Effect of Protein Content on the Cooking Quality of Spaghetti[1]

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ABSTRACT

For a number of durum wheat varieties of varying qualities studied, protein quantity has a marked effect on cooking quality of spaghetti. In all cases the cooking quality improved with higher protein content. Proteins from rapeseed meal, fish protein concentrate, soy flour and egg albumin, as well as protein components from durum wheat, were added to semolina and processed into spaghetti. The most pronounced improvement in cooking quality was found with egg albumin and with glutenin. Improvement was also found with gliadin, whereas proteins from other sources had little effect.

In a previous paper (1) it was reported that gluten quality was related to spaghetti cooking quality. Others (2,3) have related gluten quantity to spaghetti quality. Sheu et al. (4) concluded that the firmness of cooked macaroni was controlled primarily by the gluten fraction. Frey (5), on the other hand, reported that starch plays an important role in the consistency and water absorption of pasta products and that pregelatinized wheat and potato starches can be used in place of protein to make spaghetti of acceptable quality. He also found that egg-white proteins surpass the effect of vital wheat gluten on pasta consistency. Recently, Walsh and Gilles (6) showed that protein composition was related to several spaghetti quality factors. High albumin and glutenin contents were associated with poor spaghetti color. Moreover, high glutenin but low gliadin contents were associated with high spaghetti firmness.

A study was undertaken to determine the effect of protein content on spaghetti cooking quality. In one series of experiments the effect of protein content of wheat was studied; in another series, proteins from other sources were added to a control semolina to determine their effects.

MATERIALS AND METHODS

Two samples of No. 3 Canada Western Amber Durum (CWAD) wheat [one a high-protein sample (17.8%) and the other a low-protein wheat (9.8%)] were obtained, milled into semolina, and mixed to give a range of protein of 8.5 to 16.0% in the semolina. Three variety samples–Pelissier, Leeds, and a Tunisian durum–were also studied. As a range of protein levels was not available for these last three samples, semolina from each variety was fractionated into crude gluten, water-solubles, and starch. Gluten was washed out by hand in a minimum of distilled water. The washings were centrifuged to separate the starch and tailings from the water-soluble fraction. The three crude fractions were freeze-dried. To increase protein content, crude gluten and the water-soluble fraction (in the same ratio as isolated) were added to semolina. To lower protein content, starch was added. In this way a range in protein from 8 to 16% was obtained.

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To study the effect of adding proteins from other sources, the following samples were incorporated into spaghetti: rapeseed flour (protein 49.2%), fish protein concentrate (protein 79.6%), soya flour (protein 52.0%), and powdered egg albumin (protein 68.4%). Various levels of these protein-rich materials were added to commercially milled semolina and processed into spaghetti.

Gluten from a grade of durum semolina (No. 2 CWAD) was fractionated into gliadin according to the method described by Woychik et al. (7). The soluble proteins extracted with 0.01M acetate buffer, pH 5.5, were chromatographed on a carboxymethyl cellulose (CMC) column. The major peak was isolated, dialyzed against distilled water, and freeze-dried. All three fractions were added to commercial semolina and processed into spaghetti.

Spaghetti samples were processed by a modified micro macroni method (8). A 50-g. farinograph bowl was sealed so that mixing could be carried out under vacuum. Absorption was varied from 31.5 to 33.5%, depending on the durum variety. Doughs were mixed in air until the farinograph curve began to rise. Vacuum was then applied (22 to 25 mm. Hg). Mixing was continued until maximum consistency was attained. This varied from 3 to 5 min., depending on the durum wheat variety. The kneading step in the micro macaroni method was eliminated and the dough from the mixer was placed directly into the dough cylinder. Vacuum was applied at this stage to eliminate introduction of air bubbles. A four-hole, 1/16-in. Teflon spaghetti die was used for extrusion.

Cooking tests were carried out and evaluated as described previously (9,10). Tenderness index is a measure of the rate of shear of a cooked sample under an increasing force; compressibility is a measure of the extent to which a sample can be compressed under a constant force; and recovery is a measure of the elastic component or "springiness". Soft samples yield high values of compressibility and very low values of recovery. Firm samples with "good bite" yield low compressibility values and high recovery values.

Farinograms were obtained as described by Irvine et al. (11). Protein content was determined by the standard Kjeldahl method.

RESULTS AND DISCUSSION

The effects of protein content on the cooking-test parameters and on farinogram characteristics are presented in Table I. In all cases the high-protein samples are firmer (lower tenderness indes), less compressible (lower compressibility), and more elastic (higher recovery), whereas the low-protein samples are soft with little elasticity. Farinograph characteristics are markedly affected by increasing protein content. With increasing protein content, as reported by Irvine et al. (11), dough development time decreases, and both maximum consistency and tolerance index increase.

The effect on cooking quality of adding proteins from different sources is presented in Table II. Increasing the protein content by addition of rapeseed flour and fish protein concentrate impairs the cooking quality of spaghetti, while soya flour has little effect.

