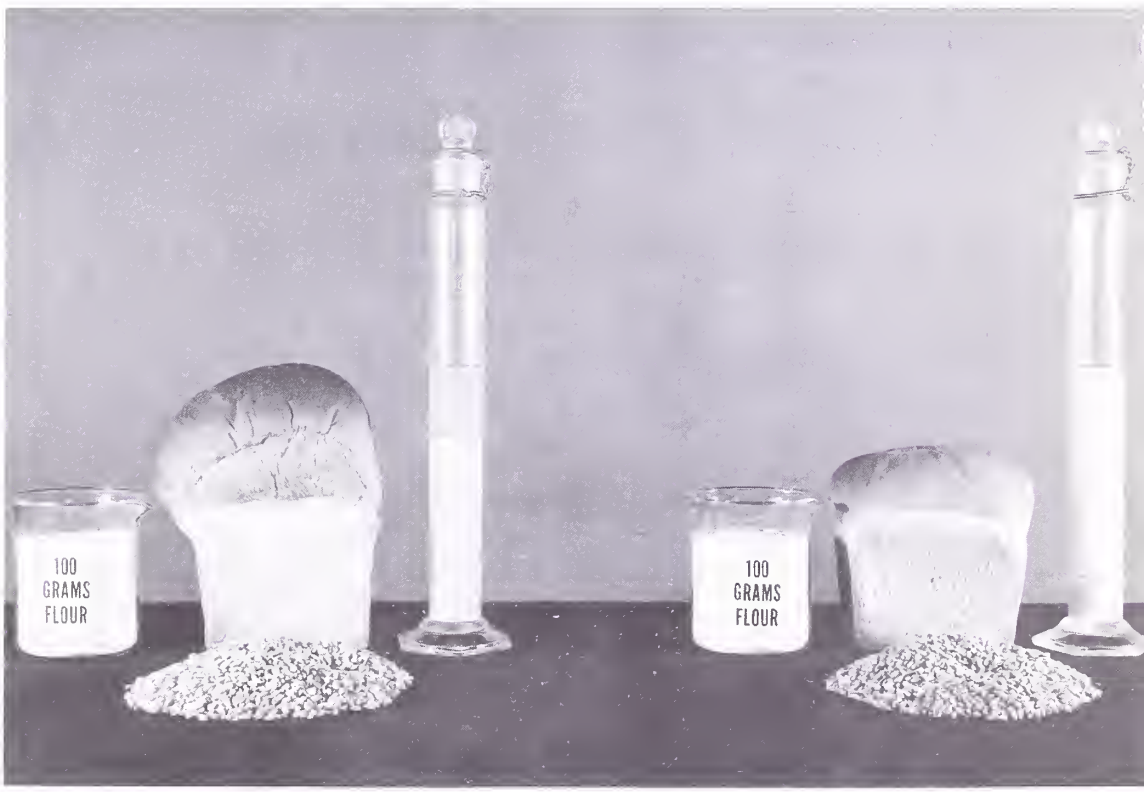
Marketing Research Report No. 680

SEDIMENTATION

AS A MEASURE OF WHEAT QUALITY • 1963 CROP



U.S. DEPARTMENT OF AGRICULTURE
Agricultural Marketing Service
Grain Division

PREFACE

The investigation described in this report was conducted by the U. S. Department of Agriculture using data supplied by Doty Laboratories, Inc., of North Kansas City, Missouri. The investigation was supported by funds provided jointly by Doty Laboratories, Great Plains Wheat, Inc., and the U. S. Department of Agriculture.

Included in this report is a summary of the combined data obtained for the 1962 and 1963 crops.

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SEDIMENTATION AS A MEASURE OF WHEAT QUALITY - 1963 CROP

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Summary

Analysis of 1801 samples of 1963-crop hard red winter and hard red spring wheat showed the sedimentation value to be more highly correlated with bread-baking quality as measured by the Doty "flour evaluation score" 4/ in most of the 33 areas of production than were either the protein content or any of the farinogram characteristics. Protein content in most areas was more highly correlated with bread-loaf volume than were either the sedimentation value or any of the farinogram characteristics. Bread-loaf volume, however, is considered to be only one of the important factors of quality included in determining the flour evaluation score, and therefore to be less reliable than flour evaluation score as an index of bread-baking quality. In most areas sedimentation was also correlated more highly than was protein content with mixing time, mixing tolerance, MTI value, and valorimeter value. Essentially the same relationships were found among sedimentation, protein, farinogram characteristics, and bread-baking quality when the 1962 and 1963 crop data were combined.

Introduction

Sedimentation value was used as a basis for determining loan value premiums in connection with the U. S. Department of Agriculture wheat price support program for the first time in 1962, and was used again for the same purpose in 1963.

For this reason it has been important to know how well the sedimentation test reflected the quality of the 1962 and 1963 hard wheat crops, especially in comparison with protein content, since sedimentation value replaced protein content as a basis for load value premiums in 1962 and was used in conjunction with protein content in 1963.

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4/ An arbitrary score used routinely by Doty Laboratories based on the generally accepted important bread and dough characteristics. For complete description see Marketing Research Report No. 587, "Sedimentation as a Measure of Wheat Quality, 1962 Crop." (January 1963)

For the past 16 years the Doty Laboratories have made annual surveys of the quality of the U. S. hard red winter wheat crops and for the past five years hard red spring wheat has been included in the surveys. For these surveys, samples were obtained from various areas of production shortly after harvest and were subjected to chemical and physical tests for quality including protein, milling, baking, and farinograph tests. Sedimentation tests were made in connection with these surveys for the first time in 1961 and were made again in the 1962 and 1963 surveys.

Statistical analysis of the 1962-crop data was reported in Marketing Research Report No. 587, issued by the U. S. Department of Agriculture in January 1963, and entitled "Sedimentation as a Measure of Wheat Quality, 1962 Crop." Sedimentation was found to be superior 5/ to protein content and to each of the important farinogram characteristics as a means of predicting bread-baking quality (flour evaluation score). Wheat sedimentation value was also found to be superior to wheat protein content as a means of predicting mixing time, mixing tolerance, MTI value, and valorimeter value as determined by the farinograph. The superiority of sedimentation over protein and over all farinogram characteristics as a measure of bread-baking quality (flour evaluation score) was evidenced in most areas of production, particularly so in the case of hard red spring wheat.

