EXTENSIVE ANALYSES OF FLOURS AND MILLFEEDS MADE FROM NINE DIFFERENT WHEAT MIXES

I. Amounts and Analyses[1]

E. P. FARRELL, ARLIN WARD, GERALD D. MILLER, AND LESLIE A. LOVETT

ABSTRACT

Samples of flour, bran, shorts, red dog, and germ were milled from five hard red winter wheats, two hard red spring wheats of different origins and protein contents, a soft red winter wheat from Indiana, and a Western white wheat from Washington. Long runs gave valuable production data. The blended samples of wheat, flour, and the four millfeeds have been analyzed for protein, ash, moisture, crude fat, crude fiber, starch, bulk density, and size (by sieving). Data for amino acids, vitamins, and minerals are reported in another paper.

From wheat, a flour mill produces one or more grades of flour and the four millfeeds: bran, shorts, red dog, and germ. Figure 1 shows where components of each feed fraction come from in Kansas State University's 200-cwt. pilot mill (1). Wheat bran (2) consists almost entirely of the coarse outer coatings of the wheat kernel. Shorts (2), also called brown shorts, standard middlings, or middlings, consists mostly of fine particles of bran and germ with very little of wheat red dog. Red dog (2), sometimes called wheat white shorts or red dog flour, is the by-product from the "tail of the mill," consisting chiefly of the aleurone layer with small particles of bran, germ, and flour. Germ, or wheat germ meal, consists of the wheat germ separated in the milling process by careful grinding and sifting.

Nearly five million tons of wheat millfeeds are produced annually by United States mills. Probably feed mills and feeders of animals do not realize the true nutritive values of these feeds compared to those of grains or other feed ingredients. One explanation is that available data are insufficient to evaluate the protein and amino acids, the vitamins, and the mineral contents of these millfeeds.

How much difference is there in the analyses of millfeeds made from hard or soft, red or white, winter or spring wheats? Does geographical origin of the same class of wheat cause great or little change in the amounts of valuable constituents in the millfeeds?

A review of the knowledge about these millfeeds was made by Johnston (3) in 1965. That millfeeds should be made, merchandised, and priced as a product rather than as a by-product has been urged by Mennel (4), Burkitt (5), Pfost (6), Johnson (7), Wilcke (8), and Robertson (9).

This research, sponsored by the Millers' National Federation, was designed

[1] Manuscript received October 14, 1966. Contribution No. 580, Department of Grain Science and Industry, Kansas State University, Manhattan.

to ascertain amounts and analyses of the four millfeeds named above. The same mill was used and the wheats were of several classes and protein contents, grown in widely separated regions of the United States.

Materials and Methods

Twelve-hour milling tests were made under controlled conditions with each of nine different wheat samples, with full-scale commercial equipment to measure milling results in great detail and to provide flour, bran, shorts, red dog, and germ for analyses. Blended samples of each milling product were stored at 0°F. for future use.

All wheat, flour, and millfeed fractions from each milling were analyzed for moisture, protein, ash, crude fat, fiber, starch, bulk density, and granulation.

Wheats Milled. MNF-HRW-L 9001: a hard red winter wheat, 10.75% protein, from Blackwell, north-central Oklahoma; probably Triumph.

MNF-HRW-H 9002: a hard red winter wheat, 13.3% protein, originating in Burdette, southwest Kansas. Early Triumph and Bison are the principal varieties grown there.

MNF-W 9005: a white wheat (Gaines), 9.2% protein, from Pullman, Washington.

MNF-SRW 9006: a soft red winter wheat, 11.75% protein, from Winchester, east-central Indiana, where Monon variety predominates.

HRS-L 9009: a hard red spring wheat, 11.1% protein, from Choteau, northwestern Montana.

HRS-H 9003: a hard red spring wheat (Pembina), 13.8% protein, from Valley City, southeastern North Dakota.

HRW-12P 9008: a hard winter wheat, 11.5% protein, grown near Manhattan, Kansas, in 1964.

HRW-12P 9007: a hard red winter wheat, 11.2% protein, grown near Manhattan, Kansas, in 1965.

HRW-12P 9010: a hard red winter wheat, 11.9% protein, a composite mix of several varieties grown in several Kansas locations.

