Japanese Noodle Qualities. I. Flour Components

H. TOYOKAWA,[1] G. L. RUBENTHALER,[2] J. R. POWERS,[3] and E. G. SCHANUS[3]

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ABSTRACT

Four wheat flours (a commercial Japanese noodle flour, a soft white and a club wheat from the Pacific Northwest, and an Australian standard white wheat) varying in noodle-making quality were used to investigate the role of flour components. A fractionation and reconstitution interchange of gluten, primary starch, tailing starch, and water solubles was used to investigate the role of each in udon noodle quality. The primary and tailing starch fractions were found to be most responsible for noodle texture. Of the two, the primary starch fraction contributed the most to the desirable viscoelasticity of noodle texture.

Soft white wheat (soft white and white club) from the U.S. Pacific Northwest is exported for use in cakes, pastries, and noodles. Japan has continuously imported soft white wheat as the subclass western white wheat from the Pacific Northwest area for many years to produce flours for these products.

Japanese noodles have been developed over the years using domestic wheat, and such products have long been accepted by the Japanese (Nagao 1981). It has been reported that Australian standard white (ASW) is superior to western white (WW) wheat in noodle quality (Oda et al 1980).

It is difficult to express the preferred characteristics for Japanese noodles. However, noodle texture is probably most important followed by color, taste, surface appearance, and weight and volume upon cooking. For the evaluation of soft white wheat quality, a Japanese noodle testing method was developed and discussed by Nagao et al (1976). Recently, a new evaluation method for Japanese noodles was by the National Food Research Institute of the Ministry of Agriculture, Forestry, and Fisheries of Japan in cooperation with the Japanese Food Agency, Japanese Flour Millers Association, the flour milling industry, and other institutes related to wheat (*personal communication*, 1984). Few studies have been reported on noodle qualities. Shimizu et al (1958) investigated the physical properties of noodles, and Yasunaga and Uemura (1962) evaluated the color characteristics of flours used for noodle manufacturing. Moss (1971) investigated the color and cooking qualities of noodles. Other quality characteristics of interest are the weight and volume of the boiled noodles and their whiteness and/or brightness throughout processing. However, the most important characteristic of noodle acceptability is the texture (the eating quality). The evaluation of texture is subjective and presents many problems to quantify the cause-and-effect relationship of this property.

There is little information (Oh et al 1983, Oda et al 1980) about the quality factors of flour that govern the eating quality of Japanese noodles. Oh et al (1983) found that the protein content of flour influenced the chewiness of cooked noodles. Oda et al (1980) also reported that the characteristics of starch are very important to the eating quality of Japanese noodles.

A fractionation and reconstitution method used in evaluating wheat and flour quality related to breadmaking has been summarized by several researchers (Finney 1971, Hoseney and Finney 1971, MacRitchie 1985). The fractionation and reconstitution technique has been applied to various soft wheat quality studies (Donelson and Wilson 1960a,b; Oh et al 1985; Sollars 1956a,b; 1958a,b; 1961; 1969; 1973a; 1973b; Sollars and Rubenthaler 1971; Yamazaki 1955). However, most studies apply to the quality of wheat flour for cakes and cookies rather than for noodles.

Therefore, the objectives of this research were to find which component of flour most affects the quality of noodles, and to find component functional differences between Australian standard white wheat and soft white wheat in Japanese noodle characteristics.

[1]Research chemist, Showa Sangyo Co., Ltd., 2-20-2, Hinode Funabashi-shi, Chiba, 273 Japan.
[2]Research food technologist, USDA, ARS, Western Wheat Quality Laboratory.
[3]Associate professor, Dept. of Food Science and Human Nutrition, Washington State University, Pullman, WA 99164.

