THE EFFECT OF GLUTEN PROTEIN FRACTIONS ON PASTA DOUGH RHEOLOGY AND SPAGHETTI-MAKING QUALITY[1]

J. E. DEXTER and R. R. MATSUO, Canadian Grain Commission, Grain Research Laboratory, Winnipeg, Manitoba R3C 3G9.

ABSTRACT

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Gluten proteins from a durum wheat and a hard red spring wheat were fractionated by precipitation from 0.005N lactic acid at various pH levels. As pH increased, the proportion of glutenins within each fraction was found to decrease concomitantly with an increase in gliadins. Reconstitution experiments demonstrated that a decrease in farinograph mixing time at pasta processing absorptions accompanied this decrease in glutenins and increase in gliadins. With the exception of the lactic acid-insoluble fraction, addition of the gluten fractions had no detrimental effect on spaghetti color. The lactic acid-insoluble gluten and the most gliadin-rich fraction imparted limited improvement to spaghetti cooking quality compared with the other fractions. Differences in cooking quality between the two wheats were consistent with differences in the distribution of their gluten proteins. Qualitative differences in their gluten proteins, however, apparently outweighed quantitative differences in determining spaghetti cooking quality.

Durum wheat (*Triticum durum* Desf.) is preferred over other classes of wheat for the production of pasta products because of the excellent rheological properties of durum wheat pasta doughs and the superior color and cooking quality of durum wheat pasta. Differences in pasta dough rheology and pasta cooking quality may be largely attributed to protein content (1–4) and the nature of proteins within the gluten complex (5–9). Gluten of medium strength appears to produce pasta of optimum cooking quality (5). In particular, a high proportion of glutenins among the gluten proteins appears to be a prerequisite for the production of superior quality pasta (7–9).

The role of various gluten protein fractions in determining bread dough properties and breadmaking quality has been extensively investigated by reconstitution techniques (10–14). Comparable data pertaining to the effect of gluten fractions on pasta dough properties and cooking quality are more limited (2,5,6).

This investigation was undertaken to examine the effect of gluten protein fractions from a durum wheat and a hard red spring wheat (*Triticum aestivum* L.) on pasta dough rheology and spaghetti-making quality and to relate these effects to the physicochemical properties of each gluten fraction. In addition, the effect of each gluten fraction on spaghetti color was also assessed.

MATERIALS AND METHODS

The samples selected for the study were Wascana durum and Manitou hard red spring wheat. The durum sample was the same as that used in a previous study (15). The wheats (20-kg samples) were washed, tempered overnight to

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16.5% moisture, and milled into either semolina or farina in a Buhler laboratory mill (16) in conjunction with a laboratory purifier. The mill room was controlled for temperature (22° C) and humidity (60%). Milling yields were 57.9% for Wascana semolina and 53.0% for Manitou farina. Protein contents (N × 5.7) as determined on a 14% moisture basis by the standard Kjeldahl procedure (17) were 12.2% for the Wascana semolina and 12.6% for the Manitou farina.

Preparation of Crude Gluten and Starch

Freeze-dried gluten was prepared by the method of Doguchi and Hlynka (18) and humidified to 15% moisture prior to fractionation. The protein contents (N × 5.7) of the humidified glutens, as determined by the Nessler procedure of Williams (19), were 64.5% for Wascana and 68.5% for Manitou on an as is moisture basis.

Starch and wash water were poured through a fine cloth sieve and centrifuged, and the supernatant was discarded. Combined starch and tailings were freeze-dried and ground with a mortar and pestle. The preparation was humidified to 14% moisture before use to minimize starch damage during rehydration (20). Protein contents (N × 5.7) of the combined starch and tailings were found to be about 0.8% for each wheat by the Kjeldahl method.

