Dual-Purpose Mill for Flour and Granular Products[1]

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ABSTRACT

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A 55 cwt pilot mill originally designed and flowed to produce bread wheat flour was modified to increase the purifier surface by 300%. After modification, the mill could produce either a granular or a fine flour product, depending on the mode of operation. Conversion from one mode to the other required about 2 hr and involved changing some of the gaps between rolls, sieve sizes, and stream flows. Roll types or corrugations were not changed. Total flour extraction ranged from 72 to 80%, depending on the wheat lot. Farina of 30–35% extraction was produced when the mill was converted to produce a granular product with a total extraction of 75–78%. The average particle size distribution of the product was 4.3, 43.3, and 44.1% over No. 20 W, 30 W, and 40 W, respectively, and 8.3% through No. 40 W. The percent extraction of semolina from 10 different varieties ranged from 56.3 to 65.4%, with an average extraction of 60.0%. The average granulation of the semolina was 3.1, 72.7, 16.8, and 4.8% over No. 40 W, 60 W, 80 W, and 100 W, respectively, and 2.6% through No. 100 W. The ash content of the semolina ranged from 0.498 to 0.614%, with an average of 0.553%.

Using the milling equipment available in a given plant to produce different types of cereal products would greatly reduce equipment and building costs. Minimizing the time required for the changes needed to produce the new products would be a key factor to success.

Shuey et al (1977b) found that the flour extraction obtained from a given quantity of wheat can be increased by regrinding the millfeed products without changing the mill settings or the procedure for regular flour production. Extension of the mill flow with an Entoleter and pin mill made it possible to obtain an additional 5% flour extraction. Additional flour produced by the extended extraction flour procedure increases the total amount of flour obtained from a given parcel of wheat which, in turn, substantially increases the value of the wheat lot.

Mills (1966) showed that considerable interest in the development of abbreviated milling flows is apparent not only in Canada and the United States but also throughout Europe and elsewhere. Several factors have contributed to this speedy transition; one is a gradual increase in roll speeds, and another is the adoption of impact mills, with consequent shortening of the reduction system. Pneumatic conveying has had the effect of lowering stock temperatures and increasing sifter throughput. Neither quality nor performance appears to suffer to any appreciable extent from use of these shorter surface mills.

Pomeranz (1977) observed an old English-built mill in Shanghai. It was one of the largest in China and could produce 2,500 tons of flour per 24 hr. The milling system included 3 B + 3 M with 2 F rolls, a much shorter diagram than the original one (6 B + 11 M); purifiers were no longer used. The Chinese maintained that shortening the diagram did not affect flour quality. However, the Chinese permitted 1.20% ash (dry matter basis) in the standard and 0.70% in the white flour.

Jones (1962) found that in most U.S. mills, the total roll surface per unit of flour milled is only about one-third of that customary in Britain.

Nordstrom (1965) stated that design capacity is the capacity of a milling unit as originally established by the mill builder. The various mill builders base this capacity on the use of a fixed number of machines and a fixed capacity of those machines.

Niernberger (1970) stated that one objective of flour milling is to combine individual flour mill streams for maximum profit under constraints of product specification and sale. Greatest attention is given to flour stream makeup when new wheat begins to arrive each crop year. In general practice, procedures focus around cumulative ash compilation of the flour streams. Data on previous crop years, the expertise of the miller and cereal chemist, and the existing milling flow of the flour mill are used as background information.

Shellenberger (1961) reported that although the properties of wheat grown in different regions vary greatly, so much wheat moves in international trade that similar experiences in evaluation have brought about rather uniform criteria of milling value. Millers in North and South America, Europe, or Australia would be likely