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MATERIALS AND METHODS

Flours

Four wheat flours were studied: Japanese noodle flour, Hoshizora (HZ); soft white winter (SW); white club (Club); and Australian standard white (ASW). The HZ flour was included to provide a reference for the other three flours throughout the study. The HZ flour was known to give excellent Japanese noodle quality. The varieties Stephens, Hill, and Daws were selected as representative of soft white winter wheat. They were blended in equal amounts and milled on a model MLU-202 pneumatic Buhler experimental mill to produce a 60% extraction flour. The varieties Moro, Crew, and Tyee, representative of white club, were similarly blended and milled. These wheats were collected from the 1986 crop at 14 locations in Washington, Oregon, and Idaho. Collectively, these SW and Club wheats represent more than 90% of the production in the region. Growing conditions were typical and harvest conditions were dry. A composite was made to simulate as closely as possible an average commercial lot of soft white and club wheat, which would be typical of that found in the market channels. Wheat (ASW) obtained from Australia (via Showa Sangyo Co., Ltd., Japan) is a nonspecific variety from nonspecific locations in Australia. ASW was milled to produce a 60% extraction flour.

Flour Fractionation and Reconstitution

Flour fractionation and reconstitution was accomplished by the procedure discribed by Finney (1943, 1971). The primary starch fraction was air-dried. The tailing starch, water-soluble, and gluten fractions were lyophilized. All fractions except the water-soluble fraction were ground using a Udy cyclone sample mill (Sollars 1969).

Reconstitution of Fractions

The fractions obtained were blended in the proportion represented in the original flour. For the interchange of fractions, flour blends were prepared by mixing one fraction of one flour with the other remaining fractions of a second flour (in proportion to the original content formula in the second flour) and noodles were made from the reconstituted flour.

Preparation of Noodles

Japanese noodles were prepared from each flour according to the following formula: 300 g of flour (14% moisture basis), 96 ml of water, 6 g of salt. These ingredients were mixed in a Hobart mixer for 6 min on slow speed. A dough sheet was passed through the rolls of an Ohtake noodle machine (Ohtake Noodle Machine Mfg. Co., Tokyo, Japan) at a 3-mm gap and then folded and put through the sheeting rolls again to combine the two layers. This operation was repeated once more. The dough sheet was then set aside to rest for 1–2 hr. The sheet was then put through the sheeting rolls three times at progressively smaller gap settings (2.83, 2.66, and 2.50 mm, respectively) to reduce the thickness of the sheet to 2.5 mm. The sheet was cut through cutting rolls (no. 10) into strips approximately 30 cm in length with a 0.30 × 0.25 cm cross section

Evaluation of Japanese Noodles

One hundred grams of wet noodle strips were cooked in at least 1,000 ml of boiling water for 23 min and then rinsed with cold water. Cooked noodles were scored for color, appearance, texture (hardness, visco-elasticity, and smoothness), and taste by 3–5 panelists in a sensory test conducted as specified by the National Food Research Institute (*personal communication,* 1984). Table I shows the criteria used to score the noodles. The sample noodles were evaluated against a freshly prepared control noodle (HZ). The higher the score the better.

A sensory test was performed to determine if the difference between ASW and SW noodles could be clearly differentiated statistically. The test included three samples of noodles that were made from ASW, SW, and a blend of ASW and SW (50:50) and were evaluated using a standard scoring method (Table I) seven to eight times by three well-trained panelists. The results were statistically analyzed by Duncan's multiple range test (SAS 1985c,e) where possible, otherwise the data from this study were statistically analyzed by Fisher's least significant difference procedure (LSD). It was not possible to replicate data in the fractionation and reconstitution study due to limited sample size, large numbers of combinations tested, and unavailability of trained panels for Japanese noodle characterization. However, sensory evaluation of cooked noodles made from five other flours was made three to four times. The LSD was then used as a guide to determine differences in the score of cooked noodles where only single determinations were available.

TABLE I
Scoring Values Used to Evaluate Japanese Cooked Noodles

Quality	Score	Scale: Good			Std	Poor		
Appearance								
Color[a]	30	30	27	24	21	18	15	12
Surface appeal[b]	20	20	18	16	14	12	10	8
Texture								
Hardness[c]	10	10	9	8	7	6	5	4
Viscoelasticity[d]	20	20	18	16	14	12	10	8
Smoothness[e]	10	10	9	8	7	6	5	4
Taste[f]	10	10	9	8	7	6	5	4
Total[g]	100				70			

[a]Brighter and whiter color is better, and slightly yellow color is acceptable. Red, brown, gray, or dull color is poor.
[b]The condition of noodle surface. Rough surface appearance of noodles is poor.
[c]Moderate firmness is good.
[d]Moderate viscosity and elasticity are good.
[e]Mouthfeel when noodles are eaten. Smoothness is good.
[f]Strange, bitter, or sour taste is poor.
[g]Sum of the score of each factor.