Gluten Fractionation

Humidified freeze-dried gluten was fractionated by a method similar to that which Shogren *et al.* (12) described. Twelve grams of gluten was stirred gently in 300 ml of 0.005*M* lactic acid for 3 hr at room temperature (22° C). The suspension was centrifuged for 20 min at 15,000 g to yield the lactic acid-insoluble material (F1). The supernatant (pH 4.40 as measured by an Accumet Model 520 Digital pH Meter) was adjusted to pH levels of 5.25, 5.40, 5.55, and 5.80, with aliquots of 0.1N sodium carbonate. Gluten precipitated at each successive pH level (F2-F5) was recovered by centrifugation prior to adjustment of the supernatant to the next higher pH level. The pH 5.80 supernatant was retained as F6. Each fraction was freeze-dried and weighed, and the protein content (N × 5.7) was determined by the Nessler procedure (19). The fractionation procedure was repeated 12 times for Manitou and 10 times for Wascana, with a precision of better than 10%. Nitrogen recoveries for each fractionation varied from 96% to 101% of total gluten nitrogen.

Characterization of Gluten Protein Fractions

Amino acid analyses were performed on a Beckman 121 Automatic Amino Acid Analyzer following the method of Spackmann *et al.* (21), with a precision of ±3%. Samples were hydrolyzed as described by Orth *et al.* (22). Nitrogen recoveries varied from 89 to 98%.

Gel filtration of 0.1*M* acetic acid, 3*M* urea, 0.01*M* cetyl trimethylammonium bromide (AUC) (23) protein extracts was performed on Sephadex G-150 as described previously (15).

Preparation of Reconstituted Samples

In order to eliminate the effect of protein content on farinograph characteristics and cooking quality parameters (1–4), samples that were enriched by a particular gluten component were prepared at a fixed protein content. Each

gluten protein fraction was combined with starch prepared from their respective wheats to yield a mixture with the same protein content as the milled product (12.2% for Wascana, 12.6% for Manitou).

Enrichment of the semolina or farina by each gluten protein fraction was examined at two levels achieved through replacement of 20 and 40%, respectively, of the control material by each starch-protein mixture. The unfractionated gluten and a reconstituted gluten (all six fractions combined in the percentages separated) were also added at each enrichment level and served as controls in conjunction with the pure semolina or farina. Combining F2 and F3 was necessary because insufficient material was available to study the two fractions independently.

Sufficient material was also available to perform a limited number of interchange experiments. F4 and F5 gluten-starch mixtures from Wascana were each added to Manitou farina, and the F4-starch mixture from Manitou was added to the Wascana semolina. The enrichment level of F4 from Wascana was 30% because of limited quantity, while the enrichment level of the others was 40%.

Farinograms

Farinograms were obtained as described by Irvine *et al.* (1). Fifty grams of sample (14% moisture basis) was mixed with distilled water in a small stainless steel farinograph bowl (59 rpm drive), using the 1:5 sensitivity setting. Absorption was held constant for each series of samples (31% for Wascana, 33% for Manitou). Mixing time was the time required to reach the peak of the curve (maximum consistency). Tolerance index was the decrease in consistency measured in Brabender units 4 min past the peak.

Spaghetti-Making

Fifty grams of sample, with sufficient distilled water to achieve optimum absorption, was mixed under vacuum in a 50 g farinograph bowl and made into spaghetti as described by Matsuo *et al.* (2). Spaghetti was dried with a controlled decrease in relative humidity for 29 hr at 39°C.

Evaluation of Spaghetti Color

Whole strands of spaghetti were mounted on white cardboard for color measurements and placed in a Beckman Color DB-G spectrophotometer. Dominant wavelength, purity, and brightness were determined by the Ten Selected Ordinates Method (24). The dominant wavelength is the wavelength of the pure spectrum color that, in combination with a tungsten lamp source, produces the color. A clear, bright yellow, which is the desired color for pasta products, is characterized by a dominant wavelength of about 576 nm. A dominant wavelength approaching 578 nm is indicative of brownness. Purity, which indicates color intensity, is directly related to pigment content. Brightness is a measure of the amount of light that the sample reflects relative to the amount that a near-perfect white surface reflects.

Evaluation of Spaghetti Cooking Quality

Ten grams of spaghetti was placed in 100 ml of rapidly boiling tap water. Normal cooking time (13 min for Wascana, 15 min for Manitou) was defined as

the time required for the white core in the strand to disappear. Removing a strand from the cooking water and crushing it between two glass plates determined this. Each spaghetti was cooked to its normal cooking time and to 10 min past its normal cooking time. Cooking quality data were obtained as described previously (3,25,26). Firm samples with good elasticity yield low values for tenderness index (25) and compressibility (26) concomitant with high values for recovery (26). Therefore, the higher the value for the cooking quality parameter (recovery/tenderness index times compressibility) (3), the better the cooking quality. Precision of the cooking test is about ±5% for each parameter.

