UNITED STATES
DEPARTMENT OF AGRICULTURE
Miscellaneous Publication No. 140

Washington, D. C. February, 1932

PROTEIN TESTS FOR WHEAT AND OIL TESTS FOR FLAXSEED AND SOYBEANS

Importance in Production and Marketing

Prepared in the
BUREAU OF AGRICULTURAL ECONOMICS

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LETTER OF TRANSMITTAL

UNITED STATES DEPARTMENT OF AGRICULTURE,
BUREAU OF AGRICULTURAL ECONOMICS,
Washington, D. C., November 16, 1931.

SIR: I submit herewith a report on the subject of Protein Tests for Wheat and Oil Tests for Flaxseed and Soybeans: Importance in Production and Marketing.

The protein test has been recognized as an important commercial measure of wheat quality since about 1923, and protein content has become a factor of material importance in determining the domestic market values of hard red spring and hard red winter wheat. The export trade has been slower than the domestic trade in adopting the protein test as a commercial measure of wheat quality, and the test has been of little significance in export commerce. During 1930 and 1931, however, several large deliveries of United States wheat were

made to European, South American, and oriental buyers under protein as well as grade specifications.

Material premiums have been paid during most years since 1923 in many domestic markets for wheat of high protein content for bread making and occasionally for wheat of low protein content for pastry and cracker making. Protein premiums for wheat of the 1930 crop were small or were nonexistent because of the abnormally large supply of high-protein wheat from the crops of 1929 and 1930. Material premiums were reestablished, however, for hard red winter wheat of the 1931 crop in spite of the abnormal carry-over from the 1929 and 1930 crops, because the average protein content of the 1931 crop of hard red winter wheat was lower than that of the two preceding crops, and because there was a mill demand for new-crop wheat that was of high protein content.

Much progress has been made during recent years in bringing out the domestic market values of wheat according to its protein content, and in perfecting the protein test for commercial use. But certain features of the practices which apply to the marketing of wheat by its protein content and to the protein-testing service, are susceptible of further improvement. The market premiums for protein, for instance, often are not established at levels that reflect accurately the relationship of the supply of and demand for wheat according to its protein content. In some important wheat areas the marketing system does not widely distribute the terminal-market protein premiums to producers. Moreover, the protein-testing service is not standardized throughout the country, especially as to the sampling procedure, the relationship of moisture content and protein content, and the methods of certification.

A national program of premarketing and current surveys and estimates of the protein content of the wheat crop, and of market news with reference to protein supply and protein premiums, would facilitate a general and equitable distribution of protein premiums among producers, would assist producers in the marketing of their wheat by its protein content, and would provide adequate information about the average protein content of the wheat supply for use in the establishment of market premiums for protein. Improvement in the intermarket uniformity of protein testing could be effected by a standardization of sampling procedure, of moisture testing in relation to protein content, and of the methods for the determination of protein content.

The oil content of flaxseed and soybeans is an index of the processing value of these crops. Oil content is of equal or even greater significance in the determination of the domestic market values of flaxseed and soybeans than is protein content in the determination of the domestic market values of wheat. A quick and accurate test has been developed for determining the oil content of flaxseed and soybeans. This test has never been incorporated in the inspection and marketing practices of the important domestic markets for these seeds. The adoption of this oil test as a definite part of the inspection service for flaxseed and soybeans would improve the marketing practices for these crops and would tend to establish market prices on a basis that would be more equitable for producers than is a basis founded on grades only.

Various proposals for the improvement of grain-marketing practices by means of the organization of national protein and oil-testing services and premarketing and current estimating services covering the supply of protein in wheat and of oil in flax, have been under discussion in the grain industry, in the State agricultural colleges, and in the Congress, for several years. This report has been prepared to present the views of this bureau on these subjects.

The information presented in this report has been gathered and prepared for publication by Messrs. Edward C. Parker, Carlos E. Campbell, E. G. Boerner, and D. A. Coleman, of the staff of the United States Bureau of Agricultural Economics. C. W. Kitchen, assistant chief in charge of service and regulatory work, and I, as chief, have directed the study and have passed upon the conclusions. This report, therefore, represents the viewpoint of this bureau.

NILS A. OLSEN, *Chief.*

Hon. ARTHUR M. HYDE,
Secretary of Agriculture.

PROTEIN PREMIUMS FOR WHEAT

Since 1923, protein content has become a factor of material importance in the domestic marketing of hard red spring, hard red winter, and durum wheats, and of some importance in the domestic marketing of the soft red winter and white wheats. Although the Bureau of Agricultural Economics of the United States Department of Agriculture does not have data to show the total protein premiums paid for wheat in important grain markets, the importance of such premiums is indicated by a statement of the Minnesota State Grain Inspection Department that, for the year ended July 31, 1929, the protein premiums paid at Minneapolis and Duluth only, totaled $10,694,770.46 (*11*).[1]

Expressed in terms of cents per bushel, the annual average premium paid at Minneapolis during the crop years 1926–27 to 1930–31, inclusive, for hard red spring wheat of 13 per cent protein content, ranged from approximately one-half cent to 22 cents per bushel, over the price of wheat that did not command a premium for its protein content; similarly, for wheat of 14 per cent protein content the annual average premium paid ranged from approximately three-fourths of a cent to 33 cents per bushel. During the crop year 1927–28, when spring wheat of high protein content [2] was scarce, the monthly average premiums at Minneapolis for hard red spring wheat having 13 per cent protein content were as high as 29 cents per bushel, and for 14 per cent protein content as high as 43 cents per bushel. During the crop year 1930–31, when wheat of high protein content was abundant, no premiums were paid during the period November to February, inclusive, for wheat of both 13 per cent and 14 per cent protein content. Protein premiums of approximately

[1] Italic numbers in parentheses refer to literature cited, p. 45.

[2] Wheat having a protein content higher than the average of the available supply is generally referred to by the grain trade as high-protein wheat, and wheat having a protein content lower than the average is generally referred to as low-protein wheat. The terms "high protein" and "low protein," as used in this report, should be interpreted accordingly. The average protein content of the available supply of wheat of any class may vary from year to year and from month to month. Thus there is no fixed base from which "high-protein wheat" and "low-protein wheat" may be defined. In commercial practice the base is often between 11.5 and 12.5 per cent.

2½ cents per bushel were reestablished, however, in August, 1931, at Minneapolis for new-crop hard red spring wheat having 13 per cent to 14 per cent protein content. A high daily average premium of 3½ cents per bushel for wheat of 14 per cent protein content was reached in September of the 1931–32 crop year. A detailed statement of the protein premiums paid at Minneapolis for the period 1926–27 to 1931–32 is given in Table 1.

TABLE 1.—*Wheat, No. 1 Dark Northern Spring:*[1] *Average premiums paid (cents per bushel) for protein over the price paid for No. 1 Northern Spring (cash close), by months, Minneapolis, 1926–27 to 1931–32*

PRICE OF NO. 1 NORTHERN SPRING (CASH CLOSE) (BASE)

Crop year	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Average
1926–27	150.9	140.8	143.5	140.1	142.4	141.5	140.4	136.2	134.3	143.9	145.7	144.1	142.0
1927–28	143.0	132.3	127.3	126.0	127.9	131.7	131.5	137.0	150.1	153.6	143.2	132.8	136.3
1928–29	112.3	110.9	111.0	111.7	111.1	115.4	123.0	121.0	115.3	105.9	108.2	137.6	115.3
1929–30	153.2	132.9	129.5	126.4	128.9	126.6	-------	-------	106.3	104.6	98.1	89.1	117.6
1930–31	89.2	84.6	81.4	74.9	79.0	76.1	75.6	76.2	79.5	81.0	73.5	64.0	77.9
1931–32	62.2	67.0	68.5	-------	-------	-------	-------	-------	-------	-------	-------	-------	------

PREMIUM FOR 12 PER CENT PROTEIN

1926–27	4.0	3.3	4.0	2.7	3.0	3.2	2.5	2.4	3.5	5.1	5.5	4.2	3.6
1927–28	4.3	5.3	5.3	6.0	8.9	9.1	7.7	7.0	8.6	6.8	7.5	8.9	7.1
1928–29	6.6	6.3	2.5	1.4	1.4	2.4	1.5	1.3	1.7	1.7	2.3	1.2	2.6
1929–30	.9	1.4	1.3	1.9	2.0	1.4	-------	-------	2.3	1.8	2.4	2.8	1.8
1930–31	1.2	.9	.3	0	0	0	0	.3	.4	1.0	.5	1.4	.5
1931–32	2.4	1.3	0	-------	-------	-------	-------	-------	-------	-------	-------	-------	------

PREMIUM FOR 13 PER CENT PROTEIN

1926–27	7.1	6.6	6.7	4.2	4.5	4.7	4.4	4.3	5.5	7.7	9.8	10.3	6.3
1927–28	9.8	12.8	18.3	18.5	22.8	29.3	27.9	25.8	28.7	26.1	21.5	22.8	22.1
1928–29	16.8	15.9	10.5	11.5	9.2	10.8	10.2	8.6	10.3	10.6	10.8	9.1	11.2
1929–30	5.1	2.4	1.5	2.2	2.5	3.6	-------	-------	4.6	4.2	5.4	5.3	3.7
1930–31	1.8	1.4	.7	0	0	0	0	.3	.4	1.0	.5	1.4	.6
1931–32	2.4	1.6	.8	-------	-------	-------	-------	-------	-------	-------	-------	-------	------

PREMIUM FOR 14 PER CENT PROTEIN

1926–27	9.4	9.1	8.6	5.7	5.5	6.0	6.1	6.3	7.5	10.1	13.3	15.1	8.6
1927–28	15.7	20.2	27.6	29.1	33.9	39.9	39.6	38.8	43.0	42.0	34.1	32.9	33.0
1928–29	24.8	25.3	18.2	20.2	17.5	20.6	20.2	17.6	19.5	22.2	22.6	17.3	20.5
1929–30	7.6	3.6	2.1	2.7	3.1	5.2	-------	-------	6.0	5.2	6.9	7.3	5.0
1930–31	2.6	1.4	1.0	0	0	0	0	.3	.4	1.0	.5	1.4	.9
1931–32	2.4	2.2	2.0	-------	-------	-------	-------	-------	-------	-------	-------	-------	------

Compiled from the Minneapolis Daily Market Record.

[1] 1926—Aug. 4, 1928, classified as No. 1 wheat. Prior to Aug. 5, 1928 protein premiums at Minneapolis for protein in No. 1 wheat were reported in terms of cents per bushel above the near future price. The future price was for No. 1 Northern Spring, the contract grade. After Aug. 5, 1928, protein premiums were reported on a cash basis. They were included in the price given for dark northern spring wheat of a specified grade containing a certain percentage of protein. It was concluded therefore that the cash basis, which has obtained since Aug. 5, 1928, was the better of the two methods. The former series which was quoted as "so much above the future price" was therefore converted to a cash basis by calculating the premium above the average of the range of the closing cash prices of No. 1 Northern. The premiums for protein in the second series were calculated by subtracting the average of the range of the closing cash price of No. 1 Northern from each of the average quoted prices of No. 1 Dark Northern containing 12, 13, and 14 per cent protein, respectively. The cash closing price of No. 1 Northern was used as a base rather than the cash closing price of the nonprotein premium No. 1 Dark Northern because a complete series of the latter was not obtainable. The price of nonprotein premium No. 1 Dark Northern usually averages slightly higher than that for No. 1 Northern.

Expressed in terms of cents per bushel, the annual average premium paid at Kansas City for the years 1924–25 to 1930–31, inclusive, for hard red winter wheat having 12.75 per cent to 12.95 per cent pro-

tein content, ranged from approximately 1½ cents to 14 cents per bushel over the price of wheat having a protein content of 11.25 to 11.45 per cent; and similarly for wheat of 13 to 13.45 per cent protein content, the annual average premium paid ranged from approximately 2 to 16 cents per bushel. During the crop year 1927–28, when spring wheat of high protein content was scarce, the monthly average premiums at Kansas City for hard red winter wheat having 12.75 per cent to 12.95 per cent protein content were as high as approximately 21 cents per bushel, and for 13 per cent to 13.45 per cent protein content as high as approximately 23½ cents per bushel. During the crop year 1930–31, when wheat of high-protein content was abundant, the premiums for wheat of 12.75 to 12.95 per cent and 13 to 13.45 per cent protein content, decreased to a low point of about one-half cent per bushel during the latter part of the season. Protein premiums at Kansas City increased, however, in July, 1931, to about 3½ cents per bushel for new-crop hard red winter wheat of 12.75 to 12.95 per cent protein content and to about 4½ cents per bushel for wheat of 13 to 13.45 per cent protein content. High daily averages of 10 cents per bushel and 12 cents per bushel, for wheat of 12.75 to 12.95 per cent and 13 to 13.45 per cent protein, respectively, were reached in October of the 1931–32 crop year. A detailed statement of the protein premiums paid at Kansas City for the period 1924–25 to 1931–32, is given in Table 2.

