Bread-Making Quality of Air-Classified Hard Red Spring Wheat Manipulated Flour Blends[1]

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ABSTRACT

Two high, one intermediate, and two low protein flour fractions were obtained by pin-milling and air-classification of selected flour streams from three hard red spring wheat varieties (Era, Red River 68, and Waldron) and from a wheat blend of equal parts of the three varieties, which were milled on a pilot mill. Ash contents, protein contents, average particle sizes, and mixograms were obtained on the flour streams and fractions. Flours were blended from combinations of flour streams and fractions to manipulate flour quality. Subsequently, ash contents, protein contents, particle sizes, and farinograms were obtained for the manipulated flour blends. Each was baked and evaluated for quality differences within each variety and for acceptability against a hard red spring wheat milling and baking standard. Bread-making quality of flour blends differed within a given variety, but improvements in baking did not necessarily raise the quality to an acceptable level. Quality characteristics of manipulated flour blends could be changed by fractionating a few flour streams rather than the entire flour, and the quality characteristics of an already acceptable variety could be improved.

Because each hard red spring (HRS) wheat variety has inherent genetic differences and exhibits different degrees of environmental response, milling characteristics and wheat flour quality can vary from year to year. Furthermore, a wheat variety with good agronomic traits may yield less acceptable flour than does a wheat with undesirable agronomic traits. Fine grinding and air-classification techniques have been used to help the millers of soft and hard winter wheats produce special blends of flour. Perhaps similar techniques could be used to manipulate the bread-making quality of HRS wheat flour.

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Finely-ground, air-classified flours from both hard and soft wheats have been studied. Elias and Scott (1957), who fortified soft wheat flour with varying amounts of air-classified high-protein fractions isolated from the same flour, reported that the amount of high-protein fraction (HPF) in each blend affected bread-making quality. Bean et al (1969) added HPF to three base flours (9.4–10.6% protein) to give blends containing 12.0% protein and concluded that dough and bread properties of the blends were significantly influenced by the HPF, the base flour, and the method of obtaining the HPF. Pence et al (1968) showed that the HPF of soft white and hard red winter wheat flours improved the bread-making characteristics of family flours when blended to give a 12.0% protein level. Although Tipples and Kilborn (1968) found little advantage in pin-milling Canadian spring wheat flour for use in conventional baking methods, they discovered that the pin-milled flour, which had elevated levels of starch damage, permitted higher baking absorption in short-time baking processes.

The baking potential of wheat flour is usually determined on a flour blend but can be determined on single flour streams or fractions and on blends of flour fractions with a starch or gluten base. Grosh et al (1959) air-classified individual hard red winter wheat flour streams from an Allis mill. Each of four streams and three fractions was baked into bread, and for all flours tested, the coarse fraction of intermediate-protein content compared best with the original stream, whereas the low-protein fraction produced the poorest quality loaves. The HPF usually gave good loaf volumes but inferior overall quality. Hayashi et al (1976) pin-milled and air-classified three pilot-milled flour streams (1M, 3M, and 2B) from four HRS wheat varieties. Addition of starch to the HPF reduced loaf volume, and addition of vital gluten to the low-protein fraction improved the bread characteristics for all varieties.

Information on the baking properties of pin-milled, air-classified HRS wheat flours is available (Wichser 1958), but previous studies were concerned with individual flour streams or fractions.

The purpose of this study was to determine whether manipulated flour blends (MFB) made by selectively combining flour streams and pin-milled, air-classified flour fractions from a single HRS wheat variety would have bread-making properties better than those of the straight-grade flour from the same variety. The HRS wheat varieties Era, Red River 68, and Waldron were selected for study because of their diverse rheological properties and bread-making qualities. Flour streams (1B, 4B, 5B, BD, 1M, 3M, and 4M) were selected for the study on the basis of previous flour fractionation work by Dick et al (1977).

MATERIALS AND METHODS

Wheat Samples

The three HRS wheat varieties were grown at the Agronomy Seed Farm at Casselton, ND, in 1972. Waldron is a conventional height variety, and Era and Red River 68 are semidwarfs. A wheat blend (WB) was made from equal parts of the three varieties and was regarded as a fourth variety.

