Pasta Regrinds: Effect on Spaghetti Quality

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Blending commerical reground pasta at seven different levels with semolina was investigated to determine the effects on spaghetti color and cooking quality. In addition, the effect of cooking time on cooking quality of the blends was investigated. Cooking times of 10, 15, 20, and 25 min were used, with 15 min representing the standard cooking time used in our laboratory. On the basis of this study it would appear that blending regrinds with semolina to produce spaghetti is not advisable beyond the 15–20% level because of the deleterious effect on color and cooking loss.

It is generally accepted in the United States that semolina from durum wheat is the material of choice for producing the highest quality pasta products. Pasta products can be processed from nondurum wheat farina or flour alone or blended with semolina. Such products usually suffer some quality deficiency with respect to appearance and/or cooking quality. Pasta products refer to macaroni, spaghetti, and noodles, each of which can be marketed in a wide variety of shapes and sizes.

Annual pasta consumption in the U.S. is approximately 10 lb per capita (Donnelly, 1979). The Bureau of the Census (1979) recently estimated the U.S. population at 219 million as of December 1, 1978. That being the case, this would place pasta consumption in the neighborhood of 2.19 billion pounds. It is generally accepted in the pasta industry that anywhere from 5 to 10% of dry goods production ends up as "regrinds". Regrinds are those dried pasta products which, due to the cutting action of knives used to trim the heads, centers, and tails of long goods, are reground to small particle size. Checked or cracked dried products can also be reground. Egg noodles, as a rule, are not and should not be reground due to the possibility of salmonella contamination. These regrinds are blended with semolina and reprocessed mainly into short goods with some going into long goods. Regrinds therefore can represent a large volume of industry production that ends up as blended products.

No published information is available detailing the effects of blending regrinds with semolina on spaghetti or macaroni quality. The purpose of this paper is to review some research that was done in this laboratory on the effect of blending regrinds at the 5, 10, 15, 20, 25, 50, and 100% replacement levels and determining the resultant effect on spaghetti color and quality. The effect of cooking time on these blends was also investigated.

MATERIALS AND METHODS

Regrinds. Five samples of regrinds were obtained from five different U.S. commercial pasta processors. For the sake of confidentiality, the companies are simply identified by the letters A, B, C, D, and E (Table I). A detailed history of each sample is not known, but they do represent primarily reground long goods which had been processed from 100% durum wheat semolina. Sample F represents a sample of spaghetti which was processed in this laboratory from Durakota no. 1 semolina (kindly supplied by North Dakota State Mill and Elevator, Grand Forks, ND) and reground on a Burr mill. This Durakota semolina and spaghetti represent the control samples.

Table I. Particle Size Distribution in Regrinds[a]

U.S. sieve no.	sieve opening, mm	Durakota semolina	regrind A	B	C	D	E	F
20	0.86	0	11	0	20	0	1	0
40	0.38	24	67	37	47	29	60	24
60	0.23	58	17	32	19	44	25	56
80	0.18	13	2	12	6	13	6	15
100	0.14	2	1	5	2	5	2	4
b		2.5	2	14	6	9	5	1

[a] Values represent percent over respective sieve number. [b] Through 100.

Blending. Blends were prepared by mixing each regrind sample with the control at the 5, 10, 15, 20, 25, 50, and 100% replacement levels.

Particle Size. Particle size distribution for each sample was obtained on a Ro-Tap, using 100 g of sample and shaking for 60 s.

Protein Content. Protein content was determined by the Kjeldahl procedure, using the standard AACC method 46-10 (1961). The results are expressed on a 14.0% moisture basis.

Ash Content. Ash was determined by the standard AACC method 08-01 (1961). The results are expressed on a 14.0% moisture basis.

Wet Gluten. Wet gluten content was determined on a Theby gluten washer, using the standard AACC method 38-11 (1961).

Farinograph Score. Farinograms were obtained by using the standard AACC method 54-21 (1961). Absorptions were adjusted so that the resulting farinograph peaks touched the 500 B.U. line. The curves were compared with standard curves developed in this department for numerical score assignment (Figure 1). Low numbers indicate weak gluten and higher numbers indicate progressively stronger gluten or mixing tolerance.

Falling Number. The falling number values were determined by using the standard AACC method 56-81B (1972).

