Functional Properties of Some European Wheats Grown in Europe and Kansas[1]

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ABSTRACT

Breadmaking properties of 17 European wheats grown in Europe and Kansas were compared. Mixing properties, loaf volumes per unit of protein, and/or crumb grains of the European wheats grown in Kansas generally were superior to those of corresponding samples grown in Europe. The wheats were placed in category A, B, C, or D according to mixogram mix time, loaf volume potential, and bread crumb grain. Nine of the 17 Kansas-grown samples were one-half to two categories higher than the corresponding European-grown samples.

The baking method previously described to evaluate U.S. wheat varieties (Finney and Barmore 1943, 1945a, 1945b; Finney 1945; Shogren and Finney 1974) was equally effective for high-yielding, low-protein wheat varieties grown in Europe (Finney et al 1977). Mixogram mix time to point of minimum mobility (mixing requirement) also was highly effective in differentiating and evaluating the breadmaking properties of those wheats. Protein contents (average about 9.5%) of the European samples were lower than desired for proper differentiation between good and poor quality varieties of wheat. Residues of most of the European-grown wheats were grown at Manhattan, KS, where their wheat protein contents averaged about 13.5%.

The objective of this study was to compare the breadmaking properties of the European wheats when grown in Europe and in Kansas and to place the wheats in quality category A, B, C, or D according to mixogram mixing requirement, loaf volume, and bread crumb grain.

MATERIALS AND METHODS

Wheat and Flour Samples

Aliquots of the 22 samples harvested in Europe in 1975 were planted at Manhattan, KS, in the fall of 1976. Only 17 survived the winter. Nitrogen (90 lb/acre) was applied at anthesis to enhance protein content. The plots were harvested with a nursery combine in July 1977. Samples harvested were Clement and Maris-Huntsman from Belgium; Clement, Hardi, Joss, Maris-Huntsman, and Talent from France; Benno, Diplomat, Feldkrone, and Maris-Huntsman (three samples) from Germany; and Bouquet, Cappelle, Champlaine, and Maris-Huntsman from Great Britain. Eagle and Newton, important Kansas wheat varieties harvested at Manhattan in 1977, were included for comparison. Straight-grade wheat flour (RBS-78), milled on an Allis experimental mill from a mixture of U.S. hard winter wheats grown at several locations throughout the Great Plains in 1977, was blended with a composite of the six Maris-Huntsman flours in the ratio of 90:10, 75:25, 50:50, and 25:75 to demonstrate carrying power.

Experimental Milling

Cleaned and mixed wheat samples were tempered to 15% moisture 18–24 hr before being milled. Weights were recorded, and each 3- to 4-lb tempered wheat sample was subjected to the Allis experimental mill flow (Finney et al 1974). Weights of coarse plus fine bran, shorts, red dog, and combined flour streams were recorded. Straight-grade flour was rebolted over a 9XX flour cloth and blended for 5 min. Flour yield was based on total products.

Breadmaking

The straight-dough breadmaking method included mixing to minimum mobility (optimum) at 100 rpm, adding optimum water, 5 ppm of potassium bromate, and 50 ppm of ascorbic acid. No bromate was needed when dough mixing requirement exceeded 3 min. Additional formula ingredients were 100 g of flour (14% mb), 6 g of sucrose, 1.5 g of salt, 3 g of shortening, 4 g of Ardex 550 soy flour (in place of nonfat dry milk), 0.25 g of barley malt (52 dextrinizing units/g, 20° C), and 3.5 ± 0.1 g of compressed yeast. Compressed yeast was a 50:50 blend of weekly shipments from Anheuser-Busch, Inc., and Standard Brands, Inc. Doughs were fermented 69 min to first punch, 103 min to second punch, and 120 min to pan and were proofed 44 ± 1 min (the time required to proof the controls to 7.8 cm) at 30° C. Loaves were weighed as they came from the oven, and volumes were determined immediately by dwarf rape seed displacement. Baking time was 24 min at 215° C. The loaf volume difference between any two treatment means ($n = 2$) required for significance was 21 cc ($P = 0.05$). Additional related details are given by Finney (1945, 1984) and Finney et al (1976).

Mixograms

Recordings of the rheological properties of the straight-grade flours of the European wheats were made on the 10-g mixograph (Finney and Shogren 1972). Mixing time is the time (min) to the peak (point of minimum mobility). Mixing tolerance is defined by the slope and width of the mixogram after the peak and by the stability of mixogram height on either side of the peak.