The 1963 survey consisted of 2,652 samples of hard red winter wheat and 950 samples of hard red spring wheat. Fifty percent of these samples were used for this analysis as described below. The winter wheat samples were obtained from 23 defined areas of production including the important wheat-producing areas of Texas, Oklahoma, Kansas, Colorado, Nebraska, Wyoming, South Dakota, Montana, Missouri, and Illinois (fig. 1). The spring wheat samples were obtained from 10 areas of production in South Dakota, North Dakota, Minnesota, and Montana (fig. 2). Samples were obtained from numerous points of origin within the individual areas of production, and, for the most part, were obtained from trucks of wheat being delivered to country elevators.

Methods

Methods of analysis, as well as milling and bread-baking test methods, were the same as those used in the 1962-crop survey and described in Marketing Research Report No. 587.

Statistical Plan

All data on 50 percent of the samples tested from each of the 33 areas of production were furnished by the Doty Laboratories to the U. S. Department of Agriculture for statistical analysis. In addition to the kind of data furnished for the 1962 crop, bread-loaf volume data were furnished for the

5/ "Superior" used throughout the text means the independent variable (a given test) is more highly correlated with the dependent variable (flour evaluation score or bread-loaf volume or farinogram characteristics) than other independent variables.

1963 crop and were used in the statistical analyses. In order to avoid any possibility of bias in the selection of the samples for which data was furnished, every second sample tested by the Doty Laboratories was selected for this purpose. Thus, the statistical analyses for the 1963-crop were made on data from a total of 1,801 samples of wheat. Statistical analyses, when possible, were also made on the combined data from the 1962 and 1963 crops and were thus based on data from a total of 2,520 samples of wheat.

Results

Hard Red Winter Wheat

The range in sedimentation value for 1,326 samples of hard red winter wheat was from 11.8 to 75.6 compared with protein content which ranged from 9.0 to 16.6 percent (table 3). A comparison of the range and mean values of the sedimentation and protein tests by areas shows that these tests do not necessarily perform alike in all geographical areas.

The simple correlation coefficients derived from correlating the various tests in hard red winter wheat are shown in tables 6, 7, 10, 11, and 12. Sedimentation value was found to be more highly correlated than protein content with bread-baking quality as measured by flour evaluation score in 20 of the 23 areas. In addition, sedimentation in most areas and in the aggregate was more highly correlated with other recognized measures of bread-baking strength -- including mixing time, mixing tolerance, MTI value, and valorimeter value -- than was protein content. Sedimentation and protein in general were about equal as indexes of water absorption. Protein content was somewhat superior to sedimentation as a means of predicting loaf volume in 21 of the 23 areas of production.

Hard Red Spring Wheat

The results from the 10 hard red spring wheat production areas (tables 8, 9, 10, 11, and 13) were somewhat similar to those for hard red winter wheat. However, the superiority of sedimentation over protein as a measure of flour evaluation score was much greater for spring than for winter wheat. Likewise, the superiority of protein over sedimentation as a measure of loaf volume alone was greater for spring wheat than for winter wheat.

1962 and 1963 Wheat Crop Data Combined

Comparison of the data in Marketing Research Report No. 587, (1962 wheat crop) with the 1963 data will show substantial differences in simple correlation coefficients for the various tests. Generally, higher coefficients were obtained (for both hard red winter and hard red spring wheats) for the sedimentation test vs. the flour evaluation score for the 1962-crop wheat than for the 1963 crop. Statistical data for the 1962 and 1963 crops combined are shown in tables 14, 15, and 16.

Discussion

Sedimentation value is shown for the 1963 crop to be superior to protein content as a measure of flour evaluation score and conversely, protein is shown to be superior to sedimentation as a measure of bread-loaf volume. The question naturally arises as to the relative merits of flour evaluation score and bread-loaf volume as measures of wheat quality. Bread-loaf volume is sometimes used as a sole measure of baking quality since it can be determined simply and objectively after the baking test is made. Most cereal chemists agree, however, that loaf volume is only one of the important bread characteristics and that other factors such as crumb grain and texture and dough characteristics must be considered to obtain a proper evaluation of baking quality.

Wheat of inferior bread-baking quality, such as soft wheat or hard wheat with poor mixing tolerance, may sometimes be capable of producing bread of good volume under ideal conditions but such bread is likely to have poor internal characteristics or the dough to have poor handling properties. In view of this situation, a score such as the Doty flour evaluation score which takes into account the various important dough and bread characteristics including loaf volume is considered to be more reliable than loaf volume alone as a measure of the quality of wheat for the production of bread.

The statistical study of the 1963-crop data, therefore, confirms the principal findings of the 1962 study--that sedimentation value in the aggregate is generally superior to protein content and to any of the important farinogram characteristics as a means of predicting bread-baking quality.

No one single test used in this study to estimate bread-baking quality (flour evaluation score) gave completely consistent results in all areas of production. However, higher correlation coefficients for the sedimentation test than for the protein test were obtained in 86 percent of the areas for the 1962 and 1963 wheat crops. Higher correlation coefficients for sedimentation than for protein or any of the farinogram characteristics were also obtained in 72 percent of the areas for this two-year period.

