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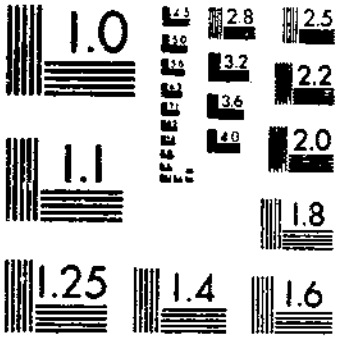

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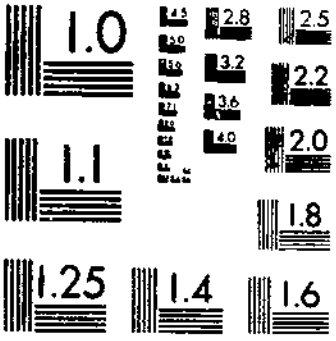

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The Chemical Composition of Various Wheats and Factors Influencing Their Composition .

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INTRODUCTION

An accumulation of burdensome surpluses of farm commodities in the 2 decades prior to World War II resulted in national economic distress. For aid to agriculture, measures curtailing production were tried, as well as measures encouraging consumption. In the latter category is the legislation passed by Congress in 1938 authorizing the establishment of four regional research laboratories in the United States Department of Agriculture.

The specific purpose of these laboratories is to conduct researches leading to the development of new scientific, chemical, and technical uses and new and extended markets and outlets for farm commodities, their products, and their byproducts. Congress specified that such research and development was to be devoted primarily to those farm commodities in which there are regular or seasonal surpluses. Wheat fits into this category and the research on this crop has been officially assigned to the Northern and Western Regional Laboratories. To the former was assigned the work on starch and oil constituents of wheat; to the latter, the work on the protein constituent.

Because of the suitability of wheat for food and its relatively higher price in comparison with other grains, nonfood uses have not been given serious consideration until recently, and interest in its chemical composition has been confined to the protein and ash constituents.

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But since some of the possible nonfood uses are based on one or more of the other chemical constituents of wheat, complete knowledge of its chemical composition becomes of primary importance. Much compositional data on wheat exist in the literature but they either do not give the comparisons of varieties and cultural conditions that are most useful, or else the data cover too few of the chemical constituents. To remedy this deficiency the Northern Regional Research Laboratory early in its existence arranged with the Bureau of Plant Industry, Soils, and Agricultural Engineering, U. S. Department of Agriculture, for suitable samples of wheat on which to make a compositional study.

The data on the physical characteristics and chemical composition are grouped, first to show differences between varieties grown under comparable conditions and, second to show differences between samples of the same variety grown under different environments. Some of the data were suitable for statistical analysis and were analyzed to evaluate the effect of variety, location, and crop year on composition. These results are presented and discussed separately.

COMMERCIAL TYPES AND AREAS OF PRODUCTION

The species of wheat of greatest consequence produced in the United States are described as common, club, and durum. For purposes of commercial usage these are divided into classes as follows: Hard red spring, durum, red durum, hard red winter, soft red winter, white, and mixed wheat. The hard red spring and hard red winter classes are entirely of the common species, but the soft red winter and white classes include varieties both of the common and club species. The wheat species of the durum and red durum classes are indicated by their names. Durum and red durum are very hard in kernel texture; hard red spring and hard red winter range from semihard to hard; soft red winter ranges from soft to semihard; and white from soft to hard.

Wheat is grown commercially in most of the 48 States, so it is not surprising that the number of our domestic varieties is very large. Production is generally limited to areas having a frost-free period of 90 days or more and, except where irrigation is possible, an annual precipitation between 12 and 45 inches.

The areas in which the several commercial classes are most generally grown are shown in figure 1.

SOURCES OF SAMPLES

The wheat samples on which the data presented here are based were obtained from 63 locations in the United States and Canada. All samples were obtained through experiment stations except in a few instances in which they were obtained from fields that had been planted with certified seed. An attempt was made to obtain the leading varieties of each of the various classes of wheat. One hundred sixteen samples of hard red spring wheat, 10 of durum, 137 of hard red winter, 107 of soft red winter, and 111 of white were examined.

Samples were collected over the period 1940 to 1944, inclusive. At least two leading varieties of each class, except for durum, were collected each year. For the Thatcher variety, samples were obtained

from five stations in Canada each year and from a similar number in the United States, in order to cover a range of climate as wide as possible.

The total number of samples of each class analyzed is shown in table 1.

The location from which the samples were obtained and the number analyzed are shown in table 2.

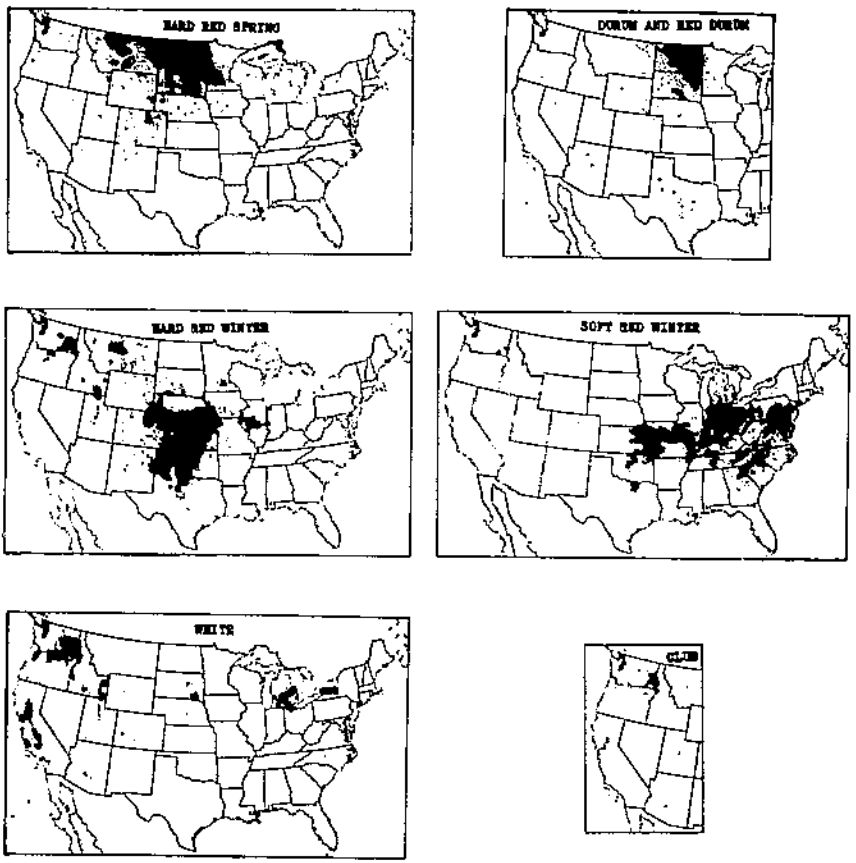

FIGURE 1.—Distribution of wheat classes in 1939. Each dot represents 2,000 acres. Estimated areas: hard red spring 13,330,648, durum and red durum, 3,372,405, hard red winter 30,456,919, soft red winter 12,552,634, white 4,198,394, and club wheat (some red and some white kerneled are also included in the soft red winter and white wheat acreages, respectively) 411,282 acres.

TABLE 1.—*Number of samples of known variety of each of the various commercial classes of wheat by crop years on which physical and chemical analyses were made*

Class	Crop year					Total
	1940	1941	1942	1943	1944	
Hard red spring	23	29	22	23	19	116
Durum	1	4				5
Red durum	1	2	1	1		5
Hard red winter	45	24	16	26	26	137
Soft red winter	56	21	8	12	10	107
White	39	23	14	21	14	111
Total	165	103	61	83	69	481

TABLE 2.—*Number of samples of wheat varieties obtained for analysis from various locations in the United States and Canada, 1940–44, inclusive*

Location of stations	Number of samples—					Total
	1940	1941	1942	1943	1944	
United States locations:						
Colfax, Wash.			1	1		2
Lind, Wash.	2	2	2	2		8
Pullman, Wash.	14	8	4	4	6	36
Moro, Oreg.		2	2	2	2	8
Pendleton, Oreg.	14	9	4	7	6	40
Union, Oreg.	2					2
Davis, Calif.	2	2				4
Aberdeen, Idaho	3	2	2	3	2	12
Moscow, Idaho	2					2
Sand Point, Idaho	2					2
Mesa, Ariz.	2	2	1	3		8
Bozeman, Mont.	5	5	4	3	3	20
Havre, Mont.	2		2	5	3	12
Moccasin, Mont.	2	2				4
Sheridan, Wyo.	4	2	3	3		12
Fort Collins, Colo.		1	1	1		3
Cleveland, N. Dak.				1		1
Dickinson, N. Dak.	2	1	2	2	2	9
Fargo, N. Dak.	10	15	4	1	4	34
Brookings, S. Dak.	3	2	2	2		9
Lincoln, Nebr.	3	2	2	3	3	13
Hays, Kans.		2	2	3	3	10
Manhattan, Kans.	8	10	2	3	2	25
Minneapolis, Kans.			1			1
Sedgwick, Kans.				1	1	2
Topeka, Kans.				1	1	2
Wamego, Kans.		1				1
Goodwell, Okla.	2					2
Lawton, Okla.	4	2	2	3	3	14
Stillwater, Okla.	2					2
Woodward, Okla.		2	2	3	3	10
Amarillo, Tex.		2	2	3	3	10

TABLE 2.—*Number of samples of wheat varieties obtained for analysis from various locations in the United States and Canada, 1940–44, inclusive*—Continued

Location of stations	Number of samples—					
	1940	1941	1942	1943	1944	Total
United States locations—Continued						
Chillicothe, Tex.	2					2
Denton, Tex.	2					2
St. Paul, Minn.	4	2	2	4	3	15
Waseca, Minn.	2					2
Columbia, Mo.	5	2		3	2	12
Glasgow, Mo.		1				1
Warrensburg, Mo.		1				1
Madison, Wis.	2					2
Urbana, Ill.	8	2		3	3	16
Lafayette, Ind.	12	2		3	3	20
Lexington, Ky.	2					2
Knoxville, Tenn.	2					2
Bannister, Mich.		1				1
East Lansing, Mich.	6	2	2			10
Elsie, Mich.			1			1
Columbus, Ohio	2					2
Wooster, Ohio	5	8	3	3	4	23
State College, Pa.	3					3
Newark, Del.	2					2
Ithaca, N. Y.	5	2	2	4	3	16
New Brunswick, N. J.	2					2
College Park, Md.	2					2
Arlington, Va.	2					2
Blacksburg, Va.	2					2
Statesville, N. C.	2					2
Canada locations:						
Beaver Lodge, Alberta		1	1	1		3
Edmonton, Alberta		1	1	1	1	4
Fort Vermilion, Alberta					1	1
Lethbridge, Alberta		1	1		1	3
Nipawin, Saskatchewan	1					1
Saskatoon, Saskatchewan		1	1	1	1	4
Total	165	103	61	83	69	481

METHODS OF PHYSICAL AND CHEMICAL ANALYSIS

After the wheat samples had dried to a moisture content of about 13 percent at ordinary room temperature and humidity conditions, they were stored at a temperature of 38° to 40° F. and a relative humidity of 55 to 60 percent.

Determination of weight per bushel was by the method prescribed by the Official Grain Standards of the United States. Determination of weight per 1,000 kernels was on whole, sound kernels.

For chemical analysis, the wheat samples were finely ground in a small buhr-type electric grinder. All foreign material and damaged kernels were removed from each sample before grinding.

The chemical analyses were by methods of the Association of Official Agricultural Chemists except in the following details:

Moisture was determined by heating at 130° C. for 1½ hours, and ash by heating at 550° for 4 hours.

Boric acid was used to receive the ammonia in the Kjeldahl-Gunning-Arnold method for nitrogen.

Sugars were run by the Scales method which has tentative A. O. A. C. approval (A. O. A. C. 1945).

Oil was determined by an 18-hour extraction with petroleum ether in a Butt apparatus (similar to the American Oil Chemists Society method for cottonseed). This extract certainly contains small quantities of materials other than glycerides but for simplicity, will be referred to as oil.

Starch was determined by the improved polarimetric method (Earle and Milner 1944) for wheat. The specific rotation of starch was considered to be 203°.

The protein figures given were arrived at by multiplying the nitrogen (N) content by 5.7, the usual conversion factor for wheat flour.