RESULTS AND DISCUSSION

Gluten Fractionation

The pH 4.40 insoluble fraction (F1) was a jelly-like substance possessing no elasticity or cohesiveness. F2 (pH 5.25 insoluble) had similar properties to F1 although it was more cohesive. F3 (pH 5.40 insoluble) was gluten-like but less extensible, whereas F4 (pH 5.55 insoluble) closely resembled whole gluten. F5 (pH 5.80 insoluble) was more extensible than the whole gluten, and F6 (pH 5.80 soluble) was sticky and extensible.

F1 contained starch and other materials that were not washed from the gluten during preparation. Consequently, its protein content (N × 5.7) (19) was quite low (35.9% for Wascana, 42.6% for Manitou) compared with the other fractions, which ranged from 72 to 87% protein. When considered on the basis of percentage of total gluten protein, the two wheats were found to yield essentially the same proportion of F1 and F2 but significantly different levels of F3, F4, F5, and F6 (Fig. 1). Wascana possessed more than twice as much F5 as Manitou but less of the other three fractions.

Characterization of Gluten Protein Fractions

Several significant differences were noted in the amino acid compositions of the individual gluten fractions (Table I). Trends noted were similar for each wheat. The pH 4.40 insoluble protein (F1) possessed a higher content of lysine, arginine, glycine, and alanine and a lower content of glutamic acid and proline than did the whole gluten. The results were in agreement with previously published values for the amino acid composition of acetic acid-insoluble protein (27,28). With each succeeding fraction up to F5 (pH 5.80 insoluble), the content of lysine, arginine, glycine, and alanine declined and the content of glutamic acid and proline increased. F6 (pH 5.80 soluble) had a lower glycine level than did F5. These trends in amino acid composition were all consistent with a decrease in the proportion of glutenins and an increase in the proportion of gliadins as pH increased (28,29). The similarity in the amino acid composition of the Wascana and Manitou gluten was expected, since previous reports showed little variation in the amino acid composition of flour (30) or individual protein fractions (29) from different classes of Canadian wheat.

Corroborating evidence for a decreasing proportion of glutenins with increasing pH was obtained by gel filtration (Fig. 2) of AUC protein extracts from each fraction. The first major peak represents glutenins, and the second gliadins, per the designations of Meredith and Wren (23). In general, the relative size of the first peak appeared to decrease compared with the size of the second

peak for each succeeding gluten fraction (Fig. 2). This was especially noticeable when the elution profiles for F5 and F6 were compared with each other and with preceding fractions. The trend of decreasing glutenin content with increasing pH agrees with the results of Shogren *et al.* (12).

In the present study, F3 was the fraction that most closely resembled the whole gluten in amino acid composition (Table I) and gel filtration elution profile (Fig. 2) for both wheats. Therefore, a reasonable supposition is that this fraction was the one that had a glutenins/gliadins ratio most closely approximating that of the whole gluten.

Farinograms

Reconstituted pasta doughs from each wheat at both the 20% enrichment level (results not shown) and the 40% enrichment level (Figs. 3,4) exhibited a wide range in mixing characteristics. Reconstitution caused some alteration in the mixing curves for both wheats. Thus, to assess the effect of each protein fraction meaningfully, comparisons are made with the curves obtained for the reconstituted gluten-enriched samples (curve C) rather than with those of the