TABLE 2.—*Wheat, No. 2 Hard Winter: Average premiums paid (cents per bushel) for protein over the price paid for wheat of the same grade having 11.25–11.45 per cent protein, by months, Kansas City, 1924–25 to 1931–32*

AVERAGE PRICE FOR 11.25–11.45[1] PER CENT PROTEIN (BASE)

Crop year	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	Yearly average
1924–25	-------	118.0	120.7	136.3	143.3	161.2	180.9	180.7	166.7	148.8	161.9	160.0	152.6
1925–26	153.3	166.0	158.0	158.4	163.4	172.4	178.2	171.1	160.1	159.4	155.5	153.7	162.5
1926–27	135.0	130.4	131.2	138.1	136.5	137.9	137.4	134.7	131.3	129.7	139.6	141.0	135.2
1927–28	135.5	133.9	129.5	128.7	129.7	130.2	131.5	130.6	134.1	150.8	154.0	143.7	136.0
1928–29	122.4	104.1	106.7	108.9	111.2	110.2	113.2	118.1	115.8	110.0	99.9	102.0	110.2
1929–30	122.9	122.3	124.4	120.9	118.3	121.8	118.1	-------	-------	102.0	98.3	90.8	114.0
1930–31	79.9	81.5	77.7	74.3	68.7	70.6	69.5	69.4	70.5	72.9	73.2	66.6	72.9
1931–32	44.0	42.0	41.4	44.1	-------	-------	-------	-------	-------	-------	-------	-------	-------

PREMIUM FOR 11.75–11.95 PER CENT PROTEIN

1924–25	-------	1.0	0.8	1.5	2.3	2.4	2.9	2.0	2.2	3.8	1.7	3.8	2.2
1925–26	.6	.6	1.4	1.4	.1	.6	.4	.3	1.0	.4	0	.2	.6
1926–27	.5	.8	1.0	1.0	.8	.0	.2	.6	.2	.2	1.0	.2	.5
1927–28	1.8	3.1	2.6	2.5	2.3	3.0	4.0	4.0	5.4	5.6	4.4	5.3	3.7
1928–29	2.6	.7	.2	.1	.7	.2	.3	.1	.2	.3	0	.3	.5
1929–30	.6	.4	0	.3	.6	.1	.1	-------	-------	.2	.1	0	.2
1930–31	.2	.3	.5	.9	.2	.1	0	0	.1	.1	.1	0	.2
1931–32	.3	.2	.6	1.0	-------	-------	-------	-------	-------	-------	-------	-------	-------

PREMIUM FOR 12.25–12.45 PER CENT PROTEIN

1924–25	-------	3.2	2.5	4.1	4.4	5.3	7.8	5.0	5.5	7.0	6.4	7.9	5.4
1925–26	2.1	1.7	2.2	1.9	.9	1.6	1.1	.9	1.3	.2	.4	.8	1.3
1926–27	1.6	2.0	2.2	1.3	.7	.4	.6	1.2	1.3	.5	1.8	3.3	1.4
1927–28	5.1	7.4	6.2	7.3	6.3	7.0	9.9	10.3	13.6	11.6	8.7	13.4	8.9
1928–29	7.4	3.7	1.8	1.9	3.0	2.1	1.9	.9	1.4	2.5	2.3	2.7	2.6
1929–30	3.1	1.3	1.0	.8	2.0	.8	.9	-------	-------	.1	.8	.8	1.2
1930–31	.6	1.2	1.8	1.5	1.3	.7	1.0	0	0	.2	0	.6	.7
1931–32	1.5	1.3	2.9	3.4	-------	-------	-------	-------	-------	-------	-------	-------	-------

[1] 1924—February, 1927, the base is 11.25–11.70 per cent.

TABLE 2.—*Wheat No. 2 Hard Winter: Average premiums paid (cents per bushel) for protein over the price paid for wheat of the same grade having 11.25–11.45 per cent protein, by months, Kansas City, 1924–25 to 1931–32*—Continued.

PREMIUM FOR 12.75–12.95 PER CENT PROTEIN

Crop year	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	Yearly average
1924–25	-------	5.3	4.6	6.3	6.5	8.2	10.9	6.8	8.3	6.5	7.9	7.4	7.2
1925–26	3.0	3.1	2.9	4.5	2.1	2.5	2.5	1.8	2.0	.8	.4	.1	2.1
1926–27	2.8	2.9	3.1	1.3	.9	.8	1.0	1.5	2.0	1.5	2.9	6.0	2.2
1927–28	8.5	10.6	9.4	9.2	8.8	12.6	17.4	16.8	21.2	16.5	15.7	20.2	13.9
1928–29	11.5	7.6	4.5	4.4	5.7	6.7	4.9	2.9	3.0	3.3	6.4	7.1	5.7
1929–30	6.6	2.6	.4	1.9	1.8	2.0	1.4	-------	-------	1.3	2.8	2.8	2.4
1930–31	1.6	2.6	2.6	4.3	3.2	.9	.6	.7	.5	.5	.4	1.1	1.6
1931–32	3.6	3.1	6.4	7.8	-------	-------	-------	-------	-------	-------	-------	-------	-------

PREMIUM FOR 13–13.45 PER CENT PROTEIN

1924–25	-------	7.0	6.3	7.6	7.7	8.7	12.2	9.2	10.8	10.8	10.6	11.1	9.3
1925–26	4.1	4.3	4.5	3.0	2.1	2.9	2.8	2.5	3.4	1.2	.5	.5	2.6
1926–27	3.1	3.3	3.5	2.2	1.3	1.0	.8	1.7	2.3	2.5	3.8	7.5	2.8
1927–28	10.4	11.9	11.2	12.8	11.2	14.4	19.7	20.8	23.4	23.1	14.5	20.6	16.2
1928–29	13.5	10.0	7.6	5.5	8.2	7.4	7.6	4.0	4.2	6.2	8.5	9.3	7.7
1929–30	9.7	3.9	2.1	2.5	2.8	2.5	2.2	-------	-------	1.5	4.8	4.8	3.7
1930–31	2.9	3.3	3.3	3.9	3.3	2.4	1.0	1.0	.6	.7	.9	.8	2.0
1931–32	4.5	3.9	7.8	9.7	-------	-------	-------	-------	-------	-------	-------	-------	-------

Compiled from Kansas City Grain Market Review.

AVERAGE PROTEIN CONTENT OF THE HARD WHEAT CROPS

The average protein content of the hard red spring and hard red winter wheat crops of the United States varies from year to year from a minimum of approximately 11.8 per cent to a maximum of approximately 14.5 per cent, as shown in Table 3. The range of protein content in individual lots of these hard wheats is commonly from 10 to 16 per cent, and in some cases from 9.5 to 20.5 per cent. (Tables 6, 7, and 8.)

Most of the large, modern, domestic flour mills, which manufacture flour from these hard wheats for bread-making purposes, strive to maintain a uniform protein content of approximately 11 to 11.5 per cent in their principal brands of flour. In order to do so, they must maintain an average of approximately 12 to 12.5 per cent protein content in their supplies of wheat.

For these reasons the protein premiums offered for hard red spring and hard red winter wheat vary through wide limits according to the domestic supply of and demand for wheat that has a protein content that meets milling requirements. During the crop year 1930–31, for example, protein premiums were either very small or were nonexistent, because an abundant supply of high-protein wheat (over 13 per cent protein) was available and in storage from the 1929 and 1930 crops. During the crop years 1927–28 and 1928–29, however, when the average protein content of the current crops of hard red spring and hard red winter wheat was relatively low (less than 12.5 per cent), and when no large carry-overs of high-protein wheat were in storage, substantial premiums were paid for those lots of wheat that had high protein content.

TABLE 3.—*Annual average protein content of hard red spring and hard red winter wheat crops and premiums for specified protein content over cash close for nonpremium wheat, 1925–26 to 1931–32*

Crop year [1]	Protein content		Premium	
	Spring wheat [2]	Winter wheat [3]	Minneapolis, 13 per cent protein [4]	Kansas City, 12.75–12.95 per cent protein [5]
	Per cent	*Per cent*	*Cents per bushel*	*Cents per bushel*
1925–26	12.48	13.00	7.5	2.1
1926–27	13.26	13.02	6.3	2.2
1927–28	11.89	12.27	22.1	13.9
1928–29	12.34	11.91	11.2	5.7
1929–30	13.59	12.27	3.4	2.4
1930–31	14.43	12.41	.3	1.6
1931–32 [6]	13.89	11.82	1.6	5.2

[1] Crop year for hard red winter wheat, begins July 1; hard red spring wheat Aug. 1.
[2] Averages of car-lot receipts at Minneapolis as determined by Investigation Department, Minnesota Railway and Warehouse Commission. These inspections cover the bulk of the spring-wheat crop.
[3] Averages of determinations made by Kansas State Grain Inspection and Weighing Department at Kansas City. These inspections cover a considerable proportion of the crop of Kansas, Oklahoma, northern Texas, and eastern Colorado, and probably give a fair index of year-to-year changes in the protein content of hard red winter wheat.
[4] Compiled from Minneapolis Daily Market Record.
[5] Compiled from Kansas City Grain Market Review.
[6] Four months only for winter wheat and three months only for spring wheat.

INDEX OF CURRENT PROTEIN SUPPLY

The supply of high-protein wheat available during any given crop year is the factor of chief importance in the determination of protein premiums for hard red spring and hard red winter wheat, because the domestic demand for such wheat is comparatively constant. Usually the most important factor in determining the available supply of high-protein wheat for domestic milling operations during any given crop year, is the supply of high-protein wheat in the current crop. The relatively large carry-over of high-protein wheat from the crops of 1929 and 1930, however, was a factor of greater importance than usual in determining the total supply of high-protein wheat for the crop year 1931–32. Other abnormal carry-overs may recur in future years; if of high protein content they would tend to depress premiums for the current crop, but if of low protein content they would not affect protein premiums materially even though the general level of wheat prices were low, because under such circumstances the mills would compete for high-protein wheat in the new crop in order to maintain the standard baking quality of their brands of flour.

Under the normal conditions pertaining to the domestic supply of and demand for high-protein wheat, the average protein content of the current crops of hard red spring and hard red winter wheat is an approximately accurate index of the supply of high-protein wheat that will be available for milling operations during any given crop year, and is an index, therefore, of material importance in the establishment of market premiums for protein. These facts are apparent from the data given in Table 3 and Figure 1, which

show the relation between the average protein content of the crops of 1925 to 1930, inclusive, and the protein premiums paid at Minneapolis and Kansas City.

For these reasons principally, the data presented in graphic form in Figures 1, 3, and 4, are based on studies of the relation between

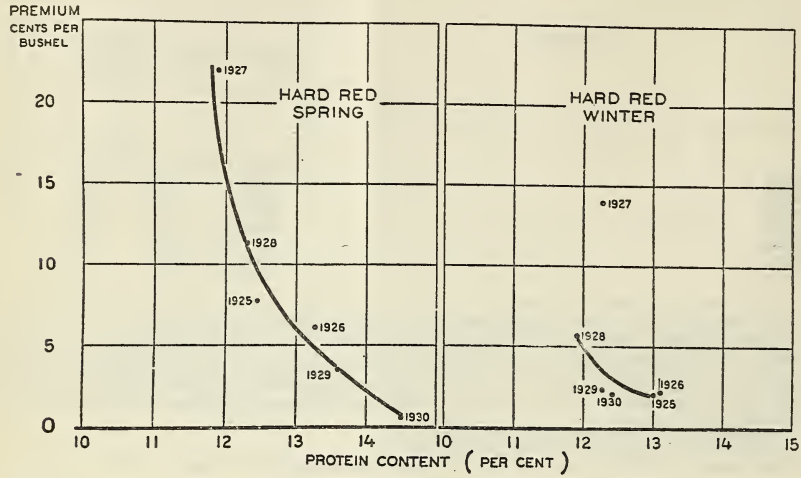

FIGURE 1.—RELATION BETWEEN THE AVERAGE PROTEIN CONTENT OF HARD RED SPRING WHEAT CROPS AND THE PREMIUMS PAID AT MINNEAPOLIS FOR WHEAT TESTING 13 PER CENT PROTEIN, AND RELATION BETWEEN THE AVERAGE PROTEIN CONTENT OF HARD RED WINTER WHEAT CROPS AND THE PREMIUMS PAID AT KANSAS CITY FOR WHEAT TESTING FROM 12.75 TO 12.95 PER CENT PROTEIN

These graphs illustrate the fact that protein premiums increase as the average protein content of the crops of hard red spring and hard red winter wheat decreases. The premiums for spring wheat that tests 13 per cent protein, above the prices obtained for wheat for which no protein premium was paid, and those for hard red winter wheat that tests from 12.75 to 12.95 per cent protein, above the prices obtaining for wheat that tests 11.25 to 11.45 per cent protein, are indicated by the scale of cents per bushel at the left-hand margin of the graph. A scale of protein percentage intervals is shown at the bottom margin. Each dot on these graphs is designated as a crop year (beginning July 1 for winter wheat and August 1 for spring wheat) and represents the relation between the annual average premium paid for high-protein wheat and the average protein content of the crop. Each of the curved lines extending through a scatter of these dots indicates, from its course and the scales at the bottom and left-hand margin of the figure, that protein premiums increase as the average protein content of the crop decreases.