Milling and Air-Classification

The four wheat varieties were milled by established procedures (Shuey and Gilles 1968, 1969) into 20 separate mill streams (three feed streams and 17 flour streams) on a 55-cwt pilot mill with a modified mill flow (Dick 1976). Seven individual pilot-milled flour streams were investigated: three middling flour streams (1M, 3M, and 4M), three break flour streams (1B, 4B, and 5B), and the break-dust flour stream. All seven streams were studied for Waldron and WB, but the streams studied for Era were 1B, break dust, 1M, 3M, and 4M, and for Red River 68 were 4B, 5B, 1M, 3M, and 4M. Each flour stream was pin-milled and air-classified (Dick 1976).

Flour Blends

MFB were made with the flour streams and fractions of a given variety. The flour streams that were not to be investigated individually were blended by variety, and these blends were used as a base "pilot mill blend" for the MFB. In addition, relative proportions of the selected pilot-milled streams were combined with the corresponding pilot mill blend to give a straight-grade, pilot flour blend (SGPL), which was used as a reference for each variety. A similar blend was made for each variety by combining the pin-milled, air-classified flour fractions with the pilot mill blend to give a reconstituted straight-grade, air-classified flour blend (SGAC).

Particle Size

The particle size (average particle diameter) of the pin-milled fractions from air-classification was determined on a Fisher Sub-Sieve Sizer (Fisher Scientific Instruments, Chicago, IL).

Analytical Methods

Standard procedures (AACC 1962) were used for ash content, Kjeldahl protein (N × 5.7), and farinogram (80-g constant dough weight) determinations. Ash content, protein content, and farinograph absorption values were calculated on a 14.0% moisture basis.

A mixogram was determined for each flour stream. Each mixogram, except for the unusually high absorption streams, was determined with 30 g of flour, 20 ml of water, and a spring setting of 10. The absorptions, obtained according to mixogram curve height and adjusted for constant consistency, were reported on a 14.0% moisture basis. The peak length represented the length in centimeters from the start of the curve to the center of the peak.

Baking Procedure

Flour blends were baked by straight-dough procedure using the following formula: flour, 100.0 g (14% moisture basis); sugar, 5.0 g; milk (non-fat, dry), 3.0 g; yeast, 3.0 g; salt, 2.0 g; shortening (melted Crisco), 2.0 g; malted barley flour, 0.1 g. The baking absorption was estimated from the mixograph absorption. Flour for baking was weighed on a 14.0% moisture basis.

Sufficient water was added for proper consistency and the dough was mixed in a 100-g size National mixer (National Mfg. Co., Lincoln, NE). Each dough was fermented at 30°C for 3 hr with the first punch after 105 min and the second punch 45 min later. Thirty minutes after the last punch, the dough was sheeted, molded in a Roll-Er-Up molder (National Mfg. Co., Lincoln, NE), and panned. Then the dough was proofed for 60 min at 30°C and baked for 20 min at 221°C. About 30 min after removal from the oven, loaf volume was determined by rapeseed displacement. The loaves were evaluated for crumb color, crumb grain, and crumb texture the next day. The samples were rebaked with 5 ppm of bromate in the bread formula.

Baking Quality Evaluation

The HRS wheat quality evaluation computer program described by Shuey et al (1975) was used to check for differences in quality of the MFB within a variety and to evaluate the acceptability of each MFB with respect to a standard flour blend. The regular milling and baking standard for the 1972 crop year was used to determine