Analytical Methods

Protein (N × 5.70), moisture, and ash contents were determined by AACC approved methods (1983). A 10-g sample was used in the mixograph to determine physical dough mixing properties and water absorption according to the method of Finney and Shogren (1972).

Statistical Analyses

Data were statistically analyzed using Duncan's multiple range

TABLE II
Analytical Data for Flours

Flour[a]	Moisture %	Protein[b] % (14% mb)	Ash % (14% mb)	Mixograph: Absorption	Mixograph: Mix Time
HZ	13.5	8.18	0.35	58.0	3.75
ASW	12.4	8.56	0.41	60.0	3.50
SW	12.3	7.96	0.38	57.0	2.75
Club	11.4	8.95	0.40	57.5	2.25

[a]HZ, Japanese noodle flour standard, Hoshizora; ASW, Australian standard white wheat; SW, soft white winter wheat; Club, white club wheat.
[b]Protein: N × 5.70.

TABLE III
Evaluation of Cooked Noodles from Different Classes of Wheats

	HZ[a] ($n = 4$)	ASW[b] ($n = 21$)	A/S[c] ($n = 18$)	SW[d] ($n = 21$)
Color	21	19.00 a	19.94 a	20.43 b
Surface appeal	14	13.24	13.44	12.81
Hardness	7	6.52 a	5.81 b	5.67 b
Viscoelasticity	14	13.76 a	12.47 b	11.43 c
Smoothness	7	7.00	7.00	6.71
Taste	7	7.00	7.00	7.00
Total	70	66.52 a	65.67 a	64.05 b

[a]Reference wheat flour from Japan, Hoshizora.
[b]Australian standard white wheat.
[c]A/S, a blend of ASW and SW flours (1:1).
[d]Soft white wheat.
[e]Values followed by the same letter or no letter are not significantly different within each row (Duncan's multiple range test).

TABLE IV
Least Significant Difference of Noodle Scores and Factors Among the Wheats

Quality	HZ[a] ($n = 6$)	ASW[b] ($n = 3$)	SW[c] ($n = 4$)	Club ($n = 3$)	LSD1[d]	LSD2[e]
Color	21	20.67 a	19.50 a	19.33 a	2.54	2.38
Surface appeal	14	14.00 a	14.00 a	13.67 a	1.12	1.05
Hardness	7	7.67 a	5.50 b	5.33 b	1.07	1.00
Viscoelasticity	14	16.00 a	12.00 b	10.33 c	1.67	1.56
Smoothness	7	7.00 ab	7.00 a	6.67 bc	0.71	0.67
Taste	7	7.00	7.00	7.00	0.50	0.47
Total	70	72.33 a	65.00 b	62.33 c	2.75	2.58

[a]Reference wheat flour from Japan, Hoshizora.
[b]Australian standard white wheat.
[c]Soft white wheat.
[d]LSD1: Fisher's least significant difference ($\alpha = 0.05$) between mean scores except SW noodles.
[e]LSD2: Fisher's least significant difference ($\alpha = 0.05$) between the mean score of SW noodles and the others. Values with the same letter and no letter are not significantly different within each row at $\alpha = 0.05$ (Fisher's least significant difference).

test, analysis of variance, Pearson correlation coefficient, analysis of covariance, partial correlation, and polynomial regression with the SAS computer packages (Freund and Littell 1981, SAS 1985a–e).

RESULTS AND DISCUSSION

Differences in Quality of ASW and SW Noodles

Tests were performed to establish differences between ASW and SW noodles. The analytical data and the mixograph properties of ASW and SW flours are shown in Table II. The protein and ash contents of ASW and SW flours were normal and acceptable for making noodles. ASW flour has longer mixing time, more mixing tolerance, and 2% more water absorption than SW and club flours.