Spaghetti Processing. The method of Walsh et al. (1971) was used to prepare spaghetti from the semolina control and the blends. Average spaghetti diameter was 1.52 mm.

Spaghetti Color Score. Spaghetti color was determined by using the reflectance technique described by Walsh (1970).

Spaghetti Cooking Quality. The cooked weight (g), cooking loss (%), and cooked firmness (g cm) values were determined by using the procedure described by Walsh et al. (1971), with 15 min as the standard cooking time. The effect of cooking time on spaghetti cooking quality was also

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0021-8561/80/1428-0806$01.00/0

Table II. Protein, Ash, Wet Gluten, and Falling Number Values for Regrinds

sample	protein,[a] %	ash,[a] %	wet gluten,[a] %	farinograph score[b]	falling number
A	12.3	0.58	31.0	3	403
B	12.7	0.68	28.0	1	405
C	12.8	0.67	31.0	1	451
D	12.7	0.70	24.0	N.A.	340
E	12.1	0.65	30.0	2	364
F	12.4	0.67	38.0	2	469
av	12.5	0.66	30.00		405

[a] Expressed on a 14.0% moisture basis. [b] Scored by reference to Figure 1.

Table III. Effect of Blending Regrinds with Semolina on Spaghetti Color[a]

	color scores						
sample	5%	10%	15%	20%	25%	50%	regrinds, 100%
A	8.0	8.0	8.0	8.0	7.5	7.0	7.0
B	8.0	8.0	8.0	7.5	7.5	7.5	7.5
C	8.0	8.0	8.0	7.5	7.5	7.5	7.5
D	8.0	8.0	8.0	7.5	7.5	7.5	7.5
E	8.0	8.0	8.0	8.0	7.5	7.5	7.5
F	8.0	8.0	8.0	8.0	8.0	7.0	7.0
av	8.0	8.0	8.0	7.8	7.6	7.3	7.3

[a] Spaghetti color processed from control: 8.0.

determined by varying cooking time from 10 to 15, 20, and 25 min.

RESULTS AND DISCUSSION

Physicochemical Properties of Regrinds. Particle size distribution for each regrind sample is presented in Table I. The standards of identity for durum semolina require that, under the sieving procedure outlined in the Materials and Methods section, "no particles will remain over a No. 20 U.S. sieve and that no more than 3% will pass through a No. 100 U.S. sieve" (Walsh and Gilles, 1974). Both the control and sample F fall within these standard limits. It is apparent from an examination of the commerical regrinds that the processors either are using different mills to grind their pasta or are using similar mills under different operating conditions. Commercial samples A and C have high percentages of coarse particles (over sieve 20). Samples B and D have relatively high percentages of flour (14 and 9%, respectively) and sample E has 1% particles over sieve no. 20 and 5% through sieve no. 100.

Protein content of all samples averaged 12.5% and ranged from a low of 12.1% for sample E to a high of 12.8% for sample C (Table II). Ash levels averaged 0.66% and ranged from a low of 0.58% for sample A to 0.70% for sample D. Wet gluten averaged 30% and ranged from a low of 24% for sample D to a high of 38% for sample F. Although the protein levels listed in Table II are normal for commercial pasta products, the wet gluten levels, with the exception of sample F, are quite low. Wet gluten levels for durum semolina having the protein levels indicated above generally will range from 36 to 44% on the average (Donnelly et al., 1975; Donnelly and Banasik, 1976, 1977, 1978). The lower levels obtained here may reflect some physical denaturation of the gluten from the extrusion process and/or from the milling process used to grind the pasta. All samples had weak gluten as indicated by the low farinograph scores. It was not possible to get a mixing curve for sample D due to its extremely weak mixing properties.

Table IV. Effect of Blending Regrinds with Semolina on Spaghetti Cooked Weight[a]

	cooked weight, g						
sample	5%	10%	15%	20%	25%	50%	regrinds, 100%
A	32.0	31.6	31.5	31.9	32.2	32.2	31.4
B	33.8	33.1	32.1	32.1	32.8	32.1	31.2
C	31.4	32.3	31.9	32.9	33.1	32.0	32.0
D	31.7	32.1	31.5	33.0	32.1	32.0	32.3
E	31.4	32.2	31.6	32.3	32.0	31.9	32.1
F	31.8	31.3	30.5	30.0	30.7	31.1	30.3
av	32.0	32.1	31.5	32.0	32.2	32.0	31.6

[a] Cooked weight of spaghetti processed from control: 31.9 g.