FIG.1 HARD RED WINTER WHEAT: 23 AREAS OF PRODUCTION SAMPLED, 1963 CROP

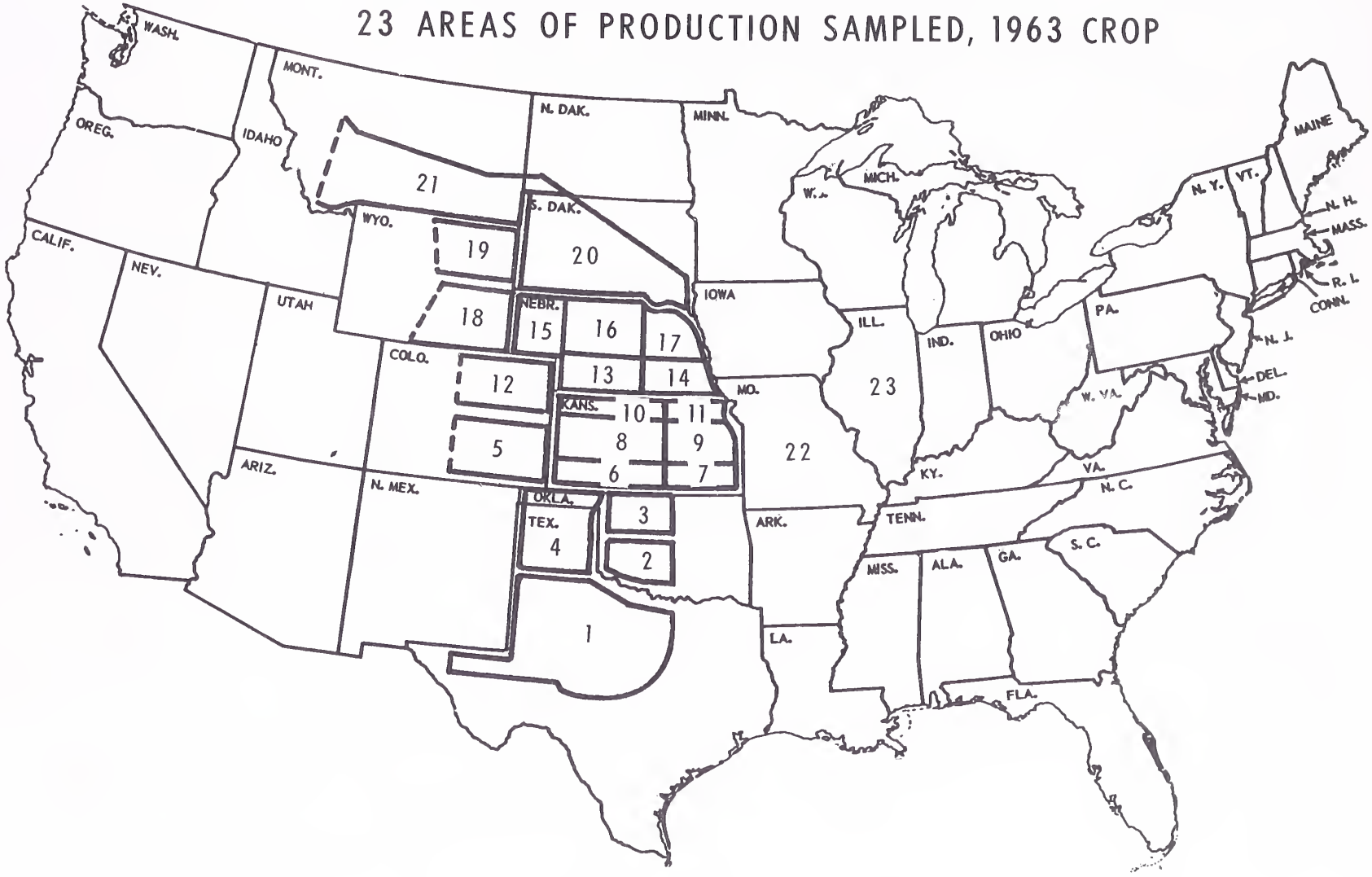

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FIG. 2 HARD RED SPRING WHEAT: 10 AREAS OF PRODUCTION SAMPLED, 1963 CROP

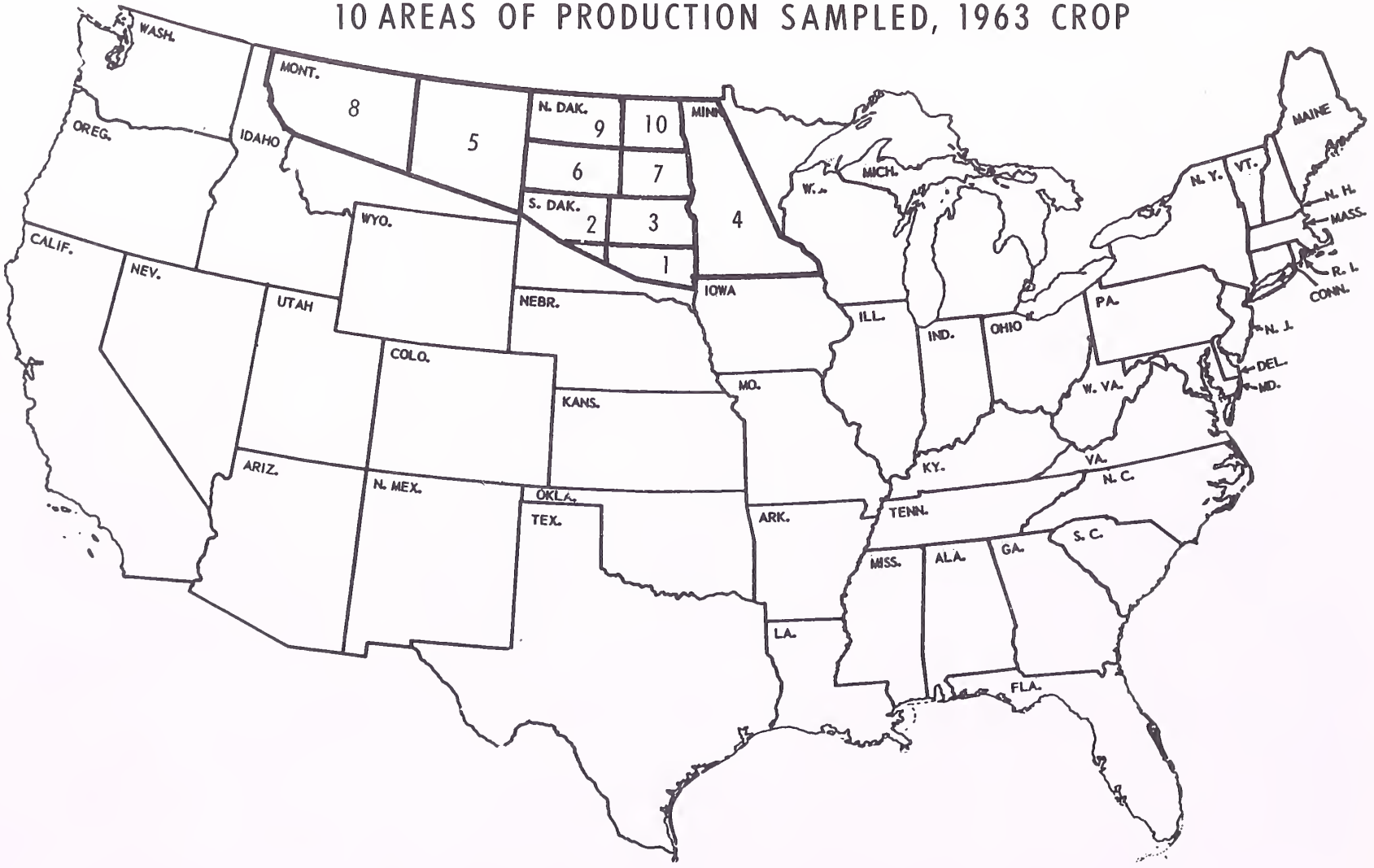

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Table 1--Hard Red Winter Wheat: Mean values for sedimentation, protein, various farinogram characteristics, bread-loaf volume, and flour evaluation score, by area of production, 1963 crop