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RESULTS AND DISCUSSION

Flour Yield and Flour Ash and Protein Contents (Kansas)

Average straight-grade flour yield of the European wheats harvested at Manhattan in 1977 was 69.5%, 4.5 percentage points less than the average for Eagle and Newton, and was attributable to bushel weights that were 5–10 lb less than those of Eagle and Newton. The European wheats were not well adapted to growing conditions in Kansas. Average flour ash and flour protein contents of the 17 European wheats were 0.45 and 13.4%, respectively, compared with averages of 0.44 and 12.9% for Eagle and Newton.

Bake Absorption and Mix Time (Kansas)

Bake absorption on a 13.5% protein basis varied from 56.8% for Cappelle to 66.2% for Hardi (Table I). The 9.4 percentage point spread in absorption is attributable to quality differences. Bake absorption of Hardi was similar to that of Eagle and of Newton.

Bake mix time to the point of minimum mobility (optimum) varied from 1¼ min for Maris-Huntsman to 4 min for Diplomat (Table I). Overall mixing properties of Diplomat were similar to those of Eagle and Newton. All six Maris-Huntsman samples had bake mix times of only 1¼–1½ min.

Loaf Volume and Crumb Grain (Kansas)

The best index of loaf volume potential of wheat flours differing materially in protein content is comparison of loaf volumes on a constant protein basis (Finney 1943, Finney and Yamazaki 1967, Finney 1979) that is about the average of all samples (Table I). For example, Clement from Belgium had a volume of 820 cc at 11.5% protein and a corrected volume of 942 cc at 13.5% protein. Talent's volume was 903 cc at 11.3% protein and 1,063 cc at 13.5%. Champlaine's volume was 1,030 cc at 15.3% protein and 923 cc at 13.5%. Five of the six Maris-Huntsman samples had questionable-to-unsatisfactory or unsatisfactory loaf volume potentials. Except for Clement from France, all samples that had unsatisfactory mixing properties also had questionable, questionable-to-unsatisfactory, or unsatisfactory loaf volume potentials. Loaf volume potentials (13.5% protein basis) of Hardi, Talent, and Diplomat grown in Kansas were excellent. Diplomat had the best overall functional properties, similar to those of Eagle and Newton.

Bread crumb grains of the European varieties grown in Kansas varied from satisfactory to unsatisfactory. Five of the six Maris-Huntsman samples had questionable-to-unsatisfactory or unsatisfactory crumb grains (Table I). All samples that had unsatisfactory mixing properties also had questionable, questionable-to-unsatisfactory, or unsatisfactory crumb grains.

TABLE I
Milling and Breadmaking Properties of European Wheats Harvested at Manhattan, KS, in 1977[a]

	Flour			Bake Absorption				Loaf Volume	
Variety and Origin	Yield (%)	Ash (%)	Protein (P) (%)	As Rec'd P (%)	13.5% P (%)	Bake Mix Time[b] (min)	Bread Crumb Grain	As Rec'd (cc)	Corrected to 13.5% P (cc)
Belgium									
Clement	70.5	0.43	11.5	58.0	60.2	1¾ (1⅝) U	U	820	942 Q
Maris-Huntsman	71.7	0.48	12.9	60.1	60.8	1½ U	Q-U	863	897 U
France									
Hardi	70.3	0.41	12.1	63.8	66.2	3⅝	S	968	1,071
Clement	69.5	0.43	12.0	59.1	60.9	1⅝ U	U	875	973
Maris-Huntsman	70.9	0.43	13.8	60.2	59.9	1⅜ U	Q	953	935 Q
Joss	67.3	0.52	13.9	59.6	59.2	2½	S	1,018	992
Talent	69.3	0.40	11.3	59.1	62.0	3⅛ (2⅞)	S	903	1,063
Germany									
Diplomat	69.2	0.46	14.1	62.0	61.3	4	S	1,128	1,083
Feldkrone	65.4	0.47	12.5	61.8	63.2	2⅛ Q	Q	940	1,008
Benno	69.1	0.43	14.0	60.3	59.8	2 Q	Q	973	942 Q
Maris-Huntsman	70.8	0.46	14.1	61.9	61.2	1⅜ U	Q-U	945	910 Q-U
Maris-Huntsman	70.6	0.46	14.8	62.2	60.6	1¼ U	Q-U	950	878 U
Maris-Huntsman	70.1	0.44	14.5	62.2	61.0	1¼ U	Q-U	965	907 Q-U
Great Britain									
Bouquet	67.8	0.42	13.4	61.2	61.3	3½	S	978	985
Cappelle	69.5	0.52	13.7	57.0	56.8	2¼ Q	S	985	972
Champlaine	68.3	0.48	15.3	59.7	58.1	2¼ Q	Q	1,030	923 Q
Maris Huntsman	71.1	0.47	14.2	61.3	60.5	1⅜ U	U	900	862 U
Average	69.5	0.45	13.4						
Kansas									
Eagle	74.3	0.44	13.8	66.5	66.0	4⅜	S	1,130	1,107
Newton	73.6	0.44	12.1	64.0	66.5	4¾	S	1,016	1,126

[a]Data expressed on a 14% mb. S = satisfactory, Q = questionable, U = unsatisfactory.
[b]Values in parentheses corrected to 12% protein basis.