Table V. Effect of Cooking Time on Spaghetti Cooking Quality of Regrinds[a]

cooking time, min	cooked weight, g				
	high	low	av	SD	control
10	29.4	25.6	27.9	0.6	29.0
15	33.8	30.0	31.9	0.7	31.9
20	37.8	34.5	36.4	0.7	37.4
25	42.9	38.0	39.8	1.0	40.9

[a] Values listed at each cooking period are for all blends.

Table VI. Effect of Blending Regrinds with Semolina on Spaghetti Cooking Loss[a]

	cooking loss, %						
sample	5%	10%	15%	20%	25%	50%	regrinds, 100%
A	7.3	7.7	8.3	8.1	8.3	9.3	9.3
B	8.0	8.6	8.7	8.7	8.9	8.8	9.3
C	7.4	7.7	8.1	8.7	9.0	9.7	10.7
D	8.4	8.6	8.6	8.3	8.4	9.0	9.4
E	7.1	7.4	7.6	7.6	7.7	8.2	8.5
F	7.2	7.2	7.6	7.7	8.6	9.4	9.5
av	7.6	7.9	8.2	8.2	8.5	9.1	9.5

[a] Cooking loss of spaghetti processed from control: 7.1%.

Falling number values for all samples were high, indicating the absence of sprout damage in the raw materials.

Effect of Blending on Spaghetti Color. Spaghetti color for the control was 8.0, indicating a relatively bright, low amber product (Table III). Inspection of color data obtained for the blends shows that blending up to the 15% level had no adverse effect on color. Blending at the 20% level produced color reduction in samples B, C, and D from 8.0 to 7.5. This may be due to the higher levels of flour present in the regrinds, causing a reduction in the yellowness of the spaghetti at this blending level. All samples, except F, show this reduction in color at the 25% blending level. Blending beyond the 25% level adversely affected the spaghetti color of all samples.

Effect of Blending on Spaghetti Cooking Quality. Cooking quality, as indicated by cooked weight, cooking loss, and cooked firmness, was determined for each of the blends, using the standard cooking time of 15 min. Cooked weight data are listed in Table IV. Inspection of the data shows that all samples were quite similar in their water absorption characteristics. The mean cooked weight for all samples was 31.9 g with a standard deviation of 0.7 g (Table V). Blending obviously did not significantly affect the cooked weight of the spaghetti.

Cooking loss data for the blends are listed in Table VI. Two points are noteworthy. First, all blends on the average had higher cooking losses than the control. Second, as the degree of blending increased average cooking losses in-

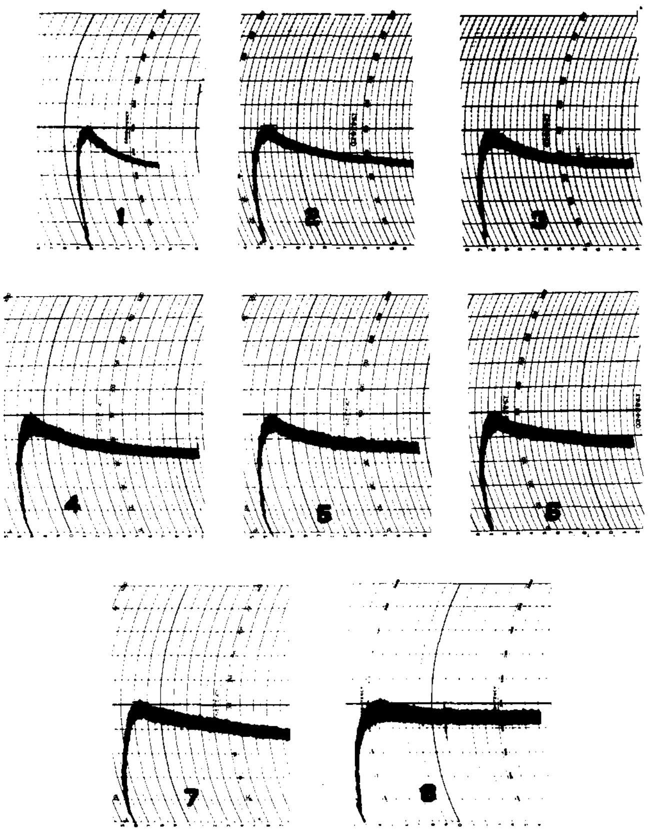

Figure 1. Standard farinograph curves of durum wheat semolina.