The graph for spring wheat shows that when the average protein content of spring wheat decreased from 14 per cent to 13 per cent the increase of premiums was less than when the average protein content of the crop decreased from 13 per cent to 12 per cent. The premiums paid for the protein content of hard red spring wheat at Minneapolis were determined principally by the average protein content of the spring-wheat crop. At Kansas City, however, the premiums paid for the protein content of hard red winter wheat were affected materially in some years by the average protein content of the spring-wheat crop, as well as by the average protein content of the crop of hard red winter wheat. The graph for hard red winter wheat at Kansas City shows that for all the years from 1925 to 1930, excepting 1927, there was a consistent relationship between the premiums at Kansas City and the average protein content of the hard red winter-wheat crop. In 1927, however, the premiums paid for 12.75 to 12.95 per cent protein at Kansas City averaged 14 cents per bushel instead of about 3½ cents per bushel which would have been the premium had the same relationship prevailed in 1927 as in the other years. The abnormal premium at Kansas City in 1927 was caused by the fact that the spring-wheat crop of that year contained an average of less than 12 per cent protein, causing an abnormal demand from the millers of spring wheat for supplies of high-protein hard red winter wheat to blend with spring wheat.

protein premiums and the average protein content of the current crops of wheat. It is realized, however, that the quantity and protein content of the carry-over of wheat in any given year, are factors in the supply of high-protein wheat which may assume material importance in some years in the determination of protein premiums,

and that the protein estimates and market news service hereinafter outlined should give more consideration to the carry-over and its relation to protein supply than has been given in the past.

RELATION BETWEEN SUPPLY OF HIGH-PROTEIN WHEAT AND PROTEIN PREMIUMS

Flour used for bread making in the United States is manufactured principally from straight hard red spring wheat, from straight hard red winter wheat, and from blends of these two classes of hard wheat. The principal millers of these wheats strive to maintain, from year to year, a uniform protein content in their flour output. Normally, the separate requirements of the domestic millers of hard red spring wheat and the domestic millers of hard red winter wheat for wheat of high protein content are fulfilled from the supply of high-protein wheat of each class of wheat. Thus the protein premiums for hard red spring wheat are determined usually in accordance with the available supply of high-protein wheat of that class, and those for hard red winter wheat are determined in a similar manner.

The annual averages of the protein premiums paid for hard red spring wheat at Minneapolis are greater usually than those paid for hard red winter wheat of similar protein content at Kansas City. (Table 3.) The millers of hard red spring wheat, as a group, utilize high-protein wheat more consistently than do the millers of hard red winter wheat, as a group, and in most years the supply of high-protein spring wheat is smaller in relation to the requirements of the spring-wheat millers than is the supply of high-protein winter wheat in relation to the requirements of the winter-wheat millers. During recent years the average annual United States production of hard red spring wheat has been about 150,000,000 bushels, of which about 4 per cent has been exported; that of hard red winter wheat has been about 350,000,000 bushels, of which about 18 per cent has been exported. Thus with a net domestic supply of hard red spring wheat that is about one-half that of hard red winter wheat, and with a more consistent milling demand for high-protein spring wheat than for high-protein winter wheat, the protein premiums for hard red spring wheat have averaged higher for the period 1925–26 to 1930–31 than have those for hard red winter wheat.

Although the protein premiums for hard red spring wheat at Minneapolis have been determined principally by the supply of high-protein spring wheat in relation to the requirements of the spring-wheat millers for such wheat, and the premiums at Kansas City principally by the supply of high-protein winter wheat in relation to the requirements of the winter-wheat millers for such wheat, there have been exceptional years in which the supply of high-protein spring wheat has been a factor of material importance in the determination of the protein premiums for hard red winter wheat.

Whenever the available supply of high-protein spring wheat is small, the big spring-wheat mills, which manufacture nationally known brands of flour, increase their purchases of hard red winter wheat for blending purposes over the quantities normally purchased, if they can obtain supplies of high-protein hard red winter wheat to maintain the desired uniform protein content in their flour out-

put. Competition under such circumstances becomes keen between the millers of hard red spring wheat and the millers of hard red winter wheat for the available supply of high-protein hard red winter wheat, and the premiums become abnormally high. Such a situation is graphically illustrated in Figure 1 by the abnormal average premium of 14 cents per bushel paid in 1927–28 for hard red winter wheat having 12.75 to 12.95 per cent protein content, in a year when the average protein content of the spring-wheat crop was less than 12 per cent.

The supply of high-protein hard red winter wheat, on the other hand, is of relatively less importance in the determination of protein premiums for hard red spring wheat. In years when the available supply of high-protein hard red winter wheat is small, the southwestern millers of such wheat do not compete with the spring-wheat millers to any great extent for supplies of high-protein spring wheat. The premiums offered for high-protein spring wheat, therefore, are not enhanced appreciably under such circumstances. The protein premiums for hard red spring wheat, however, as well as those for hard red winter wheat, are enhanced in those years when the total supply of high-protein wheat of both classes of wheat is small in relation to total milling requirements for high-protein wheat.

PREMIUMS FOR LOW-PROTEIN WHEAT

Premiums for low-protein wheat of the soft red winter and white wheats have not been established in our domestic markets on the same systematic basis as that which obtains for high-protein wheat of the hard red spring and hard red winter wheats. The flour milled from the soft red winter and soft white wheats is used chiefly in the domestic trade for pastry, cake, biscuit, and cracker baking, and to some extent in the manufacture of breakfast foods. The millers of these wheats purchase their supplies principally according to physical-texture specifications (soft and chalky kernels) which indicate the desired starchy quality, or according to those areas of production which are known from experience to yield soft wheat of the required quality.

Nevertheless, the practice is growing of negotiating sales or purchases of soft wheat on the basis of protein specifications, and of paying premiums for such wheat having a low protein content. Many special sales of individual lots of soft red winter wheat and of soft white wheat have been made during recent years under specifications for 9 per cent or less protein content, for which premiums have been paid of 2 to 8 cents per bushel over the price of wheat of the same grade sold without reference to protein content. Regular market quotations for low-protein wheat are not published, however, in the same manner as for high-protein wheat. Thus it is impracticable to give a statistical presentation of these protein premiums that would be comparable to the data given in Tables 1, 2, and 3 for the hard wheats.

Premiums are paid at times and in numerous individual cases for both soft and hard wheat of low protein content. In 1928–29, for example, a shortage in the domestic supply of soft red winter wheat caused the soft-wheat millers to purchase a material quantity of hard red winter wheat of the subclass Yellow Hard, which sub-

class, according to Federal standards, may not contain more than 25 per cent of dark, hard, and vitreous kernels. Normally, this type of hard wheat contains less protein than hard wheat of the subclasses Hard Winter and Dark Hard Winter, which have higher percentages of dark, hard, and vitreous kernels. For these reasons a brisk and an unusual commerce in yellow hard winter wheat began in the summer of 1928 and continued until the 1929 harvest; a material volume of this type of wheat was tested for protein at Omaha and Kansas City, and those lots that had a low protein content were merchandised to soft-wheat millers at premium prices.

A study was made of the published car-lot sales of yellow hard wheat at Omaha during July and August, 1928, as shown in the Omaha Price Current, that was confined to those car-lots that were free from smut and that were uniform or very nearly uniform in quality according to the factors of test weight, moisture, etc., but that varied as to protein content. An index of the premiums paid for low protein content was thus obtained for a small segment of the sales. It was observed that early in July, 1928, when the supply of soft red winter wheat was relatively small, and when the receipts of low-protein yellow hard wheat were light, a small number of sales were reported for wheat having 9.5 per cent or less protein, for which premiums of 17 to 19 cents per bushel were paid. During August, 1928, when the supply of soft wheat was larger than in July, and when the receipts of yellow hard wheat were heavier than in July, it was observed from the car-lots selected for study that those car-lots which tested 9.5 per cent protein sold for premiums of one-half cent to 4 cents per bushel. All of the data obtained from this study are shown in Figure 2.

Numerous large sales of low-protein yellow hard wheat were made at Omaha and Kansas City during 1928–29 from specially binned elevator stocks of low-protein wheat. Although no published data are available to indicate the premiums obtained for such stocks, it is known from general sources of information in the milling industry that distinct premiums were asked and bid in the merchandising of such wheat.

ESTIMATES OF THE WHEAT PROTEIN SUPPLY

The importance of the factor of protein content in determining the price of wheat in many years calls for comprehensive and accurate premarketing estimates and current data pertaining to the supply of high and low protein wheat, for the general use of the grain industry. At present (1931) the protein data that are available each year to the grain industry, prior to the heavy autumn market movement of wheat as well as thereafter, are by no means comparable in comprehensiveness and accuracy with the wheat statistics of farmers' intentions to plant, condition of the growing crop, production, supply, and storage, that are gathered and disseminated currently by the Bureau of Agricultural Economics and various commercial organizations. National wheat statistics provide more and better information with respect to quantity than to quality as indicated by protein content.

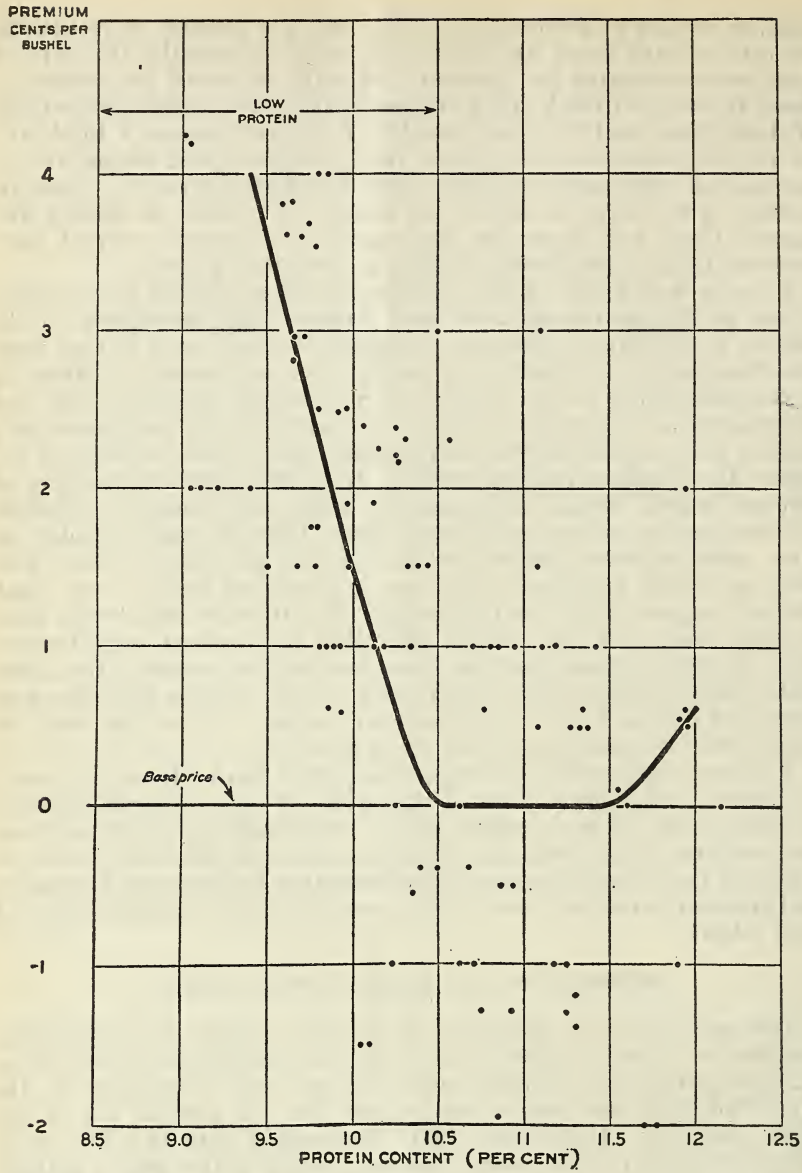

FIGURE 2.—INFLUENCE OF LOW AND HIGH PROTEIN CONTENT ON THE PRICE OF YELLOW HARD WINTER WHEAT AT OMAHA DURING AUGUST, 1928

This graph illustrates the effect of protein content on the price of yellow hard wheat at Omaha during August, 1928. From the records of the sales during this period, as published in the Omaha Price Current, 102 cars were selected that were uniform, or nearly uniform, in quality except for protein. Each dot in this graph represents a sale of one car lot of yellow hard wheat at Omaha during August, 1928. The relative prices at which these car lots sold, above or below a base price, are indicated by the scale of cents per bushel at the left-hand margin of the graph. The base price used for comparative purposes in this graph is the average price of a group of nonprotein premium car-lot sales; that is, those cars which had a protein content between 10.5 and 11.5 per cent. The protein content of each car lot is indicated by the scale of protein percentages at the bottom of the graph. The curved line extending through the scatter of dots indicates the average of the relationship of price and protein content. This curved line rises to the right of 11.5 per cent protein and to the left of 10.5 per cent protein, thus indicating that the average of prices paid for car lots of wheat testing below 10.5 per cent protein and above 11.5 per cent, was higher than for wheat testing between 10.5 and 11.5 per cent. Among the 102 car lots studied, 31 car lots of wheat testing between 9.5 and 10 per cent protein were reported, all of which sold above the base price.