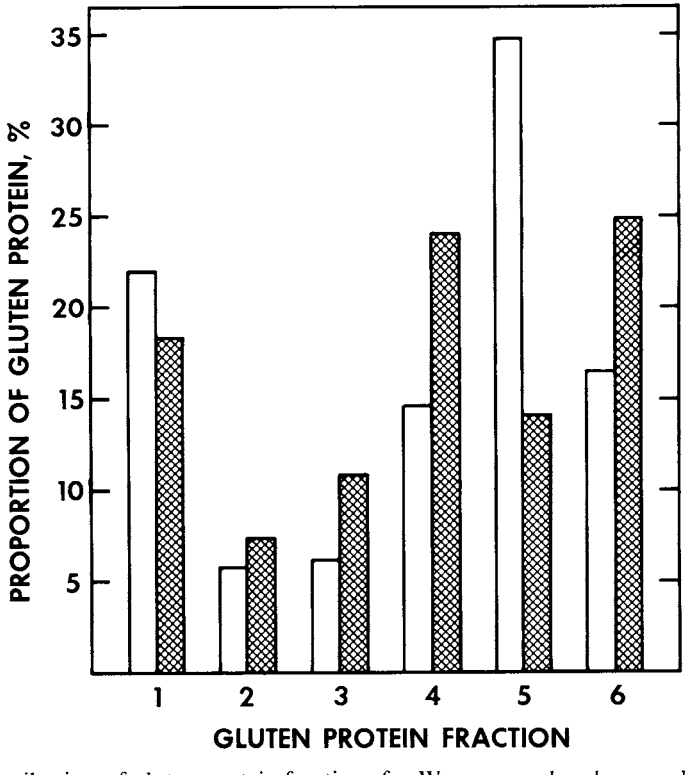

Fig. 1. Distribution of gluten protein fractions for Wascana amber durum wheat (open bar) and Manitou hard red spring wheat (crosshatched bar).

TABLE I
Amino Acid Composition of Whole Gluten and Gluten Fractions From Wascana Amber Durum Wheat and Manitou Hard Red Spring Wheat

(mol Percent on an Ammonia-Free Basis)

Amino Acid[a]	Wascana							Manitou						
	Gluten	F1	F2	F3	F4	F5	F6	Gluten	F1	F2	F3	F4	F5	F6
Lysine	1.7	3.3	2.6	1.7	1.2	0.9	1.1	1.7	3.5	2.1	1.4	1.3	1.0	1.1
Histidine	1.9	2.1	1.9	1.8	1.7	1.8	1.9	1.8	2.1	1.7	1.6	1.6	1.8	2.0
Arginine	2.7	3.8	3.4	2.8	2.4	2.1	2.5	2.5	3.5	2.8	2.4	2.3	2.1	2.3
Aspartic acid	3.6	5.2	4.3	3.6	3.2	2.8	2.8	3.3	5.4	3.6	2.9	2.8	2.7	2.7
Threonine	2.8	3.5	3.3	3.0	2.7	2.4	2.6	2.8	3.5	3.0	2.7	2.7	2.5	2.6
Serine	5.7	6.3	6.3	6.0	5.8	5.6	6.1	6.1	6.3	5.9	5.9	5.7	5.7	6.3
Glutamic acid	34.4	27.6	30.2	33.6	35.9	38.0	36.8	34.3	26.8	33.1	35.8	36.3	37.0	36.0
Proline	14.4	11.1	12.6	14.3	15.2	15.8	15.2	14.8	11.2	14.4	15.5	15.6	15.9	15.9
Glycine	5.1	7.2	6.3	5.8	5.2	4.2	3.7	5.9	7.6	6.8	6.8	6.5	5.3	3.8
Alanine	3.6	5.4	4.6	3.6	3.2	2.8	3.1	3.7	5.5	3.8	3.3	3.1	3.1	3.5
Valine	4.4	5.0	4.7	4.3	4.1	4.0	4.5	4.3	5.1	4.1	3.6	3.8	4.1	4.7
Methionine	1.7	1.8	1.7	1.6	1.6	1.4	1.8	1.3	1.4	1.2	1.1	1.1	1.2	1.4
Isoleucine	3.9	3.8	3.8	3.7	3.7	3.9	4.0	3.5	3.8	3.4	3.2	3.3	3.6	3.8
Leucine	7.4	7.6	7.5	7.3	7.2	7.3	7.5	7.0	7.4	6.9	6.5	6.6	6.9	7.4
Tyrosine	2.5	2.5	2.7	2.7	2.7	2.6	2.1	2.6	2.7	2.7	2.9	2.9	2.6	1.9
Phenylalanine	4.2	3.8	4.1	4.2	4.2	4.4	4.3	4.4	4.2	4.5	4.4	4.4	4.5	4.6

[a]Tryptophan, cysteine, and cystine were not determined.

original semolina or farina (curve A) or the whole gluten-enriched samples (curve B).

