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A MICRO UNIT FOR PRODUCING DURUM SEMOLINA[1]

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ABSTRACT

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A micro unit for producing semolina from durum wheats has been developed for 200-g samples. In one operation, the unit, a modified Brabender Quadromat Jr. Mill® and a small laboratory purifier, produces over 50% purified semolina from durum wheat. The semolina is uniform in granular size and has a low bran speck count. The micro procedure showed standard errors of 0.79% for extraction and 1.12 specks/10 sq. in. in the semolina which compares favorably with the macro method. The number of samples that can be processed has been increased 60% over the present system to 120 samples/man day.

Milling quality is an important criterion in the evaluation of new varieties of durum wheat. Accurate, rapid tests of milling quality of early generation wheats are important for a successful breeding program.

Early experimental milling and processing equipment required at least several kilograms of grain for a complete test (1–3). Micro procedures proposed by several workers (4–6) could be used to process small samples, but the procedures for milling and purifying semolina were tedious and time-consuming. Sibbitt *et al.* (7) developed a micro laboratory purifier for handling about 100 g or less of unpurified semolina and yielding enough purified product for a micro spaghetti test (6). Later, Black (8) described a laboratory purifier for durum semolina that produced a product of high yield and good quality. However, for both laboratory procedures, the number of samples that could be processed per day was limited, because the milling and purification were two separate steps. Alause (9) developed a simplified system designed for nursery samples, but milling yield was low.

The objective of our research was to develop a single unit system for milling nursery durums and purifying semolina that would be suitable for 200-g samples.

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We wanted a procedure that would detect milling and processing differences in wheat and give a large, daily sample output.

MATERIALS AND METHODS

Wheat Samples

The durum wheats were selected from samples grown in 27 counties of North Dakota during 1974. Composites were made from aliquots of individual samples of various grades blended to provide durum samples with a wide range in grain quality. Grades ranged from U.S. No. 4 Hard Amber Durum to U.S. No. 1 Heavy Hard Amber Durum. Vitreous kernel content ranged from 71–96%. For certain replicated and preliminary experiments, Leeds and Ward durums grown in 1974 were blended prior to use.

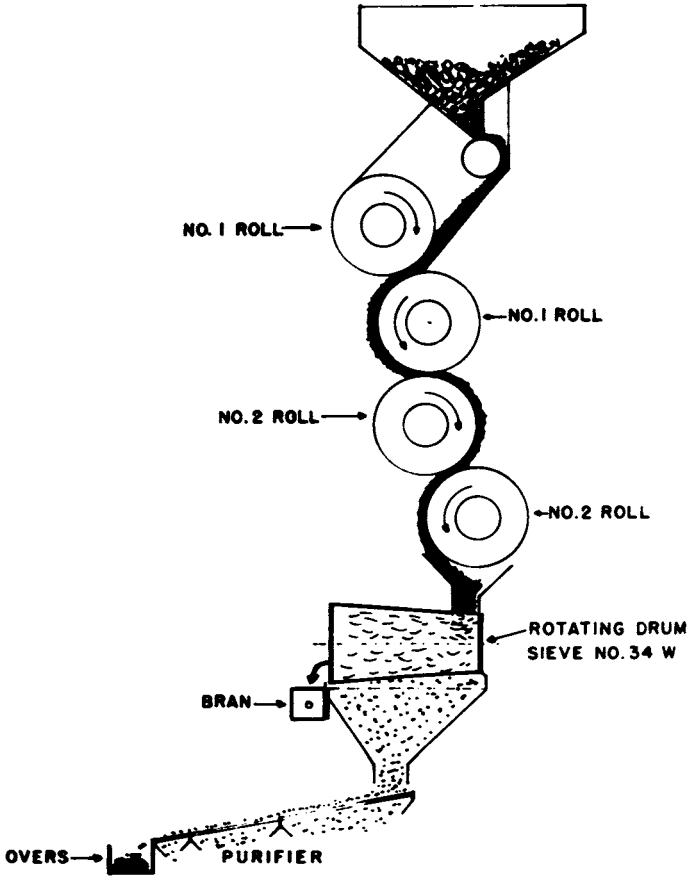

Fig. 1. Schematic flow diagram for micro milling and purification of nursery durums.