TABLE I
Pilot Mill Data for Flour Streams

Stream	Era			Red River 68			Waldron			Wheat Blend[b]		
	Ext.[c] (%)	Ash[d] (%)	Protein[d] (%)	Ext.[c] (%)	Ash[d] (%)	Protein[d] (%)	Ext.[c] (%)	Ash[d] (%)	Protein[d] (%)	Ext.[c] (%)	Ash[d] (%)	Protein[d] (%)
1B	1.1	0.58	10.5	···	···	···	1.2	0.56	15.2	1.3	0.54	12.7
BD	2.1	0.50	10.0	···	···	···	2.1	0.46	14.6	2.2	0.45	12.0
4B	···	···	···	1.9	0.54	15.5	2.2	0.49	18.9	2.2	0.51	15.7
5B	···	···	···	1.3	0.97	18.2	1.5	0.87	21.8	1.5	0.91	18.2
1M	12.2	0.38	9.8	12.1	0.33	11.9	11.7	0.29	12.7	12.0	0.32	11.5
3M	10.7	0.38	10.3	10.1	0.34	12.4	9.1	0.31	13.6	11.3	0.35	12.0
4M	11.9	0.41	10.1	11.6	0.37	12.4	10.6	0.33	13.8	10.7	0.37	12.2
PMB	37.1	0.54	11.1	37.3	0.46	12.6	35.4	0.46	14.5	33.6	0.50	12.7

[a] 1B, 4B, 5B = break streams; BD = break dust stream; 1M, 3M, 4M = middling streams; PMB = pilot mill blend of the pilot-milled flour streams that were not to be investigated as individual streams.
[b] Equal parts of Era, Red River 68, and Waldron wheat.
[c] Ext. = extraction expressed on a total product basis.
[d] Expressed on a 14.0% moisture basis.

acceptability. In addition, an arbitrary standard was developed from optimum scoring values for each series to determine what values had been altered by the MFB technique.

RESULTS

Analytical data for the pilot-milled flour streams and the pilot mill blend are given in Table I. WB was included because most wheat samples used in industry are blends rather than single varieties. The data varied widely between varieties and among individual flour streams of a single variety. Data omitted from the tables were for streams not used in the study.

Manipulated Flour Blends

Six separate blends each for Waldron and WB were made. The first three blends (1–3) of these two varieties corresponded to the three Era blends in that the same combination of flour streams was used. Likewise, the last three blends (4–6) corresponded to the Red River 68 blends. In this fashion, the MFB of Era and Red River 68 were directly compared to those of Waldron and WB. The analytical and physical data for the Era and Red River 68 blends and the corresponding data for Waldron and WB are given in Table II.

The SGPL and SGAC blends of each variety were distinguished by the fact that the SGAC contained approximately 50% pin-milled, air-classified flour, but the SGPL was 100% regular pilot-milled flour. All of the MFB contained air-classified flour in smaller amounts than did the SGAC.

For Era, all MFB had lower extraction, higher ash content, protein content, absorption, and dough strength values (peak or stability) than did the straight-grade blends. For Red River 68, all MFB had lower extraction and protein content than did the straight-grade blends, but they showed very little difference in dough strength. The MFB from Waldron and WB (1–6) showed somewhat similar responses when compared with their respective straight-grade blends for either Era or Red River 68. However, Waldron blends 4–6 showed a considerably greater decrease in mixing strength, according to the farinograph data, than did the comparable blends of Red River 68. These data indicated either that Waldron was more responsive than Red River 68 to blend manipulation or that Red River 68 was so extremely different that it overshadowed the influence of manipulation. MFB 1–3 of WB showed a large increase in farinograph stability. Furthermore, the somewhat increased stabilities for MFB 4–6 of WB were surprising because one purpose of manipulating these particular blends was to decrease the dough strength.

Comparison of farinograph absorption values of the SGPL, the SGAC, and the MFB indicated that increased absorption was affected by protein content and particle size. The SGAC and the MFB were not directly comparable because they contained