TABLE II
Breadmaking Data for Blends of Maris-Huntsman and RBS-78 Wheat Flour Composites[a]

		Bake Absorption		Bake Mix Time			Loaf Volume	
Ratio of Maris-Huntsman to RBS-78	Protein Content (%)	As Rec'd (%)	Calculated (%)	As Rec'd (min)	Calculated (min)	Bread Crumb Grain	As Rec'd (cc)	Calculated (cc)
100:0	14.1	60.7	···	1½	···	Q-U	898	···
90:10	13.9	61.2	61.0	1¾	1¾	Q	913	912
75:25	13.7	61.7	61.5	2⅛	2⅛	Q-S	950	934
50:50	13.3	62.2	62.4	2⅝	2¾	S	990	971
25:75	12.9	63.4	63.2	3⅜	3⅜	S	1,020	1,007
0:100	12.5	64.0	···	4	···	S	1,044	···

[a]Data expressed on a 14% mb. S = satisfactory, Q = questionable, U = unsatisfactory.

Flour Blends of Maris-Huntsman and RBS-78 (Kansas)

The Maris-Huntsman composite flour contained 14.1% protein, had a bake absorption of 60.7%, a bake mix time of 1½ min, a questionable-to-unsatisfactory bread crumb grain, and a loaf volume of 898 cc (Table II). RBS-78 composite flour contained 12.5% protein, had a bake absorption of 64.0%, a 4-min bake mix time, a satisfactory crumb grain, and a loaf volume of 1,044 cc. Maris-Huntsman composite flour contained 1.6 percentage points more protein but 146 cc less loaf volume than did RBS-78. The as-received absorptions, mix times, and loaf volumes of the blends were within experimental error of the calculated values. Bread crumb grains for the 75:25, 50:50, and 25:75 blends were distinctly better than calculated. In a 50:50 blend, RBS-78 carried the unsatisfactory Maris-Huntsman and yielded a loaf of very good volume and crumb grain.

Mixograph Mix Time vs. Loaf Volume (Kansas)

Loaf volume potentials (13.5% protein basis) of the European wheats harvested in Kansas were predictable from mixogram mix time corrected to 12% protein when flour protein content was less than 12% (Table III, Fig. 1; Finney and Shogren 1972). The loaf volume potential of Bouquet (985 cc), although relatively low for its mixogram mix time of 3⅜ min, was nevertheless good. Other varieties with mixogram mix times equal to or greater than 2¾ min had excellent loaf volume potentials. The data corroborate a similar study by Finney and Yamazaki (1967) on more than 300 wheat progenies.

Bake vs. Mixogram Mix Times (Europe and Kansas)

Bake and mixogram mix times were very highly correlated (r = 0.99, Fig. 2) for the European samples reported on by Finney et al (1977) and the European samples harvested in Kansas (Tables I and III). Although we determine bake mix time independently of mixogram mix time, the mixogram time to the peak (point of minimum mobility) can be used to predict bake mix time. With the formula and conditions reported here, increasing mixogram mix time of the flour-water dough by about 11% would approximate bake mix time to the point of minimum mobility. In Table II of the 1977 report by Finney et al, the as-received mix time of Hardi and Talent should be 2¾ min instead of 2⅜ min and the corrected mix time should be 1¾ instead of 1½ min.