Cleaning and Tempering. Each lot of wheat was dry-cleaned at 60 bu./hr. as follows: magnet, aspirator, milling separator, stoner, disk separator (oats), disk separator (small seeds), impactor-aspirator, and duo aspirator.

The dry-cleaned hard wheats were mixed with water in a series of screw conveyors and stored in tempering bins at 16% moisture for 20 hr. before being milled. The soft red winter and Western white wheats were similarly mixed with water and stored in tempering bins at 15.0% moisture for 20 hr. before being milled.

Milling. All wheats were milled on the pilot mill at Kansas State University (1). This unit has a capacity of 200 cwt. of flour in 24 hr., and grinds hard wheats at 18 bu./hr. and soft wheats at 15–18 bu./hr., as required.

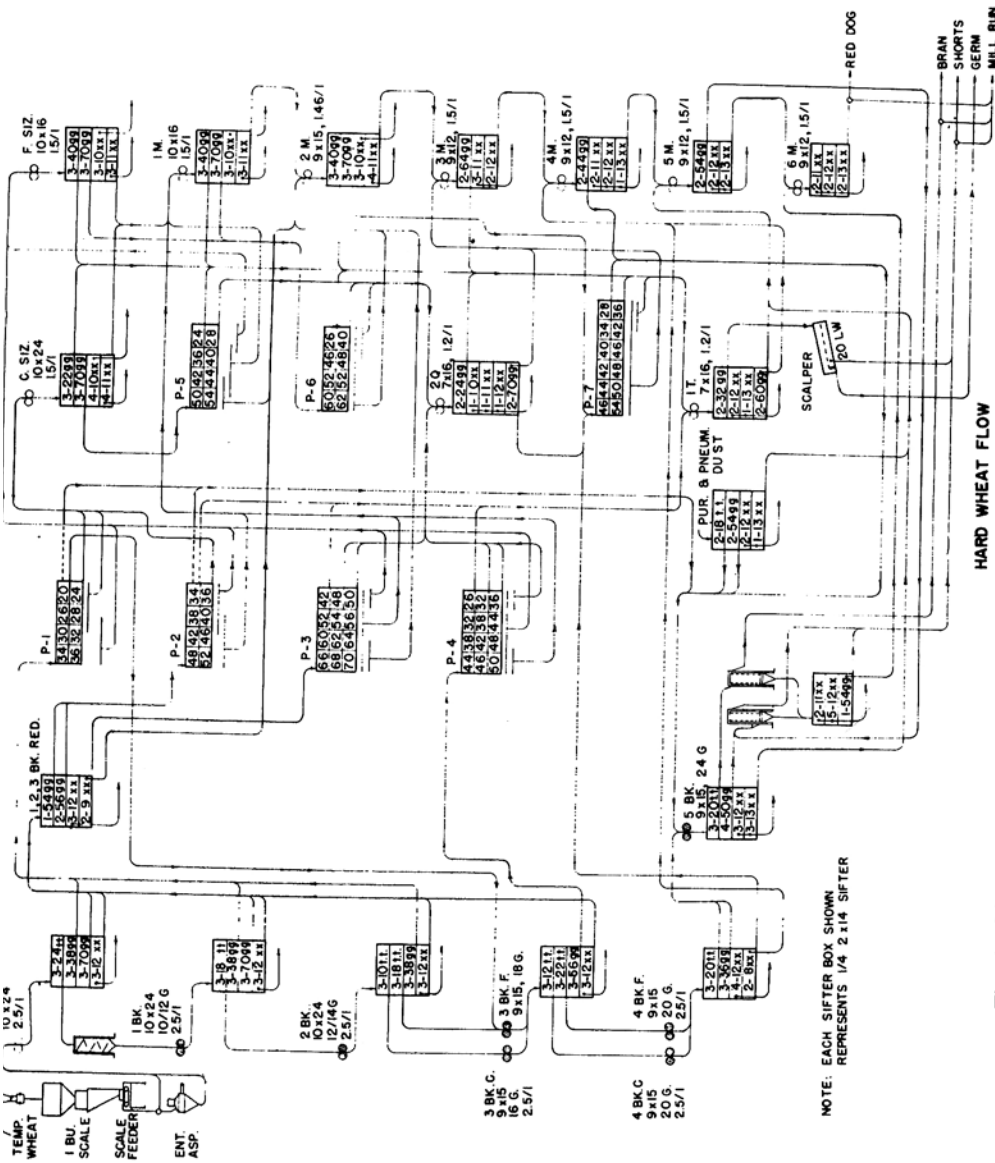

Fig. 1. Flow sheet of the 200-cwt. flour mill at Kansas State University (July 1, 1965).