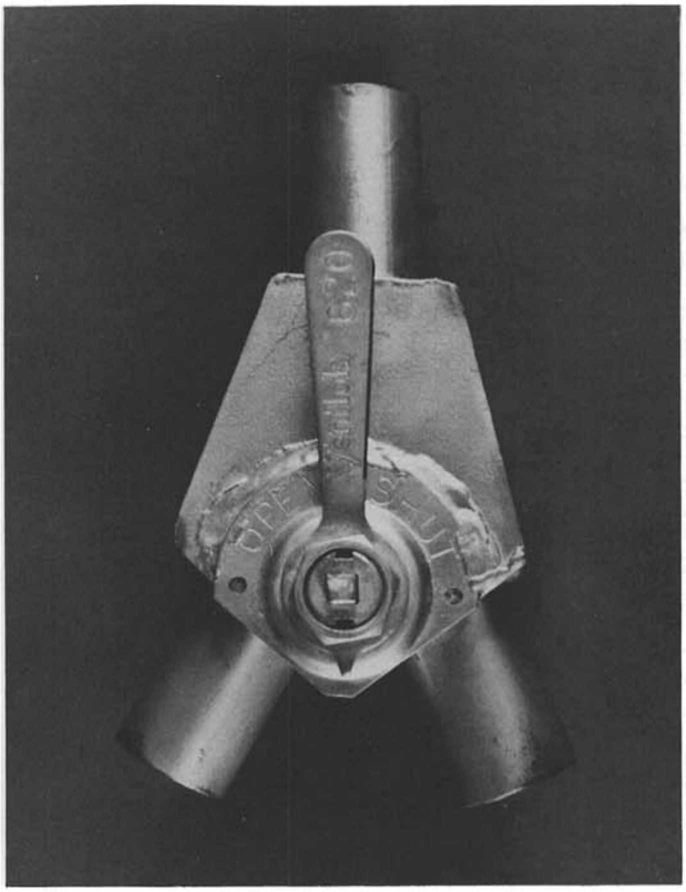

Fig. 1. Cutoff valve for changing mill flow.

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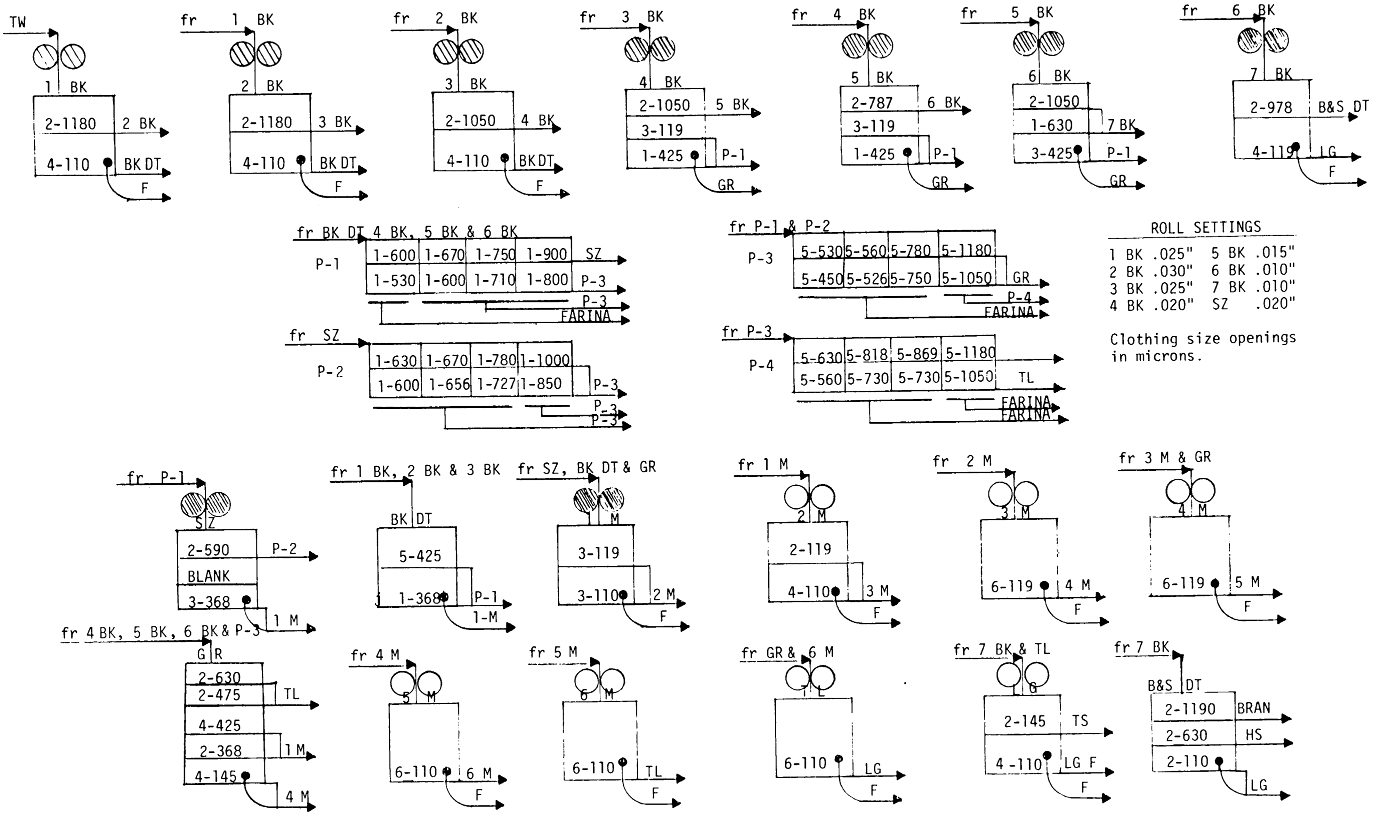