No.	Area of production	No. of samples	Wheat		Flour--farinogram characteristics					Bread-loaf volume	Flour evaluation score
			Sedimentation value	Protein content 1/	Mixing time	Mixing tolerance	Water absorption	MTI	Valorimeter value		
No.	Name			Percent	Minutes	Minutes	Percent			Ml.	
1	Texas (except panhandle)	84	50.1	12.8	4.8	8.0	59.5	40.0	57.9	737.1	85.7
2	S. W. Oklahoma	85	51.5	12.4	4.8	9.3	60.4	42.9	54.9	736.0	84.0
3	N. W. Oklahoma	50	47.5	12.3	4.7	9.8	60.7	41.4	56.1	722.0	85.0
4	Texas-Oklahoma panhandle	36	63.2	13.5	6.7	11.1	64.5	28.1	65.4	741.7	89.9
5	S. E. Colorado	41	51.1	12.3	4.8	8.8	61.8	38.8	58.8	713.4	85.4
6	S. W. Kansas	81	52.1	12.2	5.8	10.6	60.5	33.6	63.3	735.2	84.0
7	S. E. Kansas	52	46.9	12.2	4.6	8.2	62.0	40.5	58.4	717.4	82.1
8	W. Central Kansas	88	50.1	12.1	6.5	10.0	62.8	30.3	65.1	731.1	88.5
9	E. Central Kansas	47	44.2	12.2	5.0	6.9	62.5	42.0	59.8	707.2	83.4
10	N. W. Kansas	54	40.1	11.6	5.7	10.2	58.9	30.7	63.5	690.7	83.5
11	N. E. Kansas	44	36.0	12.0	4.5	6.3	59.6	49.9	56.8	671.9	81.0
12	N. E. Colorado	50	48.3	12.7	4.7	7.3	62.5	40.3	58.2	711.2	82.5
13	S. W. Nebraska	55	49.6	12.4	5.6	9.8	59.7	37.1	61.0	729.0	85.7
14	S. E. Nebraska	57	50.6	12.5	5.2	8.3	60.3	44.9	58.4	715.5	86.4
15	Nebraska panhandle	68	53.3	12.5	10.3	16.7	62.0	20.7	75.4	698.7	91.4
16	N. Central Nebraska	64	51.8	12.4	5.7	11.0	60.4	33.6	63.6	759.6	88.1
17	N. E. Nebraska	54	45.1	12.7	5.5	8.7	58.6	40.7	61.0	739.7	87.7
18	S. E. Wyoming	34	53.5	13.1	5.7	11.3	61.6	31.5	64.3	773.8	90.0
19	N. E. Wyoming	32	51.2	13.0	5.6	10.8	61.2	34.2	62.2	767.8	90.2
20	S. W. South Dakota	68	50.5	13.6	6.2	9.6	61.8	35.4	64.1	789.6	89.1
21	S. Montana	69	54.8	13.0	7.7	13.7	62.2	33.6	70.1	735.3	83.4
22	Missouri	57	31.5	11.4	3.4	5.2	58.2	58.2	55.7	616.3	72.4
23	Illinois	56	26.9	10.5	2.6	5.5	57.4	56.4	49.1	596.5	71.4
	All HRW areas combined	1,326	48.0	12.4	5.6	9.5	60.8	38.3	61.2	719.6	84.8

1/ 14.0 percent moisture basis.

Table 2--Hard Red Spring Wheat: Mean values for sedimentation, protein, various farinogram characteristics, bread-loaf volume, and flour evaluation score, by areas of production, 1963 crop

Area of production		No. of samples	Wheat		Flour--farinogram characteristics					Bread loaf volume	Flour evaluation score
			Sedimentation value	Protein content 1/	Mixing time	Mixing tolerance	Water absorption	MTI	Valorimeter value		
No.	Name			Percent	Minutes	Minutes	Percent			Ml.	
1	S. E. South Dakota	50	54.0	14.1	9.8	17.2	61.1	22.4	75.6	792.0	84.9
2	N. W. South Dakota	34	56.6	14.3	10.0	18.0	62.1	20.0	76.1	807.9	84.2
3	N. E. South Dakota	53	59.6	14.4	10.3	23.7	61.3	17.9	78.8	821.5	87.9
4	Minnesota	68	52.3	13.7	7.9	15.1	61.2	28.2	68.4	783.3	84.2
5	E. Montana	34	63.2	14.4	8.3	19.4	62.3	21.5	74.2	825.0	92.1
6	S. W. North Dakota	45	62.0	14.6	8.8	17.0	61.2	21.0	74.9	793.6	87.5
7	S. E. North Dakota	54	63.8	14.0	10.2	20.2	59.9	16.9	77.5	790.0	89.7
8	N. W. Montana	32	64.2	14.5	8.4	17.0	62.9	16.6	74.5	819.5	88.8
9	N. W. North Dakota	55	67.9	14.9	10.4	22.3	62.0	14.6	81.1	846.9	92.4
10	N. E. North Dakota	50	62.0	14.4	8.6	19.0	60.1	21.5	74.8	811.3	88.5
All HRS areas combined		475	60.5	14.4	9.3	19.0	61.6	20.4	75.8	811.1	88.3
All HRW and HRS areas combined 2/		1,801	51.3	12.9	6.5	12.0	61.0	33.6	65.0	743.7	85.7

1/ 14.0 percent moisture basis.
2/ Derived from data presented in tables 1 and 2.