Milling and Semolina Purification

The samples were cleaned by passing the wheat over an Emerson Kicker and Dockage Tester and through a modified Forester Scourer, Model 6. The cleaned samples were pretempered to 12.5% moisture for at least 72 hr prior to milling. An additional 3.0% moisture was added 18 hr before milling.

The milling and semolina purification system of Seyam *et al.* (10) was used for the macro samples (2000 g). A Buhler Experimental mill, especially modified for durum wheat and equipped throughout with corrugated rolls, was used for milling. The semolina was purified on two Miag Laboratory Purifiers. All of the stock was handled pneumatically.

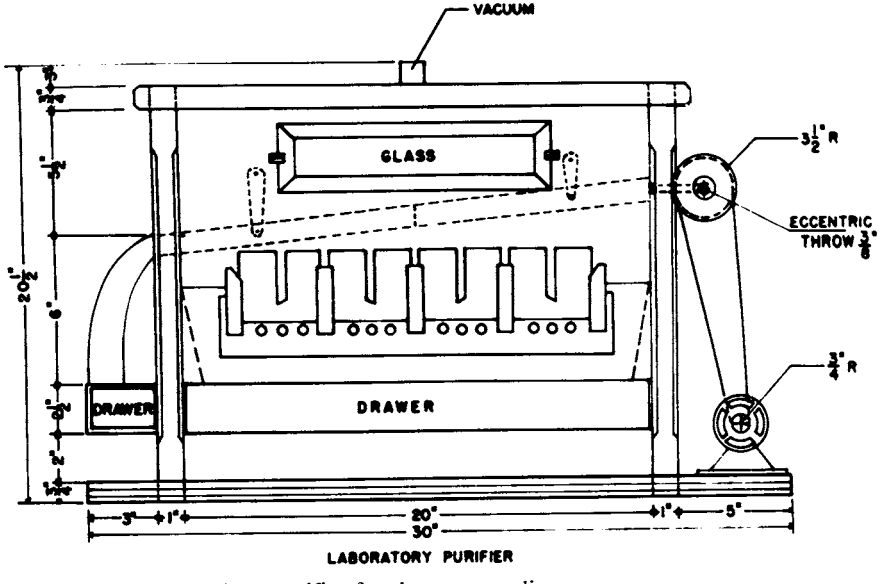

Fig. 2. Side view of micro-purifier for durum semolina.

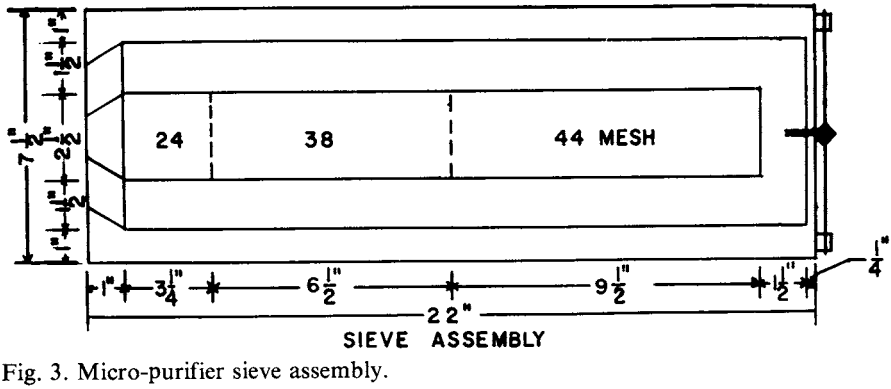

Fig. 3. Micro-purifier sieve assembly.

For development of a short-flow milling method for the micro samples (200 g), the Brabender Quadrumat Jr. mill offered the best potential. We tested a number of currugated roll combinations and a series of sieves for ascertaining the proper granulation, then made the following changes: The No. 2 roll with 26 corrugations/in. was replaced with a No. 1 roll with 13 corrugations/in. The Nos. 3 and 4 rolls were replaced with No. 2 rolls. The durum sieve of the mill was clothed with a No. 34 tin milled sieve. The flour drawer of the mill was replaced with a hopper for transfer of the unpurified semolina to the sieving section of the purifier. Figure 1 is a schematic flow diagram of the modified milling system. The roll spacings were as follows: between rolls No. 1, 0.041 in. (0.104 cm); between rolls 1 and 2, 0.018 in. (0.046 cm); and 0.003 in. (0.008 cm) between the No. 2 rolls.