Fig. 2. Farina pilot mill flow.

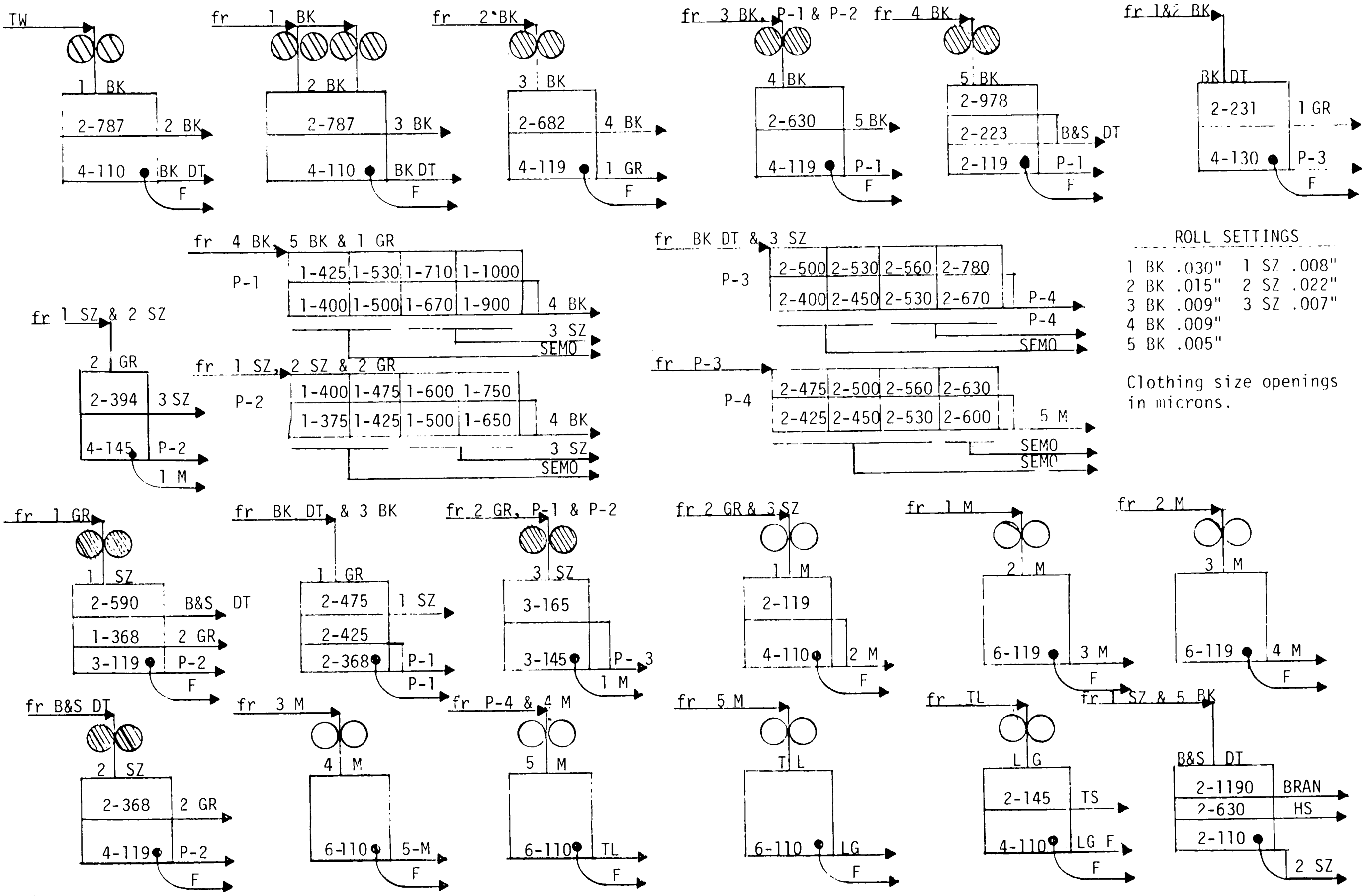

Fig. 3. Durum pilot mill flow.

to evaluate a sample of wheat for milling purposes in very nearly the same manner, using the same criteria.

Shuey (1970) demonstrated that the results obtained on the pilot mill compare favorably with those of a commercial mill.

Black (1966) noted that the controversy regarding the need for purification in the milling of flour does not apply to the milling of semolina. Semolina quality is greatly dependent on the efficiency of the purifier. Today's commercial purifiers retain the same basic principles of the early models, but the many innovations built into them have greatly improved the efficiency of purification and increased the capacity.

Nelstrop (1972) found that economic forces such as the higher prices of durum wheat, plant, and labor have led us to reexamine the background and principle of semolina milling.

Seyam et al (1974) found that different particle-size distributions of milled semolina did not appear to affect the quality of the finished pasta. A very fine granulation containing as much as 71.9% flour showed a marked effect on semolina dust color, but when the semolina was processed into spaghetti, the color was no different from that of spaghetti made with semolina of coarse granulation.

Harris et al (1955) found that length of extraction and granulation affected semolina properties; protein and ash contents and speckiness decreased directly with length of extraction. Water absorption of the dough tended to decrease also. Macaroni color was greatly improved by decreasing the extraction and to a lesser extent by reducing the amount of flour produced.

A study by Shuey et al (1977a) suggests that most of the variation in the total extraction of the durum samples they tested was attributable to the flour extraction rather than to the semolina extraction. Thus, determining the total extraction as well as the semolina extraction is important for evaluation of the potential milling value of durum wheat.