Table 3--Hard Red Winter Wheat: Means and maximum and minimum sedimentation and protein values, by area of production 1963 wheat crop

Area of production		No. of samples	Sedimentation values			Protein content 1/		
			Mean	Maximum	Minimum	Mean	Maximum	Minimum
No.	Name					Percent	Percent	Percent
1	Texas (except panhandle)	84	50.1	70.9	21.3	12.8	16.3	10.2
2	S. W. Oklahoma	85	51.5	69.5	24.0	12.4	14.7	10.2
3	N. W. Oklahoma	50	47.5	70.4	22.0	12.3	14.5	9.8
4	Texas-Oklahoma	36	63.2	72.4	28.5	13.5	15.7	11.4
5	S. E. Colorado	41	51.1	61.4	37.7	12.3	14.3	10.9
6	S. W. Kansas	81	52.1	72.3	34.0	12.2	14.7	10.1
7	S. E. Kansas	52	46.9	69.0	26.4	12.2	14.4	9.5
8	W. Central Kansas	88	50.1	69.7	32.3	12.1	14.4	10.4
9	E. Central Kansas	47	44.2	68.1	27.3	12.2	13.8	11.1
10	N. W. Kansas	54	40.1	63.3	27.2	11.6	15.2	9.4
11	N. E. Kansas	44	36.0	59.1	23.8	12.0	13.8	9.2
12	N. E. Colorado	50	48.3	68.9	30.4	12.7	14.2	10.8
13	S. W. Nebraska	55	49.6	67.3	24.2	12.4	14.4	9.9
14	S. E. Nebraska	57	50.6	70.0	24.1	12.5	14.8	9.9
15	Nebraska panhandle	68	53.3	71.1	27.7	12.5	15.4	10.1
16	N. Central Nebraska	64	51.8	71.7	24.4	12.4	14.8	10.0
17	N. E. Nebraska	54	45.1	65.8	24.2	12.7	14.7	11.1
18	S. E. Wyoming	34	53.5	71.7	35.1	13.1	15.1	11.1
19	N. E. Wyoming	32	51.2	72.1	29.4	13.0	15.3	10.8
20	S. W. South Dakota	68	50.5	68.8	27.1	13.6	16.1	11.2
21	S. Montana	69	54.8	75.6	33.0	13.0	16.6	9.3
22	Missouri	57	31.5	66.1	11.8	11.4	15.7	9.0
23	Illinois	56	26.9	44.1	18.5	10.5	12.6	9.3
	All HRW areas combined	1,326	48.0	75.6	11.8	12.4	16.6	9.0

1/ 14.0 percent moisture content.

Table 4.--Hard Red Spring Wheat: Means and maximum and minimum sedimentation and protein values, by area of production, 1963 wheat crop

Area of production		No. of samples	Sedimentation values			Protein content[1/]		
			Mean	Maximum	Minimum	Mean	Maximum	Minimum
No.	Name					Percent	Percent	Percent
1	S. E. South Dakota	50	54.0	69.0	28.4	14.1	16.6	11.2
2	N. W. South Dakota	34	56.6	70.2	40.3	14.3	16.4	11.9
3	N. E. South Dakota	53	59.6	71.2	41.4	14.4	16.7	12.2
4	Minnesota	68	52.3	69.6	27.7	13.7	16.2	11.1
5	E. Montana	34	63.2	73.1	49.2	14.4	16.6	13.1
6	S. W. North Dakota	45	62.0	72.3	53.0	14.6	16.4	13.9
7	S. E. North Dakota	54	63.8	73.2	51.5	13.9	16.1	12.7
8	N. W. Montana	32	64.2	73.3	52.4	14.5	16.4	13.3
9	N. W. North Dakota	55	67.9	71.5	56.6	14.9	15.9	13.9
10	N. E. North Dakota	50	61.9	73.0	45.0	14.4	16.0	12.2
All HRS areas combined		475	60.5	73.3	27.7	14.4	16.7	11.1

1/ 14.0 percent moisture basis.

Table 5--Selected statistical measures: Summary of maximum and minimum values, means, and standard errors for each quality factor or test, by class of wheat, 1963 wheat crop

Factor or test	Hard Red Winter Wheat (1,326 samples)				Hard Red Spring Wheat (475 samples)			
	Minimum	Maximum	Mean	Standard error	Minimum	Maximum	Mean	Standard error
Test weight, lbs.	56.0	64.0	60.7	0.037	48.0	61.5	55.8	0.092
Sedimentation value	11.8	75.6	48.0	0.317	27.7	73.3	60.5	0.390
Protein, percent	9.0	16.3	12.4	0.031	11.1	16.7	14.4	0.041
Mixing time, minutes	1.2	18.5	5.6	0.055	3.5	31.0	9.3	0.156
Mixing tolerance, minutes	2.8	29.8	9.5	0.103	3.8	52.8	19.0	0.307
Farino. absorption, percent	53.0	72.7	60.8	0.069	55.6	66.6	61.6	0.078
Mixing tolerance index, MTI	-0-	110.0	38.3	0.446	-0-	125.0	20.4	0.537
Valorimeter value	37.0	94.0	61.2	0.229	41.0	105.0	75.8	0.431
Bread-loaf volume, ml.	455.0	895.0	719.6	1.877	580.0	925.0	811.0	2.087
Flour evaluation score	60.0	97.0	84.8	0.200	66.0	98.0	88.3	0.216

Table 6--Correlation Coefficients: Various factors vs. "flour evaluation score," Hard Red Winter Wheat, by area of production

Area of production		No. of samples	Wheat		Flour--farinogram characteristics				
			Sedimentation value	Protein content 1/	Mixing time	Mixing tolerance	Water absorption	MTI	Valorimeter value
No.	Name			Percent	Minutes	Minutes	Percent		
1	Texas (except panhandle)	84	0.94	0.90	0.85	0.73	0.74	-0.89	0.86
2	S. W. Oklahoma	85	0.84	0.86	0.85	0.80	0.78	-0.81	0.77
3	N. W. Oklahoma	50	0.77	0.83	0.73	0.80	0.82	-0.77	0.74
4	Texas-Oklahoma panhandle	36	0.90	0.74	0.65	0.67	0.81	-0.69	0.67
5	S. E. Colorado	41	0.71	0.48	0.69	0.74	0.39	-0.73	0.73
6	S. W. Kansas	81	0.68	0.67	0.77	0.57	0.48	-0.63	0.77
7	S. E. Kansas	52	0.73	0.71	0.76	0.29	0.27	-0.43	0.42
8	W. Central Kansas	88	0.66	0.60	0.55	0.43	0.60	-0.54	0.51
9	E. Central Kansas	47	0.67	0.60	0.45	0.28	0.39	-0.43	0.49
10	N. W. Kansas	54	0.83	0.67	0.54	0.48	0.50	-0.48	0.47
11	N. E. Kansas	44	0.75	0.60	0.46	-0.06	0.61	-0.09	0.20
12	N. E. Colorado	50	0.53	0.49	0.55	0.44	0.54	-0.58	0.57
13	S. W. Nebraska	55	0.42	0.49	0.76	0.73	0.45	-0.83	0.88
14	S. E. Nebraska	57	0.80	0.76	0.85	0.68	0.76	-0.87	0.88
15	Nebraska panhandle	68	0.88	0.84	0.27	0.27	0.76	-0.53	0.28
16	N. Central Nebraska	64	0.71	0.67	0.67	0.61	0.61	-0.71	0.72
17	N. E. Nebraska	54	0.76	0.70	0.82	0.76	0.60	-0.82	0.82
18	S. E. Wyoming	34	0.53	0.51	0.90	0.86	0.52	-0.81	0.89
19	N. E. Wyoming	32	0.86	0.83	0.83	0.78	0.84	-0.85	0.86
20	S. W. South Dakota	68	0.77	0.48	0.58	0.54	0.39	-0.62	0.59
21	S. Montana	69	0.59	0.44	0.62	0.50	0.33	-0.61	0.65
22	Missouri	57	0.65	0.52	0.72	0.36	0.44	-0.40	0.39
23	Illinois	56	0.92	0.88	0.75	-0.05	0.42	0.16	0.44
	All areas	1,326	0.76	0.68	0.65	0.58	0.56	-0.66	0.65

