. Gore et al (1988) reported that the free lipid content of instant noodles varied 15–38%, with an average of 21%, in a survey of commercially available instant noodles from eight different countries.

Protein content negatively correlated with free lipid content of instant noodles ($r = -0.693$, $P < 0.01$), which is in agreement with the reports of Moss et al (1987) and Baik et al (1994). Wheat flours with low protein content produce instant noodle strands with coarse globules during the steaming process, which allows oil to easily penetrate through the noodle strands during the frying process (Moss et al 1987). SDS sedimentation volume and proportion of salt-soluble protein of flours also exhibited a significant relation-

TABLE II
Optimum Water Absorption and Color of Noodle Dough Sheets^a

Class	Cultivar ^b	Optimum Water Absorption (%)	CIE-Lab ^c		
			L^*	a^*	b^*
Club	Calorwa	35	77.4	-0.8	22.6
	Bruehl	37	79.8	-1.3	24.3
	Hiller	37	79.6	-1.4	23.7
SWS	Treasure	35	78.7	-0.6	20.8
	Vanna	34	76.1	-0.3	23.7
	Alpowa	36	80.8	-1.1	17.3
SWW	Stephens	35	77.2	-0.2	25.2
	OR939526	35	77.3	0.1	24.0
HW	Winsome	34	77.8	-0.1	17.9
	Nuwest	35	80.7	-0.4	20.9
	Klasic	31	81.1	0.4	14.9
	IDO377S	33	78.4	0.1	18.9
	WPB926	32	74.1	1.1	18.9
Commercial	Com1	35	81.1	-1.3	19.5
	Com2	35	80.8	-1.3	20.2
	Com3	35	80.5	-0.6	19.6
LSD ^d			0.45	0.45	0.62

^a Prepared from club, soft white spring (SWS), soft white winter (SWW), hard white (HW), and hard red spring (HRS) wheat flours, and three commercial flours for making noodles.

^b Com1 and 2, commercial noodle flours from Japan; Com3, commercial noodle flour from Korea.

^c L^* , lightness; a^* , redness-greenness; b^* , yellowness-blueness.

^d Least significant difference ($P = 0.05$). Differences between two means exceeding this value are significant.

ship with free lipid content of instant noodles ($r = -0.616$, $P < 0.01$ and $r = 0.794$, $P < 0.001$, respectively). Wheat flours with high protein content, high SDS sedimentation volume, and low proportion of salt-soluble protein, as observed in many hard wheat flours, may produce instant noodles with a smooth and compact structured surface during the steaming process, which lowers the fat absorption of instant noodles during the frying process. It is apparent that fat absorption of instant noodles is influenced not only by protein content, but also by protein quality of flour. High fat uptake of instant noodles during the frying process increases production cost and adversely affects the shelf life of instant noodles during storage (Moss et al 1987). Wheat flours with high protein content and high SDS sedimentation volume or low proportion of salt-soluble protein thus may produce instant noodles with a low free lipid content and decreased rancidity problems.

The L^* value of instant noodles was <76.4 in club and soft wheat flours. Hard wheat flours generally showed higher L^* value of instant noodles (>76.4) than soft wheat flours. There were distinct differences in b^* values of instant noodles between soft and hard wheat flours. The b^* value of instant noodles was >22.3 in club and soft wheat flours, except for SWS wheat cv. Alpowa (20.5). Hard wheat flours showed b^* values of instant noodles <19.2 , except for HW wheat cv. Nuwest. A relatively high b^* value (22.6) of instant noodles in Nuwest was probably due to its

low protein content. L^* value of instant noodles prepared from commercial noodle flours was 78.0–79.7, comparable to hard wheat flours, and the b^* value of commercial wheat flour (20.4–20.9) was higher than for hard wheat flours, but lower than in soft wheat flours, despite their similarity to soft wheat flour protein content. There was no significant difference in a^* value of instant noodles among various types of wheat flours.