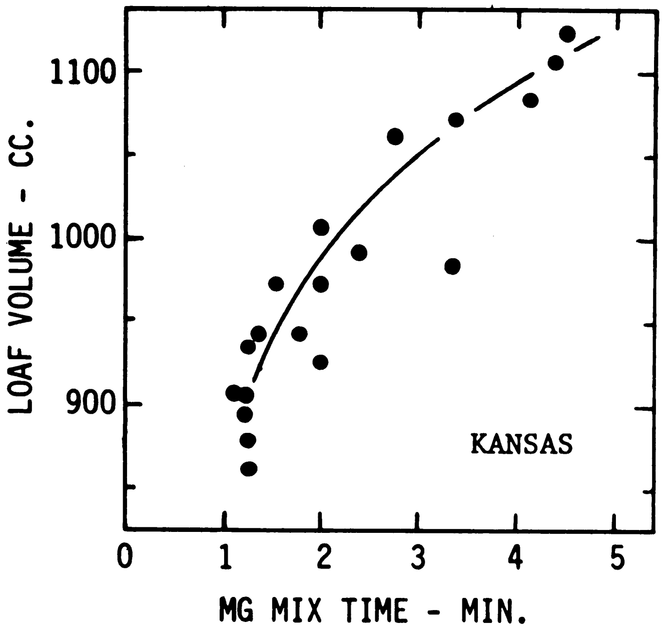

Fig. 1. Loaf volume (13.5% protein basis, 100 g of flour) and mixogram mix time (12% protein basis, 10 g of flour) of 17 European and two Kansas wheat varieties harvested in Kansas in 1977.

TABLE III
Flour Protein Content, Mixogram Mix Time, Loaf Volume, Crumb Grain, and Quality Category of European Wheats Harvested in Europe in 1975 and at Manhattan, KS, in 1977

	Flour Protein		Mixogram Mix Time: As Rec'd		Mixogram Mix Time: 12% P[c]		Loaf Volume[a]		Crumb Grain[a]		Quality Category[b]	
Variety and Origin	Europe (%)	Kansas (%)	Europe (min)	Kansas (min)	Europe (min)	Kansas (min)	Europe[d] (cc)	Kansas[e] (cc)	Europe	Kansas	Europe	Kansas
Belgium												
Clement	8.5	11.5	1¾	1½	1 VSh	1⅜ VSh	556 U^3	942 Q	U^3	U	D	CD
Maris-Huntsman	9.7	12.9	1¾	1¼	1¼ VSh	1¼ VSh	590 U^2	897 U	U	Q-U	D	D
France												
Hardi	8.8	12.1	2¾	3⅜	1¾ Sh	3⅜ M	802	1,071	Q-S	S	B	A
Clement	7.4	12.0	1¾	1½	⅞ VSh	1½ VSh	675 Q-U	973	U^2	U	D	CD
Maris-Huntsman	9.0	13.8	1¼	1¼	⅞ VSh	1¼ VSh	548 U^3	935 Q	U^3	Q	D	CD
Joss	9.3	13.9	1½	2⅜	1 VSh	2⅜ M-Sh	661 U	992	U	S	D	B
Talent	9.0	11.3	3	3	1⅞ Sh	2¾ M	746	1,063	Q-S	S	B	A
Germany												
Diplomat	9.7	14.1	4½	4¼	3⅜	4¼ ML	773	1,083	S	S	A	A
Feldkrone	9.5	12.5	1¾	2	1¼ VSh	2 Sh	730	1,008	Q	Q	C	BC
Benno	9.8	14.0	1½	1¾	1⅛ VSh	1¾ Sh	720	942 Q	Q-U	Q	CD	C
Maris-Huntsman	10.6	14.1	1½	1¼	1¼ VSh	1¼ VSh	664 U	910 Q-U	Q-U	Q-U	D	D
Maris-Huntsman	8.9	14.8	1¾	1¼	1⅛ VSh	1¼ VSh	500 U^4	878 U	U^4	Q-U	D	D
Maris-Huntsman	10.4	14.5	1½	1⅛	1¼ VSh	1⅛ VSh	633 U	907 Q-U	U	Q-U	D	D
Great Britain												
Bouquet	9.3	13.4	4	3⅜	2¾ M	3⅜ M	754	985	Q-S	S	A	AB
Cappelle	9.6	13.7	2⅜	2	1¾ Sh	2 Sh	725	972	Q-S	S	BC	BC
Champlaine	10.0	15.3	1½	2	1⅛ VSh	2 Sh	678 Q-U	923 Q	U	Q	D	C
Maris-Huntsman	9.7	14.2	1½	1¼	1⅛ VSh	1¼ VSh	636 U	862 U	U	U	D	D
Kansas												
Eagle		13.8		4⅜		4⅜ ML		1,107		S		A
Newton		12.1		4½		4½ ML		1,126		S		A

[a] S = satisfactory, Q = questionable, U = unsatisfactory; the larger the superscript, the poorer the quality.
[b] See Table IV.
[c] Corrected to 12% protein basis when flour protein content was <12% (14% mb). ML = medium long, M = medium, Sh = short, VSh = very short.
[d] Corrected to 9.5% protein basis.
[e] Corrected to 13.5% protein basis.