TABLE II
Analytical and Physical Data of Manipulated Flour Blends

Variety	Blend	Ext.[a] (%)	Ash[b] (%)	Protein[b] (%)	Particle Size (μ)	Farinograph Abs.[c] (%)	Farinograph Peak (min)	Farinograph Stability (min)
Era	SGPL[d]	75.1	0.45	10.8	18.6	57.1	2.5	6.5
	SGAC[e]	75.1	0.45	10.6	12.2	59.0	3.0	7.0
	1	52.9	0.47	11.7	11.2	59.7	2.5	19.5
	2	54.0	0.49	11.6	13.3	59.6	4.0	21.0
	3	61.1	0.46	11.3	12.7	59.2	3.0	20.0
Waldron	SGPL[d]	73.8	0.42	14.6	18.6	61.4	11.5	32.5
	SGAC[e]	73.8	0.42	14.4	9.0	63.1	16.5	36.5
	1	53.2	0.47	15.7	10.2	63.9	14.5	38.5
	2	54.4	0.47	15.6	13.1	64.6	14.5	38.5
	3	60.3	0.45	15.3	11.7	63.8	14.5	37.0
Wheat blend[f]	SGPL[d]	74.8	0.43	12.7	19.4	59.2	26.0	31.0
	SGAC[e]	74.8	0.44	12.6	10.4	60.1	22.5	37.0
	1	52.0	0.48	13.8	11.1	61.4	27.5	43.0
	2	53.4	0.49	13.6	11.8	61.3	28.5	44.0
	3	60.0	0.46	13.4	12.9	61.3	26.5	43.5
Red River 68	SGPL[d]	74.3	0.41	12.7	16.4	59.5	34.0	42.0
	SGAC[e]	74.3	0.41	12.6	10.5	61.0	31.0	40.5
	1	58.8	0.42	11.7	14.1	59.6	27.5	39.0
	2	61.1	0.42	11.9	14.3	59.9	28.5	39.0
	3	68.6	0.42	12.1	14.9	59.6	29.0	36.0
Waldron	SGPL[d]	73.8	0.42	14.6	18.6	61.4	11.5	32.5
	SGAC[e]	73.8	0.42	14.4	9.0	63.1	16.5	36.5
	4	59.3	0.43	13.4	12.4	60.0	7.0	21.0
	5	61.8	0.43	13.9	12.7	60.8	7.0	23.0
	6	68.1	0.41	14.0	14.6	61.5	6.5	24.5
Wheat blend[f]	SGPL[d]	74.8	0.43	12.7	19.4	59.2	26.0	31.0
	SGAC[e]	74.8	0.44	12.6	10.4	60.1	22.5	37.0
	4	59.6	0.42	11.6	14.8	58.6	24.5	38.0
	5	62.2	0.42	12.0	15.2	59.1	25.5	36.0
	6	69.0	0.41	12.1	16.2	59.2	24.0	32.5

[a] Ext. = extraction on a total product basis.
[b] Expressed on a 14.0% moisture basis.
[c] Abs. = absorption, expressed on a 14.0% moisture basis.
[d] SGPL = straight-grade pilot flour blend of pilot-milled flour streams.
[e] SGAC = straight-grade reconstituted flour comprised of pilot-milled flour streams and air-classified fractions.
[f] Equal parts of Era, Red River 68, and Waldron wheat.

different percentages of air-classified material and protein contents. For example, the Era variety SGAC had 1.1% less protein content than Era blend 1, but it contained about 50% air-classified material compared with 33% for Era blend 1. Because the SGAC contained more air-classified material, it would have more starch damage (Hayashi et al 1976) than the MFB would. Therefore, starch damage rather than particle size might have been the dominant factor responsible for the increased absorption in the SGAC.

Bread Baking

We wanted a loaf of bread with optimum quality characteristics for each MFB. For this reason, the better loaf of each MFB from two bakes (with and without 5 ppm potassium bromate) was selected for evaluation. For example, Waldron MFB 2 baked with 5 ppm potassium bromate in the formula gave a good loaf volume (1,010), but because it had a much poorer crumb grain (83.05) relative to the same flour blend baked with no bromate (Waldron 2, Tables III and IV), it was not selected for evaluation. Therefore, it is

TABLE III
Baking Quality Differences Within Each Variety for the Manipulated Flour Blends Compared With the Arbitrary Optimum Standard