The objective of the present study was to incorporate features into the present 55-cwt pilot mill that would allow it to be quickly converted to produce different types of cereal products.

MATERIALS AND METHODS

Wheat Samples

Two 600-lb samples, one each of hard red winter wheat (HRW) and hard red spring wheat (HRS), country-run elevator lots, were used for the farina study. Ten 325-lb Canadian durum wheat samples that ranged widely in quality were used for the semolina study. Three different classes of wheat from the 1977 crop year (ie, an HRS blend, an HRW commercial blend, and a durum wheat commercial blend) were used for the fine-cut and coarse-cut material. The commercial HRW and durum wheat blends were received cleaned and ready for milling.

The HRS and HRW samples were cleaned with commercial cleaning equipment at a rate of 25 bu per hour and in the following sequence: Carter seed cleaner No. 245 with 4¾/64 precision grader cylinder shell; Carter disc separater No. 1522 with five R-4½, seven R-5, five J, and five A discs; model A, Forsberg standard stoner; No. 10 Forster cyclone grain scourer with top aspirator; Kice aspirator (test system with 6D6 aspirator, CA-24-cyclone, and FC-9 fan).

The Canadian durum wheat samples were cleaned in a Clipper model M-2B and blended in a pharmaceutical mixer.

For the coarse granular material, two approaches were taken, one for the maximum production of farina and the other for that of semolina. The HRS and HRW used for farina were tempered to 15.5% moisture for 18 hr and then provided with 2% more moisture 20 min before they were fed to the first break roll. The durum wheats milled to semolina were tempered to 14.5% moisture for 18 hr and then brought to 17.5% moisture 30 min before milling.