Flour Protein Contents (Europe vs. Kansas)

Flour protein contents of the European samples grown in Europe varied from 7.4% for Clement from France to 10.6% for Maris-Huntsman from Germany (Table III); the average protein content was 9.4%, an undesirably low level for determining functional properties. Flour protein contents of the European samples grown in Kansas varied from 11.3% for Talent from France to 15.3% for Champlaine from Great Britain; the average was 13.4% protein, a highly desirable level.

Mixograms (Europe vs. Kansas)

Mixograms of the Kansas-grown vs. the European-grown wheats of Europe indicate that mixogram type is maintained irrespective of the wide range of environments and flour protein contents (Figs. 3–6). Mixograms of the Kansas-grown samples characteristically are higher on the mixogram paper and have sharper peaks and generally steeper slopes on either side of the peaks than the corresponding low-protein European-grown samples. If the quality per unit of protein of the European-grown varieties was equal to that of the corresponding Kansas-grown varieties, mixing time to the peaks of the European-grown samples would be longer than that to the corresponding peaks of the Kansas-grown samples, because protein contents appreciably below 12% generally lengthen mixing time (Finney and Shogren 1972). However, the quality per unit of protein of 11 of the 17 European-grown samples was inferior to that of the corresponding

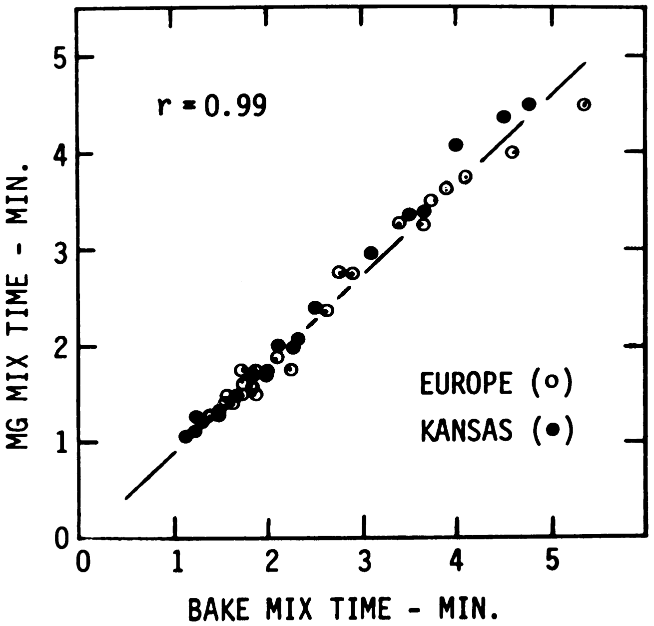

Fig. 2. Mixogram mix time (10 g of flour) and bake mix time (100 g of flour) of European wheat varieties harvested in Europe in 1975 (22 samples) and in Kansas in 1977 (17 samples) and of three Kansas controls.

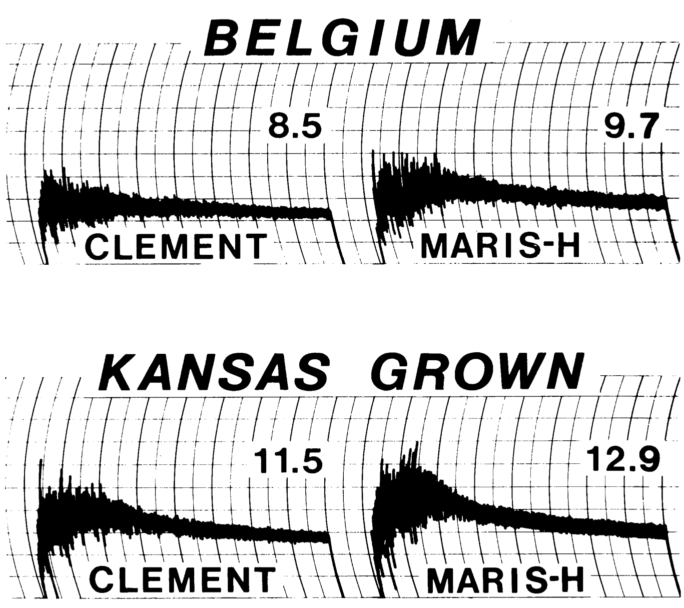

Fig. 3. Mixograms (10 g of flour) and flour protein contents (%, N × 5.7, 14% mb) of two European wheat varieties harvested in Belgium in 1975 and in Kansas in 1977.