In all cases, the mixing time of a particular Manitou sample was less than that of the corresponding Wascana sample. Trends observed with addition of each gluten fraction mixture were similar for both wheats. Addition of F1 (curve D) resulted in a long time requirement for formation of a uniform cohesive dough. F1 contained a great deal of nonprotein material, however, and these components may contribute to the long mixing time. Addition of F2 and F3 (curve E) resulted in a slightly longer mixing time than that observed for the reference sample (curve C). This was especially true for Wascana. F4 (curve F) had little effect on the farinogram for either wheat. F5 (curve G) and, in

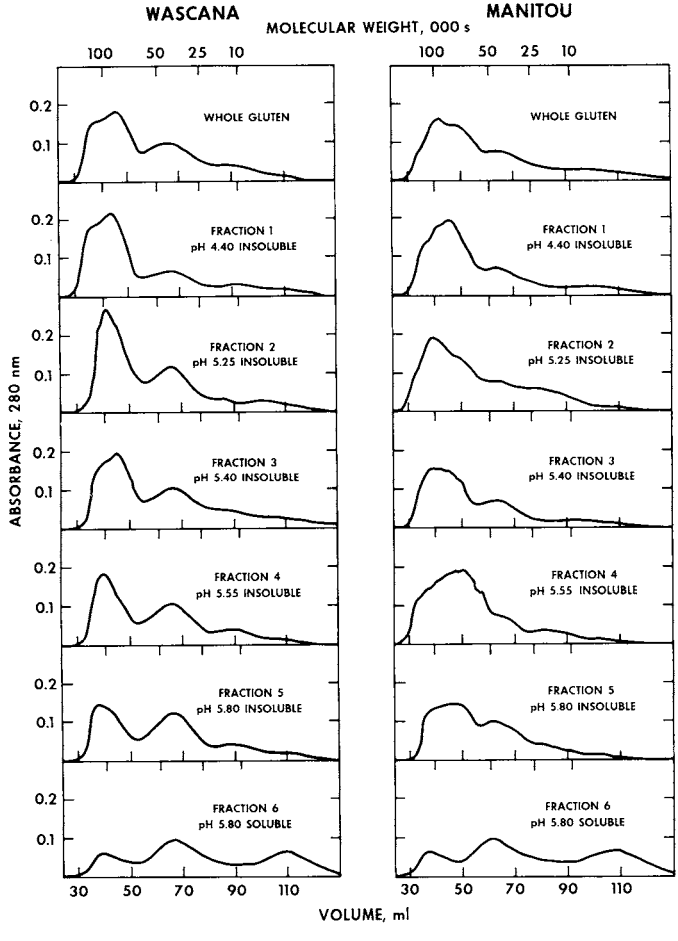

Fig. 2. Gel filtration elution profiles of AUC extracts on Sephadex G-150 for gluten protein fractions from Wascana amber durum wheat and Manitou hard red spring wheat.

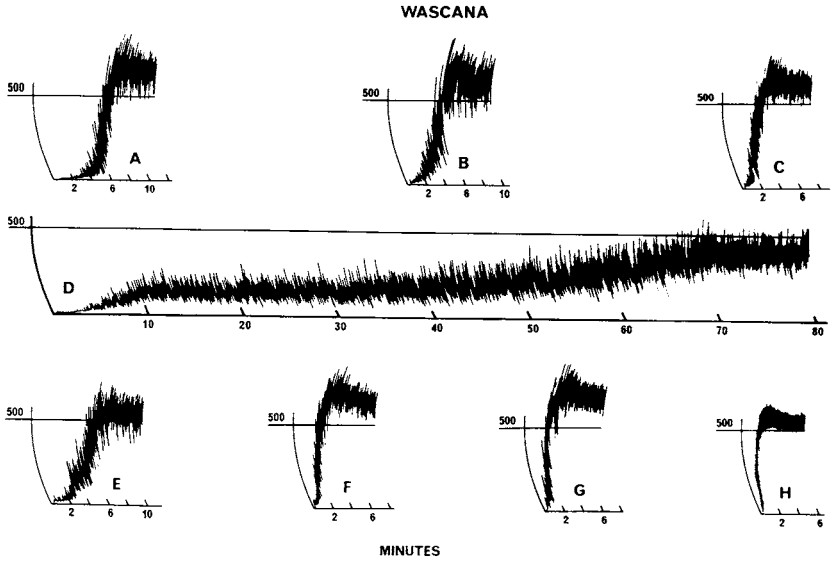

Fig. 3. Farinograph mixing curves (31% absorption) for Wascana amber durum wheat. Samples designated as in Tables II and III.