The HRS and HRW blends were tempered to 15.5% moisture, and the durum wheat blend was tempered to 16.5% moisture for 18 hr before the first break roll.

Conversion of the Mill

To reduce time for changing the mill flow from flour production to production of the coarse granular material, a cutoff valve that would simplify the change-over was designed (Fig. 1). Two sets of pipes were used, one for flour and one for the granular material. The top of the valve was attached to the material pickup funnel under the sifter. By a simple turn of the valve handle, the stock could be diverted to one of the two flows (Fig. 2). The roll corrugations were not changed for this study. The differential on first midds was changed from 1.5:1.0 to 2.5:1.0 for the semolina flow. This was the only change made on the roll speeds.

TABLE I
Large-Scale Millings of Country-Run Elevator Lots of Hard Red Winter and Hard Red Spring Wheats

	Percent Clean Dry	
Stream	Hard Red Winter	Hard Red Spring
First break	0.94	1.60
Second break	0.51	0.61
Break dust fine	8.26	9.33
Break dust coarse	0.35	0.36
Sizing	0.90	1.58
Third break	0.32	0.35
Fourth break	1.89	2.02
Fifth break	4.16	4.42
Sixth break	5.50	4.82
Seventh break fine	1.09	0.91
Seventh break coarse	8.43	7.21
Purifier one fine	3.89	3.44
Purifier one coarse	24.86	22.16
Purifier one scalps	10.27	10.20
Purifier two fine	2.55	4.18
Purifier two coarse[a]	0.69	1.50
Purifier two scalps[a]	0.61	1.48
Bran	29.36	26.51
Dregs, dust, etc.	4.81	4.12
Purifier two coarse[b]	0.30	0.15
Purifier two scalps[b]	1.24	0.85
Farina	34.35	36.27

[a] Without overs of 18W sieve.

[b] Overs of 18W sieve.

TABLE II
Farina Particle Size Distribution (%)

	Hard Red Wheat	
Size[a]	Winter	Spring
> 840	6.4	3.1
590–840	42.5	41.1
420–590	41.5	43.4
< 420	9.6	12.4

[a] In microns.

TABLE III
Complete Milling Results for a Hard Red Spring Wheat

	Percent of Clean, Tempered Wheat	
Streams	Fraction	Total
Feed		
Bran	19.6	
Shorts	3.7	
Total		23.3
Extraction[a]		
Farina		28.3
Flour		
Initial	7.5	
Break	5.5	
Reduction	31.3	
Low-grade	1.8	
Total		46.1
Loss		2.3
Total		100.0

[a] Total extraction = 74.4%.

TABLE IV
Milling Data for 10 Durum Wheats

Variety	Semolina Extraction[a] (%)	Specks per 10 sq in.	Dust Color[b]	Semolina Protein[c] (%)	Semolina Ash[c] (%)	Total Extraction (%)
Hercules	59.5	29	110	14.2	0.549	68.6
Leeds	59.4	35	113	15.0	0.614	68.2
Macoun	61.4	27	118	13.1	0.524	70.6
Pelissier	60.5	29	95	12.8	0.583	68.1
Quilafen	65.4	30	120	10.6	0.529	74.2
Stewart 63	61.2	35	100	14.1	0.573	68.8
Wakooma	56.3	27	115	13.6	0.559	64.9
Ward	61.1	30	120	13.2	0.498	69.3
Wascana	57.2	30	130	14.3	0.594	67.1
2 CWAD[d]	57.7	23	123	11.8	0.506	68.3

[a] Clean, dry basis.
[b] Determined on model XL-10 Gardner digital color difference meter.
[c] 14.0% moisture basis.
[d] No. 2 Canadian western amber durum.