These samples are all soft with little elasticity. Egg albumin and the glutenin fraction, on the other hand, have a marked influence on the cooking-test parameters. The samples are quite firm, less compressible, and very elastic. The gliadin fraction improves the cooking parameters, but not to the extent that

TABLE I. EFFECT OF PROTEIN CONTENT ON COOKING QUALITY AND FARINOGRAM CHARACTERISTICS

Durum Variety or Grade	Protein Content	Cooking Test			Farinograph		
		Tenderness index mm./sec.	Compress-ibility	Recovery	Dough develop-ment time	Maximum consis-tency	Tolerance index
	%	X 10^{-3}	%	%	min.	B.U.	B.U.
No. 3 CWAD	8.5	59	100	0	7.00	390	50
	9.8	52	100	0	5.00	450	70
	11.1	51	78	16	3.75	530	100
	12.5	48	78	28	3.00	600	140
	13.9	46	76	32	2.50	670	170
	15.2	41	73	33	2.50	740	200
	16.6	35	70	41	2.25	790	230
Pelissier	7.8	56	100	0	36.25	450	40
	11.9	52	78	14	5.50	560	30
	15.4	43	76	28	3.00	680	60
	17.2	35	73	42	3.00	700	90
Leeds	8.7	56	100	0	43.00	500	10
	11.5	54	80	17	4.25	700	140
	13.5	50	75	27	3.00	750	170
	14.6	43	76	28	2.75	830	190
	16.8	39	65	39	1.25	850	240
Tunisian	7.9	59	100	0	67.50	420	20
	10.6	47	78	3	13.00	460	0
	15.2	36	68	36	6.00	670	40
	16.7	36	61	58	4.50	720	50

TABLE II. EFFECT OF VARIOUS LEVELS OF DIFFERENT PROTEINS ON SPAGHETTI COOKING QUALITY

Protein Source	Level %	Protein Content of Sample %	Tenderness Index mm./sec. X 10^{-3}	Compress-ibility %	Recovery %
Control semolina	...	12.9	54	80	17
Rapeseed flour	1	13.2	53	100	10
	3	13.6	52	100	0
	5	14.1	52	100	0
	10	15.4	53	100	0
Fish protein concentrate	1	13.3	50	100	0
	3	14.1	51	100	0
	5	14.9	50	100	0
	10	17.0	52	100	0
Soya flour	3	13.7	54	78	11
	5	14.3	51	72	14
Powdered egg albumin	3	13.9	33	58	78
	5	14.6	33	40	88
Durum glutenin	6	15.3	38	55	53
Durum gliadin	6	15.3	43	68	28
Durum albumin	1.5	13.4	49	72	18

glutenin does; and the soluble fraction isolated on a CMC column has no effect.

It is obvious from the results obtained that increasing the protein content by addition of a readily available source of protein (e.g., rapeseed flour or soya flour) may be nutritionally advantageous but does not improve cooking quality. Both rapeseed flour and soya flour do not give a maximum on the amylograph curve, perhaps due to the very high protein content or to changes in flour during preparation. A slurry of either rape or soya flours when boiled does not change in consistency or in appearance. Consequently, in spaghetti containing either of these flours, there is no improvement in cooking quality.

The fish protein concentrate is relatively insoluble in water and therefore would tend to act only as an inert filler in spaghetti. As a result, cooking quality is impaired with addition of this protein.

The powdered egg albumin is readily soluble in water and coagulates upon heating. It appears that the coagulation of the albumin within the spaghetti increases firmness and elasticity in the cooked product. Wet gluten loses its extensibility upon boiling and becomes firm but rubbery. Thus, gluten added to spaghetti also increases firmness and elasticity, as shown in Table I.

With wheat-protein fractions, the glutenin fraction causes the greatest change in cooking characteristics. The physical properties and appearance of gliadin (the fraction soluble in 70% ethanol) are quite different from crude gluten and the glutenin fraction: this fraction is extemely sticky and plastic (no elasticity), and when boiled in water does not become firm or rubbery, but has the consistency and texture of well-masticated chewing gum. In cooked spaghetti, gliadin does not increase firmness or elasticity appreciably. The soluble protein fraction showed no effect on the cooking quality.

Protein content of wheat has an appreciable effect on cooking quality of spaghetti, as indicated by the two natural samples of 3 CWAD (Table I). Natural samples with protein content intermediate between the two may not yield the same results as the blended samples, but this relationship of higher spaghetti firmness and high protein content has been found in many samples tested in our laboratory. Again, with the three varieties studied, adding crude gluten and water solubles is admittedly not the same as natural samples with equivalent protein content, but it serves to show that protein content is an important factor in spaghetti firmness.

For the varieties studied, results indicate that the protein content should be at least 11.0% for acceptable cooking quality. Protein content can be increased by addition of protein from other sources; but all proteins do not improve the cooking quality. Of the proteins tested, only egg albumin and wheat gluten improved the cooking quality.

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