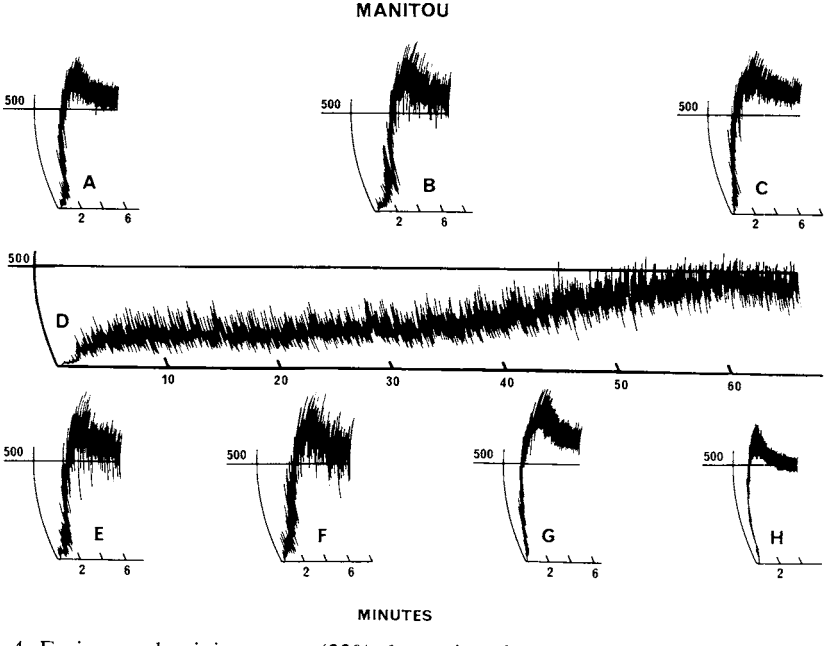

Fig. 4. Farinograph mixing curves (33% absorption) for Manitou hard red spring wheat. Samples designated as in Tables II and III.

particular, F6 (curve H) reduced the mixing time. Addition of F6 resulted in a smooth curve (lack of wildness), with lower maximum consistency.

Since the proportion of gliadins increased with each successive fraction (Table I, Fig. 2), a decrease in the proportion of glutenins (increase in gliadins) apparently results in a decrease in mixing time for pasta doughs. Other workers have reported a similar result for reconstituted bread doughs (10–14).

Results from this study corroborate previous reports (1–3,5,8,9), which have shown that durum wheats that have weak extensible glutens due to a high proportion of gliadins tend to have short farinograph mixing times at pasta absorptions. This relationship has been successfully employed to screen weak gluten types from strong gluten types in the Canadian durum wheat breeding program (31), which in turn has resulted in the development of new Canadian durum wheat varieties with significantly improved spaghetti cooking quality (32).

Spaghetti Color

The superior color of the Wascana spaghetti compared with that of the Manitou spaghetti was readily apparent from the spectrophotometric data (Table II). Wascana spaghetti was higher in pigment (purity greater) than was

TABLE II
Color of Spaghetti Processed From Original Milled Products and Reconstituted Samples for Wascana Amber Durum Wheat and Manitou Hard Red Spring Wheat

Sample Description	20% Mixture Added			40% Mixture Added		
	B (%)	P (%)	DWL (nm)	B (%)	P (%)	DWL (nm)
Wascana						
100% Original semolina	53.0	54.5	576.3	53.0	54.5	576.3
Mixtures added						
Crude gluten	52.2	53.0	576.3	52.4	51.1	576.2
Reconstituted gluten	52.8	51.0	576.4	53.8	47.5	576.0
F1	50.0	52.0	576.5	47.8	47.0	576.5
F2 and F3	nd	nd	nd	53.2	47.0	576.3
F4	53.4	51.0	576.2	54.6	45.0	576.0
F5	54.1	48.5	575.8	55.0	46.0	575.8
F6	54.1	48.5	575.8	55.7	46.7	575.7
Manitou						
100% Original farina	50.6	44.0	577.8	50.6	44.0	577.8
Mixtures added						
Crude gluten	52.4	42.0	577.2	52.8	39.0	577.0
Reconstituted gluten	52.2	41.5	577.2	52.9	38.0	577.0
F1	50.5	41.2	577.4	49.6	40.0	577.5
F2 and F3	51.7	42.8	577.5	53.3	41.2	577.0
F4	52.6	41.1	577.2	54.5	41.1	577.2
F5	52.2	39.9	577.2	55.8	34.3	576.2
F6	53.2	40.0	577.0	54.8	35.0	576.8