The relationship between protein characteristics and instant noodle color is illustrated in Fig. 1. Although protein content showed a negative relationship with L^* value of the noodle dough sheet, protein content exhibited a positive relationship with L^* value of instant noodles. This was probably caused by additional processing, including steaming and frying, as well as oil absorption by the instant noodles. Protein content negatively correlated with b^* value of instant noodles. The discrepancy in the relationship between the color of instant noodle dough and noodles with protein content of flour indicates that steaming and frying processes have a large effect on the color of instant noodles. Wheat flours with high protein content produced instant noodles with lower fat absorption, higher L^* value and lower b^* value compared with wheat flour with low protein content.

L^* value of instant noodles also positively correlated with SDS sedimentation volume and negatively correlated with the proportion of alcohol and salt soluble protein of flour (Fig. 1). The b^*

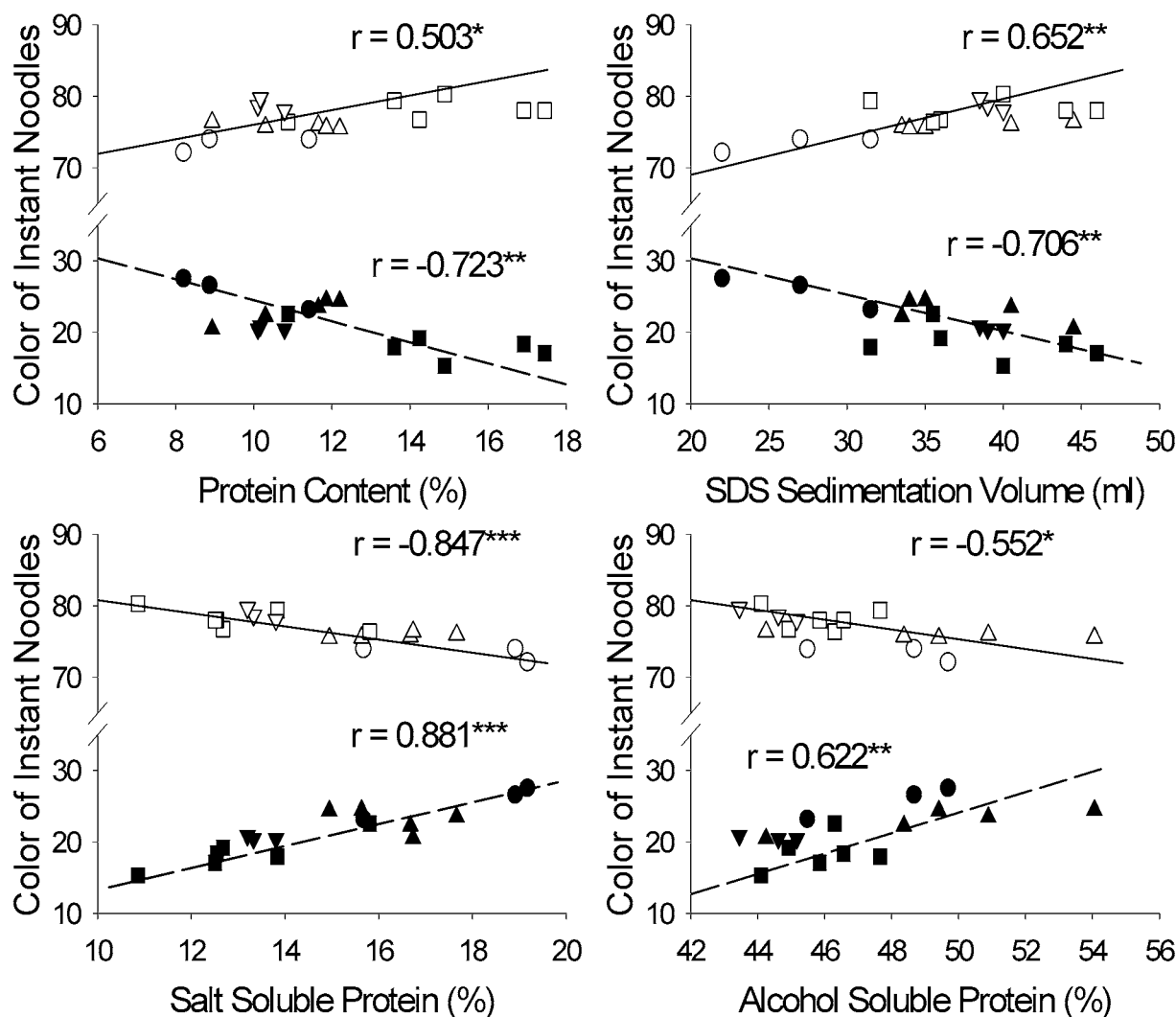


Fig. 1. Relationships between protein characteristics, and L^* value (continuous lines and open symbols) and b^* value (dashed lines and filled symbols) of instant noodles. Club wheat (○,●); soft white spring and winter wheat (△,▲); hard white and red spring wheat (□,■); commercial flours for making noodles (▽,▼).