1/ 14.0 percent moisture basis.

Table 7--Correlation Coefficients: Various factors vs. "bread-loaf volume," Hard Red Winter Wheat, by area of production

No.	Area of production	No. of samples	Wheat: Sedimentation value	Wheat: Protein content 1/	Flour--farinogram characteristics: Mixing time	Mixing tolerance	Water absorption	MTI	Valorimeter value
	Name			Percent	Minutes	Minutes	Percent		
1	Texas (except panhandle)	84	0.91	0.93	0.86	0.73	0.73	-0.86	0.85
2	S. W. Oklahoma	85	0.84	0.86	0.82	0.83	0.80	-0.82	0.72
3	N. W. Oklahoma	50	0.75	0.84	0.68	0.81	0.85	-0.71	0.75
4	Texas-Oklahoma panhandle	36	0.87	0.90	0.44	0.46	0.83	-0.48	0.47
5	S. E. Colorado	41	0.83	0.82	0.50	0.56	0.69	-0.57	0.57
6	S. W. Kansas	81	0.73	0.80	0.63	0.44	0.51	-0.52	0.63
7	S. E. Kansas	52	0.80	0.88	0.56	0.09	0.53	-0.17	0.13
8	W. Central Kansas	88	0.67	0.92	0.26	0.08	0.71	-0.27	0.24
9	E. Central Kansas	47	0.66	0.88	0.15	-0.05	0.54	-0.04	0.10
10	N. W. Kansas	54	0.86	0.81	0.53	0.45	0.66	-0.45	0.44
11	N. E. Kansas	44	0.63	0.93	0.36	-0.19	0.64	0.16	-0.05
12	N. E. Colorado	50	0.87	0.89	0.04	-0.00	0.83	-0.11	0.18
13	S. W. Nebraska	55	0.86	0.96	0.33	0.34	0.90	-0.56	0.53
14	S. E. Nebraska	57	0.96	0.96	0.73	0.56	0.95	-0.77	0.75
15	Nebraska panhandle	68	0.89	0.94	0.10	0.19	0.68	-0.35	0.14
16	N. Central Nebraska	64	0.96	0.96	0.38	0.37	0.90	-0.38	0.41
17	N. E. Nebraska	54	0.91	0.95	0.66	0.61	0.87	-0.63	0.65
18	S. E. Wyoming	34	0.94	0.94	0.50	0.46	0.94	-0.49	0.50
19	N. E. Wyoming	32	0.97	0.98	0.57	0.69	0.95	-0.64	0.68
20	S. W. South Dakota	68	0.85	0.94	0.30	0.18	0.56	-0.19	0.27
21	S. Montana	69	0.86	0.87	0.42	0.26	0.46	-0.43	0.44
22	Missouri	57	0.88	0.91	0.54	0.14	0.56	-0.30	0.03
23	Illinois	56	0.85	0.89	0.59	-0.15	0.44	0.07	0.28
	All areas	1,326	0.83	0.88	0.41	0.37	0.61	-0.47	0.42

1/ 14.0 percent moisture basis.

Table 8--Correlation Coefficients: Various factors vs. "flour evaluation score," Hard Red Spring Wheat, by area of production

Area of production		No. of samples	Wheat		Flour--farinogram characteristics				
			Sedimentation value	Protein content 1/	Mixing time	Mixing tolerance	Water absorption	MTI	Valorimeter value
No.	Name			Percent	Minutes	Minutes	Percent		
1	S. E. South Dakota	50	0.87	0.32	0.37	0.37	0.44	-0.50	0.46
2	N. W. South Dakota	34	0.78	0.73	0.11	0.12	0.63	-0.24	0.12
3	N. E. South Dakota	53	0.75	0.43	0.27	0.12	0.38	-0.17	0.27
4	Minnesota	68	0.82	0.78	0.63	0.61	0.79	-0.63	0.63
5	E. Montana	34	0.66	0.64	0.65	0.62	0.63	-0.50	0.60
6	S. W. North Dakota	45	0.46	0.25	0.15	0.22	0.11	-0.10	0.28
7	S. E. North Dakota	54	0.74	0.52	0.11	-0.07	0.50	-0.08	0.12
8	N. W. Montana	32	0.78	0.79	-0.17	-0.14	0.61	0.16	-0.14
9	N. W. North Dakota	55	0.26	0.43	0.18	0.32	0.18	-0.32	0.23
10	N. E. North Dakota	50	0.57	0.40	0.21	0.13	0.34	-0.19	0.21
	All HRS areas combined	475	0.82	0.54	0.23	0.31	0.41	-0.41	0.39

1/ 14.0 percent moisture basis

Table 9--Correlation Coefficients: Various factors vs. bread-loaf volume, Hard Red Spring Wheat, by area of production

Area of production		No. of samples	Wheat		Flour--farinogram characteristics				
			Sedimentation value	Protein content 1/	Mixing time	Mixing tolerance	Water absorption	MTI	Valorimeter value
No.	Name			Percent	Minutes	Minutes	Percent		
1	S. E. South Dakota	50	0.76	0.86	0.10	0.05	0.69	-0.20	0.13
2	N. W. South Dakota	34	0.92	0.95	0.08	0.14	0.86	-0.20	0.10
3	N. E. South Dakota	53	0.55	0.97	0.42	0.13	0.78	-0.22	0.44
4	Minnesota	68	0.92	0.98	0.65	0.61	0.94	-0.64	0.63
5	E. Montana	34	0.93	0.99	0.81	0.80	0.91	-0.69	0.78
6	S. W. North Dakota	45	0.21	0.94	0.02	-0.08	0.55	-0.02	0.01
7	S. E. North Dakota	54	0.74	0.98	0.06	-0.10	0.68	-0.25	0.17
8	N. W. Montana	32	0.94	0.99	-0.15	-0.19	0.80	0.19	-0.21
9	N. W. North Dakota	55	0.62	0.97	0.22	0.07	0.42	-0.27	0.21
10	N. E. North Dakota	50	0.87	0.96	0.55	0.29	0.70	-0.42	0.54
	All HRS areas combined	475	0.78	0.93	0.27	0.27	0.70	-0.40	0.40

1/ 14.0 percent moisture basis.