The laboratory purifier is a modification of the apparatus described by Sibbitt *et al.* (7). The major change is the replacement of the cyclone dust collector and the fan chamber with a cannister-type vacuum cleaner. The details of the purifier are shown in Fig. 2. Above the large drawer unit and below the oscillating sieve unit are four adjustable, sliding vents on each side of the unit. This venting system allows a wide degree of control of inlet air. The fine bran and flour particles are deposited in the dust collection bag of the vacuum cleaner.

The sieve assembly of the purifier, illustrated in Fig. 3, produced the best semolina yield with a minimum bran speck count. The unpurified stock moves from right to left.

Feed rate of the milling-purification system is controlled by adjusting the flow of the tempered wheat. The "overs" from the purifier sieve are collected in the small drawer (on the left in Fig. 2) and passed through the mill a second time.

A 1/8-h.p. electric motor operates the eccentric arm attached to the sieve. The 3/8-in. eccentric throw provides the screen oscillation with a frequency of about 520/min. The "overs" after the second pass through the system are combined with the bran and weighed as feed. The purified semolina is collected in the large center drawer (Fig. 2), weighed, and retained in a moistureproof container until processed.

Analytical

The ash or mineral content, wheat or semolina protein content, and spaghetti color were determined by AACC Approved Methods (11).

Granulation was determined by sieving 50 g of semolina for 30 sec in a Ro-Tap shaking device equipped with U.S. standard sieves Nos. 20, 40, 60, 80, and 100.

The speck count was determined by placing an aliquot of milled and purified semolina on a flat surface. A 3 × 4-in. glass plate with a 1-in. square marked on the center was pressed down on the semolina and the number of specks (bran and other dark particles) within the 1-in. square were counted. The determination was repeated three times and the average was expressed as specks/10 sq. in.

Micro spaghetti samples (30 g) were processed in duplicate from each semolina by extruding the pasta through a brass spaghetti die (0.073-in. diameter opening) by the method of Walsh *et al.* (12). Macro spaghetti samples (2000 g) were processed on a DeMaco vacuum unit (10).

RESULTS AND DISCUSSION

Sample Size

Sample size is an important consideration in testing the quality of semolina from nursery durums. The reproducibility of semolina extraction as influenced

by sample size was tested first with five sample sizes, varying from 50 to 250 g. A cleaned blend of 50% Leeds and 50% Ward durum was thoroughly mixed, then weighed on an as-is basis. Six millings were performed for each sample weight.

The range (Table I), standard deviation, and coefficient of variation (CV) were higher for the smaller (50 or 100 g) than for the larger samples (150 or 200 g). A 200-g sample size was selected because the standard deviation was low (0.235), and 200 g is within the range of wheat available from rod-row nursery plots.

Method Comparisons

The properties of semolina from macro- (Buhler) and micro- (Brabender) milled durums differed somewhat (Table II). The micro procedure extracted 3 percentage points more semolina than the macro method. Also, the range of extraction was greater by the micro than by the macro procedure, which indicated that the micro method is sensitive to differences in milling performance.

Semolina protein averaged 13.3% for the macro- and 13.2% for the micro-milled samples (Table II). The speck count (per 10 sq. in. of surface) averaged 32 and 33 specks for the macro and micro procedures, respectively. In ash content, the micro-processed durum semolina averaged 0.67%, which is somewhat higher than the 0.58% of the macro samples.

The significant correlations between the properties of semolina from the two milling-processing procedures are summarized in Table III. Correlations were highly significant between the macro and micro methods for protein (r=0.972),

TABLE I
Effect of Sample Size on Semolina Extraction

Sample Size g	Range %	Mean	Standard Deviation	CV[a]
50	51.7–59.2	55.3	2.732	4.9
100	52.0–54.7	53.1	1.038	2.0
150	57.1–59.0	58.1	0.628	1.1
200	57.3–57.9	57.7	0.235	0.4
250	57.8–58.8	58.8	0.321	0.5

[a]Coefficient of variation.