value of instant noodles also exhibited a significant relationship with protein quality parameters. These relationships indicate that the color of instant noodles is affected by protein quality parameters, as well as protein content. Free lipid content of instant noodles related negatively with L* value and positively with b* value of instant noodles.

Cooking Time and Textural Properties of Instant Noodles

Cooking time and textural properties of instant noodles are summarized in Table IV. Cooking time of instant noodles was 6.0–7.5 min in club, soft wheat and commercial flours and 8.0 min in hard wheat flours, except for Nuwest (7.5 min). The estimated cooking time of bag-type commercial instant noodles was 7.0–7.5 min, although the suggested cooking time for commercial instant noodles is usually 4–5 min. Determining cooking time by squeezing the noodle strand and observing the disappearance of the white core

seems to overestimate the cooking time of instant noodles. Cooking time of instant noodles showed a positive correlation overall with protein content of flour ($r = 0.786$, $P < 0.001$). However, cooking time of instant noodles leveled off with more than 13.6% protein. This could have been caused by the unique processing conditions of instant noodles, including steaming and deep fat frying, which significantly decrease cooking time of noodles by creating numerous pores on the noodle strands. A positive relationship between protein content of flour and cooking time of noodles has also been found in white salted noodles (Oh et al 1985) and yellow alkaline noodles (Moss et al 1987). Cooking time positively correlated with SDS sedimentation volume ($r = 0.625$, $P < 0.01$) and negatively correlated with the proportion of salt soluble protein ($r = -0.680$, $P < 0.01$). These results indicate that both protein content and quality may influence the cooking time of instant noodles.

TABLE III
Moisture Content, Free Lipid Content, and Color of Instant Noodles^a

Class	Cultivar ^b	Moisture (%)	Free Lipid ^c (%)	CIE-Lab		
				L*	a*	b*
Club	Calorwa	6.5	22.3	74.0	0.1	23.2
	Bruehl	6.6	23.4	74.1	0.3	26.6
	Hiller	6.4	23.6	72.2	0.1	27.6
SWS	Treasure	5.1	22.8	75.7	0.1	22.3
	Vanna	7.2	20.4	76.0	-0.2	23.5
	Alpowa	6.1	23.5	76.4	-0.3	20.5
SWW	Stephens	7.0	21.5	75.5	0.5	24.4
	OR939526	6.0	21.4	75.6	0.4	24.4
HW	Winsome	6.4	20.5	76.8	-0.4	19.2
	Nuwest	6.0	21.6	76.4	0.4	22.6
	Klasic	6.0	20.3	80.3	-0.6	15.3
	IDO377S	6.5	21.4	79.4	-0.4	18.0
HRS	WA7839	5.2	20.8	78.0	-0.2	18.4
	WPB926	5.7	20.1	78.0	-0.1	17.1
Commercial	Com1	6.3	20.8	78.7	-0.3	20.5
	Com2	7.4	20.6	79.7	-0.7	20.9
	Com3	6.3	20.7	78.0	0.1	20.4
LSD ^d		0.09	0.32	0.63	0.10	0.48

^a Prepared from club, soft white spring (SWS), soft white winter (SWW), hard white (HW), and hard red spring (HRS) wheat flours, and three commercial flours for making noodles.

^b Com1 and 2, commercial noodle flours from Japan; Com3, commercial noodle flour from Korea.

^c Free lipid content of instant noodles expressed on a dry weight basis.

^d Least significant difference ($P = 0.05$). Differences between two means exceeding this value are significant.