B = brightness, P = purity, DWL = dominant wavelength, nd = not determined.

Manitou spaghetti and exhibited no evidence of brownness (dominant wavelength near 576 nm), while most of the Manitou spaghetti samples were quite brown (dominant wavelength greater than 577 nm). F1 was the only protein fraction that had a deleterious effect on the color of spaghetti for both wheats. Addition of F1 resulted in a duller (low brightness) spaghetti with increased brownness (longer dominant wavelength) when compared with the spaghetti that was produced with added reconstituted gluten. F1 was an impure fraction, however, containing a great deal of nonprotein material. Therefore, the inferior color of spaghetti produced when this fraction was added was possibly due to its nonprotein constituents. All of the other fractions imparted no harmful effects on spaghetti color for either wheat. In all cases they yielded a product that had a brightness equal or superior to that produced with addition of reconstituted gluten, and dominant wavelengths that were comparable.

Spaghetti Cooking Quality

Cooking quality results for samples produced with 20 and 40% levels of added mixture showed the same general trends. The data for samples produced at the 40% level are presented in Table III. For each wheat, the cooking quality of each

TABLE III
Cooking Quality Data for Original Milled Products and Reconstituted Samples for Wascana Amber Durum Wheat and Manitou Hard Red Spring Wheat

	Normal Cooking Time[a]				Overcooked 10 min			
	C (%)	R (%)	T.I. (mm/sec $\times 10^3$)	CQP	C (%)	R (%)	T.I. (mm/sec $\times 10^3$)	CQP
Wascana								
100% Original semolina	69	43	43	14.5	100	0	46	0
40% Mixtures added								
Crude gluten	64	62	35	27.7	74	50	40	16.9
Reconstituted gluten	64	64	36	27.8	100	0	40	0
F1	64	62	38	25.5	100	0	42	0
F2 and F3	63	68	37	29.2	68	62	39	23.4
F4	62	66	36	29.6	67	64	36	26.5
F5	57	76	33	40.4	68	57	37	22.7
F6	67	56	39	21.4	100	0	44	0
Manitou								
100% Original farina	62	46	44	16.9	100	0	53	0
40% Mixtures added								
Crude gluten	60	70	34	34.3	100	0	43	0
Reconstituted gluten	62	63	39	26.1	100	0	41	0
F1	60	65	38	28.5	100	0	46	0
F2 and F3	61	72	36	32.8	100	0	46	0
F4	60	68	38	29.8	100	0	47	0
F5	61	72	36	32.8	100	0	43	0
F6	65	66	36	28.2	100	0	47	0

[a]Cooking times: Wascana 13 min, Manitou 15 min.
C = compressibility, R = recovery, T.I. = tenderness index, CQP = cooking quality parameter.

reconstituted sample was improved over that of the spaghetti produced from the original semolina or farina. This can be explained by the lower proportion of nongluten (soluble) proteins present in the reconstituted samples (no soluble proteins were added to the gluten-starch mixtures) that resulted in an increased gluten content. A previous report showed that soluble proteins (albumins) from durum wheat semolina have no detectable effect on spaghetti cooking quality (2). Therefore, each of the gluten fractions apparently imparts some improvement to spaghetti cooking quality.

When the normal cooking time was used, the Manitou and Wascana spaghetti appeared to have comparable cooking quality (Table III). The Wascana samples, however, were much less susceptible to overcooking than were the Manitou samples. All those 10-min overcooked Wascana samples that did not recover from compression were close to doing so. (In each case, some strands showed recovery, but the majority did not.) By contrast, all Manitou samples showed a substantial deterioration in cooking quality with even a slight degree of overcooking (1 or 2 min). At the 10-min overcooked stage, all the Manitou spaghetti samples were soft and mushy and had disintegrated to a much greater degree than had the Wascana samples. This is illustrated by the consistently lower tenderness indexes found for each Wascana spaghetti compared with the corresponding Manitou spaghetti after overcooking (Table III).