Significant differences between ASW and SW noodles were found for color, hardness, and viscoelasticity (Table III). Although the color score of SW noodles was higher than that of ASW noodles, the total score of SW noodles was significantly lower than that of ASW noodles because of poor viscoelasticity and hardness.

Interpretation of Sensory Evaluation

Means and LSDs of cooked noodle evaluations are shown in Table IV. These LSDs indicate differences in color, appearance, hardness, viscoelasticity, smoothness, taste, and total score that could be used as indicators of variability.

Noodle Quality Differences

Noodles were made using HZ, ASW, SW, and Club flours and reconstituted flours. The ratio and analytical data of each fraction of the flours are shown in Table V. Table VI shows the evaluation of cooked noodles made from the parent and reconstituted flours. All noodles exhibited similar trends of noodle quality differences (lower scores) between the noodles made from original flours and the noodles made from reconstituted flours. The largest difference in noodle quality was in texture. The noodles made from ASW had more desirable viscoelasticity than noodles made from SW and Club. This is the most desirable aspect of noodle texture in Japan (Nagao et al 1976; 1977a,b; Oda 1982; Oda et al 1980). The texture of SW noodles was firm and short (when chewed, a firmness with no elasticity is felt followed by a complete separation). However, Japanese prefer the opposite texture i.e., when noodles are chewed they want to feel a softness but also a springy resistance. The noodles made from Club flour were the least acceptable for this textural property.

The evaluation of cooked noodles from interchanged fractions is also shown in Table VI. Interchanging the gluten fraction of each wheat class with that of HZ resulted in a change in the cooked noodle color scores. However, this interchanging of the gluten fraction did not affect the texture (hardness and viscoelasticity) of cooked noodles except Club gluten fraction. The noodles made from interchanging the gluten fraction of Club with that of HZ were not good as shown by the low appearance score of 12.

Interchanging the primary starch and tailing starch fractions of each wheat class with that of HZ affected the texture of cooked noodles. The scores for viscoelasticity and hardness after interchanging the primary and tailing starch fractions from ASW

TABLE V
Yield Ratio and Analytical Data of Fractions

Flour	Fraction	Ratio (%) (14% mb)	SD[a]	Protein[b] (%)	Ash[b] (%)
Hoshizora	Gluten	10.10	0.73	62.2	0.21
	Primary starch	65.66	1.71	0.5	0.12
	Tailing starch	16.34	1.50	1.5	0.19
	Water-soluble	7.89	0.41	21.0	ND[c]
Australian standard white	Gluten	13.21	0.07	55.6	0.40
	Primary starch	66.68	0.29	0.4	0.14
	Tailing starch	13.58	0.35	1.2	0.18
	Water-soluble	6.53	0.00	13.4	ND
Soft white wheat	Gluten	11.62	0.44	56.6	0.35
	Primary starch	71.43	0.33	0.3	0.13
	Tailing starch	10.98	0.30	1.3	0.21
	Water-soluble	5.97	0.17	16.8	ND
White club wheat	Gluten	14.94	0.49	51.7	0.38
	Primary starch	70.42	0.13	0.4	0.15
	Tailing starch	9.32	0.24	1.6	0.21
	Water-soluble	5.33	0.12	18.8	ND

[a]Standard deviation of ratio.
[b]Protein (N × 5.70) and ash content are on a 14% moisture basis.
[c]Not determined.

TABLE VI
Evaluation of Cooked Noodles from Original and Reconstituted/Interchanged Fractions