EXPERIMENTAL RESULTS

To provide the fullest comparison of data for all physical and chemical constituents, tables showing the analytical data on a selected series of wheat samples of known variety and origin are presented in this publication. These data cover the chemical constituents—protein, starch, sugar, oil, and ash of the wheat—and are calculated on a moisture-free basis. In addition, they cover the physical attributes of weight per bushel and weight per 1,000 kernels on an air-dry basis, both of which are generally conceded to be related to chemical composition.

The original plan was to obtain samples of several varieties of hard red winter wheat grown at one station in the region and of two varieties of each class grown at each of several stations. Similar plans were followed for the hard red spring and the soft red winter wheat, and for the wheat from the Pacific Northwest. Crop failures at several locations in specific years made necessary some adjustments in the original plan, but data are available to show differences among varieties within each of the classes when grown under comparable conditions, and also differences among samples of the same variety when grown at different locations or at the same location in different years. The data from all the samples obtained are summarized in table 3.

Since the varieties from each class were for the most part grown at stations in the region where the class is grown commercially, the class averages, shown in table 3, give an indication of the general differences to be expected between commercial samples of the different classes. They also provide some information in regard to the variation

TABLE 3.—*Physical and chemical composition of wheats, by classes showing minimum, maximum, and average values*

Minimum, maximum, and average values of different classes	Number of samples analyzed	Air-dry basis		Moisture-free basis				
		Weight per bushel	Weight per 1,000 kernels	Protein	Starch	Sugar	Ash	Oil
		Pounds	*Grams*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
Hard red spring	116							
Minimum		50.5	14.8	11.6	54.2	2.34	1.36	1.68
Maximum		63.8	40.3	21.8	66.6	4.86	2.62	2.56
Average		58.6	27.3	16.5	61.2	3.19	2.04	2.00
Durum	5							
Minimum		60.2	33.9	14.8	59.1	3.32	1.99	1.98
Maximum		63.0	38.5	19.7	64.5	3.96	2.46	2.41
Average		61.8	36.3	16.0	63.0	3.58	2.19	2.19
Red durum	5							
Minimum		60.1	29.0	15.4	59.3	3.02	1.75	1.86
Maximum		62.1	30.3	18.4	63.1	3.58	2.38	2.14
Average		60.8	29.5	16.8	61.3	3.33	2.14	1.98
Hard red winter	137							
Minimum		50.2	15.8	8.4	55.6	1.60	1.31	1.37
Maximum		64.7	39.0	21.1	69.9	4.49	2.66	2.18
Average		59.1	27.4	15.3	63.5	2.84	1.92	1.67
Soft red winter	107							
Minimum		54.4	19.1	8.3	55.2	2.16	1.71	1.43
Maximum		64.1	46.4	18.0	70.5	4.76	2.39	2.17
Average		59.3	34.0	12.4	66.5	2.90	2.07	1.66
White	111							
Minimum		53.9	28.5	8.2	62.9	2.65	1.37	1.47
Maximum		64.7	52.6	16.1	71.1	5.90	2.55	2.31
Average		60.7	38.1	11.2	66.6	4.02	1.86	1.80

that may be expected between lots of wheat of the same class. The differences shown, however, should not be given too much consideration because of the small number of samples obtained for some of the classes, and also because the samples were not all grown during the same years or under otherwise comparable conditions. Perhaps the most significant facts brought out in this table are the extreme ranges in the weight per 1,000 kernels and the protein content, especially of the hard red spring and hard red winter classes, as contrasted with the relatively small variation in ash and oil contents. There is also a wide variation in test weight. Since the variations in starch and sugar largely complement those in protein content these variations also are large.

In the tables that follow, these data are presented in their relation to variety, location, and seasonal effects.

Composition of Comparably Grown Varieties

The differences among varieties of each class are best shown by averaging data from the stations and years where several varieties were comparably grown. Such data are presented in tables 4 to 8, inclusive, for 8 varieties of hard red spring, 1 of durum, and 1 of red durum grown at Fargo, N. Dak., in 1940 and 1941; 7 varieties of hard red winter grown at Manhattan, Kans., in 1940 and 1941; 10 varieties of soft red winter, 1 of soft white winter, and 1 of hard red winter grown at Lafayette, Ind., in 1940; 3 varieties of white club, 2 of soft white, 1 of western red, and 1 of hard red winter grown at Pullman, Wash., and Pendleton, Oreg., in 1940; and for 5 varieties of white spring and 1 of hard red spring also grown at Pullman and Pendleton in 1940.

The maximum and minimum for each character and the range among varieties within each comparable group are shown. As would be expected, the greatest differences among varieties were in weight per 1,000 kernels. Among the comparably grown varieties the greatest difference was that between Thatcher which weighed 21.7 and Mindum which weighed 37.8 grams. Although differences among other varieties were smaller they have been found to be consistent. The greatest difference in test weight was found also among the spring varieties, where the test weight for Thatcher and Marquis was 57.7 and for Mindum 61.4 pounds (table 4).

Differences in the chemical composition among comparably grown varieties, except for oil content, were rather small and as will be shown later were much smaller than differences in samples of the same variety grown under different environments.

The maximum difference between comparably grown varieties (table 5) in ash content was 0.26 percent between the hard red winter varieties Pawnee (1.72 percent) and Cheyenne, (1.98 percent). Differences among comparably grown varieties in the other regions (tables 4, 6, 7, and 8) did not exceed 0.21 percent.

The greatest difference in protein content was 2.0 percent between Onas (12.7 percent) and Marquis (14.7 percent) grown at Pullman and Pendleton in 1940 (table 8) and between Marquis (16.0 percent) and Pilot (18.0 percent) grown at Fargo, N. Dak. in 1940 and 1941 (table 4).

The greatest difference in oil content was 0.74 percent between Baart (1.58 percent) and Marquis (2.32 percent) grown at Pullman and Pendleton in 1940 (table 8). The differences in oil content as will be shown later were greater among comparably grown varieties than within the same variety grown at different stations or in different years.

Sugar content of the winter varieties grown at Pullman and Pendleton in 1940 varied from 2.95 percent for Hymar to 3.97 for Golden, a difference of 1.02 percent (table 7). Differences among comparably grown varieties in the other regions were smaller.

The greatest difference in starch content, 4.8 percent, was between Marquis (61.5 percent) and Federation (66.3 percent) grown at Pullman and Pendleton in 1940 (table 8).

TABLE 4.—*Physical characteristics and chemical composition of hard red spring and durum wheat varieties grown at Fargo, N. Dak., in 1940 and 1941*

Class and variety	Air-dry basis		Moisture-free basis				
	Weight per bushel	Weight per 1,000 kernels	Ash	Protein (N×5.7)	Oil	Sugar	Starch
	Pounds	*Grams*	*Per-cent*	*Percent*	*Per-cent*	*Per-cent*	*Per-cent*
Hard red spring:							
Ceres	59. 4	27. 0	2. 00	16. 8	1. 85	2. 82	61. 4
Marquis	57. 7	24. 3	2. 17	16. 0	2. 16	3. 25	61. 4
Merit	58. 8	28. 7	2. 12	17. 6	1. 88	2. 92	61. 4
Pilot	58. 9	28. 2	2. 12	18. 0	2. 11	2. 80	60. 4
Premium	60. 9	33. 5	2. 08	17. 5	2. 16	3. 19	61. 4
Renown	59. 8	27. 2	2. 08	17. 9	2. 02	2. 92	61. 4
Rival	60. 0	33. 0	2. 13	17. 4	1. 94	3. 09	61. 6
Thatcher	57. 7	21. 7	2. 10	17. 4	1. 87	2. 78	61. 4
Maximum	60. 9	33. 5	2. 17	18. 0	2. 16	3. 25	61. 6
Minimum	57. 7	21. 7	2. 00	16. 0	1. 85	2. 80	60. 4
Range	3. 2	11. 8	. 17	2. 0	. 31	. 45	1. 2
Durum:							
Mindum	61. 4	37. 8	2. 06	17. 2	2. 06	3. 72	61. 8
Red durum:							
Pentad	61. 3	29. 8	2. 04	16. 9	1. 94	3. 53	61. 2

TABLE 5.—*Physical characteristics and chemical composition of hard red winter varieties grown at Manhattan, Kans. in 1940 and 1941*

Class and variety	Air-dry basis		Moisture-free basis				
	Weight per bushel	Weight per 1,000 kernels	Ash	Protein (N×5.7)	Oil	Sugar	Starch
	Pounds	*Grams*	*Per-cent*	*Percent*	*Per-cent*	*Per-cent*	*Per-cent*
Hard red winter:							
Blackhull	60. 0	25. 4	1. 87	15. 8	1. 48	2. 43	63. 2
Cheyenne	59. 9	26. 8	1. 98	14. 4	1. 56	2. 22	65. 3
Chiefkan	61. 3	28. 7	1. 85	15. 3	1. 43	2. 41	65. 0
Kharkof	58. 7	23. 8	1. 96	15. 0	1. 50	2. 08	64. 4
Nebred	59. 8	23. 4	1. 96	15. 0	1. 59	2. 24	63. 6
Pawnee	59. 1	25. 4	1. 72	15. 6	1. 76	3. 16	63. 8
Tenmarq	58. 4	28. 0	1. 91	14. 4	1. 64	2. 58	65. 4
Maximum	61. 3	28. 7	1. 98	15. 8	1. 76	3. 16	65. 4
Minimum	58. 4	23. 4	1. 72	14. 4	1. 43	2. 22	63. 2
Range	2. 9	5. 3	. 26	1. 4	. 33	. 94	2. 2

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TABLE 6.—*Physical characteristics and chemical composition of winter wheat varieties grown at Lafayette, Ind., in 1940*

Class and variety	Air-dry basis		Moisture-free basis				
	Weight per bushel	Weight per 1,000 kernels	Ash	Protein (N×5.7)	Oil	Sugar	Starch
	Pounds	*Grams*	*Per-cent*	*Percent*	*Per-cent*	*Per-cent*	*Per-cent*
Soft red winter:							
Early Premium	61.5	32.5	1.98	11.6	1.43	2.49	67.7
Fairfield	59.0	34.7	1.93	10.3	1.76	3.07	68.8
Kawvale	61.2	30.8	1.95	11.0	1.57	2.65	68.3
Nittany	60.1	37.5	2.10	11.9	1.71	2.64	67.2
Purdue No. 1	61.5	32.4	1.97	10.3	1.75	2.79	68.6
Purdue No. 7	59.8	34.0	2.04	10.9	1.84	2.89	68.3
Red Rock	61.3	38.8	2.01	11.7	1.85	2.53	67.5
Thorne	59.1	33.6	1.97	10.8	1.66	2.89	68.0
Trumbull	61.2	35.3	2.14	12.0	1.53	2.73	67.9
Wabash	60.8	30.5	1.99	10.9	1.82	2.33	68.9
Soft white winter:							
Dawson	60.4	36.2	1.90	11.1	1.88	2.90	67.2
Hard red winter:							
Purkof	60.6	29.8	1.93	10.9	1.97	2.67	67.3
Maximum	61.5	38.8	2.14	12.0	1.97	3.07	68.9
Minimum	59.0	29.8	1.90	10.3	1.43	2.33	67.2
Range	2.5	9.0	.21	1.7	.54	.74	1.7

TABLE 7.—*Physical characteristics and chemical compositions of winter wheat varieties grown at Pullman, Wash., and Pendleton, Oreg., in 1940*

Class and variety	Air-dry basis		Moisture-free basis				
	Weight per bushel	Weight per 1,000 kernels	Ash	Protein (N×5.7)	Oil	Sugar	Starch
	Pounds	*Grams*	*Per-cent*	*Percent*	*Per-cent*	*Per-cent*	*Per-cent*
White club:							
Albit	62.0	30.0	1.91	10.8	1.94	3.64	66.6
Hybrid 128	62.2	31.7	1.90	11.2	1.93	3.04	67.4
Hymar	62.6	33.6	1.87	10.9	1.82	2.95	67.7
Soft white:							
Rex	61.2	37.5	1.90	10.6	2.04	3.83	67.9
Golden	61.3	36.7	1.88	11.0	2.08	3.97	65.3
Western red:							
Triplet	64.1	33.9	1.75	10.9	1.79	3.60	66.0
Hard red winter:							
Kharkof	61.4	37.4	1.82	11.3	1.60	3.55	66.0
Maximum	64.1	37.5	1.91	11.3	2.08	3.97	67.9
Minimum	61.2	30.0	1.75	10.6	1.60	2.95	65.3
Range	2.9	7.5	.16	.7	.48	1.02	2.4