Table VII. Effect of Blending Regrinds with Semolina on Spaghetti Cooked Firmness[a]

	cooked firmness, g cm						
sample	5%	10%	15%	20%	25%	50%	regrinds, 100%
A	5.6	5.1	5.4	4.6	4.8	4.5	4.4
B	4.7	4.0	4.4	4.3	4.5	4.7	4.5
C	5.2	5.1	4.9	4.3	4.4	4.7	3.8
D	5.1	5.2	4.5	4.6	5.0	4.6	4.1
E	5.0	4.8	5.0	4.5	4.8	4.8	4.6
F	5.0	5.0	5.1	5.3	5.4	4.5	4.5
av	5.1	4.9	4.9	4.6	4.8	4.6	4.3

[a] Cooked firmness of spaghetti processed from control: 5.3 g cm.

creased from 7.6% for the 5% blend to 9.5% for 100% regrinds. On the basis of the results blending beyond the 25% level would appear to produce, on the average, unacceptable cooking losses since values higher than 9.0% are generally considered unacceptable.

Cooked firmness, like cooking loss, also showed undesirable average trends as the degree of blending increased (Table VII). All average blends were slightly softer than the control and as the degree of blending increased beyond 25% the products became progressively softer. However, although the cooked products on the average were significantly lower than the control at blend levels higher than 10%, all average values were within acceptable cooked firmness limits.

Effect of Cooking Time on Spaghetti Cooking Quality. Cooking times were varied from 10 to 15, 20, and 25 min and the effect on spaghetti cooked weight, cooking loss, and cooked firmness determined. Average cooked weight for all samples showed an almost linear increase with cooking time from 27.9 g at 10 min to 39.8 g at 25 min (Table V). Standard deviations were similar at 10, 15, and 20 min and slightly higher at 25 min. None of the samples were significantly different, on the average, from the control. The high and low values presented in the table represent one sample that had those particular values.

Table VIII. Effect of Cooking Time on Spaghetti Cooking Quality of Regrinds[a]

cooking time, min	cooking loss, %				
	high	low	av	SD	control
10	8.2	5.0	6.3	0.7	6.1
15	10.7	7.1	8.4	0.5	7.1
20	11.3	7.5	9.1	0.7	8.4
25	11.7	8.2	9.7	0.7	9.4

[a] Values listed at each cooking period are for all blends.

Table IX. Effect of Cooking Time on Spaghetti Cooking Quality of Regrinds[a]

cooking time, min	cooked firmness, g cm				
	high	low	av	SD	control
10	6.5	4.1	5.5	0.5	5.9
15	5.7	3.8	4.7	0.4	5.3
20	4.8	3.4	4.0	0.3	4.2
25	4.3	2.9	3.5	0.3	3.3

[a] Values listed at each cooking period are for all blends.

The effect of cooking time on cooking loss is shown in Table VIII. Although average cooking losses increased with cooking time, they increased at a decreasing rate from 6.3% at 10 min to 9.7% at 25 min. Standard deviations were 0.7% at 10, 20, and 25 min and 0.5% at 15 min. Cooking losses on the average were also higher than the control at each cooking time, an effect noticed previously at the standard cooking time of 15 min.

As cooking time increased, average cooked firmness decreased from 5.5 g cm at 10 min to 3.5 g cm at 20 and 25 min (Table IX). The standard deviations for all samples at each cooking time were quite similar. Cooking beyond 15 min produced average tenderness scores of 4.0 and 3.5 g cm at 20 and 25 min, respectively. Both values would be considered too soft for cooked pasta of the dimensions used in this study. In general, the blends produced softer cooked pasta than the control at 10, 15, and 20 min of cooking.

ACKNOWLEDGMENT

The author thanks Slavko Vasiljevic for his technical assistance in this study.

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Received for review September 10, 1979. Accepted April 9, 1980. Published with the approval of the Director, North Dakota State Agricultural Experiment Station, Fargo, North Dakota, as Journal Series No. 1045.