Flours[a]	Color	Surface	Hardness	Visco-elasticity	Smoothness	Taste	Total Score
Original							
HZ	21.0	14	7	14	7	7	70.0
ASW	20.5	14	8	16	7	7	72.5
SW	19.0	14	5.5	12	7	7	64.5
Club	18.5	13	5.5	10.5	6	7	60.5
Reconstituted							
HZ (control)	18.5	14	6.5	12	7	7	65.0
ASW	18.5	14	7	12	7	7	65.5
SW	18.5	14	5.5	10	7	7	57.5
Club	16.0	13	5.5	9	7	7	57.5
Interchanged gluten in HZ							
ASW	16	14	6.5	12	7	7	62.5
SW	17	14	6	12	7	7	63.0
Club	17	12	5	12	6	7	59.0
Interchanged primary starch in HZ							
ASW	17	14	6.5	12.5	7	7	64.0
SW	18	14	5	11	7	7	62.0
Club	17	14	5.5	10.5	7	7	61.0
Interchanged tailings starch in HZ							
ASW	18	13	6.5	13	7	7	64.5
SW	18	13	6	12	7	7	63.0
Club	18.5	13	6	12.5	7	7	64.0
Interchanged water-solubles in HZ							
ASW	18	13	6.5	12	7	7	63.5
SW	18	13	6	12	7	7	63.0
Club	18	13	5.5	12	7	7	62.5

[a]HZ = Hoshizora, reference flour; ASW = Australian standard white; SW = soft white; Club = white club wheat.

with those of HZ were higher than those of the primary and tailing starch fractions from SW and Club (Table VI). The water-soluble fraction had the least influence on cooked noodle texture.

These results differ from those of Oh et al (1985), who concluded that the gluten fraction most influenced the cooked noodle strength and surface firmness and that the primary starch and water-soluble fractions did not affect any noodle quality factors. They found that the tailing starch fraction was responsible for the color difference and dry noodle strength. In their study they used hard red winter wheat to make dry noodles; it is probable that protein quality and quantity and starch quality differ from those of soft white wheat.

Our interchange studies suggest that both the primary and tailing starch fractions are important in noodle texture (viscoelasticity and hardness). To investigate which of these fractions was the most important to cooked noodle viscoelasticity, the primary and tailing starch from ASW (good source) was interchanged with that of SW (poor source). Switching the primary and tailing starch fractions from SW to ASW caused the viscoelasticity scores to increase from 8 to 13–14 (Table VII). These results indicated that the starch fractions of SW were responsible for the poor textural (viscoelastic) property of noodles. It also confirmed that the starch fractions rather than the gluten fraction was the most important factor in determining quality for Japanese style noodles.

After observing the effect of the interchange of the primary and tailing starch fractions, 20% of the primary starch fraction was replaced with equal weights of tailing starch fraction. As the primary starch level of ASW was increased, the texture of noodles became more desirable in terms of viscoelasticity (Table VIII). On the other hand, as the level of tailing starch fraction of ASW was increased, the noodles had poorer viscoelasticity (12 vs. 11). The trend was similar to that observed in Table VII when the primary and tailing starch fractions from ASW were interchanged with SW.

TABLE VII
Evaluation of Cooked Noodles of Interchanged Flour Fractions Between Australian Standard White (ASW) and Soft White Wheat

		Reconstituted		Interchanged Fraction[b]		
Parameter	**HZ[a] Control**	**HZ**	**Soft White**	**P-ASW**	**T-ASW**	**PT-ASW**
Fractions						
Gluten	···	HZ	SW	SW	SW	SW
Primary starch	···	HZ	SW	ASW	SW	ASW
Tailings starch	···	HZ	SW	SW	ASW	ASW
Water-soluble	···	HZ	SW	SW	SW	SW
Evaluation						
Color	21	21	20	21	21	21
Surface appeal	14	14	14	14	14	14
Hardness	7	7	5	7	6.5	7
Viscoelasticity	14	13	8	14	13	14
Smoothness	7	7	7	7	7	7
Taste	7	7	7	7	7	7
Total	70	69	61	70	68.5	70

[a]Hoshizora, reference flour.
[b]P = prime starch, and T = tailing starch.

CONCLUSIONS

Experiments with 21 replicate trials showed statistically significant differences in color, hardness, viscoelasticity, and total score of cooked noodles made from one ASW flour and a flour blend of Pacific Northwest soft white wheats that were used in the study. The ASW noodles were better in hardness, viscoelasticity, and total score, whereas the SW noodles were better in color. Components in the primary and tailing starch fractions appeared to be responsible for the desirable viscoelasticity quality of Japanese noodles made from ASW flour. The primary starch fraction consistently had a greater effect on noodle texture than the tailing starch fraction. However, because the tailing starch accounted for a fifth as much of the flour weight as primary starch, the tailing starch appears to have a more profound effect than an equal weight of prime starch.