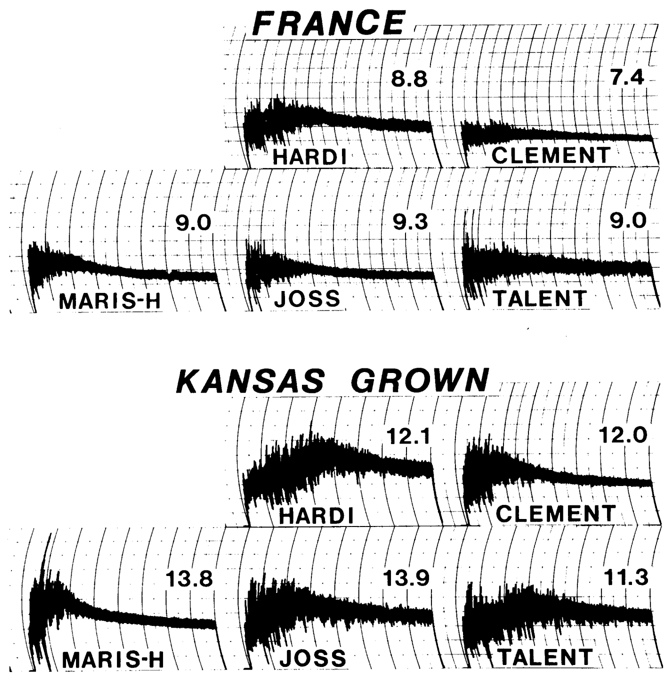

Fig. 4. Mixograms (10 g of flour) and flour protein contents (%, N × 5.7, 14% mb) of five European wheat varieties harvested in France in 1975 and in Kansas in 1977.

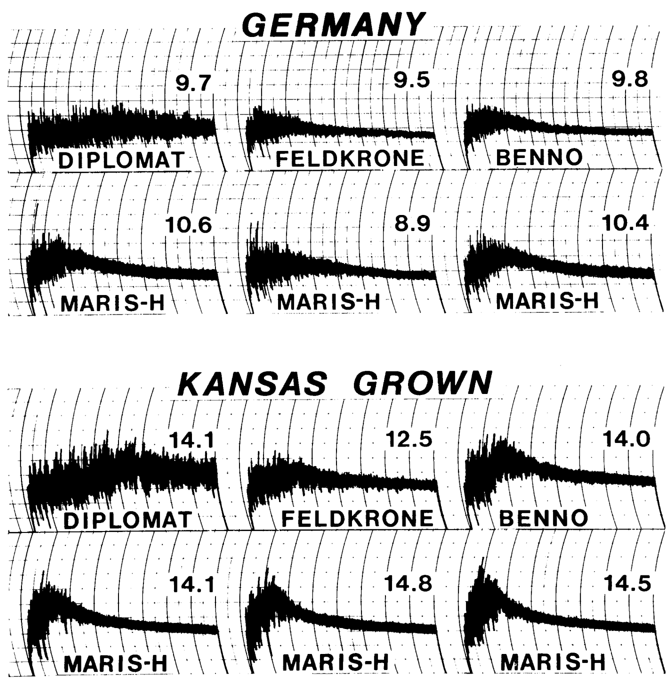

Fig. 5. Mixograms (10 g of flour) and flour protein contents (%, N × 5.7, 14% mb) of six samples of four European wheat varieties harvested in Germany in 1975 and in Kansas in 1977.

Kansas-grown samples (Table III). Reduced quality generally is associated with reduced mixing time. Thus, only some of the European-grown samples have somewhat longer mixogram peak times than those of the corresponding Kansas-grown varieties (Fig. 7).

The line in Figure 7 is not the regression for the points but simply the line on which all points would fall if the corresponding mixogram peak times for the European-grown and Kansas-grown samples were equal. If the unit protein quality of each of the European-grown samples had been as good as that of each of the corresponding Kansas-grown samples, all points would have been materially below the line, because of the effect on mix time of the low protein contents of the European-grown samples. Instead, some points are only somewhat below the line and others are above.

Reexamination of the mixogram peaks of the European-grown samples indicates that the as-received peak times of Hardi and Talent from France should be 2¾ and 3 min, respectively (Fig. 4), instead of 2½ and 2 min as shown in Table III of the 1977 report by Finney et al. The corresponding corrected mix times should be 1¾ and 1⅞.