INADEQUACY OF PRESENT PROTEIN ESTIMATES

It has been shown in Table 3 and Figure 1, and in the accompanying discussions, that the average protein premiums for wheat vary principally and normally in accordance with the average protein content of each crop. The premiums paid at the terminal markets, especially during the summer and autumn months, have not always reflected the correct relation between the supply of and demand for high and low-protein wheat. The principal reason is that, under existing conditions, the premarketing and current data available annually regarding the average protein content of the current wheat crops and the protein content of the yearly carry-overs, are neither assembled in a sufficiently accurate and comprehensive manner, nor released in a sufficiently prompt and regular manner, to constitute a reliable foundation of information for the determination of protein premiums.

Such estimates of wheat protein content as are now made prior to the main market movement of each new crop are those based on surveys conducted by a few of the State agricultural colleges or grain-inspection departments, and those conducted by millers, grain merchants, and elevator operators. The usefulness of such estimates of protein content is limited because the information so obtained is often based on an inadequate number of samples and is too local in character to provide an accurate estimate of the average protein content for each class of wheat.

Similarly the estimates of protein content, based on early terminal-market receipts and the tests made by the State grain-inspection department and commercial laboratories, can not be relied upon as accurate indexes of the average protein content of the crop because the early market receipts are not necessarily representative of a large producing area and because estimates can not be made from such sources of information early enough in the marketing period to be of material value in establishing premiums for the early wheat movement.

Early estimates of the average protein content of the crops of hard red winter and hard red spring wheat are made annually by the large flour-milling and grain-elevator companies. These interests, through their field representatives and their private protein-testing laboratories, undoubtedly obtain much advance information about the protein content of the wheat crops at many shipping stations. Such information, however, is not generally available to members of the grain trade nor to producers and country shippers. Therefore it does not operate with the same effect in the establishing of protein premiums on a competitive basis for the early market movement of wheat as would information gathered and disseminated by public agencies.

NECESSITY FOR ADEQUATE PROTEIN ESTIMATES

Since protein became a factor in the marketing of wheat, the current protein premiums have been more unstable than the current prices paid for wheat on a grade basis only. (Tables 1 and 2.) Protein premiums, especially during the early autumn period of

marketing, often have not reflected the correct relationship of the protein supply and demand. An important cause of the relative instability of protein premiums has been the lack of adequate, accurate, public information about the supply of high and low-protein

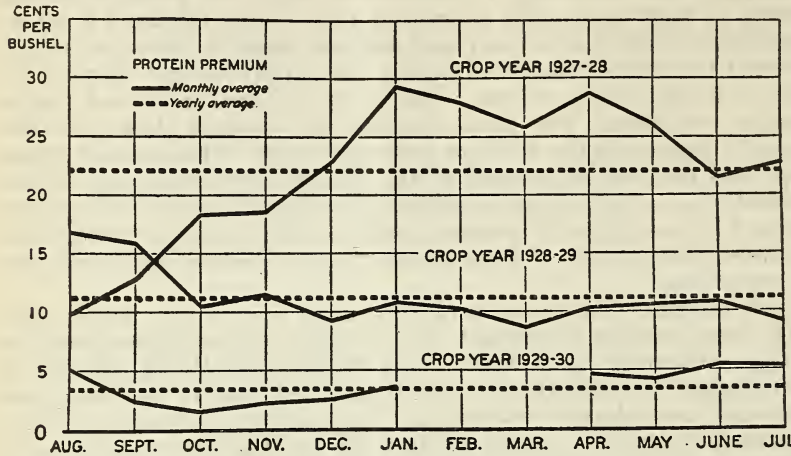

FIGURE 3.—PREMIUMS PAID FOR NO. 1 DARK NORTHERN SPRING WHEAT TESTING 13 PER CENT PROTEIN ABOVE PRICES PAID FOR NO. 1 NORTHERN SPRING WHEAT (NO PROTEIN PREMIUM), BY MONTHS, AT MINNEAPOLIS, 1927-28, 1928-29, AND 1929-30.

This graph illustrates the monthly course of protein premiums paid for hard red spring wheat at Minneapolis, in their relation to the average protein premium for each of the years 1927–28, 1928–29, and 1929–30. The premium for 13 per cent protein wheat, above the prices obtaining for wheat for which no protein premiums were paid, are indicated by the scale of cents per bushel at the left-hand margin of the graph. A scale of monthly intervals is shown at the bottom margin. The dotted horizontal lines represent the average yearly protein premium paid for each of the years 1927–28, 1928–29, and 1929–30. The irregular line extending above and below each of the horizontal lines indicates the monthly course of the premiums for a given year in relation with the average yearly premium. Although the average protein premiums at Minneapolis are associated closely with the average protein content of the crop (see fig. 1), the monthly fluctuations of the premiums are material.

It may be observed that protein premiums, during the early part of each marketing season are usually associated more closely with the protein content of the previous year's crop than with that of the current crop. In 1927–28, for example, when the average protein content of the spring wheat crop was relatively low, the average yearly protein premium at Minneapolis was over 20 cents per bushel, yet the premiums paid for the first four months of that crop year were considerably below the yearly average. The average protein content of the 1928 crop was higher than that of the 1927 crop, thus the protein premiums were on a lower average level for the year 1928–29 than for the year 1927–28. A carry-over of influence from the 1927–28 situation may be observed, however, in the premiums paid during the first two months of the 1928–29 season, during which time the premiums were considerably above the average yearly premiums for 1928–29. The monthly course of the protein premiums during 1929–30 was similar to that of 1928–29 but the premiums were smaller.

By comparing the course of the 1927–28 premiums with those of 1928–29 and 1929–30, it is seen that in 1927–28, when the average protein content of the crop was low, the premiums opened on a low level and that about four months elapsed after August 1 before they were increased to a point in accordance with the facts about the average protein content of the crop, whereas in both 1928–29 and 1929–30, when the average protein content of each of these crops was relatively high, the premiums opened at comparatively high levels, but were decreased in about two months in 1928–29 and in about one month in 1929–30, to low levels that were in accordance with the facts about the average protein content of the crops.

wheat. Inadequate or inaccurate information about the supply of high and low-protein wheat, at the beginning of the marketing season, may cause the premiums to be established either too high or too low at the outset. Then as more information becomes available

from the tests made on market receipts, the premiums fluctuate sharply if the preliminary estimates are found to be incorrect.

Such fluctuations, when they occur, may be either highly profitable or highly unprofitable to producers, country elevators, terminal elevators, or millers. If the early premiums paid are too high, as proved by subsequent information, the producer who has sold his wheat early is the gainer, whereas the country elevator, terminal elevator, or miller, is the loser. On the other hand, if the early premiums paid are too low, as proved by subsequent information, the producer who has sold his wheat early is the loser, whereas the elevator and milling interests are the gainers.

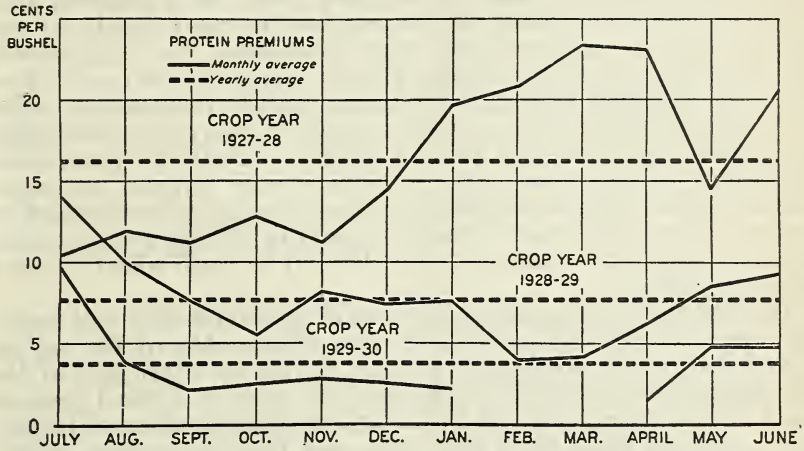

FIGURE 4.—PREMIUMS PAID FOR NO. 2 HARD WINTER WHEAT TESTING 13 TO 13.45 PER CENT PROTEIN ABOVE PRICES PAID FOR WHEAT OF THE SAME GRADE TESTING 11.25 TO 11.45 PER CENT PROTEIN, BY MONTHS, AT KANSAS CITY, 1927-28, 1928-29, AND 1929-30

This graph illustrates the monthly course of protein premiums paid for hard red winter wheat at Kansas City in their relation to the average protein premium for each of the years 1927–28, 1928–29, and 1929–30. The premiums for wheat having 13 to 13.45 per cent protein, above the prices obtaining for wheat testing 11.25 to 11.45 per cent, are indicated by the scale of cents per bushel at the left-hand margin of the graph. A scale of monthly intervals is shown at the bottom margin. The horizontal lines represent the average yearly protein premium paid for each of the years 1927–28, 1928–29, and 1929–30. The irregular lines extending above and below each of the horizontal lines indicate the monthly course of the premiums for a given year in relation to the average yearly premium.

The monthly course of protein premiums at Kansas City for these years was approximately the same as at Minneapolis. (Fig. 3.) Owing to the fact, however, that protein premiums at Kansas City are influenced occasionally by the average protein content of the spring-wheat crop as well as by that of the winter-wheat crop (fig. 1), the monthly fluctuations of the premiums at Kansas City are greater, at times, than at Minneapolis. The adjustment of premiums during the early months of the crop years 1927–28, and 1928–29, in accordance with the average protein content of these crops, was delayed at Kansas City longer than at Minneapolis, whereas the adjustment to a low level of premiums was equally as rapid in 1929–30.

Two outstanding facts with reference to the extent of terminal-market protein premiums heretofore prevailing at different seasons of the crop years are shown in Figures 3 and 4. First, during the early months of each of the crop years 1927–28, 1928–29, and 1929–30, the protein premiums were associated more closely with the average protein content of the previous crop than with that of the current crop. Second, when the test on the receipts of new-crop wheat indicated a relatively high average protein content, the prevailing high

premiums were reduced promptly, but when the early premiums were established on a relatively low level and the tests of new-crop receipts indicated a relatively low average protein content, the markets reacted much more slowly in increasing the premiums for high-protein wheat to their proper level.

The tendency for protein premiums to be established, during the early part of each crop year, in accordance with the protein content of the previous crop rather than with that of the current crop, may be explained largely by the fact that comprehensive, reliable information about the protein content of the current crop and the protein content of the carry-over are not available to the grain industry during the first few months of each crop year. It is believed, also, that the existing tendency of the markets to react slowly to the establishing of comparatively high premiums for high-protein wheat, in years when the average protein content of the crop is low, would be modified materially if early, reliable information about the protein content of the current crop and the carry-over were made available to producers and country shippers. Publicity, under such conditions, would cause many producers and shippers of high-protein wheat either to demand premiums during the early marketing period, or to hold back a material quantity of high-protein wheat in the country, thus causing market demand for such wheat to react more promptly.

The importance of establishing protein premiums that will represent, as accurately as possible, the true relationship of the supply of and demand for high-protein wheat during the early part of the marketing season, is illustrated by the data given in Table 4 pertaining to the receipts of wheat by months at Minneapolis and Kansas City. For the three years 1910, 1915, and 1920, an average of 33.1 per cent of the year's receipts of wheat at Minneapolis were received during August, September, and October, and 35.1 per cent of those at Kansas City during July, August, and September. The extensive use of the combine-harvester since 1925 has increased the early marketings of wheat, so that, for the crop of 1929, 51.5 per cent of the yearly receipts at Minneapolis were received during the first three months of the crop year, and at Kansas City, 60.2 per cent.

REFLECTION OF PROTEIN PREMIUMS TO PRODUCERS AND COUNTRY SHIPPERS

DISTRIBUTION OF PREMIUMS IN SOUTHWESTERN STATES

The inadequacy of public information with reference to wheat-protein supply, as well as of educational work on the entire subject of marketing wheat by its protein content, is especially noticeable in the comparatively new hard red winter wheat areas of the Southwestern States. The wheat of these areas is largely harvested with combines and is sold by producers to the country elevators immediately after harvest. Few such elevators have made any attempt to buy wheat according to protein content. Then, too, the practice of reflecting protein premiums to many of these communities by means of mill and terminal-elevator purchases made from so-called "map" or "station" protein averages has not been established to the same extent as in the spring-wheat area.