From these interchange studies, it was concluded that the primary starch fraction of flour appeared to be most responsible for the desirable viscoelastic texture of cooked noodles. The gluten fraction of flour affected the raw and cooked noodle color but did not affect the cooked noodle texture (viscoelasticity). The water-soluble fraction did not affect the cooked noodle texture (viscoelasticity) or other measured properties.

LITERATURE CITED

AMERICAN ASSOCIATION OF CEREAL CHEMISTS. 1983. Approved Methods of AACC. Methods 08-01 and 44-15A, revised October 1981; Method 46-10, revised September 1985. The Association: St. Paul, MN.

DONELSON, D. H., and WILSON, J. T. 1960a. Effect of the relative quantity of flour fraction on cake quality. Cereal Chem. 37:241-262.

DONELSON, D. H., and WILSON, J. T. 1960b. Studies on the effect of flour-fraction interchange upon cake quality. Cereal Chem. 37:683-710.

FINNEY, K. F. 1943. Fractionating and reconstituting techniques as tools in wheat flour research. Cereal Chem. 20:381-396.

FINNEY, K. F. 1971. Fractionating and reconstituting techniques to relate functional (bread making) to biochemical properties of wheat-flour

TABLE VIII
Effect of Level of Primary and Tailings Starch in Reconstituted Flour on Cooked Noodle Quality

		Interchanged Primary Starch[b]			Interchanged Tailings Starch		
Parameter	**R-HZ[a]**	**ASW+**	**ASW**	**ASW−**	**ASW+**	**ASW**	**ASW−**
Fractions							
Gluten	HZ	HZ	HZ	HZ	HZ	HZ	HZ
Primary starch	HZ	ASW+	ASW	ASW−	HZ−	HZ	HZ+
Tailing starch	HZ	HZ−	HZ	HZ+	ASW+	ASW	ASW−
Water-soluble	HZ	HZ	HZ	HZ	HZ	HZ	HZ
Evaluation							
Color	19	21	21	18	19	19	20
Surface appeal	14	13	14	14	14	14	14
Hardness	7	6	7	5.5	6.5	7.0	6.5
Viscoelasticity	12	14	12.5	10	11	12	12
Smoothness	7	7	7	7	7	7	7
Taste	7	7	7	7	7	7	7
Total	65.0	69.0	68.5	61.5	64.5	66.0	66.5

[a]R-HZ = Reconsituted Hoshizora, reference flour. HZ+ or HZ−, The total starch fraction weight was adjusted to a constant level by addition or deletion of HZ starch.
[b]ASW+, 20% additional starch fraction; ASW−, 20% less starch fraction.