The flow sheet, Fig. 1, shows the process of milling hard wheat from the tempering bins to completion. The mill has a complete breaking system consisting of a prebreak and five breaks and a separate bran duster and shorts duster. Seven sieve purifiers are used. Operations making up the

reduction system are: two sizings, six middlings, second quality (2Q), and first tailings (1T).

When the soft wheats (Gaines 9005 and SRW 9006) were milled, the first, second, and third break redust sifter section was changed to use 3–54 GG, 2–10 xx, 3–12 xx, and 2–9 xx instead of 3–54 GG, 3–12 xx, 2–9 xx. In addition, because of difficulty in getting flour to go through the fine flour cloths, the flour cloths in the 3M sifter were changed from 3–11 xx, 2–12 xx to 2–10 xx, 3–11 xx, and the 4M sifter was changed from 2–11 xx, 2–12 xx, 1–13 xx to 1–10 xx, 3–11 xx, and 1–12 xx when Gaines 9005 was milled.

The day each wheat was milled, the pilot mill was started with a wheat similar to the one tested. About 2 hr. was spent getting the rolls and sifters warmed and adjusted. When operations were judged to have stabilized, the test wheat mix was put on the mill. Temperature in the mill was kept at 85° ± 5°F. and the relative humidity was regulated automatically to 70%.

Each pair of break rolls was adjusted to produce a unit extraction through a 20-mesh (1,050-micron opening) sieve in the sample sifter as follows: 1 BK., 30%; 2 BK., 40%; 3 BK.C., 30%; 3 BK.F., 55%; 4 BK.C., 20%; 4 BK.F., 35%; 5 BK., 30%.

Reduction rolls were adjusted by the miller, with feel, sight, and performance on the mill as criteria.

The flour made was straight grade. It was weighed by a 1,500-lb. suspension hopper scale with a small holding bin above to retain flour while it was weighed in the hopper and emptied into the packing bin.

Bran was weighed in a 1,000-lb. suspension hopper scale.

Shorts and germ were collected in containers and weighed.

All production figures (Table I) are expressed as percentages of total products (all flour and millfeeds made from the total test run).

Sieve analyses of the bran, shorts, red dog, and germ are reported in Table II.

TABLE I

PERCENTAGES OF THE PRODUCTS OF MILLING NINE DIFFERENT LOTS OF WHEAT

Exp. No., Wheat, and Date	Flour	Bran	Shorts	Red Dog	Germ	Total Feed	Total Products
	%TP[a]	% TP	% TP	% TP	% TP	% TP	% TP
9001, HRW-L, 10/15/65	72.98	16.86	6.94	2.53	0.69	27.02	100.00
9002, HRW-H, 10/29/65	72.44	13.80	8.87	3.66	0.58	28.25[b]	100.02
9008, HRW-R1, 1/21/66	74.57	14.26	7.07	3.35	0.75	25.43	100.00
9007, HRW-R2, 5/13/66	75.82	15.31	6.60	1.39	0.88	24.18	100.00
9010, HRW-R3, 6/7/66	74.95	13.82	7.79	2.57	0.87	25.05	100.00
9009, HRS-L, 2/1/66	76.73	13.82	6.80	1.80	0.85	23.27	100.00
9003, HRS-H, 2/25/66	74.68	14.68	7.93	1.64	1.06	25.31	99.99
9005, GAINES, 11/19/65	77.03	12.52	7.83	1.67	0.95	22.97	100.00
9006, SRW, 11/5/65	72.33	14.21	8.00	4.69	0.77	27.67	100.00

[a]TP = Total products.

[b]Includes 64 lb. of fifth break stock, more like feed than flour, collected after a choke of the fifth break pneumatic lift.