TABLE 8.—*Physical characteristics and chemical composition of spring wheat varieties grown at Pullman, Wash., and Pendleton, Oreg., in 1940*

Class and variety	Air-dry basis		Moisture-free basis				
	Weight per bushel	Weight per 1,000 kernels	Ash	Protein (N×5.7)	Oil	Sugar	Starch
	Pounds	*Grams*	*Per-cent*	*Percent*	*Per-cent*	*Per-cent*	*Per-cent*
White spring:							
Baart	61. 9	39. 7	1. 66	14. 2	1. 58	4. 16	63. 4
Federation	59. 4	32. 9	1. 63	12. 8	1. 79	3. 80	66. 3
Idaed	59. 2	31. 3	1. 64	13. 6	1. 63	3. 42	64. 6
Onas	58. 6	33. 1	1. 68	12. 7	1. 91	3. 98	64. 4
White Federation	-------	35. 9	1. 69	14. 0	2. 07	3. 97	62. 5
Hard red spring:							
Marquis	59. 8	28. 5	1. 72	14. 7	2. 32	3. 75	61. 5
Maximum	-------	39. 7	1. 72	14. 7	2. 32	4. 16	66. 3
Minimum	-------	28. 5	1. 60	12. 7	1. 58	3. 42	61. 5
Range	-------	11. 2	. 12	2. 0	. 74	. 74	4. 8

COMPOSITION OF THE SAME VARIETY GROWN AT DIFFERENT STATIONS AND IN DIFFERENT YEARS

The influence of environment on test weight, size of kernel, and protein and ash contents of wheat varieties is well known but little data have been published on their content of oil, sugar, and starch. Data on the physical and chemical composition of 11 varieties each grown at several stations in each of several years are given in table 9. The maximum, minimum, and range among all the samples of each variety are also given. Averages are summarized in table 10 for each variety at certain stations where they were grown in the same years. These averages show, as would be expected, that characteristics like test weight, kernel size, and the chemical constituents—protein, sugar, and starch—are different when a variety is grown at different locations. On the other hand, oil content shows very little variability between different stations.

TABLE 9.—*Physical characteristics and chemical composition of varieties grown at several stations and in different years*

Class, variety, and location	Year	Air-dry basis		Moisture-free basis				
		Weight per bushel	Weight per 1,000 kernels	Ash	Protein (N×5.7)	Oil	Sugar	Starch
HARD RED SPRING								
Pilot:		*Pounds*	*Grams*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Bozoman, Mont.	1940	61.6	36.2	1.95	11.6	2.12	3.99	66.4
	1941	58.9	33.9	1.98	12.9	2.16	3.36	65.4
	1942	62.3	35.7	2.04	14.6	2.09	3.82	64.4
	1944	62.3	37.4	2.01	13.6	2.08	3.99	62.6
Average	1940–42	60.9	35.3	1.99	13.0	2.12	3.72	65.4
Range	1940–42	3.4	2.3	0.09	3.0	0.07	0.63	2.0
Havre, Mont.	1942	52.7	19.7	2.27	20.3	2.14	3.51	56.4
	1943	52.7	21.0	1.98	20.8	2.26	3.94	56.0
	1944	53.2	21.9	2.04	18.9	2.01	3.72	56.0
Mocassin, Mont.	1941	56.6	20.9	2.29	18.5	2.10	3.18	57.9
Sheridan, Wyo.	1940	56.4	23.2	2.01	19.6	2.15	3.64	57.7
	1941	56.8	23.1	2.02	19.6	2.13	3.59	57.2
	1942	54.7	19.2	1.98	21.2	2.19	3.36	57.0
	1943	58.6	26.2	1.90	17.9	2.04	3.67	59.9
Average	1940–42	56.0	21.8	2.00	20.1	2.16	3.53	57.3
Range	1940–42	2.1	4.0	.04	1.6	.06	.28	.7
Dickinson, N. Dak.	1941	59.7	31.9	2.06	18.5	2.22	3.41	59.2
	1942	61.4	31.4	1.73	14.8	2.16	2.86	64.0
	1944	60.9	26.4	2.08	15.0	2.01	2.95	62.7
Fargo, N. Dak.	1940	58.4	26.5	1.90	20.0	2.03	3.03	58.7
	1941	59.4	29.9	2.29	15.6	2.18	2.74	63.1
	1942	60.5	30.9	1.86	17.3	2.08	2.55	61.7
	1944	59.0	26.7	2.16	13.2	2.05	2.65	65.0
Average	1940–42	59.4	29.1	2.02	17.6	2.10	2.77	61.2
Range	1940–42	2.1	4.4	.43	4.4	.15	.48	4.4
Brookings, S. Dak.	1940	55.8	32.8	2.27	19.0	2.09	3.16	58.4
	1941	56.9	23.8	2.25	16.1	2.20	3.38	60.4
	1942	57.1	28.7	2.30	16.9	2.02	2.55	63.5
	1943	55.1	28.6	2.41	18.0	2.12	2.77	58.6
Average	1940–42	56.6	28.4	2.27	17.3	2.10	3.03	60.8
Range	1940–42	1.3	9.0	.05	2.9	.18	.83	5.1
St. Paul, Minn.	1940	58.0	30.0	2.42	15.4	2.01	2.69	62.9
	1941	57.5	28.0	2.34	16.1	2.20	2.77	62.3
	1942	58.1	27.2	2.16	16.5	2.01	2.60	62.3
	1943	57.3	23.9	2.32	15.6	2.07	2.70	61.6
	1944	60.4	29.5	2.10	11.6	2.05	2.57	66.6
Average	1940–42	57.9	28.4	2.31	16.0	2.07	2.69	62.5
Range	1940–42	.6	2.8	.26	1.1	.19	.17	.6
Maximum		62.3	37.4	2.42	21.2	2.22	3.99	66.6
Minimum		52.7	19.2	1.73	11.6	2.01	2.55	56.0
Range		9.6	18.2	.69	9.6	.21	1.44	10.6

TABLE 9.—*Physical characteristics and chemical composition of varieties grown at several stations and in different years*—Continued

Class, variety, and location	Year	Air-dry basis		Moisture-free basis				
		Weight per bushel	Weight per 1,000 kernels	Ash	Protein (N×5.7)	Oil	Sugar	Starch
HARD RED SPRING—Con.								
Thatcher:		*Pounds*	*Grams*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Bozeman, Mont.	1940	62.7	33.0	1.96	12.2	1.81	3.57	66.1
	1941	58.5	29.6	1.92	12.1	2.03	3.05	65.8
	1941	58.6	33.0	1.84	12.1	2.01	3.17	66.0
	1942	62.8	33.5	1.97	12.7	1.92	3.41	65.4
	1944	62.9	32.2	1.99	14.5	1.89	3.54	63.0
	1944	61.4	33.9	1.79	13.9	1.85	4.28	63.3
Average	1940–42	60.6	32.2	1.92	12.3	1.94	3.30	65.8
Range	1940–42	4.3	3.9	.13	.6	.22	.52	.7
Havre, Mont.	1942	51.3	17.5	2.18	21.8	2.05	3.74	54.2
	1943	54.8	22.1	1.86	19.8	2.03	3.68	56.7
	1943	55.1	21.0	1.89	20.5	2.04	3.65	55.4
	1944	53.7	21.1	1.93	19.8	1.94	3.58	57.1
	1944	53.9	21.2	1.86	19.3	1.94	3.47	57.0
Moccasin, Mont.	1941	55.9	19.1	2.07	19.7	1.93	3.50	56.4
Sheridan, Wyo.	1940	56.4	20.4	2.11	20.8	1.96	3.33	56.7
	1941	55.9	21.8	2.02	20.8	2.01	3.55	55.9
	1942	54.2	18.8	2.16	20.7	2.04	3.62	55.3
	1942	55.5	20.3	2.15	19.1	1.94	3.62	58.0
	1943	59.1	26.4	1.98	18.2	1.98	3.49	58.5
	1943	58.7	26.1	2.16	18.8	2.00	3.68	59.3
Average	1940–42	55.5	20.3	2.11	20.4	1.99	3.53	56.5
Range	1940–42	2.2	3.0	.14	1.7	.10	.29	2.7
Dickinson, N. Dak.	1942	60.7	26.3	1.79	14.9	1.91	2.71	63.7
	1943	60.8	28.4	1.77	17.3	1.90	3.02	61.0
	1943	63.8	28.2	2.07	15.1	1.80	2.92	63.5
	1944	60.9	25.9	1.90	15.1	1.83	2.85	62.9
Fargo, N. Dak.	1940	58.5	22.3	1.79	18.6	1.86	2.92	60.1
	1941	55.8	20.6	2.11	16.5	2.05	2.92	61.3
	1941	56.9	21.0	2.25	15.8	1.84	2.83	62.4
	1942	57.4	23.0	2.05	17.0	1.92	2.51	61.7
	1942	59.3	24.0	2.03	16.9	1.83	2.61	61.4
	1944	57.6	20.1	1.90	16.9	1.85	2.75	62.0
	1944	60.1	23.1	2.02	14.2	1.90	2.53	64.3
Average	1940–42	57.6	22.2	2.05	17.0	1.90	2.76	61.4
Range	1940–42	3.5	3.4	.46	2.8	.22	.41	2.3
Brookings, S. Dak.	1940	56.9	21.4	2.22	19.1	1.93	3.28	58.2
	1941	57.1	20.5	2.46	16.4	1.91	3.38	61.4
	1942	50.5	18.4	2.62	17.4	1.76	2.47	60.6
	1943	53.8	20.7	2.43	18.1	1.98	2.91	60.4
Average	1940–42	54.8	20.1	2.43	17.6	1.87	3.04	60.1
Range	1940–42	6.6	3.0	.40	2.7	.17	.91	3.2

TABLE 9.—*Physical characteristics and chemical composition of varieties grown at several stations and in different years*—Continued

Class, variety, and location	Year	Air-dry basis		Moisture-free basis				
		Weight per bushel	Weight per 1,000 kernels	Ash	Protein (N×5.7)	Oil	Sugar	Starch
HARD RED SPRING—Con.								
Thatcher—Continued		*Pounds*	*Grams*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
St. Paul, Minn.	1940	57.5	24.7	2.14	15.2	1.80	2.75	63.6
	1941	53.1	19.3	2.44	16.1	1.90	2.88	61.5
	1942	56.0	22.2	2.06	16.1	1.82	2.57	61.8
	1943	55.7	21.9	2.35	16.0	1.88	2.87	61.8
	1943	55.8	21.3	2.29	16.3	1.84	2.81	61.3
	1944	59.1	23.8	2.06	13.4	1.77	2.60	64.8
Average	1940–42	55.5	22.1	2.21	15.8	1.84	2.73	62.3
Range	1940–42	4.4	5.4	.38	.9	.10	.31	2.1
Ft. Collins, Colo.	1941	60.1	32.2	1.92	16.3	2.05	3.01	62.4
	1942	59.9	28.8	2.35	16.6	1.84	2.70	65.1
	1943	61.9	30.8	2.02	13.6	1.93	3.17	64.7
Beaverlodge, Alta.	1941	58.5	32.1	1.63	16.6	1.88	2.99	62.3
	1942	59.5	26.1	1.42	16.0	1.99	3.22	60.9
	1943	62.1	32.6	1.36	14.8	1.88	4.53	61.8
Edmonton, Alta.	1941	59.9	25.4	1.57	18.4	2.14	3.12	59.3
	1942	62.0	38.5	1.84	18.9	1.83	2.96	60.3
	1943	62.5	38.0	1.87	17.3	1.95	3.04	61.3
	1944	63.7	34.8	1.50	16.2	1.83	3.40	62.6
Lethbridge, Alta.	1941	58.7	28.5	1.94	16.7	2.03	2.85	61.5
	1942	60.7	36.6	2.00	16.5	1.90	2.91	63.1
	1944	61.7	30.6	2.04	15.8	1.87	2.85	61.5
Saskatoon, Sask.	1941	60.3	26.4	1.50	18.2	2.03	3.25	60.1
	1942	61.6	30.1	1.86	14.8	1.86	2.79	64.8
	1943	61.4	31.6	1.50	18.0	1.90	3.87	60.2
	1944	62.3	34.8	1.67	18.1	1.74	2.98	60.9
Nipawin, Sask.	1940	61.3	32.2	1.80	14.3	2.04	3.37	64.2
Mesa, Ariz.	1941	-------	24.7	2.25	17.4	2.20	3.38	60.6
	1941	-------	24.2	2.08	18.1	1.92	4.49	58.8
	1942	60.1	29.2	1.96	13.4	2.07	3.45	63.8
	1943	60.1	28.4	1.79	13.7	1.93	3.24	63.6
Maximum		63.8	38.5	2.62	21.8	2.20	4.53	66.1
Minimum		50.5	17.5	1.36	12.1	1.74	2.47	54.2
Range		13.3	21.0	1.26	9.7	.46	2.06	11.9
HARD RED WINTER								
Kharkof:								
Lawton, Okla.	1940	60.4	27.9	1.52	18.0	1.52	2.39	62.7
	1941	57.2	21.2	1.81	18.8	1.49	1.99	61.7
	1942	58.4	20.7	1.67	19.6	1.56	1.96	60.0
	1943	58.9	23.7	1.68	17.9	1.55	2.44	59.1
	1944	60.5	23.9	1.38	17.0	1.37	1.60	63.9
Average	1941–44	58.8	22.4	1.64	18.3	1.49	2.00	61.2
Range	1941–44	3.3	3.2	.43	2.6	.19	.84	4.8