Glucosinolate Products in Commercial Sauerkraut

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Three varieties of cabbage, Roundup, Sanibel, and TBR Globe, were commercially processed into sauerkraut. The aglucon products from two of the three glucosinolates abundant in kraut cabbage were measured at intervals from fresh cabbage to canning of the sauerkraut. Within the first 2 weeks of fermentation, all the glucosinolates were hydrolyzed. Thiocyanate ion and 1-cyano-3-methylsulfinylpropane, the aglucon products measured, varied little from 2 weeks of fermentation to finished sauerkraut. In the finished kraut, thiocyanate ion ranged from 9 to 17 ppm and 1-cyano-3-methylsulfinylpropane ranged from 16 to 25 ppm. No isothiocyanates or goitrin were present. No nitriles from allyl glucosinolate were found.

A number of potential toxicants occur in cruciferous vegetables, but apparently pose no human health hazard as currently used. To evaluate whether new varieties with possible increased toxicant levels might pose a health problem (Senti and Rizek, 1974), it is necessary to know both the composition of current varieties and the effects of food processing on the toxicants. The toxic properties of glucosinolates that are found in cruciferous vegetables depend in part on the type of aglucon products formed from them during food processing.

Glucosinolates may hydrolyze to form nitriles instead of isothiocyanates in a number of cruciferous crops, depending upon the treatment of the plant material and the conditions during hydrolysis (VanEtten et al., 1966; VanEtten and Daxenbichler, 1971; Tookey, 1973). Cabbage leaves autolyze to form organic nitriles from the glucosinolate aglucons (Daxenbichler et al., 1977). The present study was undertaken because preliminary evidence indicated that nitriles from glucosinolates were found in commercial sauerkraut preparations (Daxenbichler et al., 1977).

EXPERIMENTAL SECTION

Fresh Cabbage Sample Preparation. Three varieties of cabbage, Roundup grown in Oregon and in New York and Sanibel and TBR Globe grown in Wisconsin, were each commercially harvested and processed into sauerkraut in 1976. Five representative heads of each cabbage variety and location were selected. Hot methanol extracts were prepared and analyzed as described for glucosinolate aglucons (Daxenbichler and VanEtten, 1977) and total glucosinolate (VanEtten and Daxenbichler, 1977). These methods are outlined in Daxenbichler et al. (1979).

Fermented Cabbage Sample Preparation. Samples were collected at weekly intervals during the sauerkraut fermentation and were held frozen at −18 °C until just before analysis. The final sauerkraut sample, a commercially canned product, was held under refrigeration until analysis. These fermentation samples were separated into juice and residue by draining through cheesecloth. The juice was analyzed separately. Juice and residue were also recombined in the same proportion as the original to obtain samples of the whole fermentation. The recombined samples were treated with hot methanol as described by Daxenbichler et al. (1979). The juice was analyzed without hot methanol treatment.

Salt and Lactic Acid. These substances were determined by the method of VanEtten (1978).

Thiocyanate Ion. Assay for thiocyanate ion in fresh cabbage was made by a method similar to that of Josefsson (1968). In this method the optical absorbance of the ferric–thiocyanate complex is measured both before and after decomposition of the complex with mercuric ion. The absorbance after decomposition provides a correction for background interferences. Addition of thiocyanate ion to fermentation samples containing salt and lactic acid demonstrated that only about 16% of the ferric–thiocyanate complex was decomposed by mercuric ion. To overcome this problem, thiocyanate ion was estimated by measuring the colored complex and subtracting the sample solution (without ferric nitrate) as a blank. Under these conditions, quantitative recovery of added thiocyanate ion was then obtained.

1-Cyano-3-methylsulfinylpropane. The 1-cyano-3-methylsulfinylpropane is relatively nonvolatile and elutes where there is little or no interference from other compounds on both EGSSX and Apiezon columns described by Daxenbichler and VanEtten (1977). However, gas–liquid chromatography (GLC) estimation of some aglucon nitriles in the fermentation samples was not possible because of interfering peaks from unknown substances in the dichloromethane extracts.

Satisfactory conditions for complete extraction of 1-cyano-3-methylsulfinylpropane from the fermentation samples were found empirically. Known amounts of pure 1-cyano-3-methylsulfinylpropane added were recovered by the following procedure: A sample of 25 mL of aqueous extract or juice (pH 3.5 to 4.0) was adjusted to pH 8.0–8.8

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