TABLE II
PROXIMATE ANALYSES OF WHEAT, FLOUR, AND MILLFEEDS[a]

	HRW-L 9001	HRW-H 9002	HRW-R-1 9008	HRW-R-2 9007	HRW-R-3 9010	HRS-L 9009	HRS-H 9003	Gaines 9005	SRW 9006
WHEAT									
Protein, %	10.75	13.3	11.5	11.2	11.9	11.1	13.8	9.2	11.75
Ash, %	1.69	1.66	1.44	1.5	1.35	1.5	1.65	1.2	1.61
Moisture, %	13.5	12.1	10.4	14.0	11.2	14.0	11.2	13.0	14.75
Crude Fat, %	1.64	1.54	1.54	1.1	1.7	1.75	1.90	1.61	1.74
Crude Fiber, %	2.0	2.22	2.11	2.4	2.5	2.14	2.61	2.08	1.74
Starch, %	54.14	61.78	56.28	56.90	54.86	56.78	59.14	59.24	55.74
FLOUR									
Percent of TP[b]	72.98	72.44	74.57	75.82	74.95	76.73	74.68	77.03	72.33
Protein	9.75	12.65	10.7	10.2	10.5	10.4	13.0	8.35	10.8
Ash	0.39	0.42	0.40	0.40	0.40	0.39	0.40	0.36	0.35
Moisture	14.4	13.6	13.6	12.7	13.6	13.5	11.2	13.3	13.9
Crude fat	0.81	0.89	0.87	0.75	0.83	0.93	0.98	0.91	0.9
Starch	71.89	73.72	68.40	66.49	66.55	66.12	70.20	64.34	70.19
GERM									
Percent of TP	0.69	0.58	0.75	0.88	0.87	0.85	1.06	0.95	0.77
Protein	21.9	22.0	22.0	22.5	22.1	23.5	24.5	22.8	21.7
Ash	4.2	4.34	4.05	4.1	4.3	4.1	4.2	3.5	4.02
Moisture	12.8	12.8	12.9	11.1	12.1	12.1	11.3	11.7	12.4
Crude fat	6.3	7.1	6.5	7.7	8.2	10.1	10.6	7.3	8.35
Crude fiber	3.0	3.35	3.55	3.5	4.0	2.84	2.7	3.1	3.05
Starch	14.43	14.91	21.40	19.54	23.92	19.16	19.22	13.96	15.95

(continued)

TABLE II (continued)

	HRW-L 9001	HRW-H 9002	HRW-R-1 9008	HRW-R-2 9007	HRW-R-3 9010	HRS-L 9009	HRS-H 9003	Gaines 9005	SRW 9006
RED DOG									
Percent of TP	2.53	3.66	3.35	1.39	2.57	1.80	1.64	1.67	4.69
Protein	12.65	14.1	13.1	13.5	13.2	14.0	15.1	12.65	15.2
Ash	2.18	1.99	1.49	2.1	2.1	2.7	2.4	2.03	1.47
Moisture	13.0	13.4	13.5	12.6	13.0	11.4	11.2	10.8	12.20
Crude fat	3.06	2.88	2.29	2.7	3.0	4.7	3.97	3.4	2.94
Crude fiber	2.2	1.99	1.19	2.9	2.2	2.4	2.8	3.2	1.37
Starch	47.55	47.76	42.36	36.96	43.70	36.22	45.08	39.95	46.20
SHORTS									
Percent of TP	6.94	8.87	7.07	6.60	7.79	6.8	7.93	7.83	8.0
Protein	15.2	16.5	16.4	14.4	14.7	15.4	16.0	13.8	13.9
Ash	3.84	4.34	3.79	3.5	4.1	4.05	4.02	3.1	3.9
Moisture	12.7	12.7	11.5	9.7	12.3	10.8	16.6	11.4	11.8
Crude fat	5.02	4.63	4.9	4.6	5.0	6.3	5.8	3.7	4.6
Crude fiber	5.6	5.9	5.7	6.6	7.2	6.8	7.0	6.7	6.0
Starch	18.12	19.09	18.47	21.70	17.93	15.94	15.90	20.48	21.31
BRAN									
Percent of TP	16.86	13.80	14.26	15.31	13.82	13.82	14.68	12.52	14.21
Protein	12.9	14.5	13.8	13.7	13.3	12.1	15.4	13.6	13.9
Ash	7.1	7.0	6.1	5.9	6.5	6.2	6.8	4.72	7.0
Moisture	11.5	12.8	11.9	11.1	12.6	10.7	13.3	10.8	11.6
Crude fat	3.6	3.1	3.0	3.0	3.6	4.2	3.73	3.1	3.22
Crude fiber	10.2	9.5	10.1	10.3	11.6	10.9	10.8	9.3	9.2
Starch	4.64	6.39	5.46	6.31	6.65	5.22	4.71	7.21	5.71

[a]All analyses corrected to 14.0% moisture.
[b]TP = total products.