TABLE II
Properties of Semolina from 27 Micro- and Macro-Milled Durum Wheats

	Macro		Micro	
Property	Range	Mean	Range	Mean
Extraction, %	48.8–54.4	51.7	51.4–60.5	54.7
Protein, %[a]	11.0–16.1	13.3	10.8–15.5	13.2
Specks/10 sq. in.	20–45	32	17–40	33
Ash, %[a]	0.490–0.650	0.582	0.570–0.750	0.669

[a]Expressed on a 14% moisture basis.

ash (r = 0.778), and specks (r = 0.616). The correlation (significant at the 5% level) for percentage extraction between the two procedures was lower than expected, possibly because of differences in granulation. The only other significant relations were between the ash content of macro-milled semolina and the protein content of the semolina from either method.

Method Performance

The analyses of variance of the semolina extraction and the speck count for duplicate samples of 18 milled samples by the micro method are shown in Table IV. The sample mean squares were highly significant for semolina extraction and

TABLE III
Correlation Coefficients between Macro- and Micro-Processing Methods

Semolina Properties Correlated	Correlation Coefficient
Macro extraction *vs.* micro extraction	0.471*
Macro ash *vs.* macro protein	0.530*
Macro protein *vs.* micro protein	0.972**
Macro bran specks *vs.* micro bran specks	0.616**
Macro ash *vs.* micro ash	0.778**
Macro ash *vs.* micro protein	0.445*

TABLE IV
Analysis of Variance of Extraction and Speck Count for Duplicate Micro-Milled Samples

Source of Variation	d.f.	Mean Squares	
		Extraction	Specks
Replicates	1	9.00	0.03
Samples	17	48.60**	137.60**
Error	17	5.30	10.70
Total	35		

TABLE V
Average Particle-Size Distribution of Micro-Milled and Purified Durum Semolina Samples

U.S. Sieve No.	% Macro	% Micro
40	8.9	3.5
60	64.7	66.2
80	16.9	18.2
100	5.9	6.6
Thru 100	3.7	5.5

TABLE VI
Analysis of Variance of Duplicate Samples for Particle Size

Source of Variation	d.f.	Mean Squares, U.S. Standard Sieve No.				
		#40	#60	#80	#100	Thru #100
Replicates	1	0.01	1.21	0.28	0.30	0.27
Samples	17	0.73	1.47	1.07*	0.75**	0.73**
Error	17	0.34	0.92	0.37	0.20	0.17
Total	35					

specks. Thus, durum of high extraction and low speck count could be selected by the micro-milling and purifying method.

The standard errors between duplicate samples (data not shown) were 0.79% for extraction and only 1.12 specks/10 sq. in. In reproducibility, the micro procedure compares favorably with the macro procedure developed by Seyam *et al.* (10), in which the errors were 0.57% extraction and 1.03 specks/10 sq. in. Binnington and Geddes (1) reported a standard error of 0.70% for mill extraction.

The average particle-size distributions of the micro and macro durum semolina samples are given in Table V. The micro procedure produced a little finer semolina than the macro, as indicated by higher fraction totals found between the U.S. No. 60 and through the No. 100; semolina on the No. 40 sieve was more than 5 percentage points higher for the macro process.

Table VI contains an analysis of variance for the same 18 duplicate samples for particle size that are summarized in Table V. Only sample variance for the Nos. 80, 100, and −100 fractions was significant. Apparently, significant differences between samples were caused by differences in endosperm hardness, which could be associated with the environment because the samples represented 18 North Dakota counties.

The properties of micro-processed durum spaghetti have been reported (4–6, 13). In general, micro-processed spaghetti has more air bubbles in its structure (5) and tends to have pigment values lower than macro-processed samples (13). Ten wheat samples were selected from the 1974 durum composites to provide a range of color in the finished spaghetti. Spaghetti was processed by the macro and micro procedures from durums milled and purified by macro and micro methods.

Color scores averaged 9.20 for the macro- and 8.15 for the micro-produced spaghetti. The correlation between the two sets of data was significant at the 5% level, and probably would have been better if the range of pigmented durums had been greater. Some variability was noted in the lower color range, but with both procedures the same durum produced spaghetti with the highest color score.

From the data presented in this study it can be concluded that the micro-milling and purification procedure meets the requirement of the plant breeder, and with that procedure the cereal chemist could provide early information on durum wheat quality (4th or 5th generation), thus ensuring that the plant breeder would have good quality durums in the advanced yield trial tests.

The micro unit can process 120 samples/man day. This is a 60% increase, or 45 more samples than could be processed by the two-stage procedure (7).

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