Variety	Blend	Baking Abs[b] (%)	Mixing Time (Min)	Dough Char[c]	Crumb Color[d]	Crumb Grain[e]	Loaf Vol. (cc)	Evaluation		Differences[a]	
								Baking[f]	Gen.[g]	Minor	Major
Era	STD.[h]	60.6	6.25	3	100.8	89.99	935	2	4	...	
	SGPL[i]	55.2	5.75	3	100.0	89.99	880	8	1	...	BA
	SGAC[j]	58.6	6.25	5	100.8	85.05	855	8	1	LV	BA, DO
	1	60.6	6.00	4	98.5	88.09	915	4	3	DO	...
	2	58.8	5.75	5	100.7	86.07	935	8	1	BA	DO
	3	59.0	5.50	5	100.7	86.07	880	8	1	BA	DO
Waldron	STD.[h]	64.2	5.00	3	101.6	89.99	985	2	4	...	...
	SGPL[i]	60.2	5.00	3	101.6	89.99	940	8	1	...	BA
	SGAC[j]	62.7	4.75	5	99.5	89.99	895	8	1	BA, LV	DO
	1	64.2	4.50	3	98.5	88.10	985	2	4	...	...
	2	64.0	4.25	3	99.0	88.01	880	3	4	LV	...
	3	63.3	4.50	3	98.5	86.10	975	2	4	...	...
Wheat blend[k]	STD.[h]	61.9	6.50	3	101.8	89.99	1010	2	4	...	...
	SGPL[i]	57.3	6.50	3	101.8	88.10	945	8	1	...	BA
	SGAC[j]	61.5	6.50	3	101.0	87.07	950	3	4	...	...
	1	61.5	6.25	3	96.5	87.07	975	3	4	COL	...
	2	61.2	6.00	3	100.0	87.07	970	2	4	...	...
	3	61.9	6.00	3	99.0	89.99	1010	2	4	...	...
Red River 68	STD.[h]	62.6	9.75	1	104.9	83.07	980	2	4	...	...
	SGPL[i]	59.3	9.75	1	100.7	82.07	980	8	1	...	BA
	SGAC[i]	62.6	9.75	1	101.8	82.07	905	3	4	LV	...
	1	59.4	9.25	1	102.9	83.07	905	8	1	LV	BA
	2	60.1	9.50	1	103.9	82.07	935	8	1	...	BA
	3	61.0	9.50	1	104.9	81.07	975	4	3	BA	...
Waldron	STD.[h]	64.2	5.00	3	101.6	89.99	985	2	4	...	...
	SGPL[i]	60.2	5.00	3	101.6	89.99	940	8	1	...	BA
	SGAC[j]	62.7	4.75	5	99.5	89.99	895	8	1	BA, LV	DO
	4	62.0	4.75	3	99.8	88.99	920	5	3	...	BA
	5	61.0	4.75	3	99.8	86.99	910	8	1	LV	BA
	6	60.8	4.50	3	99.8	86.99	925	8	1	...	BA
Wheat blend[k]	STD.[h]	61.9	6.50	3	101.8	89.99	1010	2	4	...	...
	SGPL[i]	57.3	6.50	3	101.8	88.10	945	8	1	...	BA
	SGAC[i]	61.5	6.50	3	101.0	87.07	950	3	4	...	...
	4	58.3	6.25	3	101.8	89.99	870	8	1	LV	BA
	5	59.1	6.25	3	100.8	85.99	920	8	1	LV	BA
	6	59.5	6.00	3	100.8	86.99	925	8	1	LV	BA