Table 10--Correlation Coefficients: Various factors vs. "flour evaluation score," Hard Red Winter and Hard Red Spring Wheat, all areas

Class	No. of samples	Wheat		Flour--farinogram characteristics				
		Sedimentation value	Protein content 1/	Mixing time	Mixing tolerance	Water absorption	MTI	Valorimeter value
			Percent	Minutes	Minutes	Percent		
Hard Red Winter Wheat	1,326	0.76	0.68	0.65	0.58	0.56	-0.66	0.65
Hard Red Spring Wheat	475	0.82	0.54	0.23	0.31	0.41	-0.41	0.39
Combined HRW and HRS	1,801	0.77	0.64	0.52	0.48	0.55	-0.64	0.59

1/ 14.0 percent moisture basis.

Table 11--Correlation Coefficients: Various factors vs. bread-loaf volume, Hard Red Winter and Hard Red Spring Wheat, all areas

Class	No. of samples	Wheat		Flour--farinogram characteristics				
		Sedimentation value	Protein content 1/	Mixing time	Mixing tolerance	Water absorption	MTI	Valorimeter value
			Percent	Minutes	Minutes	Percent		
Hard Red Winter Wheat	1,326	0.83	0.88	0.41	0.37	0.61	-0.47	0.42
Hard Red Spring Wheat	475	0.78	0.93	0.27	0.27	0.70	-0.40	0.40
Combined HRW and HRS	1,801	0.86	0.92	0.54	0.56	0.60	-0.59	0.60

1/ 14.0 percent moisture basis.

Table 12--Correlation Coefficients: Wheat sedimentation, wheat protein, and farinogram characteristics, Hard Red Winter Wheat, by area of production

No.	Area of production	No. of samples	Mixing time vs. Sed.	Mixing time vs. Prot.	Mixing tolerance vs. Sed.	Mixing tolerance vs. Prot.	Farino. absorption vs. Sed.	Farino. absorption vs. Prot.	MTI vs. Sed.	MTI vs. Prot.	Valorimeter vs. Sed.	Valorimeter vs. Prot.	Sed. vs. Prot.
No.	Name												
1	Texas (except panhandle)	84	0.85	0.85	0.79	0.69	0.78	0.68	-0.87	-0.77	0.86	0.82	0.90
2	S. W. Oklahoma	85	0.73	0.77	0.74	0.77	0.86	0.88	-0.63	-0.70	0.59	0.67	0.94
3	N. W. Oklahoma	50	0.72	0.63	0.74	0.74	0.78	0.87	-0.73	-0.64	0.72	0.68	0.90
4	Texas-Oklahoma panhandle	36	0.52	0.29	0.57	0.29	0.91	0.80	-0.62	-0.29	0.56	0.34	0.78
5	S. E. Colorado	41	0.28	0.23	0.37	0.30	0.66	0.80	-0.40	-0.36	0.35	0.37	0.75
6	S. W. Kansas	81	0.35	0.28	0.22	0.05	0.51	0.57	-0.37	-0.22	0.35	0.26	0.71
7	S. E. Kansas	52	0.58	0.39	0.38	-0.09	0.36	0.63	-0.42	-0.06	0.35	-0.00 1/	0.75
8	West Central Kansas	88	0.37	0.13	0.29	-0.05	0.57	0.69	-0.35	-0.14	0.35	0.13	0.67
9	East Central Kansas	47	0.20	-0.02	0.32	-0.16	0.69	0.46	-0.35	-0.06	0.32	0.07	0.59
10	N. W. Kansas	54	0.48	0.35	0.40	0.24	0.59	0.77	-0.46	-0.24	0.40	0.20	0.83
11	N. E. Kansas	44	0.38	0.31	0.12	-0.24	0.44	0.65	-0.24	0.32	0.27	-0.17	0.53
12	N. E. Colorado	50	-0.01	-0.03	-0.06	-0.06	0.88	0.89	0.02	-0.00 2/	0.06	0.08	0.92
13	S. W. Nebraska	55	0.30	0.25	0.30	0.26	0.91	0.93	-0.47	-0.47	0.41	0.42	0.92
14	S. E. Nebraska	57	0.68	0.67	0.54	0.54	0.95	0.96	-0.72	-0.71	0.70	0.68	0.97
15	Nebraska panhandle	68	0.24	0.07	0.19	0.10	0.74	0.74	-0.41	-0.32	0.21	0.08	0.92
16	N. Central Nebraska	64	0.33	0.30	0.33	0.29	0.93	0.92	-0.36	-0.31	0.38	0.33	0.96
17	N. E. Nebraska	54	0.68	0.64	0.64	0.62	0.83	0.92	-0.66	-0.60	0.67	0.62	0.92
18	S. E. Wyoming	34	0.36	0.35	0.32	0.30	0.98	0.98	-0.36	-0.33	0.36	0.32	0.98
19	N. E. Wyoming	32	0.64	0.57	0.72	0.73	0.97	0.98	-0.69	-0.68	0.75	0.72	0.98
20	S. W. South Dakota	68	0.40	0.17	0.30	0.07	0.58	0.53	-0.38	-0.04	0.39	0.15	0.74
21	S. Montana	69	0.47	0.22	0.25	0.05	0.65	0.67	-0.37	-0.18	0.47	0.21	0.90
22	Missouri	57	0.50	0.34	0.16	-0.03	0.60	0.49	-0.28	-0.17	0.10	-0.06	0.85
23	Illinois	56	0.64	0.64	-0.02	-0.24	0.43	0.44	0.07	0.12	0.41	0.26	0.87
	All areas	1,326	0.52	0.37	0.48	0.28	0.70	0.67	-0.53	-0.35	0.51	0.37	0.83