TABLE III
BULK DENSITIES OF MILLFEEDS

Code	Wheat Mix	Bran	Shorts	Red Dog	Germ
		lb./cu. ft.	lb./cu. ft.	lb./cu. ft.	lb./cu.ft.
9001	HRW-L	10.2	19.3	17.8	21.9
9002	HRW-H	10.7	18.8	20.9	18.7
9008	HRW-R1	9.3	18.6	24.4	19.8
9007	HRW-R2	10.2	19.5	25.6	18.5
9010	HRW-R3	9.7	19.5	20.2	18.5
9009	HRS-L	9.4	18.8	20.4	18.92
9003	HRS-H	8.5	17.6	19.5	19.8
9005	Gaines	11.3	19.6	16.2	22.6
9006	SRW	11.6	19.0	17.0	21.1

Bulk densities (Table III), in lb./cu. ft., were calculated from data obtained by dropping 1.25 qt. of material through the funnel of the Boerner test weight apparatus into the 1-qt. test kettle aand weighing the leveled contents of the kettle as lb./bu. with the specially calibrated scale. Test weight in lb./bu. × 0.8 bu./cu. ft. equals lb./cu. ft.

Sample Blending. Germ and red dog were each blended in a horizontal batch mixer and packed in 5-lb. hand-tied plastic bags and stored in fiber drums at 0°F.

Random selections of bags of bran and shorts were each blended in a 17-cu.-ft. horizontal batch mixer, sacked off, placed in fiber drums, and stored at 0°F.

Samples of the blended materials, along with blended portions of clean dry wheat and flour, were sent to the analytical laboratory.

Methods of Analysis. The analyses for protein, ash, moisture, and crude fiber were made by methods given in *Official Methods of Analysis* of the Association of Official Agricultural Chemists, 10th edition.

Crude fat was analyzed by the method prescribed by the American Oil Chemists' Society.

Starch was determined by the *Standard Analytical Methods* of the Member Companies of the Corn Industries Research Foundation, Inc., 1st edition, CIRF Method A-20 (June 3, 1957).

Results

The percentage distribution of each product obtained by each milling test is shown in Table I. Flour yields of 9001 and 9002 were lower than expected. The data seem to indicate that had the fifth break rolls in test 9001 been set closer, the yield would have been improved somewhat; and had the reduction end of the mill during test 9002 been set to clean out a little more flour, less red dog and more flour would have been produced. The yield for SRW 9006 is not considered low, but the high amount of red dog confirms observations during milling that more effective sifting of ground middlings would have recovered more flour and less red dog.