TABLE 4.—*Wheat: Monthly percentages of total yearly receipts at Minneapolis and Kansas City for the crop years 1910–11, 1915–16, 1920–21, 1925–26, 1929–30; and averages for the 20-year period 1910–11 to 1929–30*

MINNEAPOLIS

Crop year	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Total
1910–11	------	10.2	14.3	12.8	9.0	10.9	8.8	5.1	6.9	5.1	5.5	5.7	5.7	100
1915–16	------	3.3	11.9	14.0	14.7	17.1	5.3	7.1	7.5	4.6	4.5	4.9	5.1	100
1920–21	------	6.8	11.8	14.2	12.2	8.8	7.6	6.2	6.2	6.2	5.4	8.[illegible]	6.5	100
1925–26	------	11.6	18.0	10.6	9.9	11.8	7.0	5.7	5.2	4.4	4.1	4.2	7.5	100
1929–30	------	26.1	15.3	10.1	6.1	6.5	4.8	7.9	5.1	2.5	4.6	5.0	6.0	100
Average, 1910–11 to 1929–30	------	9.6	15.4	14.7	10.9	10.8	7.1	6.2	6.5	4.6	4.6	4.8	4.8	100

KANSAS CITY

1910–11	18.8	21.5	15.4	13.2	6.4	6.8	5.0	2.9	2.4	1.7	3.1	2.9	------	100
1915–16	5.2	8.2	10.3	9.5	15.6	13.0	9.4	8.1	4.5	5.2	7.1	3.9	------	100
1920–21	7.7	9.7	8.6	7.6	8.5	7.6	11.7	7.4	6.6	7.8	8.4	8.4	------	100
1925–26	20.4	16.2	8.7	6.3	8.2	9.9	5.8	4.9	3.7	3.4	3.6	8.8	------	100
1929–30	39.0	14.0	7.2	6.5	3.4	6.0	4.6	4.1	3.3	4.2	3.1	4.6	------	100
Average, 1910–11 to 1929–30	20.9	18.1	10.7	8.9	7.6	7.0	5.9	5.2	3.9	3.4	4.1	4.3	------	100

Compiled from Chicago Daily Trade Bulletin.

The practice of consigning wheat known to have high protein content in order to obtain the terminal premiums, has not developed to any appreciable extent in these areas, because many of the southwestern markets have not made organized efforts to quote and pay premiums according to protein content, and because producers and shippers, as a rule, are not so fully conversant with protein testing, protein premiums, and the market practices which govern the sale of high-protein wheat, as are the producers and shippers of the spring-wheat area or the older hard red winter-wheat areas.

Many producers and shippers of wheat in Oklahoma obtained low returns for their wheat of the 1927 crop because much of their wheat that year was of low test weight, and was, therefore, graded as low as No. 3 or No. 4 and purchased by the country elevators at material discounts under the price for No. 1 Hard Winter wheat. A large part of this low-test-weight wheat was tested for protein after it passed out of the possession of the producers and was found to be of high protein content. It was then specially binned in the terminals and eventually sold out of storage for prices that were as much as 30 to 50 cents per bushel higher than those for wheat of 60-pound test weight but having low protein content.[3]

One of the reasons that protein premiums have been paid less commonly in parts of the hard red winter-wheat area than in the spring-wheat area is that about 18 per cent of the hard red winter wheat produced during the period 1925 to 1928, inclusive, was exported; whereas for the same period, only about 4 per cent of the hard red spring wheat produced was exported. There has been no demand for high-protein wheat for export purposes; thus, protein

[3] Summarized from the following: LINZEE, E. H., PREMIUMS FOR PROTEIN IN WHEAT. Okla. State Bd. Agr. 1928. [Mimeographed.]

content has not been given so much attention in the marketing methods of the southwestern winter-wheat areas, which export a material part of their wheat, as in the spring-wheat area, where nearly all the wheat goes into domestic consumption and where protein is a market factor of material importance. The absence of protein premiums for wheat has been especially noticeable in that part of the hard red winter-wheat area that is in close proximity to the Gulf-port markets, in which markets the demand for wheat is almost entirely for export purposes.

PARTIAL REFLECTION OF PREMIUMS IN SPRING-WHEAT AREA

As a general rule, protein premiums have been reflected to producers and shippers more generally in the spring-wheat area than in the hard red winter-wheat area. Since about 1915 it has been a rather common practice for the mill and grain trade at Minneapolis and Duluth to quote prices for and make purchases of high-protein wheat at country points on the basis of "map" or "station" protein averages, as ascertained from private sources of protein information, and since 1925 as ascertained from the early season tests of wheat receipts made by the laboratories of the Minnesota State Grain Inspection Department. Under this practice, producers in a localized area in which the wheat was known to have a relatively high protein content, have participated to some extent in the terminal-market premiums. Since 1923 a large part of the spring-wheat crop has been merchandised according to protein content as well as by grade and largely on the basis of Minneapolis and Duluth inspection and protein tests.

In the spring-wheat area, as a whole, more public interest in protein testing, protein surveys, and marketing wheat by its protein content, has been displayed since 1923 than in the winter-wheat area as a whole. Much educational work among producers and country shippers has been done for the purpose of developing new marketing methods that reflect a higher percentage of the terminal-market protein premiums to the producers and shippers than are reflected by the "map buying" or "station average" methods. The State of Montana has established protein-testing laboratories at a number of interior points to assist producers in obtaining tests of their grain prior to selling it, and for several years the Minnesota State Grain Inspection Department has made sample protein tests for producers free of charge prior to the heavy market movement of wheat each year.

In the hard red winter-wheat area some similar educational work has been done, principally in Kansas. The Kansas State Grain Inspection Department has operated several protein laboratories at interior shipping points to aid producers to market their wheat advantageously, and a State laboratory for the same purpose has been established at Oklahoma City by the Oklahoma State Department of Agriculture.

MAP-BUYING METHOD INEQUITABLE

The wheat-marketing studies and educational work that have been conducted by the Bureau of Agricultural Economics and by the States, as well as the records of the State, exchange, and commercial

protein laboratories, reveal wide ranges in the protein content of wheat for any given season, as between States, counties, shipping stations, farms, and even the fields within one farm. Climatic variations often cause marked variation in the protein content of the wheat crops of different States, and similar causes, together with other variables such as soil fertility, varieties of wheat, and time of cutting the crop, are constantly effecting variations in the protein content of wheat grown on relatively smaller areas. These variations are shown in Tables 5, 6, 7, and 8.

TABLE 5.—*Average protein content of hard red spring wheat and of hard red winter wheat, by States, 1924–25 to 1930–31 (per cent)* [1]

Crop year	Hard red spring wheat				Hard red winter wheat			
	Montana	North Dakota	South Dakota	Minnesota	Kansas	Nebraska	Oklahoma	Texas
1924–25	13–14	11–12			12–13			
1925–26	14.25	11.95	12.95	12.10	12–13			
1926–27	14.05	13.20	13.60	12.40	14–15			
1927–28	12.00	11.70	12.40	11.45	13–14	12–13	12–13	15–16
1928–29	12.65	12.15	12.65	12.35	11–12	10–11	12–13	13–14
1929–30	15.30	13.75	13.65	12.05	12–13	11–12	12–13	12–13
1930–31	16.05	14.85	15.62	13.04	12.41	11.37		12.82

[1] Data from records of the Kansas, Minnesota, and Missouri State Grain Inspection Departments, the Fort Worth Grain and Cotton Exchange, the Omaha Grain Exchange, the Enid Board of Trade, and the Montana Agricultural Experiment Station.

TABLE 6.—*Average protein content of spring wheat, by counties, North Dakota, 1922 to 1930 (per cent)*

County	1922	1923	1924	1925	1926	1927	1928	1929	1930
Adams	13.33	12.43	13.18	13.72	14.86	11.65	11.79	14.1	15.9
Barnes	11.34	13.94	11.43	10.57	14.19	11.42	12.13	13.4	15.8
Benson	11.46	12.50	12.15	12.69	14.29	11.94	11.78	14.6	13.2
Bottineau	12.30	11.76	11.03			12.60	12.17		
Bowman	11.63		10.53			12.05	11.32		15.6
Burke	11.63	12.86	9.75			12.17		12.9	14.3
Burleigh	12.43		10.69	13.41	11.51	12.15	12.02	13.8	
Cass	11.35	12.83	11.41	11.78	12.69	11.18	12.60	12.3	14.5
Cavalier	15.33	13.07	10.95	10.73	11.60	12.05	12.29	12.6	12.2
Dickey	13.74	13.22	11.35	12.77	14.78	12.24	12.68		13.0
Divide	11.55	12.36	10.68			11.41	12.44		
Dunn	11.03			13.53	15.39	11.91	11.88	16.2	
Eddy					13.89	12.13			
Emmons	14.80		11.30			12.11	12.00		
Foster	11.96	13.40	10.52			12.40	12.44	14.5	
Golden Valley	13.88	13.30	12.27	15.62	16.49	12.01	12.81	14.0	16.4
Grand Forks	11.19	12.94	12.43	11.16	11.51	11.72	12.13	13.3	13.4
Grant	11.63	12.09	10.14	11.88	15.92	11.60	11.91	14.5	15.7
Griggs			11.44			11.66	13.12		
Hettinger	12.04		10.31	12.95	15.30	11.51	12.25	13.0	15.5
Kidder	11.23	13.29	11.51		14.06	11.96	10.75	15.8	16.4
La Moure	11.99	12.99	11.49	11.02	15.32	12.22	13.36	12.6	14.7
Logan	11.93		11.54			12.23	11.83		
McHenry	12.83	14.61				11.92	11.99		
McIntosh	12.77		12.16			11.95	11.37		
McKenzie	11.80	13.58	10.23	12.58	14.88	12.22	12.28	16.0	16.1
McLean	12.67	13.80	10.12	12.81	15.88	11.37	11.97	13.5	15.2
Mercer	11.51		10.72	11.20	15.11	11.61	12.28		
Morton	12.90		11.32	11.84	17.01	12.46	11.97	13.9	16.2
Mountrail	11.54	13.27	10.59	11.62	13.82	11.60	12.09	15.1	16.5
Nelson	12.77	14.17	11.80	12.10	13.60	11.74	11.94	13.5	14.2
Oliver	11.57					11.26	11.75	15.2	
Pembina	11.74	12.99	10.79	11.60	11.24	11.01	11.42	11.9	12.6
Pierce	13.92	14.30	12.65	11.54	14.24	11.65	11.55	12.6	14.5
Ramsey	11.05	14.00	11.24	11.78	14.49	12.17	12.58	13.6	14.7
Ransom			11.46			11.50	13.42		
Renville	13.07	11.68	9.65	11.79	13.62	11.82	12.23		
Richland	9.56	12.31	11.35	11.65	14.06	12.42	12.91	12.8	13.6
Rolette	15.33						12.93		

TABLE 6.—*Average protein content of spring wheat, by counties, North Dakota, 1922 to 1930 (per cent)*—Continued

County	1922	1923	1924	1925	1926	1927	1928	1929	1930
Sargent	9.91					12.34			
Sheridan	11.12					11.39	11.34		
Sioux			12.28			11.85			
Slope	12.03	13.70	11.69	12.36	15.35	11.72	11.28	13.2	14.8
Stark	11.74	13.04	10.67	13.59	15.40	11.76	12.03	13.7	15.3
Steele	12.54		11.85			11.32	11.94	13.7	15.2
Stutsman			11.20	11.24	14.88	12.33	12.19	13.8	14.2
Towner	12.31	13.38	12.00	12.34	13.83	11.86	11.86	14.7	14.3
Traill	12.43		11.52			11.35	11.77	12.1	
Walsh	12.03	14.99	11.21	11.23	12.72	11.43	11.90	13.2	13.3
Ward	11.72	13.93	10.59			11.67	12.12	14.1	16.9
Wells	9.70	14.33	12.18	12.12	14.72	11.58	11.86	15.2	16.3
Williams	12.27	12.81	10.52	14.07	14.43	12.14	12.10	15.1	16.1
Average	12.00	13.29	11.33	12.30	14.23	11.82	12.12	13.7	15.0

Source: North Dakota Agricultural Experiment Station Bulletins 191, 208, 213, and 222 (*7, 8, 9, 10*). Mimeographed reports for crops of 1929 and 1930.]

TABLE 7.—*Average protein content of all car lots of spring wheat received at Minneapolis, from each of certain Montana shipping stations, August 1, 1929, to February 1, 1930* [1]

Station	Cars received	Protein	Station	Cars received	Protein
	Number	*Per cent*		*Number*	*Per cent*
Agawam	3	11.75	Colstrip	19	15.00
Amherst	2	13.85	Columbus	3	14.35
Amsterdam	1	12.80	Comertown	9	14.50
Antelope	19	15.35	Conrad	4	15.70
Archer	2	14.95	Crane	13	13.00
Atkins	1	9.50	Culbertson	31	15.50
Bainville	44	15.45	Cut Bank	3	12.55
Baker	174	13.65	Daleview	1	17.60
Beaverton	2	15.60	Denton	8	15.80
Belfry	1	13.20	Devon	11	13.60
Belt	3	15.35	Dillon	2	15.85
Benz	1	15.10	Dodson	4	15.55
Big Horn	1	17.20	Dooley	8	15.30
Big Sandy	11	14.80	Dupuyer	2	13.85
Billings	4	14.65	Edgar	21	13.70
Bole	2	15.55	Essig	1	13.00
Bowdoin	3	16.85	Fallon	40	13.40
Box Elder	6	13.80	Fairview	15	15.40
Boyd	1	13.20	Fife	1	17.70
Bozeman	29	13.00	Finch	1	16.10
Brady	1	13.10	Flaxville	24	14.75
Bridger	1	12.70	Forest Grove	1	16.10
Brockton	29	16.60	Forsyth	3	13.90
Brockway	29	16.50	Fort Benton	12	14.55
Busch	1	11.20	Four Buttes	8	14.10
Calais	8	17.10	Fowler	1	16.00
Camp Creek	1	13.50	Fox	3	12.95
Carlyle	53	14.15	Franklin	1	13.70
Carter	7	16.85	Frazer	25	17.20
Cascade	1	13.00	Fresno	2	18.10
Chapman	1	17.30	Fromberg	3	14.00
Chappell	1	16.00	Froid	77	16.15
Chelsea	5	15.35	Galata	5	17.10
Chester	19	14.30	Garneill	1	16.30
Chinook	22	15.70	Geraldine	13	14.65
Christina	3	16.10	Gildford	31	14.65
Circle	19	18.00	Glasgow	34	17.25
Clew	1	14.20	Glendive	70	14.60
Clyde Park	2	12.35	Glentana	18	16.00
Coalwood	1	12.70	Gluten	2	17.05
Coburg	4	14.95	Grassy Butte	1	13.20
Coffee Creek	8	17.35	Grass Range	9	16.45

[1] Data from the protein laboratory records of the Minnesota State Grain Inspection Department.