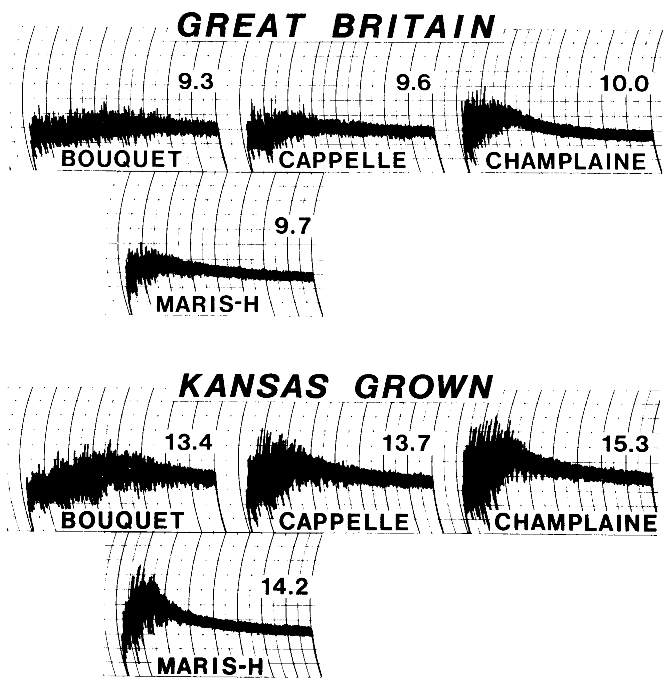

Fig. 6. Mixograms (10 g of flour) and flour protein contents (%, N × 5.7, 14% mb) of four European wheat varieties harvested in Great Britain in 1975 and in Kansas in 1977.

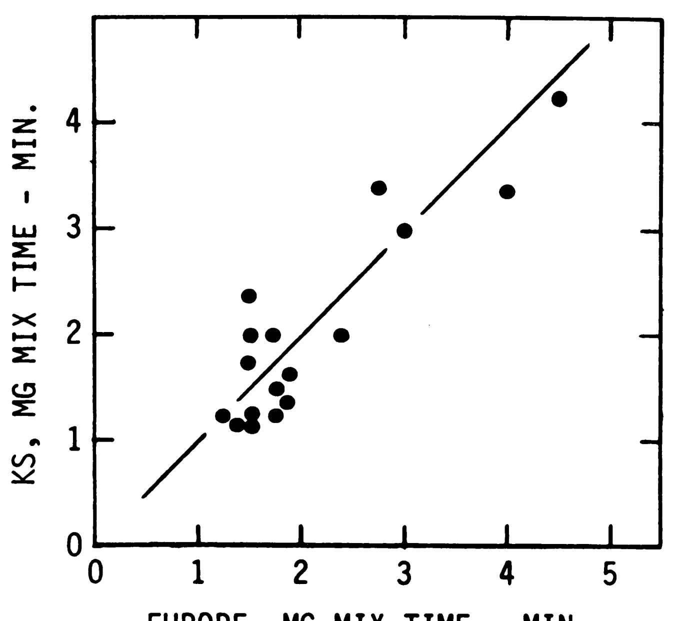

Fig. 7. Mixogram mix time (10 g of flour) of 17 samples of 11 European wheat varieties harvested in Europe in 1975 and in Kansas in 1977. All points would fall on the line if the corresponding mixogram peak times for the European-grown and Kansas-grown samples were equal.

Loaf Volumes (Europe vs. Kansas)

Loaf volumes of about half of the Kansas-grown European wheats were distinctly greater than those of the corresponding European-grown samples (Table III). The line in Figure 8 is not the regression for the points but simply the line on which all points would fall if the unit protein quality of each of the corresponding Kansas-grown and European-grown samples was equal.

Quality Categories (Europe vs. Kansas)

Each of the European wheats was categorized according to mixogram mix time to the peak, loaf volume corrected to a