TABLE 9.—*Physical characteristics and chemical composition of varieties grown at several stations and in different years*—Continued

Class, variety, and location	Year	Air-dry basis		Moisture-free basis				
		Weight per bushel	Weight per 1,000 kernels	Ash	Protein (N×5.7)	Oil	Sugar	Starch
HARD RED WINTER—Continued								
		Pounds	*Grams*	*Per-cent*	*Per-cent*	*Per-cent*	*Per-cent*	*Per-cent*
Kharkof—Continued								
Goodwell, Okla.	1940	53.1	18.3	2.38	20.3	1.60	2.92	55.7
Stillwater, Okla.	1940	60.7	30.1	1.39	15.5	1.53	2.90	64.5
Woodward, Okla.	1941	57.0	24.5	2.07	14.1	1.68	2.43	65.6
	1942	57.8	23.3	1.97	15.0	1.62	2.34	63.5
	1943	60.7	24.7	2.18	14.8	1.63	2.54	64.3
	1944	60.8	28.9	1.89	11.4	1.48	2.07	68.6
Average	1941–44	59.1	25.4	2.03	13.8	1.60	2.34	65.5
Range	1941–44	3.8	5.6	.29	3.6	.20	.47	5.1
Denton, Tex.	1940	55.3	24.4	1.88	10.9	1.62	3.08	67.9
Chillicothe, Tex.	1940	58.7	23.9	1.96	20.9	1.50	2.47	58.0
Amarillo, Tex.	1941	55.4	23.8	2.02	13.1	1.58	2.84	65.8
	1942	59.2	23.5	1.87	18.4	1.61	2.84	58.9
	1943	58.6	27.6	2.17	19.2	1.63	2.80	59.2
	1944	61.4	29.3	1.98	17.6	1.50	2.70	64.5
Average	1941–44	58.6	26.1	2.01	17.1	1.58	2.80	62.1
Range	1941–44	6.0	5.8	.30	6.1	.13	.14	6.9
Hays, Kans.	1941	59.6	24.4	2.05	16.0	1.59	2.50	63.6
	1942	58.1	22.5	2.24	21.1	1.46	2.36	57.2
	1943	57.4	20.7	2.26	21.0	1.67	3.14	56.4
	1944	51.4	15.8	2.66	20.2	1.76	3.69	56.5
Average	1941–44	56.6	20.8	2.30	19.6	1.62	2.92	58.4
Range	1941–44	8.2	8.6	.61	5.1	.30	1.33	7.2
Manhattan, Kans.	1940	60.8	27.6	2.05	13.4	1.65	2.96	64.2
	1941	56.5	20.0	2.01	15.6	1.51	2.11	63.9
	1942	54.4	20.1	2.21	16.5	1.49	2.34	63.2
	1943	59.6	27.5	2.08	14.9	1.54	2.12	64.3
Lincoln, Nebr.	1940	60.2	25.0	1.75	20.7	1.51	2.50	58.6
	1941	55.8	20.5	2.26	17.6	1.57	2.64	61.1
	1942	60.0	29.6	1.87	14.1	1.47	2.10	64.8
	1943	58.5	25.5	1.97	16.3	1.66	2.35	63.0
	1944	57.4	24.5	2.32	16.0	1.57	2.12	62.3
Average	1941–44	57.9	25.0	2.10	16.0	1.57	2.30	62.8
Range	1941–44	4.2	9.1	.45	3.5	.19	.54	3.7
Sheridan, Wyo.	1940	61.4	31.5	1.61	16.5	1.53	3.11	62.8
Waseca, Minn.	1940	62.7	31.1	2.11	13.1	1.51	2.81	66.0
Dickinson, N. Dak.	1940	52.0	24.8	1.98	19.2	1.75	3.93	55.9
Havre, Mont.	1940	54.4	20.4	1.85	19.1	1.51	3.57	57.7
Moccasin, Mont.	1940	58.4	23.8	1.64	18.0	1.60	3.28	60.1

TABLE 9.—*Physical characteristics and chemical composition of varieties grown at several stations and in different years*—Continued

Class, variety, and location	Year	Air-dry basis		Moisture-free basis				
		Weight per bushel	Weight per 1,000 kernels	Ash	Protein (N×5.7)	Oil	Sugar	Starch
HARD RED WINTER—Continued								
Kharkof—Continued		*Pounds*	*Grams*	*Per-cent*	*Per-cent*	*Per-cent*	*Per-cent*	*Per-cent*
Pullman, Wash.	1940	62.6	39.0	1.87	13.7	1.54	4.10	63.2
	1941	62.2	37.5	1.94	11.1	1.58	4.42	64.5
	1942	64.7	38.1	1.65	13.1	1.58	3.17	65.5
	1944	61.9	38.7	1.83	9.5	1.66	3.82	66.6
Moscow, Idaho	1940	60.6	33.9	1.77	10.1	1.50	3.49	68.7
Sandpoint, Idaho	1940	62.0	38.0	1.83	9.9	1.63	3.28	68.1
Pendleton, Oreg.	1940	60.2	35.8	1.74	8.8	1.63	3.18	69.1
	1941	60.5	34.8	1.87	8.9	1.56	3.26	69.0
	1942	58.9	33.1	1.68	8.4	1.71	3.96	69.5
	1943	62.2	35.7	1.71	9.4	1.69	3.14	69.1
	1944	62.3	34.7	1.72	8.6	1.61	3.11	69.8
Average	1941–44	61.0	34.6	1.74	8.8	1.64	3.37	69.4
Range	1941–44	3.4	2.6	.19	1.0	.15	.85	.8
Union, Oreg.	1940	60.8	34.9	1.57	8.8	1.65	3.10	69.9
Moro, Oreg.	1941	60.9	29.2	1.86	10.3	1.56	3.58	66.2
	1942	54.6	22.6	2.05	12.6	1.71	4.49	61.6
	1943	60.8	35.8	1.71	9.2	1.60	3.10	68.1
	1944	60.2	29.5	1.82	9.9	1.58	3.32	67.5
Average	1941–44	59.1	29.3	1.86	10.5	1.61	3.62	65.8
Range	1941–44	6.3	13.2	.34	3.4	.13	1.39	6.5
Maximum	-------	64.7	39.0	2.66	21.1	1.61	4.49	69.9
Minimum	-------	51.4	15.8	1.38	8.4	1.37	1.60	55.7
Range	-------	13.3	23.2	1.28	12.7	.39	2.89	14.2
Tenmarq:								
Denton, Tex.	1940	56.3	28.9	1.91	10.3	1.83	3.16	67.0
Chillicothe, Tex.	1940	58.6	25.8	1.82	19.6	1.60	3.86	61.0
Amarillo, Tex.	1941	55.5	28.2	1.99	12.9	1.94	3.36	66.3
	1942	59.2	25.4	1.76	17.2	1.83	3.52	62.5
	1943	57.1	24.6	1.94	19.4	1.89	3.09	60.1
	1944	60.8	30.5	1.87	14.0	1.74	3.14	65.4
Average	1941–44	58.2	27.2	1.89	15.9	1.85	3.28	63.6
Range	1941–44	5.3	5.9	.23	6.5	.20	.43	6.2
Lawton, Okla.	1940	61.1	37.0	1.60	17.3	1.75	3.23	62.6
	1941	56.1	23.0	1.74	17.6	1.77	2.63	62.3
	1942	58.2	23.4	1.47	18.4	1.84	2.83	61.5
	1943	60.7	26.8	1.43	16.9	1.68	2.89	62.6
	1944	60.3	26.1	1.31	16.2	1.51	2.48	64.9
Average	1941–44	58.8	24.8	1.49	17.3	1.70	2.71	62.8
Range	1941–44	4.6	3.8	.43	2.2	.33	.41	3.4

TABLE 9.—*Physical characteristics and chemical composition of varieties grown at several stations and in different years*—Continued

Class, variety, and location	Year	Air-dry basis		Moisture-free basis				
		Weight per bushel	Weight per 1,000 kernels	Ash	Protein (N×5.7)	Oil	Sugar	Starch
HARD RED WINTER—Continued								
Tenmarq—Continued		*Pounds*	*Grams*	*Per-cent*	*Per-cent*	*Per-cent*	*Per-cent*	*Per-cent*
Stillwater, Okla.	1940	59.7	32.7	1.44	15.7	1.71	3.11	64.1
Goodwell, Okla.	1940	53.5	23.0	2.35	19.9	1.79	4.02	56.9
Woodward, Okla.	1941	58.2	28.0	2.04	14.3	1.69	2.36	65.4
	1942	59.8	26.6	1.94	14.0	1.69	3.23	64.3
	1943	62.4	28.1	2.02	13.7	1.71	3.12	65.8
	1944	59.6	30.1	1.66	12.2	1.66	2.48	69.4
Average	1941–44	60.0	28.2	1.92	13.6	1.69	2.92	66.2
Range	1941–44	4.2	3.5	.38	2.1	.05	.75	5.1
Hays, Kans.	1941	60.2	28.5	1.96	16.2	1.78	2.92	64.6
	1942	55.6	19.8	2.22	20.2	1.77	2.69	57.4
	1943	58.8	22.9	2.10	19.8	1.92	3.43	58.4
	1944	54.9	20.4	2.49	17.3	1.91	3.06	59.7
Average	1941–44	57.4	22.9	2.19	18.4	1.84	3.02	60.0
Range	1941–44	5.3	8.7	.53	4.0	.15	.74	7.2
Manhattan, Kans.	1940	60.2	30.7	2.16	13.1	1.59	2.89	66.3
	1941	56.5	25.3	2.03	15.8	1.68	2.52	63.8
	1942	54.5	23.2	2.01	17.7	1.67	2.64	61.2
	1943	60.1	31.5	1.77	14.4	1.70	2.46	64.4
	1944	58.4	24.8	2.03	13.4	1.86	3.08	64.9
Average	1941–44	57.4	26.2	1.96	15.3	1.73	2.68	63.6
Range	1941–44	5.6	8.2	.26	4.3	.19	.62	3.7
Lincoln, Nebr.	1940	58.7	23.2	1.85	21.0	1.70	3.11	57.5
	1941	57.3	24.1	2.18	16.9	1.60	3.28	61.9
	1942	59.4	32.8	1.92	14.0	1.66	2.48	66.3
	1943	58.5	28.2	2.12	15.8	1.89	2.87	64.6
	1944	58.8	27.9	2.36	15.7	1.73	3.00	62.9
Average	1941–44	58.5	28.3	2.14	15.6	1.72	2.91	62.9
Range	1941–44	2.1	8.7	.44	2.9	.29	.80	4.4
Maximum		62.4	37.0	2.49	21.0	1.94	4.02	69.4
Maximum		53.5	19.8	1.31	10.3	1.51	2.46	56.9
Range		8.9	17.2	1.18	10.7	.43	1.56	12.5
Minturki:								
St. Paul, Minn.	1940	60.0	31.0	1.90	15.0	1.79	3.25	64.6
Waseca, Minn.	1940	61.5	32.3	1.93	13.6	1.72	2.98	66.6
Dickinson, N. Dak.	1940	50.2	22.7	2.05	19.3	1.94	2.80	55.6
Sheridan, Wyo.	1940	60.2	28.3	1.69	17.2	1.74	3.09	62.8
Moccasin, Mont.	1940	58.6	25.5	1.61	17.4	1.62	3.22	61.4
Havre, Mont.	1940	54.3	22.2	2.05	18.8	1.63	3.25	59.1
Maximum		61.5	32.3	2.05	19.3	1.94	3.25	66.6
Minimum		50.2	22.2	1.61	13.6	1.62	2.80	55.6
Range		11.3	10.1	.44	5.7	.32	.45	11.0