[a] BA = baking absorption, MT = mixing time, DO = dough characteristic, COL = crumb color, GR = crumb grain, LV = loaf volume.
[b] Abs. = absorption, expressed on a 14.0% moisture basis.
[c] 1 = bucky, 2 = very elastic, 3 = elastic, 4 = elastic-pliable, 5 = pliable-elastic.
[d] xxx.9 = bright white, xxx.8 = white, xxx.7 = slightly creamy, xxx.6 = bright creamy, xxx.5 = creamy, xxx.0 = normal. The xxx indicates the comparative brightness of the bread crumb.
[e] xx.01 = harsh; xx.05 = open, irregular; xx.07 = irregular, open; xx.09 = open; xx.10 = irregular; xx.99 = normal. The xx indicates the comparative overall appearance of the crumb grain.
[f] 2 = satisfactory, 3 = satisfactory-questionable, 4 = questionable-satisfactory, 5 = questionable, 6 = questionable-unsatisfactory, 7 = unsatisfactory-questionable, 8 = unsatisfactory.
[g] 1 = no promise, 2 = little promise, 3 = some promise, 4 = good promise. Calculated on the assumption that all quality factors other than the baking characteristics were equal to the standard.
[h] An arbitrary standard established by selecting the optimum value for each independent variable within a given wheat variety.
[i] SGPL = straight-grade pilot flour blend of pilot-milled flour streams.
[j] SGAC = straight-grade reconstituted flour comprised of pilot-milled flour streams and air-classified flour fractions.
[k] Equal parts Era, Red River 68, and Waldron wheat.

not shown in any of the tables. Baking quality differences within a variety are given in Table III. Era and Red River 68 each showed only one MFB (Era No. 1 and Red River 68 No. 3) that was better than the SGPL. Red River 68 SGAC was the best blend. Several scores differed for the Waldron and WB blends. Waldron MFB 1–4 and WB MFB 1–3 showed improvement over the SGPL. In addition, the SGAC rated better than the SGPL did for the WB samples. For each variety, the SGAC gave higher baking absorption than the SGPL did. Except for WB, the breads made with SGAC showed lower loaf volume than did those made with SGPL.

Baking acceptability of the flour blends was compared with the 1972 milling and baking standard in Table IV. For Era, only the No. 1 MFB was comparable with the 1972 standard blend, but it showed a minor deficiency for weak dough characteristics. The other Era blends, including SGPL and SGAC, had major faults in either low baking absorption or weak dough. All blends for Red River 68 were unacceptable because of too long mixing time and too tough dough properties. The breads of Era and Red River 68 were characterized by a more open crumb grain than to that of the Waldron variety.

Waldron showed good baking qualities for all blends except SGAC, which had weak dough characteristics. Perhaps either the small particle size or increased starch damage was responsible for the weak dough of this and the Era blends. However, this observation was not substantiated by the WB SGAC sample, which showed normal dough properties. The WB SGPL sample was totally unacceptable for baking because of low baking absorption. Improvement of WB baking quality appeared to be the result of wheat blending, change in physical structure of flour, and manipulation of flour streams and fractions. Apparently either the

TABLE IV
Baking Acceptability of the Manipulated Flour Blends Compared with the 1972 Milling and Baking Standard