Addition of F2 and F3, F4, or F5 to Wascana imparted the greatest resistance to overcooking (Table III). Therefore, these four fractions apparently are the ones that have the optimum characteristics for imparting satisfactory spaghetti cooking quality. F1 does not appear to be of major importance in determining cooking quality despite the fact that it had by far the greatest impact on mixing properties (Fig. 3,4). Addition of F6 yielded a spaghetti that consistently performed most poorly in the cooking test (Table III). This was to be expected, since this fraction is gliadin-rich (Table I, Fig. 2), and it is well established that glutenins are more responsible for excellence in spaghetti cooking quality than are gliadins (1–3,7–9). Manitou gluten possessed a much greater proportion of F6 than did Wascana gluten (Fig. 1), which may be part of the explanation for the inferior cooking quality of Manitou compared with Wascana. This is not the complete answer to quality differences, however, because even when F2 and F3, F4, or F5 were enriched in the Manitou, the spaghetti showed little improvement in cooking quality (Table III). Therefore, qualitative differences between the two classes of wheat in the nature of the proteins that make up the gluten fractions may be of greater importance than are quantitative differences in determining spaghetti cooking quality.

Sufficient amounts of the F4 mixtures from both wheats remained to allow this possibility to be explored by interchange of this fraction (Table IV). Whereas none of the Manitou samples tested earlier stood up to overcooking (Table III), replacement of Manitou farina with the Wascana F4 mixture at the 30% level produced a spaghetti that withstood overcooking fairly well (Table IV). By contrast, replacement of Wascana semolina with the Manitou F4 mixture at the 40% enrichment level yielded a spaghetti with no tolerance to overcooking (Table IV) despite the generally superior overcooking quality of a number of the reconstituted Wascana samples tested earlier (Table III). These results clearly illustrate F4 from Wascana to be far more effective in improving spaghetti cooking quality than is F4 from Manitou.

TABLE IV
Cooking Quality Data for Samples Reconstituted With Interchanged Gluten Fractions

	Normal Cooking Time[a]				Overcooked 10 min			
	C (%)	R (%)	T.I. (mm/sec $\times 10^3$)	CQP	C (%)	R (%)	T.I. (mm/sec $\times 10^3$)	CQP
70% Manitou farina 30% Wascana F4 mixture	54	76	39	36.1	68	51	47	16.0
60% Wascana semolina 40% Manitou F4 mixture	57	72	44	28.7	100	0	47	0
60% Manitou farina 40% Wascana F5 mixture	53	76	35	41.1	100	0	52	0

[a]Cooking time 14 min.
C = compressibility, R = recovery, T.I. = tenderness index, CQP = cooking quality parameter.

Since F5 was by far the largest fraction in the Wascana gluten (Fig. 1), the ability of this fraction to improve the cooking quality of Manitou was also determined (Table IV). At the 40% enrichment level it imparted no detectable improvement in cooking quality. Insufficient material was available to test the effect of the Wascana F2 and F3 fractions on the Manitou cooking quality. Although on the basis of these limited enrichment experiments F4 appears to be the fraction most responsible for the superior cooking quality of Wascana over Manitou, the importance of F2 and F3 cannot be ruled out.

CONCLUSIONS

A relationship between superior spaghetti cooking quality and a long pasta dough mixing time has been shown previously (1,3,5,31). As expected, the gluten fraction that imparted the poorest cooking quality (F6) shortened the mixing time markedly. The gluten fraction that may be most important in imparting excellent spaghetti cooking quality (F4), however, had no detectable effect on the mixing time. Qualitative differences were also found in the F4 fraction from Wascana and the F4 fraction from Manitou that influenced their ability to improve spaghetti cooking quality, yet this was not reflected by a difference in their effect on farinograph mixing time. A relatively long mixing time may imply a low proportion of F6-like gluten protein, but gives no indication of the relative abundance or type of F4-like gluten protein. Thus, while desirable farinogram characteristics may be a prerequisite, they do not guarantee superior spaghetti cooking quality.

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