TABLE IV
Cooking Time and Textural Parameters of Cooked Instant Noodles^a

Class	Cultivar ^b	Cooking Time (min)	TPA Parameters		
			Hardness (N)	Springiness (Ratio)	Cohesiveness (Ratio)
Club	Calorwa	7.5	3.00	0.83	0.55
	Bruehl	6.0	2.30	0.82	0.56
	Hiller	6.0	2.18	0.81	0.53
SWS	Treasure	7.5	2.83	0.85	0.57
	Vanna	7.5	2.90	0.86	0.60
	Alpowa	7.5	2.91	0.82	0.55
SWW	Stephens	7.5	2.97	0.86	0.60
	OR939526	7.5	3.07	0.86	0.60
HW	Winsome	8.0	3.72	0.89	0.63
	Nuwest	7.5	3.52	0.86	0.56
	Klasic	8.0	3.88	0.90	0.65
	IDO377S	8.0	3.65	0.91	0.62
HRS	WA7839	8.0	3.96	0.86	0.62
	WPB926	8.0	4.12	0.85	0.62
Commercial	Com1	7.0	2.93	0.87	0.62
	Com2	7.0	3.11	0.85	0.61
	Com3	7.0	3.12	0.88	0.63
LSD ^c		...	0.16	0.02	0.01

^a Prepared from club, soft white spring (SWS), soft white winter (SWW), hard white (HW), and hard red spring (HRS) wheat flours, and three commercial flours for making noodles.

^b Com1 and 2, commercial noodle flours from Japan; Com3, commercial noodle flour from Korea.

^c Least significant difference ($P = 0.05$). Differences between two means exceeding this value are significant.

TABLE V
Correlation Coefficients Between Parameters
of Cooked Instant Noodles

Parameters	TPA Parameters		
	Hardness	Springiness	Cohesiveness
Protein	0.904*** ^a	0.545*	0.676**
SDS sedimentation vol.	0.645**	0.293	0.552*
Salt-soluble protein	-0.845***	-0.724**	-0.857***
Alcohol-soluble protein	-0.382	-0.172	-0.261
Free lipid content	-0.730***	-0.727**	-0.882***

^a *, **, and ***, $P = 0.05, 0.01, \text{ and } 0.001$.

Instant noodles prepared from hard wheat flours generally exhibited harder and more elastic texture than those from soft wheat flours. Hardness of cooked instant noodles was 2.18–3.12 N in club, soft wheat flours, and commercial noodle flours, whereas hardness was >3.52 N in hard wheat flours. Springiness of cooked instant noodles was 0.81–0.86 in club and soft wheat, and 0.85–0.91 in hard wheat and commercial noodle flours. Cohesiveness from hard wheat flours was higher (0.62–0.65) than club and soft wheat flours (0.53–0.60), except for Nuwest (0.56). Cohesiveness of commercial noodle flours was similar to hard wheat flours. The aberration of Nuwest in springiness and cohesiveness of cooked noodles could have been caused by its low protein content (10.9%).

Table V shows the relationship between flour protein characteristics, free lipid content, and textural parameters of cooked instant noodles. Protein content positively correlated with hardness, cohesiveness, and springiness of cooked instant noodles. Protein quality parameters also exhibited a significant relationship with texture parameters of cooked instant noodles. SDS sedimentation volume of flour correlated positively with hardness of instant noodles. The proportion of salt-soluble protein of flour correlated negatively with all three textural parameters of cooked instant noodles. Baik et al (1994) also reported that both protein content and protein quality parameters were highly correlated with TPA parameters of instant noodles. Textural parameters of cooked instant noodles showed a negative correlation with free lipid content of instant noodles.

CONCLUSIONS

Both protein content and protein quality of wheat flours influence the characteristics of instant noodles, including fat absorption, color, and textural properties, as well as noodle dough properties, including water absorption and color of noodle dough. Instant noodles prepared from wheat flours with high protein content, high SDS sedimentation volume, and low proportion of alcohol- and salt-soluble protein exhibit bright color, low fat absorption during the frying process, and firm and elastic cooked noodle texture. Color of instant noodles and texture of cooked instant noodles are related to fat absorption, which is affected by steaming and frying processes, as well as protein characteristics of the flour.

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[Received May 27, 2003. Accepted July 31, 2003.]