TABLE 9.—*Physical characteristics and chemical composition of varieties grown at several stations and in different years*—Continued

Class, variety, and location	Year	Air-dry basis		Moisture-free basis				
		Weight per bushel	Weight per 1,000 kernels	Ash	Protein (N×5.7)	Oil	Sugar	Starch
HARD RED WINTER—Continued								
Purkof:		*Pounds*	*Grams*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Ithaca, N. Y.	1940	61.0	32.4	1.92	11.5	2.04	2.76	64.6
	1943	60.9	30.3	2.23	13.7	1.95	2.49	64.0
	1944	60.8	30.9	2.03	13.2	1.94	2.59	65.0
Average	1940–1943–44	60.9	31.2	2.06	12.8	1.98	2.61	64.5
Range	1940–1943–44	0.2	2.1	.31	2.2	.10	.27	1.0
Wooster, Ohio	1940	59.6	31.2	2.01	13.3	1.88	2.59	65.6
	1943	61.2	31.3	2.09	12.7	2.00	2.50	65.2
	1944	59.9	30.4	2.13	14.2	1.97	3.05	64.1
Average	1940–1943–44	60.2	31.0	2.08	13.4	1.95	2.71	65.0
Range	1940–1943–44	1.6	.9	.12	1.5	.12	.55	1.5
Lafayette, Ind.	1940	60.6	29.8	1.93	10.9	1.97	2.67	67.3
	1943	59.1	25.6	2.24	12.1	2.00	2.46	67.8
	1944	60.5	28.1	2.07	12.0	1.93	2.71	65.9
Average	1940–1943–44	60.1	27.8	2.08	11.7	1.97	2.61	67.0
Range	1940–1943–44	1.5	4.2	.31	1.2	.07	.25	1.9
Urbana, Ill.	1941	54.6	20.3	2.06	13.6	2.06	2.76	63.2
	1943	58.0	24.0	2.19	16.1	1.86	2.58	62.3
	1944	58.8	24.8	2.18	16.1	1.91	2.52	62.6
Average	1940–1943–44	57.1	23.0	2.14	15.3	1.94	2.62	62.7
Range	1940–1943–44	4.2	4.5	.13	2.5	.20	.24	.9
Columbia, Mo.	1940	------	23.5	2.16	12.5	1.99	2.38	64.2
	1943	58.7	27.8	2.02	12.3	1.61	2.56	67.4
	1944	57.1	23.3	2.09	10.0	2.18	2.70	67.0
Average	1940–1943–44	------	24.9	2.09	11.6	1.93	2.55	66.2
Range	1940–1943–44	------	4.5	.14	2.5	.57	.32	3.2
Maximum		61.2	32.4	2.24	16.1	2.18	3.05	67.8
Minimum		54.6	20.3	1.92	10.0	1.61	2.38	62.3
Range		6.6	12.1	.32	6.1	.57	.67	5.5

TABLE 9.—*Physical characteristics and chemical composition of varieties grown at several stations and in different years*—Continued

Class, variety, and location	Year	Air-dry basis		Moisture-free basis				
		Weight per bushel	Weight per 1,000 kernels	Ash	Protein (N×5.7)	Oil	Sugar	Starch
SOFT RED WINTER								
Trumbull:		*Pounds*	*Grams*	*Per-cent*	*Per-cent*	*Per-cent*	*Per-cent*	*Per-cent*
Wooster, Ohio	1940	59.0	36.4	2.06	13.8	1.51	2.59	65.8
	1941	59.7	43.0	2.05	12.6	1.57	3.05	67.5
	1942	58.0	29.5	2.20	13.7	1.48	2.71	65.9
	1943	59.7	34.4	2.25	13.2	1.58	2.70	66.2
	1944	61.1	35.3	2.09	12.8	1.59	2.66	65.9
Average	1940–41, 1943–44	59.9	36.8	2.11	13.1	1.56	2.75	66.4
Range	1940–41, 1943–44	2.1	6.6	.20	1.2	.08	.46	1.7
Ithaca, N. Y.	1940	61.7	36.4	1.90	12.3	1.64	3.73	66.5
	1941	61.4	40.0	1.99	12.0	1.54	3.24	67.1
	1942	61.3	32.9	2.00	11.9	1.55	3.09	67.9
	1943	60.7	33.9	2.38	14.6	1.51	2.57	65.8
	1944	60.2	34.1	2.08	13.5	1.60	2.83	66.7
Average	1940–41, 1943–44	61.0	36.1	2.09	13.1	1.57	3.09	66.5
Range	1940–41, 1943–44	1.5	6.1	.48	2.6	.13	1.16	1.3
Lafayette, Ind.	1940	61.2	35.3	2.07	11.8	1.52	3.18	67.7
	1941	60.6	34.5	2.07	11.2	1.59	3.06	69.3
	1943	58.5	30.9	2.22	12.9	1.63	2.40	67.4
	1944	59.8	32.8	2.16	12.3	1.58	2.79	67.5
Average	1940–41, 1943–44	60.0	33.4	2.13	12.0	1.58	2.86	68.0
Range	1940–41, 1943–44	2.7	4.4	.15	1.7	.11	.78	1.9
Urbana, Ill.	1940	54.6	22.1	2.12	14.4	1.60	3.07	64.1
	1941	55.4	24.8	2.18	14.6	1.56	2.78	64.2
	1943	55.9	27.2	2.29	15.8	1.59	2.67	63.4
	1944	58.7	30.8	2.33	14.1	1.55	2.93	65.6
Average	1940–41, 1943–44	56.2	26.2	2.23	14.7	1.58	2.86	64.3
Range	1940–41, 1943–44	4.1	8.7	.21	1.7	.05	.40	2.2

TABLE 9.—*Physical characteristics and chemical composition of varieties grown at several stations and in different years*—Continued

Class, variety, and location	Year	Air-dry basis		Moisture-free basis				
		Weight per bushel	Weight per 1,000 kernels	Ash	Protein (N×5.7)	Oil	Sugar	Starch
SOFT RED WINTER—Continued								
Trumbull—Continued		*Pounds*	*Grams*	*Per-cent*	*Per-cent*	*Per-cent*	*Per-cent*	*Per-cent*
Columbia, Mo.	1940	58. 5	28. 5	2. 23	12. 9	1. 50	2. 66	66. 1
	1941	54. 4	29. 8	2. 10	13. 4	1. 54	2. 65	65. 8
	1943	60. 1	27. 3	2. 07	13. 0	1. 98	2. 39	65. 8
	1944	58. 3	27. 1	2. 11	9. 9	1. 77	2. 82	68. 7
Average	1940–41, 1943–44	57. 8	28. 2	2. 13	12. 3	1. 70	2. 63	66. 6
Range	1940–41, 1943–44	5. 7	2. 7	. 16	3. 5	. 48	. 43	2. 9
East Lansing, Mich.	1940	61. 6	38. 7	1. 94	11. 4	1. 60	3. 91	67. 3
	1940	61. 5	39. 7	2. 01	11. 6	1. 62	3. 84	67. 3
	1941	60. 5	35. 8	2. 01	10. 2	1. 61	3. 57	68. 4
	1942	59. 4	34. 4	2. 02	10. 9	1. 56	3. 35	67. 8
Columbus, Ohio	1940	61. 7	34. 0	2. 21	11. 9	1. 69	2. 78	67. 2
Lexington, Ky.	1940	58. 4	30. 7	2. 14	11. 3	1. 52	2. 57	68. 2
Madison, Wis.	1940	57. 7	36. 6	2. 22	10. 8	1. 48	3. 29	68. 7
State College, Pa.	1940	60. 0	38. 6	1. 89	10. 2	1. 56	3. 77	69. 0
New Brunswick, N. J.	1940	59. 9	37. 6	2. 09	11. 2	1. 53	3. 38	68. 9
Newark, Del.	1940	60. 7	33. 1	2. 11	10. 9	1. 53	2. 73	69. 2
College Park, Md.	1940	58. 9	32. 8	1. 88	9. 8	1. 46	2. 75	70. 5
Arlington, Va.	1940	58. 9	32. 1	1. 96	14. 0	1. 44	2. 68	66. 5
Blacksburg, Va.	1940	58. 7	32. 7	2. 18	14. 5	1. 71	2. 64	65. 1
Statesville, N. C.	1940	59. 8	30. 7	1. 77	15. 6	1. 46	2. 75	63. 2
Knoxville, Tenn.	1940	57. 3	37. 6	2. 18	14. 4	1. 49	3. 04	65. 4
Maximum		61. 7	41. 0	2. 33	15. 8	1. 98	3. 91	70. 5
Minimum		54. 4	22. 1	1. 77	9. 8	1. 44	2. 39	63. 2
Range		7. 3	18. 9	. 56	6. 0	. 54	1. 52	7. 3
Nittany:								
Ithaca, N. Y.	1940	58. 3	38. 1	1. 95	11. 7	1. 66	3. 55	67. 4
	1941	59. 6	42. 0	2. 06	11. 7	1. 68	2. 94	68. 2
	1942	61. 1	39. 1	1. 99	10. 9	1. 69	2. 92	69. 8
Average	1940–42	59. 7	39. 7	2. 00	11. 4	1. 68	3. 14	68. 5
Range	1940–42	2. 8	3. 9	. 11	. 8	. 03	. 63	2. 4
Wooster, Ohio	1940	58. 6	41. 5	2. 25	13. 5	1. 63	2. 55	65. 8
	1941	60. 0	46. 4	2. 15	13. 8	1. 71	2. 88	65. 6
	1942	58. 5	34. 7	2. 22	13. 4	1. 66	2. 67	66. 6
Average	1940–42	59. 0	40. 9	2. 21	13. 6	1. 67	2. 70	66. 0
Range	1940–42	1. 5	11. 7	. 10	. 4	. 08	. 33	1. 0

TABLE 9.—*Physical characteristics and chemical composition of varieties grown at several stations and in different years*—Continued

Class, variety, and location	Year	Air-dry basis		Moisture-free basis				
		Weight per bushel	Weight per 1,000 kernels	Ash	Protein (N×5.7)	Oil	Sugar	Starch
SOFT RED WINTER—Continued								
Nittany—Continued		*Pounds*	*Grams*	*Per-cent*	*Per-cent*	*Per-cent*	*Per-cent*	*Per-cent*
East Lansing, Mich.	1940	60.3	42.0	1.91	10.9	1.73	3.59	67.1
	1941	59.1	41.2	2.06	9.6	1.81	3.40	69.0
	1942	60.2	40.0	1.85	10.5	1.74	3.30	68.5
Average	1940–42	59.9	41.1	1.94	10.3	1.76	3.43	68.2
Range	1940–42	1.2	2.0	.21	1.3	.08	.29	1.9
Lafayette, Ind.	1940	60.1	37.5	1.97	11.7	1.75	2.82	67.2
	1941	60.3	39.5	2.12	10.8	1.71	2.92	68.1
Urbana, Ill.	1940	56.6	24.2	1.85	14.6	1.44	2.16	61.2
	1941	56.8	25.9	2.13	14.5	1.72	2.63	64.2
Columbia, Mo.	1940	58.1	32.1	2.19	12.3	1.64	2.66	65.3
	1941	54.9	34.6	2.23	12.3	1.72	2.57	66.0
New Brunswick, N. J.	1940	61.5	42.4	2.17	11.6	1.65	3.26	67.5
College Park, Md.	1940	58.1	37.9	1.87	10.0	1.58	2.82	69.0
Arlington, Va.	1940	58.9	36.3	1.96	14.4	1.58	2.59	65.5
Newark, Del.	1940	59.5	38.1	2.07	10.5	1.69	2.71	68.6
Blacksburg, Va.	1940	57.1	31.4	2.23	14.0	1.59	2.66	63.6
Statesville, N. C.	1940	57.6	37.1	1.94	16.2	1.51	2.73	62.3
Knoxville, Tenn.	1940	57.5	37.7	2.04	13.1	1.62	2.91	65.6
State College, Pa.	1940	60.4	42.7	2.02	9.6	1.74	3.46	69.7
Columbus, Ohio	1940	60.6	37.0	2.16	12.3	1.61	2.75	67.4
Lexington, Ky.	1940	57.2	33.0	2.22	11.1	1.68	2.58	67.9
Madison, Wis.	1940	57.7	41.6	2.02	10.1	1.67	3.32	67.7
Maximum		61.5	46.4	2.25	16.2	1.81	3.59	69.8
Minimum		54.9	24.2	1.85	9.6	1.44	2.16	62.3
Range		6.6	22.2	.40	6.6	.37	1.43	7.5
WHITE WHEAT								
Rex:								
Pullman, Wash.	1940	62.9	38.7	1.92	12.2	2.01	3.38	66.6
	1941	63.4	41.3	2.05	10.2	2.04	4.04	67.8
	1942	61.8	38.1	1.96	9.9	1.99	3.62	67.5
	1944	60.8	37.1	1.96	9.6	2.12	3.70	67.9
Average	1941–42, 1944	62.0	38.8	1.99	9.9	2.05	3.79	67.7
Range	1941–42, 1944	2.6	4.2	.09	.6	.13	.42	.4