Table II shows proximate analyses for each of nine wheat samples and of

TABLE IV

SIEVE ANALYSES OF MILLFEEDS PRODUCED FROM NINE DIFFERENT LOTS OF WHEAT, 250 GRAMS SIFTED BY ROTAP SIFTER FOR 4 MINUTES

Tyler Sieve	Experiment No. and Wheat Designation								
	9001 HRW-L	9002 HRW-H	9008 HRW-R1	9007 HRW-R2	9010 HRW-R3	9009 HRS-L	9003 HRS-H	9005 Gaines	9006 SRW
	%	%	%	%	%	%	%	%	%
					Bran				
+ 8W	11.16	7.60	10.80	8.80	12.00	15.20	9.60	9.60	10.00
+12W	49.40	46.40	47.60	53.20	53.60	46.40	54.00	46.40	46.40
+14W	8.76	10.80	9.60	11.20	8.40	8.40	7.60	10.40	10.40
+20W	19.92	24.00	20.00	20.80	18.00	20.00	19.70	21.60	20.80
+28W	5.98	7.20	6.80	4.00	4.40	8.00	6.00	6.80	7.60
Pan	4.38	4.00	4.80	2.00	3.20	2.00	2.80	5.20	4.80
Total	99.60	100.00	99.60	100.00	99.60	100.00	99.70	100.00	100.00
					Shorts				
+14W	0.40	0.40	0.40	0.40	0.40	0.40	0.40	1.20	0.40
+20W	12.45	11.60	6.80	10.80	10.40	12.95	11.60	9.60	7.20
+28W	34.54	35.20	31.20	33.20	29.60	32.0	37.60	34.40	35.80
+35W	20.48	21.20	23.20	21.20	23.60	19.05	20.80	22.80	23.90
Pan	32.13	31.60	38.80	34.00	35.60	35.60	29.60	32.00	32.60
Total	100.00	100.00	100.40	99.60	99.60	100.00	100.00	100.00	99.90
					Red dog				
+35W	0.40				0.40	0.41	0.40		
+48W	8.80	4.00	1.60	3.60	2.00	3.30	3.60	8.40	4.30
+65W	40.00	32.00	17.60	16.80	14.40	22.30	32.80	44.20	35.90
+100W	33.20	37.60	48.00	50.00	57.20	45.00	38.00	32.30	33.90
Pan	17.60	26.40	32.80	21.60	26.00	28.90	25.20	15.10	23.90
Total	100.00	100.00	100.00	100.00	100.00	99.91	100.00	100.00	100.00
					Germ				
+10W		0.80		0.80	0.40	1.62	0.40		
+12W	5.62	9.52	1.20	17.60	16.00	24.30	28.00	0.40	4.00
+14W	14.06	17.05	19.60	21.20	27.20	22.20	32.40	19.20	19.20
+20W	44.98	54.80	57.20	50.40	49.20	36.40	36.00	61.20	61.20
+28W	14.86	9.52	12.80	8.00	6.00	10.92	2.40	11.20	9.60
Pan	20.48	8.33	8.80	2.00	1.20	4.45	0.80	8.00	6.00
Total	100.00	100.02	99.60	100.00	100.00	99.89	100.00	100.00	100.00

the flour, germ, red dog, shorts, and bran milled from each wheat mix.

Loose bulk densities of millfeeds, germ, red dog, shorts, and bran are shown in Table III.

Size distributions of the four millfeeds from each wheat, as shown by sieving test with a stack of sieves in the Rotap sifter, are listed in Table IV.

Discussion

While this pilot mill has more rolls, sifter, and purifier surface per unit of capacity than commercial mills, they have been carefully adapted to milling at the relatively low feed rates of wheat into the mill. The result is a flour lower in ash than usually expected, but the flour yield and the amounts, percentages, and characters of the bran, shorts, red dog, and germ are considered similar to those from larger commercial mills.

The proximate analyses and physical properties of bulk density and size distribution provide data from well-defined representative samples. Another report (10) gives the quantitative amounts of amino acids, vitamins, minerals, and gross energy of the same wheat flour and millfeed samples.

Literature Cited

1. FARRELL, E. P., and WARD, A. B. Flow rates and analyses for ash and protein of all streams in the Kansas State University pilot flour mill. Bull. Assoc. Operative Millers **1965:** 2842–2847.
2. MORRISON, F. B. Feeds and feeding (22nd ed.), pp. 441–443. Morrison Pub. Co.: Clinton, Iowa (1959).
3. JOHNSTON, W. R. Millfeed, present and future. Northwest. Miller, July 1965; pp. 18–26.
4. MENNEL, D. M. Millfeed—product? by-product? Introduction to the problem. Northwest. Miller, June 10, 1963; pp. 13–18.
5. BURKITT, W. H. Wheat millrun—help it be recognized. Northwest. Miller, June 24, 1963; pp. 40–43.
6. PFOST, H. B. Millfeed Research—past, current, and future. Northwest. Miller, July 8, 1963; pp. 24–26.
7. JOHNSON, M. D. S. The case for upgrading millfeed. Northwest. Miller, July 22, 1963; pp. 17–20.
8. WILCKE, H. L. Millfeeds for the feed industry. Northwest. Miller, Aug. 5, 1963; pp. 26-28.
9. ROBERTSON, J. E. Do we appreciate the value of millfeed? Northwest. Miller, Feb. 1966; pp. 22–28.
10. WAGGLE, D. H., LAMBERT, M. A., MILLER, G. D., FARRELL, E. P., and DEYOE, C. W. Extensive analyses of flours and millfeeds made from nine different wheat mixes. II. Amino acids, minerals, vitamins, and gross energy. Cereal Chem. **44:** 48–60 (1967).