components. Cereal Sci. Today 16:342-356.
FINNEY, K. F., and SHOGREN, M. D. 1972. A ten-gram mixograph for determining and predicting functional properties of wheat flours. Baker's Dig. 46(2):32-42,77.
FREUND, R. J., and LITTELL, R. C. 1981. SAS for Linear Models. A Guide to the ANOVA and GLM Procedures. SAS Institute Inc.: Cary, NC.
HOSENEY, R. C., and FINNEY, K. F. 1971. Functional (breadmaking) and biochemical properties of wheat flour components. XI. A review. Baker's Dig. 45:30-40,64,67.
LEACH, H. W., McCOWEN, L. D., and SCHOCH, T. J. 1959. Structure of the starch granule. I. Swelling and solubility patterns of various starches. Cereal Chem. 36:534-544.
MacRITCHIE, F. 1985. Studies of methodology for fractionation and reconstitution of wheat flours. J. Cereal Sci. 3:221-230.
MOSS, H. J. 1971. The quality of noodles prepared from the flours of some Australian wheats. Aust. J. Exp. Agric. Anim. Husb. 11(April):243-247.
NAGAO, S., IMAI, S., SATO, T., KANEKO, Y., and OTSUBO, H. 1976. Quality characteristics of soft wheats and their use in Japan. I. Methods of assessing wheat suitability for Japanese products. Cereal Chem. 53:988-997.
NAGAO, S., ISHIBASHI, S., IMAI, S., SATO, T., KANBE, T., KANEKO, Y., and OTSUBO, H. 1977a. Quality characteristics of soft wheats and their utilization in Japan. II. Evaluation of wheats from the United States, Australia, France and Japan. Cereal Chem. 54:198-204.
NAGAO, S., ISHIBASHI, S., IMAI, S., SATO, T., KANBE, T., KANEKO, Y., and OTSUBO, H. 1977b. Quality characteristics of soft wheats and their utilization in Japan. III. Effects of crop year and protein content on product quality. Cereal Chem. 54:300-306.
NAGAO, S. 1981. Soft wheat uses in the Orient. Pages 267-304 in: Soft Wheat: Production, Breeding, Milling, and Uses. W. T. Yamazaki and C. T. Greenwood, ed. Am. Assoc. Cereal Chem.: St. Paul, MN.
ODA, M. 1982. Men no hon (A book about noodles), 2nd ed. Shokuhin Sangyo Shinbunsha.
ODA, M., YASUDA, Y., OKAZAKI, S., YAMAUCHI, Y., and YOKOYAMA, Y. 1980. A method of flour quality assessment for Japanese noodles. Cereal Chem. 57:253-254.
OH, N. H., SEIB, P. A., DEYOE, C. W., and WARD, A. B. 1983. Noodles I. Measuring the textural characteristics of cooked noodles. Cereal Chem. 60:433-438.
OH, N. H., SEIB, P. A., WARD, A. B., and DEYOE, C. W. 1985. Noodles VI. Functional properties of wheat flour components in oriental dry noodles. Cereal Foods World. 30:176-178.
SAS INSTITUTE. 1985a. SAS Introductory Guide for Personal Computers. Version 6 edition. The Institute: Cary, NC.
SAS INSTITUTE. 1985b. SAS Language Guide for Personal Computers. Version 6 edition. The Institute: Cary, NC.
SAS INSTITUTE. 1985c. SAS Procedures Guide for Personal Computers. Version 6 edition. The Institute: Cary NC.
SAS INSTITUTE. 1985d. SAS User's Guide: Basics. Version 5 edition. The Institute: Cary, NC.
SAS INSTITUTE. 1985e. SAS User's Guide: Statistics. Version 5 edition. The Institute: Cary, NC.
SHIMIZU, T., FUKUKAWA, H., and ICHIBA, A. 1958. Physical properties of noodles. Cereal Chem. 35:34-36.
SOLLARS, W. F. 1956a. A new method of fractionating wheat flour. Cereal Chem. 33:111-120.
SOLLARS, W. F. 1956b. Evaluation of flour fractions for their importance to cookie quality. Cereal Chem. 33:121-128.
SOLLARS, W. F. 1958a. Fractionation and reconstitution procedures for cake flours. Cereal Chem. 35:85-99.
SOLLARS, W. F. 1958b. Cake and cookie flour fractions affected by chlorine bleaching. Cereal Chem. 35:100-110.
SOLLARS, W. F. 1961. Chloride content of cake flours and flour fraction. Cereal Chem. 38:487-500.
SOLLARS, W. F. 1969. Flour constituents affecting MacMichael viscosity. Cereal Chem. 46:44-55.
SOLLARS, W. F. 1973a. Fractionation and reconstitution techniques for studying water-retention properties of wheat flours. Cereal Chem. 50:708-716.
SOLLARS, W. F. 1973b. Water-retention properties of wheat flour fractions. Cereal Chem. 50:717-722.
SOLLARS, W. F., and RUBENTHALER, G. L. 1971. Performance of wheat and other starches in reconstituted flours. Cereal Chem. 48:397-410.
YAMAZAKI, W. T. 1955. The concentration of a factor in soft wheat flours affecting cookie quality. Cereal Chem. 32:26-37.
YASUNAGA, T., and UEMURA, M. 1962. Evaluation of color characteristics of flours obtained from various types and varieties of wheat. Cereal Chem. 39:171-183.

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