TABLE 9.—*Physical characteristics and chemical composition of varieties grown at several stations and in different years*—Continued

Class, variety, and location	Year	Air-dry basis		Moisture-free basis				
		Weight per bushel	Weight per 1,000 kernels	Ash	Protein (N×5.7)	Oil	Sugar	Starch
WHITE WHEAT—Con.								
Rex—Continued		*Pounds*	*Grams*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Pendleton, Oreg.	1940	59. 5	36. 3	1. 88	8. 9	2. 06	4. 27	69. 1
	1941	61. 2	38. 9	1. 90	8. 2	2. 13	4. 47	70. 0
	1942	61. 3	34. 7	1. 86	8. 6	2. 29	4. 60	68. 6
	1943	60. 6	36. 9	1. 74	10. 4	2. 25	3. 67	67. 0
	1944	62. 5	36. 9	1. 79	8. 9	2. 12	4. 32	68. 6
Average	1941–42, 1944	61. 7	36. 8	1. 85	8. 6	2. 18	4. 46	69. 1
Range	1941–42, 1944	1. 3	4. 2	. 11	. 7	. 16	. 28	1. 4
Moro, Oreg.	1941	60. 3	34. 9	1. 87	9. 8	2. 03	4. 36	68. 1
	1942	58. 3	26. 8	1. 95	12. 5	2. 02	4. 63	64. 4
	1943	60. 5	35. 2	2. 03	11. 2	1. 99	4. 06	66. 5
	1944	59. 7	32. 5	1. 94	9. 6	1. 96	4. 22	67. 2
Average	1941–42, 1944	59. 4	31. 4	1. 92	10. 6	2. 00	4. 40	66. 6
Range	1941–42, 1944	2. 0	8. 1	. 08	2. 9	. 07	. 41	3. 7
Union, Oreg.	1940	61. 1	34. 0	1. 48	16. 1	1. 97	3. 20	63. 8
Moscow, Idaho	1940	59. 9	35. 3	1. 88	10. 5	1. 94	4. 02	65. 5
Sandpoint, Idaho	1940	61. 6	38. 2	1. 79	10. 3	2. 09	3. 65	68. 2
Maximum		63. 4	41. 3	2. 05	16. 1	2. 29	4. 63	70. 0
Minimum		58. 3	26. 8	1. 48	8. 2	1. 94	3. 20	63. 8
Range		5. 1	14. 5	. 57	7. 9	. 35	1. 43	6. 2
Baart:								
Pullman, Wash.	1940	63. 0	40. 4	1. 38	15. 8	1. 48	3. 71	63. 6
	1941	60. 1	37. 7	2. 55	13. 7	1. 58	3. 63	63. 0
	1942	63. 9	42. 2	2. 15	10. 4	1. 55	5. 18	65. 4
	1943	61. 9	44. 3	2. 12	11. 1	1. 57	4. 81	64. 2
	1944	61. 6	41. 7	2. 17	12. 2	1. 59	4. 36	64. 6
Average	1940–42	62. 3	40. 1	2. 03	13. 3	1. 54	4. 17	64. 0
Range	1940–42	3. 8	4. 5	1. 17	5. 4	. 10	1. 55	2. 4
Pendleton, Oreg.	1940	60. 7	38. 9	1. 90	12. 5	1. 54	4. 75	64. 7
	1941	62. 5	50. 9	2. 19	10. 6	1. 59	5. 90	64. 6
	1942	62. 4	44. 9	2. 09	12. 0	1. 55	5. 48	64. 2
	1943	63. 2	46. 2	1. 87	11. 9	1. 67	5. 03	64. 5
	1944	63. 0	41. 6	1. 99	11. 4	1. 71	4. 47	65. 3
Average	1940–42	61. 9	44. 9	2. 06	11. 7	1. 56	5. 38	64. 5
Range	1940–42	1. 8	12. 0	. 29	1. 9	. 05	1. 15	. 5

TABLE 9.—*Physical characteristics and chemical composition of varieties grown at several stations and in different years*—Continued

Class, variety, and location	Year	Air-dry basis		Moisture-free basis				
		Weight per bushel	Weight per 1,000 kernels	Ash	Protein (N×5.7)	Oil	Sugar	Starch
WHITE WHEAT—Con.								
Buart—Continued		*Pounds*	*Grams*	*Per-cent*	*Per-cent*	*Per-cent*	*Per-cent*	*Per-cent*
Aberdeen, Idaho	1940	64.2	51.9	1.79	13.4	1.53	4.58	65.1
	1941	63.4	49.4	1.92	11.2	1.57	3.76	67.2
	1942	61.8	40.7	1.53	12.4	1.94	3.85	66.1
	1943	63.5	49.9	1.81	12.3	1.50	4.32	65.0
	1944	64.7	49.4	1.87	11.8	1.79	3.93	66.1
Average	1940–42	63.1	47.3	1.75	12.3	1.68	4.06	66.1
Range	1940–42	2.4	11.2	.39	2.2	.41	.82	2.1
Lind, Wash	1940	60.4	36.8	1.78	15.0	1.53	4.16	63.7
	1941	59.6	41.0	1.95	11.9	1.58	4.00	65.0
	1942	61.4	40.7	1.74	13.4	1.54	4.71	64.3
Average	1940–42	60.5	39.5	1.82	13.4	1.55	4.29	64.3
Range	1940–42	1.8	4.2	.21	3.1	.05	.71	1.3
Bozeman, Mont	1940	63.5	48.2	2.01	11.7	1.58	4.33	65.5
	1941	57.4	41.4	2.06	11.3	1.56	3.99	65.6
	1942	63.6	52.6	2.05	13.8	1.51	3.93	63.8
	1943	61.7	47.7	2.06	13.4	1.62	3.44	64.6
Average	1940–42	61.5	47.4	2.04	12.3	1.55	4.08	65.0
Range	1940–42	6.2	11.2	.05	2.5	.07	.40	1.8
Davis, Calif.	1940	61.6	42.1	1.86	13.2	1.52	4.04	65.0
	1941	61.8	40.7	2.19	11.3	1.62	3.57	66.0
Mesa, Ariz.	1940	62.7	49.4	2.22	11.2	1.55	4.22	66.2
	1943	63.4	48.2	1.67	12.8	1.53	4.44	65.3
Maximum		64.7	52.6	2.55	15.8	1.94	5.90	67.2
Minimum		57.4	36.8	1.38	10.4	1.48	3.44	63.0
Range		7.3	15.8	1.17	5.4	.46	2.46	4.2
Federation:								
Pullman, Wash	1940	60.4	33.1	1.37	14.1	1.73	3.76	65.9
	1941	57.8	31.0	2.09	10.3	1.78	3.65	67.7
	1942	60.3	34.6	1.85	9.4	1.79	4.59	68.1
	1943	60.0	36.5	1.75	9.1	1.75	4.39	68.3
	1944	60.0	31.9	2.02	11.3	1.83	3.44	68.0
Average	1940–42	59.5	32.9	1.77	11.3	1.77	4.00	67.2
Range	1940–42	2.6	3.6	.72	4.7	.06	.94	2.2

TABLE 9.—*Physical characteristics and chemical composition of varieties grown at several stations and in different years*—Continued

Class, variety, and location	Year	Air-dry basis		Moisture-free basis				
		Weight per bushel	Weight per 1,000 kernels	Ash	Protein (N×5.7)	Oil	Sugar	Starch
WHITE WHEAT—Con.								
Federation—Continued		*Pounds*	*Grams*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Pendleton, Oreg.	1940	58.3	32.6	1.83	11.2	1.76	4.26	67.7
	1941	56.8	33.6	1.88	8.8	1.78	4.85	67.6
	1942	59.7	36.5	1.83	9.9	1.79	4.75	67.5
	1943	58.2	36.3	1.79	10.0	1.83	4.93	66.8
	1944	59.3	34.6	1.79	10.3	1.90	4.59	67.1
Average	1940–42	58.3	34.2	1.85	10.0	1.78	4.62	67.6
Range	1940–42	2.9	3.9	.05	2.4	.03	.59	.2
Aberdeen, Idaho	1940	62.1	41.8	1.67	11.5	1.72	4.45	67.9
	1941	58.3	33.2	1.87	9.4	1.92	3.63	68.0
	1942	60.2	36.2	1.63	14.2	1.70	3.94	65.9
	1943	60.2	39.3	1.66	10.6	1.77	4.00	68.7
	1944	60.9	38.4	1.55	10.3	1.82	3.46	69.0
Average	1940–42	60.2	37.1	1.72	11.7	1.78	4.01	67.3
Range	1940–42	3.8	8.6	.24	4.8	.22	.82	2.1
Bozeman, Mont.	1940	61.1	40.7	1.79	9.3	1.80	4.50	68.8
	1941	53.9	30.0	1.86	8.4	1.85	4.27	68.2
	1942	61.6	41.7	1.89	10.4	1.76	4.88	68.0
	1943	59.5	41.6	1.72	9.6	1.90	4.81	67.7
Average	1940–42	58.9	37.5	1.85	9.4	1.80	4.55	68.3
Range	1940–42	7.7	11.7	.10	2.0	.09	.61	.8
Lind, Wash.	1940	58.1	29.4	1.57	13.6	1.73	3.68	65.4
	1941	57.7	31.1	2.00	11.1	1.80	4.09	66.7
	1942	59.6	32.1	1.63	12.7	1.65	3.89	65.6
Average	1940–42	58.5	30.9	1.73	12.5	1.73	3.89	65.9
Range	1940–42	1.9	2.7	.43	2.5	.15	.41	1.3
Davis, Calif.	1940	60.4	38.0	1.75	12.1	1.68	3.68	66.8
	1941	57.2	31.2	2.10	10.2	1.87	3.85	66.9
Mesa, Ariz.	1940	58.7	40.7	2.01	9.1	1.76	4.15	69.8
Maximum		62.1	41.8	2.10	14.2	1.92	4.93	69.8
Minimum		53.9	29.4	1.37	8.4	1.65	3.44	65.4
Range		8.2	12.4	.73	5.8	.27	1.49	4.4

TABLE 10.—*Physical characteristics and chemical composition averages for varieties grown at several stations in the same year*