Variety	Blend	Baking Abs.[b] (%)	Mixing Time (Min)	Dough Char.[c]	Crumb Color[d]	Crumb Grain[e]	Loaf Vol. (cc)	Evaluation: Baking[f]	Evaluation: Gen.[g]	Deficiencies[a]: Minor	Deficiencies[a]: Major
Chris	MBS[h]	59.9	5.00	3	100.0	91.99	940	2	4	···	···
Era	SGPL[i]	55.2	5.75	3	100.0	89.99	880	8	1	···	BA
	SGAC[i]	58.6	6.25	5	100.8	85.05	855	8	1	BA, LV	DO
	1	60.6	6.00	4	98.5	88.09	915	5	3	DO	···
	2	58.8	5.75	5	100.7	86.07	935	8	1	BA	DO
	3	59.0	5.50	5	100.7	86.07	880	8	1	···	DO
Waldron	SGPL[i]	60.2	5.00	3	101.6	89.99	940	2	4	···	···
	SGAC[i]	62.7	4.75	5	99.5	89.99	895	8	1	···	DO
	1	64.2	4.50	3	98.5	88.10	985	2	4	···	···
	2	64.0	4.25	3	99.0	88.01	880	2	4	···	···
	3	63.3	4.50	3	98.5	86.10	975	2	4	···	···
Wheat blend[k]	SGPL[i]	57.3	6.50	3	101.8	88.10	945	8	1	···	BA
	SGAC[i]	61.5	6.50	3	101.0	87.07	950	2	4	···	···
	1	61.5	6.25	3	96.5	87.07	975	2	4	···	···
	2	61.2	6.00	3	100.0	87.07	970	2	4	···	···
	3	61.9	6.00	3	99.0	89.99	1010	2	4	···	···
Red River 68	SGPL[i]	59.3	9.75	1	100.7	82.07	980	8	1	MT	DO
	SGAC[i]	62.6	9.75	1	101.8	82.07	905	8	1	MT	DO
	1	59.4	9.25	1	102.9	83.07	905	8	1	MT	DO
	2	60.1	9.50	1	103.9	82.07	935	8	1	MT	DO
	3	61.0	9.50	1	104.9	81.07	975	8	1	MT, GR	DO
Waldron	SGPL[i]	60.2	5.00	3	101.6	89.99	940	2	4	···	···
	SGAC[i]	62.7	4.75	5	99.5	89.99	895	8	1	···	DO
	4	62.0	4.75	3	99.8	88.99	920	2	4	···	···
	5	61.0	4.75	3	99.8	86.99	910	2	4	···	···
	6	60.8	4.50	3	99.8	86.99	925	2	4	···	···
Wheat blend[k]	SGPL[i]	57.3	6.50	3	101.8	88.10	945	8	1	···	BA
	SGAC[i]	61.5	6.50	3	101.0	87.07	950	2	4	···	···
	4	58.3	6.25	3	101.8	89.99	870	5	3	BA	···
	5	59.1	6.25	3	100.8	85.99	920	2	4	···	···
	6	59.5	6.00	3	100.8	86.99	925	2	4	···	···

[a] BA = baking absorption, MT = mixing time, DO = dough characteristic, COL = crumb color, GR = crumb grain, LV = loaf volume.
[b] Abs. = absorption expressed on a 14.0% moisture basis.
[c] 1 = bucky, 2 = very elastic, 3 = elastic, 4 = elastic-pliable, 5 = pliable-elastic.
[d] xxx.9 = bright white, xxx.8 = white, xxx.7 = slightly creamy, xxx.6 = bright creamy, xxx.5 = creamy, xxx.0 = normal. The xxx indicates the comparative brightness of the bread crumb.
[e] xx.01 = harsh; xx.05 = open, irregular; xx.07 = irregular, open; xx.09 = open; xx.10 = irregular; xx.99 = normal. The xx indicates the comparative overall appearance of the crumb grain.
[f] 2 = satisfactory, 3 = satisfactory-questionable, 4 = questionable-satisfactory, 5 = questionable, 6 = questionable-unsatisfactory, 7 = unsatisfactory-questionable, 8 = unsatisfactory.
[g] 1 = no promise, 2 = little promise, 3 = some promise, 4 = good promise. Calculated on the assumption that all quality factors other than the baking characteristics were equal to the standard.
[h] MBS = milling and baking standard for the 1972 crop year.
[i] SGPL = straight-grade pilot flour blend of pilot-milled flour streams.
[j] SGAC = straight-grade reconstituted flour comprised of pilot-milled flour streams and air-classified flour fractions.
[k] Equal parts Era, Red River 68, and Waldron wheat.

combination of wheat blending and of physical change in the flour caused by pin-milling and air-classification had a masking affect on the undesirable characteristics of Era and Red River 68, or complementary effects existed that were not apparent.

MFB quality characteristics were changed by fractionating a few flour streams rather than the entire flour blend. The flour streams were chosen to effect desired changes. Bread-making quality of flour blends differed in a variety, but baking quality did not improve to an acceptable level. For example, Era MFB 1 and 2 showed increased baking absorptions and loaf volumes over the Era SGPL but gave relatively poor dough characteristics compared with the baking standard (Table IV). The quality of an already acceptable wheat, such as Waldron, was improved. Manipulative blending gave Waldron MFB 1 and 3 better baking absorptions and loaf volumes than those of the Waldron SGPL, without markedly affecting other qualities. Even by manipulation of flour blends and fractions, good bread-making quality was very difficult to extract from or concentrate in a poor quality HRS wheat flour.

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