TABLE 7.—*Average protein content of all car lots of spring wheat received at Minneapolis, from each of certain Montana shipping stations, August 1, 1929, to February 1, 1930*—Continued.

Station	Cars received	Protein	Station	Cars received	Protein
	Number	*Per cent*		*Number*	*Per cent*
Great Falls	4	13.80	Plentywood	9	15.80
Greenwood	1	15.10	Plevna	102	13.75
Hanover	2	16.25	Pompey's Pillar	1	13.80
Hardin	10	14.40	Poplar	80	16.45
Harlem	12	13.45	Portage	2	16.95
Harrison	6	13.75	Rapelje	4	15.45
Hathaway	5	15.55	Raymond	26	16.35
Havre	37	15.95	Red Lodge	1	11.80
Helena	1	12.50	Redstone	23	17.40
Hilger	3	14.95	Reed Point	1	14.00
Hingham	31	13.65	Reserve	23	15.50
Hinsdale	7	16.30	Richey	44	16.65
Hogeland	17	14.70	Richland	10	15.90
Homestead	22	15.80	Rimroad	4	15.60
Hoyt	1	12.20	Roberts	18	12.95
Huffine	1	12.10	Rogers Spur	1	20.50
Ingomar	13	15.50	Ronan	1	12.40
Intake	9	15.10	Rosebud	19	13.90
Ismay	60	14.35	Roundup	8	15.85
Inverness	8	13.70	Roy	1	14.70
Joliet	1	15.50	Rudyard	48	14.10
Joppa	2	13.15	Ryegate	4	15.10
Joplin	37	14.40	Saco	17	14.75
Joseph	1	17.20	Savage	8	15.60
Kalispell	2	10.55	Schumaker	1	15.10
Kremlin	7	14.35	Scobey	25	16.65
Lakeside	4	17.30	Shaws Spur	2	12.50
Lambert	22	15.85	Shelby	1	12.90
Lane	1	13.80	Shepherd	1	12.80
Lanark	2	15.70	Shawmut	1	15.90
Larslan	2	12.80	Sidney	76	16.00
Laurel	12	14.20	Sprole	37	15.45
Ledger	1	12.00	Square Butte	2	12.75
Lewistown	24	14.50	State Line Siding	1	11.80
Lindsay	20	14.90	Stevenson	1	12.00
Livingston	1	11.40	Stipek	3	13.35
Lodge Grass	7	13.30	Stockett	2	17.85
Lohman	8	16.15	Suffolk	8	15.80
Loring	22	15.30	Sumatra	15	16.00
Lothair	13	13.60	Sunburst	12	10.95
Lux	3	11.95	Sun River	1	16.70
McCabe	11	15.15	Sweet Grass	7	10.35
McElroy	22	14.30	Teigen	1	15.20
Macon	3	17.60	Terry	66	14.70
Malta	55	15.90	Tiber	2	16.40
Manhattan	3	14.75	Tunis	1	18.30
Manson	2	12.20	Turner	33	16.60
Marsh	32	13.90	Valier	41	14.00
Medicine Lake	71	15.40	Vananda	8	15.55
Melstone	8	16.75	Vandalia	3	16.25
Midby	5	17.90	Vincent	1	13.30
Mildred	30	14.10	Volburg	1	14.00
Miles City	135	14.80	Wagner	5	12.95
Molt	2	15.55	Ware	2	18.25
Montague	3	16.70	Westby	60	15.80
Moore	8	15.80	Westmore	17	14.30
Moulton	2	16.05	Whately	1	18.30
Musselshell	3	16.30	Wheat Basin	1	12.50
Myers	1	14.80	Whitetail	23	16.95
Nashua	34	17.65	Whitewater	16	17.05
Nibbe	2	13.50	Wibaux	115	14.25
Nohle	15	15.55	Williams	2	15.15
Ollie	15	14.35	Wilsall	4	13.35
Orange	2	16.35	Winifred	6	14.90
Oswego	15	17.65	Winnett	14	15.60
Outlook	52	16.30	Wolf Point	81	17.10
Opheim	30	14.20	Wyola	1	13.10
Pablo	1	12.60	Yates	11	13.90
Park City	5	12.60	Youngs Point	3	13.45
Peerless	15	16.65	Zurich	7	14.05
Pendroy	2	15.35			
Piper	3	13.35	226 stations	3,274	14.85

TABLE 8.—*Wheat: Average and range of protein content for 18 growers located around a station in eastern Montana, crop of 1924*[1]

Grower No.	Tests	Average protein content	Grower's range	Grower No.	Tests	Average protein content	Grower's range
	Number	*Per cent*	*Per cent*		*Number*	*Per cent*	*Per cent*
1	3	13.01	12.80–13.40	11	3	12.00	11.20–12.95
2	3	12.90	11.40–13.75	12	3	13.40	10.50–15.10
3	2	11.70	11.45–11.95	13	2	12.70	11.40–14.00
4	2	13.30	13.00–13.60	14	4	12.58	10.80–13.95
5	2	13.07	12.55–13.60	15	2	12.37	12.10–12.65
6	2	11.50	10.30–12.70	16	2	12.80	12.75–12.85
7	2	12.65	11.85–13.45	17	2	13.07	12.90–13.25
8	4	12.98	12.15–14.65	18	2	12.10	12.10–12.10
9	2	12.55	11.70–13.40				
10	2	10.97	10.90–11.05	All	44	12.59	10.30–15.10

[1] From the following: KUHRT, W. J. A STUDY OF FARMER ELEVATOR OPERATION IN THE SPRING WHEAT AREA PART II. VARIATION IN THE PROTEIN CONTENT OF SPRING WHEAT, ESPECIALLY THE 1924 CROP, AND THE EFFECT OF SUCH VARIATION ON PRICES RECEIVED AND MARKETING METHODS USED BY FARMERS' ELEVATORS. U. S. Dept. Agr., Bur. Agr. Econ. [Pub.], p. 9. October, 1926. [Mimeographed.]

Variations in the average protein content of several wheat samples from each of 18 farms located around one shipping station in eastern Montana (Table 8) were as great as 2.43 per cent, and variations in different samples from the same farm were found to be as great as 4.6 per cent. Such variations plainly illustrate the fact that an equitable distribution of premiums among individual producers is not accomplished when premiums are based on the "station average." Under this system those producers who have low-protein wheat may obtain a price in excess of the actual commercial value of their wheat, whereas those who deliver wheat having a protein content above the station average may receive a price that is often materially less than the current market value of their product. On the other hand, the policy of paying a price for each individual lot of grain on the basis of its exact quality, gives the individual producer an incentive to strive for high quality in order to reap the rewards therefor. Investigational data showing the effect of certain farm-management practices on the protein content of wheat are given by the Kansas State Agricultural College (*2*).

CONSIGNMENT OF WHEAT TO TERMINALS TO OBTAIN FULL PREMIUMS

In some localities in which the local market practices do not reflect protein premiums adequately, many individual producers consign their wheat to commission firms in the terminal markets where it may be tested for protein content and where the full current protein premiums may be obtained.

The practice of consigning wheat shipments is often advantageous to those producers who are located in an area tributary to terminal markets in which the practice of purchasing wheat on the basis of its protein content is well established, especially when (1) the total supply of either hard wheat of high protein content or soft wheat of low protein content is small, and when the individual lots of wheat to be marketed are known to have protein content above or below the average, (2) the prevailing terminal-market protein premiums can not be obtained from local elevators, mills, or track buyers, (3) sufficient wheat is available, either as owned by the individual producer or controlled by a cooperative pool, to make possible the

consignment of car lots, and when (4) farm-storage facilities are available when necessary for assembling and storing the wheat prior to shipment.

Producers who have high or low protein wheat and who wish to consign it to the terminal markets have been handicapped in making decisions at harvest time as to the relative profitableness of immediate consignment or of farm storage and future consignment because early-season, comprehensive, and reliable estimates of the supply of high and low protein wheat have not been available. As a result, the protein premiums heretofore established during the early autumn months have not always reflected accurately the relation between the current supply of and demand for either high or low protein wheat. (Figs. 3 and 4.)

COUNTRY ELEVATOR PROBLEMS IN BUYING BY PROTEIN CONTENT

Farm conditions are such that the majority of wheat producers are required, or they prefer, to dispose of their wheat through the country elevators. For this reason the problem of reflecting protein premiums to individual producers must give much consideration to the country elevator and its problems in handling wheat as it is delivered directly from the combines and threshing machines.

Numerous attempts have been made by the country elevators in the spring-wheat area to distribute protein premiums to their individual customers in accordance with the tests made on composite samples of each customer's wheat. Difficulties have been encountered in the operation of this plan. It has been found difficult, for instance, to balance the total premiums paid to the individual customers with the premiums actually received by the country elevator on its car-lot shipments to the mills or terminal markets.

In the second place, the instability of protein premiums at the terminal markets, especially during the early part of each shipping season (figs. 3 and 4) has made it difficult for the country elevator to maintain an accounting balance between its actual receipts for protein premiums and its currently incurred premium obligations to its customers. Many country elevators have suffered heavy losses for this reason, and these losses have discouraged the plan of reflecting protein premiums to producers according to the tests of their individual deliveries. In solving this feature of the protein-premium problem, it should be kept in mind that market hedging of purchases based on protein specifications is not possible as is the case with purchases based on grade specifications.

Various causes have contributed to this difficulty. In the first place, storage and handling conditions at the country elevators during the heavy, early-season grain movement often have been such as to prevent the separate binning and loading of wheat lots of different protein content. Neither bin space nor time has been available always during the harvest rush of grain to bin and handle the wheat according to its protein content. Often the elevator manager has known little or nothing about the protein content of the various small, individual lots he was handling daily while he was awaiting reports from the protein laboratories of the tests made on the customers' composite samples. As a matter of fact, many small, individual lots of grain passed into the country elevator, were assembled in larger

lots, were moved to the terminal market and sold on a car-lot protein test before the manager knew anything about the protein content of the many individual lots he had been handling. Thus, wheat of relatively high protein content may have been loaded in a car with wheat of low protein content, or with wheat of station-average content, so that, at the end of the shipping season, the car-lot sales to the terminal market of 14 per cent, 13 per cent, 12 per cent, and 11 per cent protein wheat, respectively, often did not correspond to the quantities of 14 per cent, 13 per cent, 12 per cent, and 11 per cent protein wheat, respectively, received by the elevator and credited to its customers according to the tests made on their individual deliveries.[4]

The problem of the country elevator with respect to balancing the quantities of wheat of 14, 13, 12 per cent, etc., protein content, which it sells in the terminal markets, with the quantities of wheat of similar protein percentages which it receives from producers, is one that may be solved through operating experience and adequate data. Data obtained from several years of operation would determine the approximate percentage variation between the protein contents of the car-lot sales and those of the receipts from producers, which percentage variation could be employed as a necessary operating cost and charged to the deliveries made by each customer. A similar practice is now followed by many country elevators in connection with the handling of grain by grade.

A number of progressive country-elevator managers in the spring-wheat area have solved this problem in elevator management by means of a preharvest protein survey in the local area from which the elevator draws its wheat. Samples are collected from the fields of numerous sections within the local area at harvest time and are tested for protein content. From the data so obtained the area is mapped to show the variations in the protein content of the local crop in an approximate manner. Subsequently, as the wheat is delivered, it can be divided, according to the protein map, into lots of high, medium, and low protein content, and binned or shipped accordingly. Although this method for segregating wheat of varying protein content is not accurate, it serves, nevertheless, as a practical and useful guide, and permits the elevator manager to maintain an approximate balance between his sales of, and obligations for, 14 per cent, 13 per cent, 12 per cent, etc., protein wheat, respectively. Under this plan, the premiums paid to growers are not based on the local-area protein map but on actual tests made from composite samples of deliveries. The practicability of this plan is contingent on close proximity of the country elevator to protein laboratories that are equipped to render prompt and accurate reports on the preharvest samples.