Class and location	Air-dry basis		Moisture-free basis				
	Weight per bushel	Weight per 1,000 kernels	Ash	Protein (N×5.7)	Oil	Sugar	Starch
	Pounds	*Grams*	*Per-cent*	*Per-cent*	*Per-cent*	*Per-cent*	*Per-cent*
Pilot, 1940–42:							
Bozeman, Mont.	60. 9	35. 3	1. 90	13. 0	2. 12	3. 72	65. 4
Sheridan, Wyo.	56. 0	21. 8	2. 00	20. 1	2. 16	3. 53	57. 3
Fargo, N. Dak.	59. 4	29. 1	2. 02	17. 6	2. 10	2. 77	61. 2
Brookings, S. Dak.	56. 6	28. 4	2. 27	17. 3	2. 10	3. 03	60. 8
St. Paul, Minn.	57. 9	28. 4	2. 31	16. 0	2. 07	2. 69	62. 5
Thatcher, 1940–42:							
Bozeman, Mont.	60. 6	32. 3	1. 92	12. 3	1. 94	3. 30	65. 8
Sheridan, Wyo.	55. 5	20. 3	2. 11	20. 4	1. 99	3. 53	56. 5
Fargo, N. Dak.	57. 6	22. 2	2. 05	17. 0	1. 90	2. 76	61. 4
Brookings, S. Dak.	54. 8	20. 1	2. 43	17. 6	1. 87	3. 04	60. 1
St. Paul, Minn.	55. 5	22. 1	2. 21	15. 8	1. 84	2. 73	62. 3
Kharkof, 1941–44:							
Lawton, Okla.	58. 8	22. 4	1. 64	18. 3	1. 49	2. 00	61. 2
Woodward, Okla.	59. 1	25. 4	2. 03	13. 8	1. 60	2. 34	65. 5
Amarillo, Tex.	58. 6	26. 1	2. 01	17. 1	1. 58	2. 80	62. 1
Hays, Kans.	56. 6	20. 8	2. 30	19. 6	1. 62	2. 92	58. 4
Lincoln, Nebr.	57. 9	25. 0	2. 10	16. 0	1. 57	2. 30	62. 8
Pendleton, Oreg.	61. 0	34. 6	1. 74	8. 8	1. 64	3. 37	69. 4
Tenmarq, 1941–44:							
Lawton, Okla.	58. 8	24. 8	1. 49	17. 3	1. 70	2. 71	62. 8
Woodward, Okla.	60. 0	28. 2	1. 92	13. 6	1. 69	2. 92	66. 2
Amarillo, Tex.	58. 2	27. 2	1. 89	15. 9	1. 85	3. 28	63. 6
Hays, Kans.	57. 4	22. 9	2. 19	18. 4	1. 84	3. 02	60. 0
Manhattan, Kans.	57. 4	26. 2	1. 96	15. 3	1. 73	2. 68	63. 6
Lincoln, Nebr.	58. 5	28. 3	2. 14	15. 6	1. 72	2. 91	63. 9
Trumbull, 1940–41; 1943–44:							
Wooster, Ohio	59. 9	36. 8	2. 11	13. 1	1. 56	2. 75	66. 4
Ithaca, N. Y.	61. 0	36. 1	2. 09	13. 1	1. 57	3. 09	66. 5
Lafayette, Ind.	60. 0	33. 4	2. 13	12. 0	1. 58	2. 86	68. 0
Urbana, Ill.	56. 2	26. 2	2. 23	14. 7	1. 58	2. 86	61. 3
Columbia, Mo.	57. 8	28. 2	2. 13	12. 3	1. 70	2. 63	66. 6
Rex, 1941–42, 1944:							
Pullman, Wash.	62. 0	38. 8	1. 99	9. 9	2. 05	3. 79	67. 7
Pendleton, Oreg.	61. 7	36. 8	1. 85	8. 6	2. 18	4. 46	69. 1
Moro, Oreg.	59. 4	31. 4	1. 92	10. 6	2. 00	4. 40	66. 6
Baart, 1940–42:							
Pullman, Wash.	62. 3	40. 1	2. 03	13. 3	1. 54	4. 17	64. 0
Pendleton, Oreg.	61. 9	44. 9	2. 06	11. 7	1. 56	5. 38	64. 5
Aberdeen, Idaho	63. 1	47. 3	1. 75	12. 3	1. 68	4. 06	66. 1
Lind, Wash.	60. 5	39. 5	1. 82	13. 4	1. 55	4. 29	64. 3
Bozeman, Mont.	61. 5	47. 4	2. 04	12. 3	1. 55	4. 08	65. 0
Federation, 1940–42:							
Pullman, Wash.	59. 5	32. 9	1. 77	11. 3	1. 77	4. 00	67. 2
Pendleton, Oreg.	58. 3	34. 2	1. 85	10. 0	1. 78	4. 62	67. 6
Aberdeen, Idaho	60. 2	37. 1	1. 72	11. 7	1. 78	4. 01	67. 3
Bozeman, Mont.	58. 9	37. 5	1. 85	9. 4	1. 80	4. 55	68. 3
Lind, Wash.	58. 5	30. 9	1. 73	12. 5	1. 73	3. 89	65. 9

Comparison of Varietal and Environmental Differences in Composition

One or more varieties in each region were grown at several stations from 1 to 5 years. The maximum, minimum, and range for specified characteristics of each of the varieties grown in different years and at various locations referred to in table 9 are summarized in table 11, along with similar data from tables 4 to 8 in which is shown the variability between varieties grown in comparable tests.

It is evident that differences in weight per bushel, weight per 1,000 kernels, ash, protein, sugar, and starch are generally greater among samples of the same variety grown under different conditions than among different varieties grown under comparable conditions. Samples of Thatcher and of Kharkof differed by as much as 13.3 pounds per bushel in test weight when grown at different stations but the greatest difference between varieties grown under comparable conditions was only 3.7 pounds.

Similarly, the greatest difference in kernel size due to environment was 23.2 gm. between Kharkof grown at Pullman, Wash., in 1940 (39.0 gms. per 1,000) and that grown at Hays, Kans., in 1944 (15.8 gm.) while the greatest difference between comparably grown varieties was only 16.1 grams per 1,000 kernels between the hard red spring variety Thatcher (21.7 gm.) and the durum variety Mindum (37.8 gm.). The greatest difference in ash content between comparably grown varieties was only 0.26 percent between the hard red winter varieties Pawnee (1.72 percent) and Cheyenne (1.98 percent) while the differences between samples of the same variety were as great as 1.28 percent for Kharkof grown at Lawton, Okla., in 1944 (1.38 percent) and at Hays, Kans., in 1944 (2.66 percent).

The effect of variety and environment on protein content is of special interest and the data show clearly what is well known, that environment, including soil, has a much greater influence on protein content than does variety. The protein content of 51 samples of Kharkof grown at different locations and in different years varied from 8.4 percent at Pendleton, Oreg., to 21.1 percent at Hays, Kans. On the other hand, the greatest difference between comparably grown varieties was only 2.0 percent between Onas (12.7 percent) and Marquis (14.7 percent), both at Pullman, Wash., and Pendleton, Oreg., in 1940, and between Marquis (16.0 percent) and Pilot (18.0 percent) grown at Fargo, N. Dak., in 1940 and 1941. The average difference between Hymar (10.9 percent), a white club variety, and Kharkof (11.3 percent), a hard red winter variety, grown both at Pullman, Wash., and Pendleton, Oreg., in 1940 was only 0.4 percent.

These data support those presented in Technical Bulletin 887 and elsewhere which show differences between the protein content of varieties grown under the same conditions to be relatively small.

The sugar, starch, and oil content of wheat varieties grown under comparable conditions and of the same variety grown under different environments have not been extensively studied in the past. The sugar and starch data show that the variations due to environment are much greater than those due to variety, although there are varietal differences. The sugar content of Kharkof, for example, varied from 1.60 percent when grown at Lawton, Okla., in 1944 to 4.49 percent

TABLE 11.—*Summary of variability of each characteristic within the individual variety due to environment and among different varieties grown in the same tests*

Variety or region where grown	Number of samples analyzed	Air-dry basis						Moisture-free basis															
		Weight per bushel			Weight per 1,000 kernels			Ash			Protein (NX5.7)			Oil			Sugar			Starch		
		Max.	Min.	Range	Max.	Min.	Range	Max.	Min.	Range	Max.	Min.	Range	Max.	Min.	Range	Max.	Min.	Range	Max.	Min.	Range
		Lbs.	*Lbs.*	*Lbs.*	*Gms.*	*Gms.*	*Gms.*	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
Variety:																						
Pilot	28	62.3	52.7	9.6	37.4	19.2	18.2	2.42	1.73	0.69	21.2	11.6	9.6	2.22	2.01	0.21	3.99	2.55	1.44	66.6	56.0	10.6
Thatcher	61	63.8	50.5	13.3	38.5	17.5	21.0	2.62	1.36	1.26	21.8	12.1	9.7	2.20	1.74	.46	4.53	2.47	2.06	66.1	54.2	11.9
Kharkof	51	64.7	51.4	13.3	39.0	15.8	23.2	2.66	1.38	1.28	21.1	8.4	12.7	1.76	1.37	.39	4.49	1.60	2.89	69.9	55.7	14.2
Tennarq	51	62.4	53.5	8.9	37.0	19.8	17.2	2.49	1.31	1.18	21.0	10.3	10.7	1.94	1.51	.43	4.02	2.46	1.56	69.4	56.9	12.5
Purkof	15	61.2	54.6	6.6	32.4	20.3	12.1	2.24	1.92	.32	16.1	10.0	6.1	2.18	1.61	.57	3.05	2.38	.67	67.8	62.3	5.5
Minturki	6	61.5	50.2	11.3	32.3	22.2	10.1	2.05	1.61	.44	19.3	13.6	5.7	1.94	1.62	.32	3.25	2.80	.45	66.6	55.6	11.0
Trumbull	37	61.7	54.4	7.3	41.0	22.1	18.9	2.33	1.77	.56	15.8	9.8	6.0	1.98	1.44	.54	3.91	2.39	1.52	70.5	63.2	7.3
Nittany	26	61.5	54.9	6.6	46.4	24.2	22.2	2.25	1.85	.40	16.2	9.6	6.6	1.81	1.44	.37	3.59	2.16	1.43	69.8	62.3	7.5
Rex	16	63.4	58.3	5.1	41.3	26.8	14.5	2.05	1.48	.57	16.1	8.2	7.9	2.29	1.94	.35	4.63	3.20	1.43	70.0	63.8	6.2
Banrt	26	64.7	57.4	7.3	52.6	36.8	15.8	2.55	1.38	1.17	15.8	10.4	5.4	1.94	1.48	.46	5.90	3.44	2.46	67.2	63.0	4.2
Federation	25	62.1	53.9	8.2	41.8	29.4	12.4	2.10	1.37	.73	14.2	8.4	5.8	1.92	1.65	.27	4.93	3.44	1.49	69.8	65.4	4.4
Region:																						
Hard red spring	16	60.9	57.7	3.2	33.5	21.7	11.8	2.17	2.00	.17	18.0	16.0	2.0	2.16	1.85	.31	3.25	2.80	.45	61.6	60.4	1.2
Hard red winter	14	61.3	58.4	2.9	28.7	23.4	5.3	1.98	1.72	.26	15.8	14.4	1.4	1.76	1.43	.33	3.16	2.22	.94	65.4	63.2	2.2
Soft winter	12	61.5	59.0	2.5	38.8	29.8	9.0	2.14	1.90	.21	12.0	10.3	1.7	1.97	1.43	.54	3.07	2.33	.74	68.9	67.2	1.7
Western winter	14	64.1	61.2	2.9	37.5	30.0	7.5	1.91	1.75	.16	11.3	10.6	.7	2.08	1.60	.48	3.97	2.95	1.02	67.9	65.3	2.6
Western spring	12	------	------	------	39.7	28.5	11.2	1.72	1.60	.12	14.7	12.7	2.0	2.32	1.58	.74	4.23	3.42	.81	66.3	61.5	4.8

when grown at Moro, Oreg., in 1942. It was higher for all varieties when grown in the Pacific Northwest or under conditions where the fruiting period was not shortened by high temperatures, drought, or other factors than when grown under conditions such as are usually found in the hard red winter wheat region of the southern Great Plains.

The largest difference in sugar content between comparably grown varieties was 1.02 percent between Hymar (2.95 percent) and Golden (3.97 percent) grown both at Pullman, Wash., and Pendleton, Oreg., in 1940. Starch content also varied much more between samples of the same variety grown at different stations than between varieties grown under comparable conditions. The starch content of Kharkof, for example, varied from 55.7 percent when grown at Goodwell, Okla., in 1940 to 69.9 percent at Union, Oreg., in 1940. Where comparably grown, the greatest varietal difference, 4.8 percent, was that between Marquis (61.5 percent) and Federation (66.3 percent) grown both at Pullman and Pendleton in 1940. Most varietal differences were less than 2.0 percent.

The oil content, unlike the other chemical constituents studied, seems to be largely an inherent varietal characteristic and is much less affected by environment than protein, starch, sugar, and ash. The difference between Marquis (2.32 percent) and Baart (1.58 percent) was 0.74 percent while the greatest difference between samples of any variety grown at different stations or in different years was only 0.54 percent for Trumbull grown at Arlington, Va., in 1940 (1.44 percent) and at Columbia, Mo. in 1943 (1.98 percent).

DISCUSSION OF SPECIAL DATA

Results of Analysis of Variance

As the work was planned originally, it was desired to use statistical methods to evaluate data from several varieties of each class for a period of years at several stations. Crop failures and other causes prevented the collection of sufficient data, however, to carry out this work so that data for only a few varieties, all commercially important were adaptable to the use of the analysis of variance technique. For these, comparisons were made for each of the chemical components, and the results substantiate the conclusions drawn from observation of the data and presented in the preceding sections.