1/ -0.0035
2/ -0.0007

Table 13--Correlation Coefficients: Wheat sedimentation, wheat protein, and farinogram characteristics, Hard Red Spring Wheat, by area of production

Area of production	No. of samples	Mixing time vs.		Mixing tolerance vs.		Farino. absorption vs.		MTI vs.		Valorimeter vs.		Sed. vs. Prot.
		Sed.	Prot.	Sed.	Prot.	Sed.	Prot.	Sed.	Prot.	Sed.	Prot.	
No. Name												
1 S. E. South Dakota	50	0.31	-0.06	0.26	-0.15	0.55	0.57	-0.39	0.17	0.41	-0.15	0.46
2 N. W. South Dakota	34	0.16	0.14	0.17	0.22	0.82	0.90	-0.21	-0.21	0.13	0.16	0.92
3 N. E. South Dakota	53	0.33	0.36	0.32	0.10	0.40	0.80	-0.30	-0.15	0.38	0.37	0.45
4 Minnesota	68	0.67	0.62	0.64	0.57	0.90	0.94	-0.58	-0.60	0.63	0.59	0.92
5 E. Montana	34	0.88	0.77	0.91	0.78	0.88	0.91	-0.84	-0.67	0.88	0.76	0.93
6 S. W. North Dakota	45	0.35	-0.01	0.41	-0.14	0.29	0.57	-0.24	-0.02	0.37	-0.07	0.07
7 S. E. North Dakota	54	0.23	0.03	0.07	-0.11	0.48	0.65	-0.15	-0.22	0.30	0.16	0.66
8 N. W. Montana	32	-0.19	-0.14	-0.27	-0.19	0.79	0.81	0.22	0.16	-0.27	-0.20	0.95
9 N. W. North Dakota	55	0.39	0.20	0.31	0.00[1/]	0.38	0.41	-0.42	-0.21	0.39	0.18	0.58
10 N. E. North Dakota	50	0.56	0.58	0.37	0.34	0.71	0.73	-0.48	-0.47	0.55	0.56	0.86
All HRS areas combined	475	0.31	0.22	0.38	0.19	0.54	0.71	-0.47	-0.30	0.48	0.34	0.71
HRS and HRW [2/] all areas	1,801	0.57	0.54	0.58	0.55	0.66	0.61	-0.62	-0.53	0.62	0.60	0.84

1/ 0.0071

2/ Derived from source data of table 12.

Table 14--Correlation Coefficients and Other Parameters: Hard Red Winter Wheat, 1962 and 1963 crop data combined

Item	No. of samples	Wheat		Flour--farinogram characteristics					Flour evaluation score
		Sedimentation value	Protein content	Mixing time	Mixing tolerance	Water absorption	MTI	Valorimeter value	
			Percent	Minutes	Minutes	Percent			
Mean 1/	1,856	47.2	12.1	5.3	9.6	59.8	40.1	59.6	84.1
Standard Deviation 1/		11.5	1.2	2.1	3.8	3.0	16.0	9.0	7.5
Simple Correlation Coefficients									
Sedimentation		1.00		.58	.55	.66	-.60	.62	.81
Protein			1.00	.44	.35	.73	-.45	.52	.69
Mixing time				1.00	.83	.49	-.76	.87	.68
Mixing tolerance					1.00	.31	-.78	.80	.61
Water absorption						1.00	-.48	.53	.59
MTI							1.00	-.82	-.70
Valorimeter								1.00	.72
Flour evaluation score									1.00
Multiple correlation coefficient (R)		.86 2/	.83 3/						
Standard error of estimate		3.8	4.16						

1/ Data are in original units.
2/ Sedimentation test and farinogram characteristics correlated with the "flour evaluation score."
3/ Protein test and farinogram characteristics correlated with the "flour evaluation score."

Table 15--Correlation Coefficients and Other Parameters: Hard Red Spring Wheat, 1962 and 1963 crop data combined

Item	No. of samples	Wheat		Flour--farinogram characteristics					Flour evaluation score
		Sedimentation value	Protein content	Mixing time	Mixing tolerance	Water absorption	MTI	Valorimeter value	
			Percent	Minutes	Minutes	Percent			
Mean 1/	661	60.7	14.1	8.3	16.5	62.0	23.7	72.1	89.4
Standard Deviation 1/		8.2	1.0	3.4	7.2	2.1	12.8	10.3	4.8
Simple Correlation Coefficients									
Sedimentation		1.00		.24	.27	.48	.39	.36	.77
Protein			1.00	.36	.34	.37	-.35	.45	.30
Mixing time				1.00	.83	-.06	-.65	.90	.02
Mixing tolerance					1.00	-.14	-.75	.89	.04
Water absorption						1.00	-.07	-.03	.46
MTI							1.00	-.82	-.22
Valorimeter								1.00	.11
Flour evaluation score									1.00
Multiple correlation coefficient (R)		.80 2/	.52 3/						
Standard error of estimate		2.9	4.1						

1/ Data are in original units.
2/ Sedimentation test and farinogram characteristics correlated with the "flour evaluation score."
3/ Protein test and farinogram characteristics correlated with the "flour evaluation score."

Table 16--Correlation Coefficients and Other Parameters: Combined Hard Red Winter and Hard Red Spring Wheat, 1962 and 1963 crop data combined

Item	No. of samples	Wheat		Flour--farinogram characteristics					Flour evaluation score
		Sedimentation value	Protein content	Mixing time	Mixing tolerance	Water absorption	MTI	Valorimeter value	
			Percent	Minutes	Minutes	Percent			
Mean 1/	2,517	50.8	12.7	6.1	11.4	60.4	35.8	62.9	85.5
Standard Deviation 1/		12.3	1.5	2.8	5.8	3.0	16.9	10.9	7.2
Simple Correlation Coefficients									
Sedimentation		1.00		.57	.56	.68	-.66	.66	.82
Protein			1.00	.56	.53	.70	-.57	.65	.67
Mixing time				1.00	.87	.41	-.75	.89	.53
Mixing tolerance					1.00	.30	-.77	.86	.48
Water absorption						1.00	-.50	.49	.62
MTI							1.00	-.85	-.67
Valorimeter								1.00	.63
Flour evaluation score									1.00
Multiple correlation coefficient (R)		.85 2/	.77 3/						
Standard error of estimate		3.8	4.6						

1/ Data are in original units.
2/ Sedimentation test and farinogram characteristics correlated with the "flour evaluation score."
3/ Protein test and farinogram characteristics correlated with the "flour evaluation score."

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