The problem of the country elevator in protecting its protein transactions with individual customers from possible losses caused by the fluctuations of protein premiums at the terminal markets is much more difficult of solution. Early-season adjustment of protein premiums to reflect accurately the current relationship of the supply of and demand for high-protein wheat would materially

[4] Additional information regarding this problem in country-elevator management is given in the following: STOKDYK, E. A., and HOFFMAN, A. C., PROTEIN AND COUNTRY-ELEVATOR BUYING. Kans. Stat. Agr. Col. Marketing Notes v. 4, no. 5. May, 1928. [Mimeographed.]

assist the country-elevator manager in the development of operating methods whereby terminal-market premiums, after the deducting of reasonable operating and risk charges, could be reflected to producers in accordance with the protein tests of their individual deliveries.

NATIONAL PROTEIN SURVEYS, MARKET NEWS, AND EDUCATIONAL WORK

The marketing of wheat by its protein content would be facilitated and improved by (1) annual, national, premarketing protein surveys; (2) authentic current estimates of the average protein content of the wheat crops based on premarketing surveys and on current tests of market receipts; (3) current information and market news with respect to protein premiums and the protein content of the current crop and carry-over; and (4) educational work among producers and country shippers regarding the entire subject of marketing wheat by its protein content. Any plan to improve the practices which now govern the marketing of wheat by its protein content should give special consideration to an annual, national premarketing protein survey of the wheat crop.

Service work of this character would be of material importance in the adjustment of terminal-market premiums at all seasons of the year to represent properly the demand for high-protein wheat in relation to the available supply, and in assisting producers to make decisions as to whether immediate sale, farm storage, sale by consignment to terminal markets, direct sale to millers, or sale through the country elevators, would be most advantageous in obtaining maximum protein premiums.

Nation-wide premarketing protein surveys do not lend themselves readily to private enterprise. It is not likely that the grain industry itself will organize and conduct these premarketing protein surveys in a nationally comprehensive manner. Many representative samples would have to be obtained quickly from many shipping points in each important producing area during the short harvest season; the survey samples would have to be tested promptly and accurately; and the data so obtained would have to be collated and disseminated quickly to be of value to producers and shippers in making decisions with respect to the sale of their crops and to be of value to the grain trade in the establishment of early-season premiums.

IMPORTANCE OF PREMARKETING ESTIMATES OF PROTEIN CONTENT

It has been shown by Table 3 and Figure 1 that normally the premiums for high-protein wheat are determined principally by the average protein content of the current crop. It follows that if comprehensive premarketing protein surveys were made of each new crop of hard red winter and hard red spring wheat and if estimates prepared therefrom were released promptly for each large producing area, together with estimates of the quantity of the carry-over and its protein content, such estimates would normally function (1) as a basis for the early establishment of protein premiums that would reflect in an approximately accurate manner the relation between the supply of and the demand for high-protein wheat, and (2) as an in-

dex of market conditions with respect to protein, which producers and country shippers could use in planning the marketing of their crops.

The harvesting of hard red winter wheat extends through a period of about six weeks—June 1 to July 15—and that of hard red spring wheat through a period of about two months—July 15 to September 15. For this reason, a final estimate of the average protein content of the total crop of each of these classes of wheat can not be made at the outset of each marketing season. But preliminary estimates could be made that would be approximately accurate indexes of the final estimate of the average protein content of the entire crop of each of these hard wheats. This would be possible because the major part of the total acreage of hard red winter wheat is in Texas, Oklahoma, and Kansas, and is harvested largely within a period of three weeks and because the major part of the acreage of hard red spring wheat is in South Dakota, North Dakota, and Montana, and is harvested largely within a period of four weeks. Thus it would be possible to release preliminary estimates of protein content from a major part of the producing area, within relatively short periods of time, that would correspond closely to the final estimates.

A series of protein-content estimates based on thorough premarketing surveys, and released periodically as the harvest progresses from Texas to Montana, would be much more reliable and useful than the inadequate, nonrepresentative, and often confidential character of the protein data for the whole crop now available.

The experiences of the Minnesota State Grain Inspection Department and the Montana and North Dakota Agricultural Experiment Stations in conducting premarketing protein surveys in parts of the spring-wheat area, have demonstrated the feasibility of making comprehensive, preliminary estimates of the average protein content of the crops of wheat of different classes that would correspond in an approximately accurate manner with the final estimates based on protein tests of market receipts. (Table 9.)

TABLE 9.—*Comparison of premarketing estimates of the average protein content of portions of the spring-wheat crops in Minnesota, Montana, and North Dakota, with the average protein content determined from market receipts, 1926, 1927, and 1928 (per cent)*

State	Average protein content in certain counties in—					
	1926–27		1927–28		1928–29	
	Premarketing survey	Market receipts	Premarketing survey	Market receipts	Premarketing survey	Market receipts
Minnesota	[1] 12.75	[2] 12.40	[2] 11.45	[2] 11.45	[2] 12.30	[2] 12.35
Montana [3]	13.94	14.00	12.24	12.39	12.24	12.22
North Dakota	[4] 14.73	[2] 13.20	[5] 11.75	[2] 11.70	[5] 12.12	[2] 12.15

[1] Sherwood, R. C. (*13*).
[2] Data from Minnesota State Grain Inspection Department, presented by A. H. Andresen, Congressman from Minnesota, at hearings before the Committee on Agriculture, House of Representatives (*18*).
[3] From unpublished records of the Montana Agricultural Experiment Station furnished by the courtesy of Clyde McKee, agronomist.
[4] Mangels, C. E., Stoa, T. E., and Guy, W. (*10*).
[5] ———, Stoa, T. E., and Dynes, R. C. (*9*).

OBJECTIVES OF EDUCATIONAL SERVICE

In addition to the current estimates of crop protein content, and market-news service pertaining to protein premiums, protein supply, and demand for high and low protein wheat, an educational program pertaining to the marketing of wheat by its protein content would be of benefit to producers and shippers in assisting them to market their wheat advantageously.

Such educational work should emphasize the advantages to producers of obtaining protein tests on their wheat each season prior to marketing, and should advise them how and where to obtain such tests. It should provide specific instructions with respect to sampling methods that would assure a representative sample, so that protein tests made on the samples submitted by producers would not vary materially from the tests made on their deliveries in terminal markets. It should further provide information on the use of "agreed samples" for protein testing in connection with transactions between producers and country elevators, track buyers, interior flour mills, or other buyers of country-run wheat, for the purpose of avoiding disputes as to the test that shall determine the contract of sale.

Such educational work also should include the subjects of farm storage, country-elevator buying of wheat by its protein content, and the interpretation of the protein-survey and market-news data so as to meet community and individual marketing problems. Educational work of this character would require close cooperation among several branches of the United States Department of Agriculture, the State agricultural colleges and agricultural extension services, the State departments of agriculture and grain-inspection departments, and other public organizations.

USE OF PROTEIN TEST IN WHEAT MARKETING

PROTEIN TEST AS THE COMMERCIAL MEASURE OF BAKING QUALITY

The domestic milling and baking trade has adopted the protein test as the most reliable commercial measure of the potential baking quality of wheat for bread and pastry-making purposes. Flour millers commonly maintain their own protein-testing laboratories and rely chiefly on the protein tests to govern the mill mixing of various lots of wheat so as to maintain a uniform protein content in the flour. Other laboratory tests of wheat and flour to ascertain baking quality are made by many millers and bakers, such as the gluten test and the actual baking test, but it is generally conceded that the protein test is the most practicable scientific test to use as a commercial standard for the determination of baking quality.

Indexes of the potential baking quality of wheat, such as hardness and softness of kernel texture, that were commercially satisfactory 10 or 15 years ago when home baking was usual, are no longer entirely satisfactory to all bakers in these days of extensive factory production of bread, pastries, and crackers. The machine methods of factory baking, as well as the public demand for a high-class bread, pastry, or cracker product, have made it necessary for the

mills to manufacture flour of uniform quality as well as flour of different special types, in order to meet the exacting requirements of the baking trade.

The factory bread bakers analyze their flour supply in a particular manner with respect to the quality of bread it will produce, the number of loaves it will produce per barrel of flour, and the suitability of the flour to machine methods of preparation for baking. Flour is demanded that will stand the stress of the modern mechanical mixing devices, and that will make a light-textured loaf of large volume in proportion to weight, to fulfill the requirements of the retail trade. Flour made from high-protein wheat usually meets these requirements better than does flour made from low-protein wheat.

The factory bakers of pastries, biscuits, and crackers, on the other hand, prefer a flour of relatively low protein content. The pastry manufacturers desire a flour from which tender, mealy products may be made, and the cracker manufacturers desire close texture in their product rather than light texture. Among the bread bakers, the European factory bakers, as well as many home bakers in the United States, prefer a loaf of relatively small volume with a firm, close texture. The requirements of all such bakers are best met by flour made from soft wheat of low protein content.

It is these special requirements of the baking trade that are chiefly responsible for the adoption of the protein test in many markets as the commercial measure of the potential baking quality of wheat.

KERNEL TEXTURE AS A MEASURE OF PROTEIN CONTENT

In the early days of grain standardization and inspection whatever market recognition was given to the potential baking quality of wheat was based on the general appearance and physical texture of the grain and was expressed chiefly by the individual preferences of buyers in sample markets. From these early experiences in wheat marketing and flour manufacturing the characters of dark color and hardness of kernel texture came to be associated with a high degree of potential baking quality in wheat for bread-making purposes. Thus, eventually, grade specifications for kernel color and texture were included in many of the wheat standards which preceded the Federal standards. These early color and texture specifications, however, were not very precise, and much latitude existed in their application by inspectors.

The Federal standards for wheat, promulgated in 1917, were so formulated as to provide subclasses based on definite specifications of hard and vitreous kernels for the classes of Hard Red Spring, Hard Red Winter, Durum, and White Wheat. These definite subclass specifications, applied by uniform, definite methods of interpretation, are a distinct improvement in the use of physical characters to measure variations in the potential baking quality of wheat. At the time of their adoption they gave partial recognition to the problem of providing a measure of the potential baking quality of wheat that could be used regularly in commercial practice in the place of mere buyers' preferences.

Research has shown that a fairly strong tendency exists for protein content to increase as the percentage of dark, hard, and vitreous

kernels increases, and that the relation between such kernels and protein content is pronounced in samples having a high percentage of dark, hard, and vitreous kernels (*14*). Nevertheless, the correlation is not constant. Modern protein testing has revealed the fact that many car lots of hard red spring wheat of the subclass Northern have a higher protein content in a given season than do other car lots of the superior subclass Dark Northern; also that many car lots of hard red winter wheat of the subclass Hard Winter have a higher protein content than other car lots of the superior subclass Dark Hard Winter. Millers, therefore, can not rely solely on the Federal subclass specifications as measures of the potential baking quality of wheat, and in order to regulate their purchases and mill mixes so as to maintain uniform flour quality, they must supplement the evidence given by the Federal grades with the evidence derived from the protein test.

Although in many markets the subclasses of the Federal wheat standards are no longer relied upon as the sole measure of potential baking quality, they still function widely and usefully as approximate measures of such quality in grain-futures contracts, export contracts, and other contracts, in grain-storage practice, and in the marketing of wheat at those country points at which protein-testing facilities are not available. In addition to being approximate indexes of the potential baking quality of wheat, the subclasses that are based on a high percentage of hard and vitreous kernels, are indexes usually of good condition and quality for milling. Wheat of these subclasses, also, usually has a bright and fancy appearance that makes it attractive to buyers. For these reasons the subclasses of the Federal wheat standards still function in reflecting market requirements, and are of importance to producers and country shippers. This is evidenced by the fact that premiums prevail for wheat of the subclasses Dark Northern Spring, Dark Hard Winter, Amber Durum, and Hard White, even in seasons such as 1929–30 and 1930–31 when protein premiums were very small or were nonexistent.

CERTIFICATION OF EXACT PROTEIN CONTENT

Commercial practice in the merchandising of wheat by protein content usually recognizes variations in protein content as low as 0.2 to 0.25 per cent, and price differentials are established on such variations in those years when protein is a factor of importance. In fact, there have been times when high-protein wheat was so scarce that premiums over a basic percentage of protein have been paid of 1 cent for each 0.1 per cent protein.

This established commercial practice requires that protein content be determined as exactly as possible and that exact statements of protein content be recorded on certificates. Approximate determinations of the protein content with certification in such general terms as "high," "medium," and "low," would not satisfy trade requirements.

PROTEIN CONTENT NOT A PRACTICABLE GRADE FACTOR

All proposals to include protein content as a grade factor in the Federal wheat standards are entirely impracticable. To illustrate the difficulties that would be encountered in making protein a

grade factor, the present Federal standards for hard red spring wheat are shown, in abbreviated form, in Table 10, with assumed grade specifications for protein added thereto in such a way as to comprise the range of protein content that exists in the major part of the commercial lots of spring wheat.

If protein were made a grade factor, as shown in Table 10, the factor of protein would be given equal weight with the factors of test weight, moisture, damaged kernels, etc., in the determination of grade; thus the grade of wheat might be lowered because of its protein content although it met all the requirements of No. 1 grade according to all factors other than protein.