By arranging the data by years, it was possible to make the maximum number of comparisons of two varieties. A summary of these results is shown in table 12. The years and locations compared are identified in table 13.

For all the varieties except Baart and Federation on which there are data for the 5 years, it appears that oil is largely a varietal characteristic, and that starch, sugar, and protein are chiefly affected by location. Inspection of the Trumbull and Nittany group indicates the same trends as those of the Pilot-Thatcher and Tenmarq-Kharkof groups. The same trends are apparent for Trumbull and Purkof, except in the case of the sugar constituent which is not significantly different for either variety or location. The results for the other two groups, Rex-Kharkof and Minturki-Kharkof, are presented for the one available year.

TABLE 12.—*Significance of variation attributable to certain factors, by years, for specified pairs of varieties*

Varieties—source of variation	Protein (N×5.7)					Oil					Starch					Sugar				
	1940	1941	1942	1943	1944	1940	1941	1942	1943	1944	1940	1941	1942	1943	1944	1940	1941	1942	1943	1944
Federation-Baart:																				
Stations	(**)	(†)	(†)	(†)	(*)	(*)	(†)	(†)	(**)	(†)	(**)	(*)	(†)	(†)	(†)	(*)	(†)	(†)	(†)	(†)
Varieties	(**)	(**)	(†)	(**)	(**)	(**)	(**)	(†)	(**)	(*)	(**)	(†)	(*)	(†)	(**)	(†)	(*)	(†)	(**)	(†)
Pilot-Thatcher:																				
Stations	(†)	(**)	(**)	(**)	(**)	(†)	(†)	(*)	(†)	(†)	(**)	(**)	(**)	(**)	(**)	(*)	(**)	(**)	(**)	(**)
Varieties	(†)	(†)	(†)	(†)	(†)	(**)	(**)	(**)	(**)	(**)	(†)	(†)	(†)	(†)	(†)	(†)	(†)	(†)	(†)	(†)
Tennarq-Kharkof:																				
Stations	(**)	(**)	(**)	(**)	(†)	(†)	(†)	(†)	(*)	(**)	(**)	(**)	(*)	(**)	(**)	(†)	(**)	(*)	(**)	(†)
Varieties	(†)	(†)	(†)	(*)	(†)	(**)	(*)	(**)	(**)	(**)	(†)	(**)	(**)	(**)	(†)	(*)	(†)	(†)	(*)	(†)
Trumbull-Purkof:																				
Stations	(**)	----	----	(**)	(*)	(*)	----	----	(†)	(**)	(*)	----	----	(*)	(**)	(†)	----	----	(†)	(†)
Varieties	(**)	----	----	(†)	(†)	(**)	----	----	(†)	(**)	(*)	----	----	(†)	(**)	(†)	----	----	(†)	(†)
Trumbull-Nittany:																				
Stations	(**)	(**)	(*)	----	----	(†)	(*)	(*)	----	----	(**)	(**)	(†)	----	----	(**)	(*)	(*)	----	----
Varieties	(†)	(†)	(†)	----	----	(**)	(**)	(*)	----	----	(†)	(**)	(†)	----	----	(*)	(†)	(†)	----	----
Rex-Kharkof:																				
Stations	(†)	----	----	----	----	(†)	----	----	----	----	(†)	----	----	----	----	(†)	----	----	----	----
Varieties	(†)	----	----	----	----	(**)	----	----	----	----	(†)	----	----	----	----	(†)	----	----	----	----
Minturki-Kharkof:																				
Stations	(**)	----	----	----	----	(*)	----	----	----	----	(**)	----	----	----	----	(**)	----	----	----	----
Varieties	(†)	----	----	----	----	(*)	----	----	----	----	(†)	----	----	----	----	(†)	----	----	----	----

*Significant difference (5-percent level).
**Highly significant difference (1-percent level).
†No significant difference.

TABLE 13.—*Available comparable composition data by stations and years for pairs of varieties*

Station	Crop years [1]				
	1940	1941	1942	1943	1944
Pilot-Thatcher:					
St. Paul, Minn.	x	x	x	x	x
Brookings, S. Dak.	x	x	x	x	
Dickinson, N. Dak.			x	x	x
Fargo, N. Dak.	x	x	x		x
Sheridan, Wyo.	x	x	x	x	
Bozeman, Mont.	x	x	x	x	
Havre, Mont.			x	x	x
Moccasin, Mont.		x			
Minturki-Kharkof:					
Waseca, Minn.	x				
Dickinson, N. Dak.	x				
Sheridan, Wyo.	x				
Havre, Mont.	x				
Moccasin, Mont.	x				
Tenmarq-Kharkof:					
Amarillo, Tex.		x	x	x	x
Chillicothe, Tex.	x				
Denton, Tex.	x				
Goodwell, Okla.	x				
Lawton, Okla.	x	x	x	x	x
Stillwater, Okla.	x				
Woodward, Okla.		x	x	x	x
Hays, Kans.		x	x	x	x
Manhattan, Kans.	x	x	x	x	
Lincoln, Nebr.	x	x	x	x	x
Rex-Kharkof:					
Moscow, Idaho	x				
Sand Point, Idaho	x				
Pendleton, Oreg.	x				
Union, Oreg.	x				
Pullman, Oreg.	x				
Trumbull-Nittany:					
Statesville, N. C.	x				
Knoxville, Tenn.	x				
Arlington, Va.	x				
Blacksburg, Va.	x				
Newark, Del.	x				
College Park, Md.	x				
New Brunswick, N. J.	x				
Ithaca, N. Y.	x	x	x		
State College, Pa.	x				
Lexington, Ky.	x				
Columbus, Ohio	x				
Wooster, Ohio	x	x	x		
Lafayette, Ind.	x	x			
East Lansing, Mich.	x	x	x		
Urbana, Ill.	x	x			
Madison, Wis.	x				
Columbia, Mo.	x	x			

Footnote at end of table, p. 31.

TABLE 13.—*Available comparable composition data by stations and years for pairs of varieties*—Continued

Station	Crop years [1]				
	1940	1941	1942	1943	1944
Trumbull-Purkof:					
Ithaca, N. Y.	x			x	x
Wooster, Ohio	x			x	x
Lafayette, Ind.	x			x	x
Urbana, Ill.	x			x	x
Columbia, Mo.	x			x	x
Baart-Federation:					
Mesa, Ariz.	x				
Davis, Calif.	x	x			
Bozeman, Mont.	x	x	x	x	
Aberdeen, Idaho	x	x	x	x	x
Pendleton, Oreg.	x	x	x	x	x
Lind, Wash.	x	x	x		
Pullman, Wash.	x	x	x	x	x

[1] x indicates years in which samples of varieties were obtained from specified stations.

For a 4-year period, although not 4 consecutive years, comparisons were made of Baart and Federation of the white class; Tenmarq and Kharkof of the hard red winter class; Pilot and Thatcher of the hard red spring class; and for a 3-year period, Trumbull and Purkof, red winter wheats of the soft wheat area. A summary of the variance tables for each component, showing where the significant differences appeared, is given in table 14.

The Baart and Federation varieties show significant differences in practically all respects—variety, location, and years; Pilot and Thatcher show significant differences due to location; and the two remaining groups, Tenmarq-Kharkof and Trumbull-Purkof, show no consistent differences. It would appear that the varieties in each of these last two groups were not particularly different in chemical composition.

For another comparison, the two white wheat varieties, Baart and Federation, were available for 5 years at three stations. Here again there are highly significant differences between the two varieties for each of the physical and chemical components except sugar, in which there is just a significant difference. It appears that these varieties are not similar in composition. These data are shown in table 15.

For Thatcher wheat there were samples available for 4 years from four locations. An analysis of variance was run for these data and the results are shown in table 16. This indicates that the differences varied among years and among stations, therefore the differences can not be ascribed to either, with the possible exception of weight per 1,000 kernels. In this instance, both years and stations showed, at least, significant differences.

TABLE 14.—*Summary of significant differences among wheat varieties, years, and stations, by constituents*

Varieties—source of variation	Weight per bushel	Weight per 1,000 kernels	Protein	Oil	Starch	Sugar	Ash
Baart—Federation: [1]							
Years	(**)	(*)	(**)	(†)	(†)	(†)	(**)
Varieties	(**)	(**)	(**)	(**)	(**)	(†)	(**)
Stations	(*)	(**)	(*)	(†)	(†)	(**)	(**)
Tenmarq—Kharkof: [2]							
Years	(**)	(**)	(**)	(†)	(†)	(**)	(*)
Varieties	(†)	(**)	(†)	(**)	(†)	(**)	(†)
Stations	(†)	(†)	(**)	(†)	(*)	(†)	(**)
Pilot—Thatcher: [3]							
Years	(†)	(†)	(*)	(*)	(†)	(**)	(†)
Varieties	(†)	(*)	(†)	(**)	(†)	(†)	(†)
Stations	(†)	(†)	(**)	(**)	(**)	(**)	(**)
Trumbull—Purkof: [4]							
Years	------	(†)	(**)	(†)	(†)	(*)	(**)
Varieties	------	(**)	(†)	(**)	(**)	(*)	(*)
Stations	------	(**)	(**)	(†)	(**)	(†)	(†)

*Significant difference at the 5-percent level.
**Significant difference at the 1-percent level.
†No significant difference.
[1] Years 1940–43; Pendleton, Oreg.; Pullman, Wash.; Bozeman, Mont.; and Aberdeen, Idaho.
[2] Years 1940–43; Manhattan, Kans.; Lincoln, Nebr.; and Lawton, Okla.
[3] Years 1940–43; St. Paul, Minn.; Sheridan, Wyo.; and Brookings, S. Dak.
[4] Years 1940, 1943, and 1944; Urbana, Ill.; Lafayette, Ind.; Ithaca, N. Y.; Columbia, Mo.; and Wooster, Ohio.

TABLE 15.—*Summary of significant differences between Baart and Federation, grown at three stations for 5 years* [1]

Component	Baart and Federation		
	Years	Varieties	Stations
Protein	(**)	(**)	(*)
Oil	(†)	(**)	(†)
Starch	(**)	(**)	(†)
Sugar	(†)	(*)	(**)
Ash	(**)	(**)	(**)
Weight per bushel	(*)	(**)	(**)
Weight per 1,000 kernels	(†)	(**)	(**)

*Significant difference at the 5-percent level.
**Significant difference at the 1-percent level.
†No significant difference.
[1] Pendleton, Oreg.; Pullman, Wash.; and Aberdeen, Idaho, for the period 1940–44.

SUMMARY

A total of 480 wheat samples from experiment stations in the United States and Canada were analyzed for ash, protein, oil, sugar, and starch. An effort was made to obtain samples of each of the leading varieties of each commercial class.

TABLE 16.—*Significance of variation in Thatcher wheats attributable to certain factors, with data covering 4 years and four stations* [1]

Component	Years	Stations
Protein	(†)	(†)
Oil	(†)	(†)
Starch	(†)	(†)
Sugar	(†)	(*)
Ash	(†)	(**)
Weight per bushel	(**)	(†)
Weight per 1,000 kernels	(*)	(**)

*Significant difference at the 5-percent level.
**Significant difference at the 1-percent level.
†No significant difference.
[1] Edmonton, Saskatoon, Fargo, St. Paul, 1941–44.

Differences in test weight, ash, protein, sugar and starch between grain of the same variety grown in different environments were much larger than between grain of different varieties grown under comparable conditions. Largely because of the environmental conditions where the samples analyzed in these studies were grown, the durum and hard red spring wheat varieties were, in general, high in protein and ash and low in starch content: the white and soft red winter wheat varieties were, in general, high in starch and low in protein; and the white wheat varieties, from the Pacific Northwest, were high in sugar. There was a negative correlation between starch and protein contents. While there were small differences among varieties, starch and protein were greatly affected by crop year and location.

Differences in oil content, on the other hand, were greater between comparably grown varieties than between grain of the same variety grown under different environments. The oil content, although influenced by other factors, appeared to be a definite varietal characteristic.

It was possible in only a relatively few cases to use methods of statistical analysis in determining the significance of the differences in chemical composition. Baart and Federation were significantly different in all constituents analyzed except sugar; Trumbull and Purkof were significantly different in oil and sugar content; and Pilot and Thatcher were similar in composition except in oil content.

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