TABLE V
Semolina Particle Size Distribution (%)

Variety	Size[a]				
	> 420	250–420	177–250	149–177	< 149
Hercules	2.5	73.5	17.0	5.0	2.0
Leeds	3.0	71.0	18.0	5.0	3.0
Macoun	2.5	72.0	17.5	5.5	2.5
Pelissier	3.5	75.5	15.0	4.0	2.0
Quilafen	3.0	71.5	17.0	5.0	3.5
Stewart 63	3.0	74.5	16.0	4.5	2.0
Wakooma	3.0	74.0	16.5	4.5	2.0
Ward	3.0	73.0	16.5	5.0	2.5
Wascana	2.5	71.5	17.5	5.0	3.5
2 CWAD[b]	2.5	72.5	17.0	5.0	3.0

[a] In microns.
[b] No. 2 Canadian western amber durum.

Approximately 2 hr was required to change from one milling process to the other.

Milling

On the mill flow used for farina (Fig. 2), only the break side of the mill was used, with the purifier surface increased by 300%. The rolls were adjusted to yield the desired product. The average feed rate to first break was 180 lb/hr.

The mill flow for durum was similar to that for farina. As shown in Fig. 3, a third sizing roll with a differential of 2.5:1.0 and two sifters for grading material were used in addition to the break system of the mill. Tempered wheat was fed to the first break roll at the average rate of 216 lb/hr.

Three different studies were conducted with the 55-cwt pilot mill as described by Shuey et al (1971). The studies were: 1) mill was changed completely to a granular system; 2) no changes were made in the HRS wheat flow, but certain streams were taken out for use as is; 3) same as 2, except that a fine or coarse cut was taken off the mill.

Physical Tests

Test weight, 1,000-kernel weight, kernel size distribution, and specks per 10 sq in. were determined as described by Shuey (1977).

Particle size distribution was determined with a Ro-Tap testing shaker (W. S. Tyler Co., Cleveland, OH). The U.S. standard sieves 20, 30, 40, 60, 80, and 100 were used. The sample (100 g) was sifted for 1 min. The percentage of each fraction was determined from the weight of the overs on each wire.

Methods of Analysis

Moisture, ash, and protein were determined by AACC Methods 44-15, 08-01, and 46-11, respectively.

RESULTS AND DISCUSSION

Table I shows that the HRS yielded about two percentage points more farina than did the HRW. Table II shows that the percentage of material over a 20 wire was about three points more for the HRW than for the HRS and that the percentage passing through the 40 wire was about three points lower for the HRW than for the HRS. The differences between the two samples could be attributed to the higher vitreousness of the spring wheat. The farina from both wheats was clean and sharp and had a good appearance.

The data for the complete milling of a sample of HRS are given in Table III. The offals from the pilot mill and purifiers were combined and ground on the Buhler mill. Percentages were calculated on a clean, tempered wheat basis. The farina yield was 28.3% and flour yield 46.1%, with a total extraction of 74.4%.

Semolina extraction ranged from 56.3 to 65.4% (Table IV). Specks ranged from 23–35 and dust color from 95–130. The specks per 10 sq in. were very similar, considering the range in extraction.

Table IV shows that the varieties varied widely both in protein (10.6–15.0%) and in total extraction (64.9–74.2%). Semolina ash values did not correlate with semolina extraction or semolina protein. The lowest ash value (0.498) corresponded to 61.1% semolina extraction and the highest ash value (0.614), to 59.4% extraction.

Table V shows very little difference in particle size distribution among the samples. The major differences in milling were due to the durum variety.

Availability of one or more coarse corrugated roll stands would have given more flexible control of particle size. We found, however, that roll corrugations required for milling granular products were not as critical as expected.

Selected Mill Streams

Fernandes et al (1978) found that the intermediate-size granular mill streams appear to be the most promising for pasta production from bread wheats if their physical, analytic, and rheological data are similar to those of granular material of known pasta production capabilities. Selection of mill streams from a pilot mill specifically flowed for producing bread flour appeared to afford a wide range of farina types that could possibly be used for pasta production.