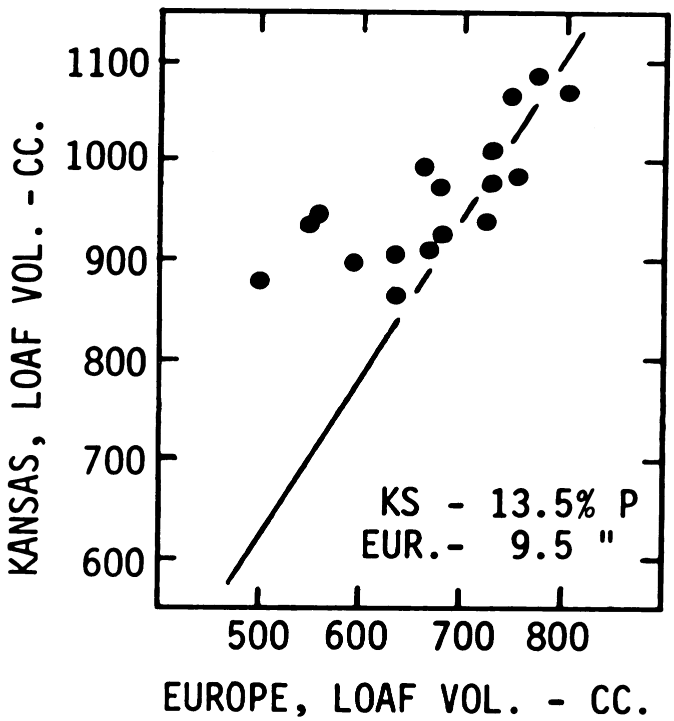

Fig. 8. Loaf volume (100 g of flour) of 17 samples of 11 European wheat varieties harvested in Europe in 1975 (9.5% protein [P] basis) and in Kansas in 1977 (13.5% P basis). All points would fall on the line if the unit protein quality of each of the corresponding Kansas-grown and European-grown samples was equal.

TABLE IV
Quality Categories and Components

Quality Category	Mixogram Mix Time[a] (min)	Loaf Volume[b] (cc)	Crumb Grain[c]
A	M to ML	VG to Ex	S
B	Sh	G to VG	S
C	Sh	F	Q
D	Sh to VSh	P	U

[a]Corrected to 12% protein basis when flour protein content was <12% (14% mb). L = long (≥5¼ min), ML = medium long (3¾–4¾ min), M = medium (2¾–3¼ min), Sh = short (1¾–2¼ min), VSh = very short (1–1½ min).

[b]Corrected to constant protein basis (14% mb). Ex = excellent, VG = very good, G = good, F = fair, P = poor (see Table V).

[c]S = satisfactory, Q = questionable, U = unsatisfactory.

TABLE V
Evaluation of Loaf Volumes (100 g of Flour) at Two Protein Quantity Levels Within Quality Levels of 30 to 78 cc per 1% of Protein[a]

Loaf Volume Change per 1% of Protein (cc)	Loaf Volume (cc) at Protein Level of: 9.5%	13.5%	Evaluation[b]
78	807	1,119	
74	781	1,077	Ex
70	755	1,035	VG
66	729	993	G
62	703	951	F (Q)
58	677	909	P (U)
54	651	867	VP (U)
50	625	825	EP (U^2)
46	599	783	(U^2)
42	573	741	(U^3)
38	547	699	(U^3)
34	521	657	(U^4)
30	495	615	

[a]Data expressed on a 14% mb.
[b]Ex = excellent, VG = very good, G = good, F = fair, P = poor, VP = very poor, EP = exceptionally poor. Q = questionable, U = unsatisfactory; the larger the superscript, the poorer the quality.

constant protein basis, and bread crumb grain (Table IV). The basis for evaluation of bread volume (Table V) is the family of loaf volume and protein content regression lines reported by Finney (1979). Categorizing the wheats sometimes required interpolation. For example, the mix time of Kansas-grown Clement from France (1½ min, very short) in the D category and the loaf volume (973 cc) in the B category gave it an average in the C category. However, its crumb grain (unsatisfactory) in the D category lowered its average to the CD category.

Nine of the 17 Kansas-grown samples were one-half to two categories higher than the corresponding European-grown samples (Table III), primarily because of improved loaf volumes and mixing properties. Loaf volumes of five of the six samples of Maris-Huntsman were improved when grown in Kansas, but not enough to get them out of the D category.

CONCLUSIONS

Average straight-grade flour ash and protein contents of 17 European wheats were 0.45 and 13.4%, respectively, when grown in Kansas and 0.45 and 9.4% when grown in Europe. Mixing properties, loaf volumes per unit of protein, and crumb grains of the European wheats varied from exceptionally poor to very good when grown in Europe and from poor to excellent when grown in Kansas. Loaf volume potentials (constant protein basis) of the European wheats harvested in Kansas were predictable from mixogram mix time. Bake and mixogram mix time were very highly correlated ($r = 0.99$) for the combined European- and Kansas-grown samples. Mixogram type was maintained irrespective of the wide range of environments and flour protein contents. When the wheats were placed in category A, B, C, or D according to mixogram mix time, loaf volume potential, and crumb grain, nine of the 17 Kansas-grown samples were one-half to two categories higher than the corresponding European-grown samples.

The mixogram peaks (points of minimum mobility) of some of the low-protein European-grown samples were more difficult to determine consistently than were those of the medium-high-protein Kansas-grown samples. The doughs with low protein content were developed slowly to minimum mobility, then overdeveloped slowly over a relatively long period of time that involved a low rate of rise or fall on the mixogram paper, because of the difficulty in forming a continuous phase of gluten protein. Mixogram peaks for flours containing 10.0–10.5% or more protein usually can be determined easily and consistently.

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