We, therefore, conducted large-scale millings on the 55-cwt pilot mill according to Fernandes et al (1978), using three different classes of wheat blends. The big difference between samples (Table VI) was total extraction, which was probably because of the hardness of the durum sample. Streams were collected at purifier one (P1) and purifier two (P2) and blended together for a coarse granulation mill stream. Sizing II produced an intermediate granulation mill stream. Particle-size distribution followed a trend (Table VII), the most vitreous wheat having the largest particle size. Table VIII shows the same trend, the most vitreous wheat having the highest protein, ash, and starch damage. The high color of the

TABLE VI
Data on Three Classes of Wheat Blends[a]

Class of Wheat Blend	Test Weight (lb/bu)	1,000-Kernel Weight (g)	Kernel Size (%) Lg.	Med.	Sm.	Protein[b] (%)	Ash[b] (%)	Total Extraction[c] (%)
HRS[d]	62.5	36.8	56	44	0	13.8	1.60	77.1
HRW[d,e]	61.7	37.3	24	62	14	12.0	1.64	77.2
Durum[e]	62.8	50.5	46	54	0	13.6	1.51	68.1

[a] 1977 crop.
[b] 14.0% moisture basis.
[c] Total products basis.
[d] HRS = Hard red spring, HRW = hard red winter.
[e] Commercial blend.

TABLE VII
Particle Size Distribution (%) in Purified Mill Streams from Three Wheat Blends[a]

Wheat Blend[b] Stream[c]	Size[a] > 420	250–420	177–250	149–177	< 149
HRS					
Sizing II	···	2.8	9.2	25.2	62.8
P1 and P2 blend	59.3	39.6	0.5	0.2	0.4
HRW					
Sizing II	···	1.0	7.4	21.9	69.7
P1 and P2 blend	62.4	36.3	0.6	0.2	0.5
Durum wheat					
Sizing II	···	5.9	24.8	28.2	41.1
P1 and P2 blend	58.5	39.8	0.9	0.2	0.6

[a] In microns.
[b] HRS = Hard red spring, HRW = hard red winter.
[c] P1 = purifier one, P2 = purifier two.

TABLE VIII
Data for Purified Mill Streams from Three Wheat Blends

Wheat Blend[a] Stream[b]	Extraction[c] (%)	Protein[d] (%)	Ash[d] (%)	Color Score[e]	Starch Damage[f]
HRS					
Sizing II	8.2	10.9	0.328	5.0	10.6
P1 and P2 blend	7.7	11.7	0.338	8.0	3.2
HRW					
Sizing II	7.4	9.8	0.391	6.0	9.1
P1 and P2 blend	5.7	10.1	0.432	8.5	1.8
Durum wheat					
Sizing II	12.1	12.2	0.480	10.5	16.4
P1 and P2 blend	9.1	12.6	0.554	14.0	3.7

[a] HRS = Hard red spring, HRW = hard red winter.
[b] P1 = Purifier one, P2 = purifier two.
[c] Total products basis.
[d] 14.0% moisture basis.
[e] Determined on model XL-10 Gardner digital color difference meter.
[f] Farrand equivalent units expressed on a dry basis.

TABLE IX
Spaghetti Data for Purified Mill Streams from Three Wheat Blends[a]

Wheat Blend[b] Stream[c]	Color Score	Cooked Weight (g)	Cooking Loss (%)	Firmness Score
HRS				
Sizing II	4.0	26.9	6.6	5.3
P1 and P2 blend	5.0	26.1	4.0	7.7
HRW				
Sizing II	4.2	27.1	5.4	5.7
P1 and P2 blend	4.2	27.9	5.4	6.7
Durum wheat				
Sizing II	9.5	28.1	7.3	5.0
P1 and P2 blend	9.0	28.4	5.5	6.3

[a] Method described by Shuey (1977).
[b] HRS = Hard red spring, HRW = hard red winter.
[c] P1 = Purifier one, P2 = purifier two.

P1 and P2 blend of HRS and HRW was due to the larger particle size.

Spaghetti data (Table IX) were obtained according to Shuey (1977). The firmness scores of spaghetti from the HRS and HRW blends were higher and therefore more desirable than those of spaghetti made from the durum blend. The color scores were considerably lower for the HRS and HRW spaghetti than for the durum spaghetti, although the HRS and HRW products appeared good and clean.

CONCLUSION

Certain types of streams used for products other than bread can be taken off a mill specifically flowed for producing bread flour without adversely affecting the flour quality. Acceptable granular products can also be produced with a minimum of changes and down time.

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