TABLE 10.—*Illustration of standards for hard red spring wheat, which would include protein as a grade factor*

Grade No.	Minimum limits of—		Maximum limits of—						
	Protein [1]	Test weight, per bushel	Moisture	Damaged kernels		Foreign material other than dockage		Wheats of other classes	
				Total	Heat damage	Total	Matter other than cereal grains	Total	Durum
	Per cent	*Pounds*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
1	14	58	14.0	2	0.1	1	0.5	5	2
2	13	57	14.5	4	.2	2	1.0	10	5
3	12	55	15.0	7	.5	3	2.0	10	10
4	11	53	16.0	10	1.0	5	3.0	10	10
5	9	50	16.0	15	3.0	7	5.0	10	10

[1] Protein is not a grade factor in the United States grain standards.

With grade requirements for protein such as those given in Table 10, a material part of the spring-wheat crop, in most years, would grade No. 3 and No. 4, according to the factor of protein, irrespective of its other qualities according to the factors of test weight, moisture, damage, etc. Moreover, in years when the average protein content of spring wheat is high, or in years when the protein content varies widely in different producing areas, a material part of the market receipts would test 14 per cent or more protein and would grade No. 1, according to the protein factor. Under such circumstances the grade designation of No. 1 would not indicate the superior quality of those lots of wheat which have more than 14 per cent protein content, and, therefore, would not function as a proper index of the market value of such lots of wheat. In years when the protein content of spring wheat is spotted throughout the producing areas, a range of protein content from 9 to 18 per cent may exist, and occasional lots may test as high as 20 per cent. It would be an injustice to those producers who have wheat testing from 14 to 18 per cent protein, to grade all such wheat under a widely inclusive No. 1 grade based on a minimum protein requirement of 14 per cent.

It may be contended that such an injustice may be obviated by providing a higher protein requirement for grade No. 1—such as 16

per cent—and by establishing intervals of about 2 per cent between the protein percentage requirements for each of the five numerical grades. By this plan the grade requirements for protein would then read: Grade No. 1, 16 per cent; No. 2, 14 per cent; No. 3, 12 per cent; No. 4, 10 per cent; and No. 5, 8 per cent. Such grade requirements for protein would be more unjust to producers and shippers, as a matter of fact, than those given in Table 10, because, in all years. only a small fraction of the market receipts would grade No. 1, and a large fraction would be graded lower than No. 2 irrespective of its qualities according to the factors of test weight, moisture, damage, etc.

It is impossible to establish protein specifications for five numerical wheat grades that will meet commercial requirements and reflect relative market values equitably to producers. Because premiums are paid at times for protein variations as small as 0.25 to 0.2 per cent, any grade specifications for protein which have either 2 per cent protein content intervals between grades, or 1 per cent intervals between numerical grades with a wide range of 4 to 6 per cent protein content in the No. 1 grade, are entirely impracticable.

Another reason that it is impracticable to make protein a grade factor is that the importance of the protein factor in the determination of market value varies from year to year to a far greater extent than do such official grade factors as test weight, moisture, damage, foreign material, and wheats of other classes. Protein is a negligible factor in determining the market value of the hard wheats in those years in which the total supply of high-protein wheat is relatively large, whereas such factors as test weight, moisture, damage, and foreign material, function constantly as measures of value because they reveal the quality and condition of the wheat for transportation, storage, and mixing purposes, as well as for milling purposes. Thus, were protein content made a grade factor, it would function in the determination of grade in some years when it has little or no bearing on market value.

It should be recalled, also, that in some of the wheat classes, especially Hard Red Winter wheat, both high and low protein content may establish premiums, according to the demand for each type of wheat. Thus, if the standards required a relatively high protein content for the No. 1 grade and a relatively low protein content for the No. 5 grade, the grade of the grain would be determined inversely at times according to market evaluation of the protein content.

Finally, there are many more commercial transactions in wheat that are not based on protein specifications than are based on specifications which include protein content. Protein specifications are not used extensively in export or future-delivery contracts, nor in the many transactions at country elevators between producers and elevator managers, nor in the many transactions between country shippers and terminal elevators. Thus, if protein content were made a grade factor the grades would be encumbered with a technical measure of quality that is not essential to a vast number of the commercial transactions in wheat.

Protein content should be recorded on certificates in exact terms and should be stated separately from the grade designation.

PROTEIN-TESTING SERVICE ESTABLISHED BY STATE AND COMMERCIAL LABORATORIES

To meet the commercial demand for protein tests of wheat that has arisen since about 1923, protein-testing laboratories have been established by State, grain-exchange, and private organizations at many places in the principal hard red spring, hard red winter, and white wheat areas. Other protein-testing laboratories have been established at the State agricultural colleges in the important grain States for experimental purposes and for rendering some limited service to wheat growers. The majority of the large flour mills in the hard red spring, hard red winter, and white wheat areas also maintain protein-testing laboratories for use in connection with their purchases of wheat and their mixing and manufacturing operations.

The State, exchange, and commercial laboratories, which function principally to make tests for commercial use, are usually self-supporting from the fees charged for the tests, which fees usually range from 50 cents to $1 per sample for either a single or duplicate test.

The laboratories established in the United States during the period 1925 to 1930, which are equipped to make protein tests and which are now available to the public, are shown in Table 11. This table shows also that in several instances laboratories that were established at interior shipping points during the years when high-protein premiums were being paid (1927–28 and 1928–29) were abandoned subsequently, when the demand for tests declined as a result of decreased

TABLE 11.—*Laboratories equipped to make protein tests in the United States, available to the public: Location, number, and ownership, 1925–1930* [1]

[Abbreviations representing ownership: P=private; S=State; E=grain exchange]

Location	Operating 1925	Established 1926	Established 1927	Established 1928	Established 1929	Established 1930	Operating 1930
California:							
Los Angeles [2]							2-P
Sacramento					1-P		1-P
San Francisco [2]							3-P
Colorado:							
Denver			1-P				1-P
Fort Collins	1-S						1-S
Idaho:							
Moscow	1-S						1-S
Pocatello	1-P				1-S		1-P, 1-S
Illinois: Chicago [2]							10-P
Indiana:							
Indianapolis [2]							3-P
Lawrenceburg		1-P					1-P
Iowa: Sioux City	1-E						1-E
Kansas:							
Dodge City				1-P			1-P
Hutchinson	1-S						1-S
Leavenworth	1-P						1-P
Salina	1-P						1-P
Wichita	1-S						1-S
Louisiana: New Orleans	3-P						3-P
Minnesota:							
Duluth	1-P			1-P	1-P		1-P
	1-S						1-S
Minneapolis	3-P			2-P			5-P
	1-S						1-S
	1-E						1-E
Mississippi: Meridian	1-P						1-P
Missouri:							
Kansas City	2-P						2-P
	2-S						2-S
St. Joseph	1-P						1-P
St. Louis	1-P			1-E			1-E, 1-P

[1] Some of the private laboratories given in this list are commercial chemical laboratories which are not conducted primarily for the purpose of making protein tests on grain.

[2] Date established not reported.

premiums. The location of these laboratories in 1930 and their ownership, whether State, exchange, or private, are shown in Figure 5.

TABLE 11.—*Laboratories equipped to make protein tests in the United States, available to the public: Location, number, and ownership, 1925–1930*—Con.

[Abbreviations representing ownership: P=private; S=State; E=grain exchange]

Location	Operating 1925	Established 1926	Established 1927	Established 1928	Established 1929	Established 1930	Operating 1930
Montana:							
Bainville		1-P					[3] 1-P
Billings				1-P			[3] 1-P
Bozeman	1-S						1-S
Conrad				1-S			[3] 1-S
Glasgow				1-S			[3] 1-S
Glendive				1-S			[3] 1-S
Great Falls	1-S						1-S
Harlowton				1-S			1-S
Havre				1-S			[3] 1-S
Lewistown			1-P		1-S		1-P
Nebraska:							
Grand Island		1-P					1-P
Nebraska City					1-E		1-E
Omaha	1-E				1-P		1-E, 1-P
Schuyler				1-P			1-P
New York: New York City [2]							2-P
North Dakota:							
Fargo						1-P	1-P
Grand Forks [4]	1-P, 1-S						2-P, 1-S
Minot				1-P	1-P		1-P
Williston					1-P		1-P
Ohio:							
Columbus [2]							1-P
Troy	1-P						1-P
Oklahoma:							
Alva	1-P						1-P
Blackwell	1-P						1-P
Chickasha					1-P		1-P
El Reno	2-P						2-P
Enid	3-P						3-P
Kingfisher	1-P						1-P
Oklahoma City	1-P			1-S			1-P, 1-S
Ponca City	1-P						1-P
Oregon:							
Astoria	1-P						1-P
Corvallis	1-S						1-S
Pendleton	2-P						2-P
Portland	1-S				1-S		1-S
The Dalles	1-P						1-P
Texas:							
Amarillo	1-P		1-P		1-P		1-P
Dallas	1-P			1-P	1-P		1-P
Fort Worth	1-P	1-P		1-P	2-P	1-E	1-E
	1-E						1-P
Galveston	1-P						1-P
Lubbock					1-P		1-P
Houston	2-P						2-P
Plainview	1-P						1-P
San Antonio	2-P						2-P
Sherman	1-E				1-P		1-E
Wichita Falls	1-P						1-P
Wolfe City				1-P			1-P
Utah:							
Ogden	2-P						2-P
Salt Lake City	1-P						1-P
Virginia: Norfolk	1-P						1-P
Washington:							P
Pasco	1-P						[3] 1-P
Pullman	1-S						1-S
Seattle	3-P						2-P
Spokane	3-P						3-P
Tacoma	5-P						3-P
Waitsburg	1-P						1-P
Wisconsin: Superior	1-S						1-S
Total	58-P	4-P	3-P	10-P	12-P	1-P	95-P
	5-E			1-E	1-E		7-E
	15-S			6-S	3-S	1-E	22-S

[2] Date established not reported.
[3] Closed after 1930.
[4] Date established for 1 laboratory not reported.

During the crop years 1927–28 and 1928–29, when protein was a factor of material importance in the determination of wheat prices, evidence was gathered and was given publicity, by representatives of the wheat producers and country shippers, to establish the fact that material variations in protein tests between the State, exchange, and private laboratories were so common as to be a cause of dissension between sellers and buyers and often to cause losses in the premiums obtained. Evidence submitted, for example, to the Committee on Agriculture of the House of Representatives in January, 1929 (*16, p. 25–43*), shows many variations as great as 0.4 to 0.6 per cent in the protein determinations made on the same car lots of wheat by different laboratories, and occasional variations as great as 1 to 1.7 per

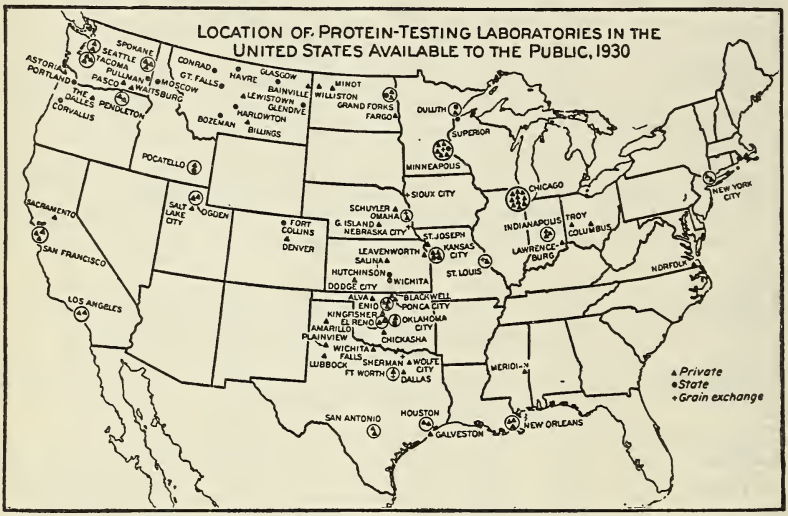

FIGURE 5.—LOCATION OF THE PRINCIPAL STATE, GRAIN-EXCHANGE, AND PRIVATELY OPERATED LABORATORIES EQUIPPED TO MAKE PROTEIN TESTS THAT WERE AVAILABLE TO THE PUBLIC IN 1930

Some of the private laboratories shown are commercial chemical laboratories that are equipped to make protein tests but that do not make protein testing their chief business. The number of nonterminal State and private laboratories operated solely for wheat-protein-testing purposes has fluctuated somewhat from year to year in accordance with the varying importance of protein content as a factor in the determination of market values for wheat.

cent. Such variations, at the premium then being paid for protein, affected the price in many instances as much as 4 to 7 cents per bushel and in some instances as much as 15 to 20 cents per bushel.

The principal causes of variations in the protein tests made at present (1931) by different laboratories are (1) protein content commonly is not computed on a uniform moisture base, nor is the moisture content noted on protein certificates to indicate the exact relation between protein content and the dry matter of the wheat, (2) sampling of commercial lots of wheat does not always employ the systematic and thorough methods of probing necessary to obtain a representative sample, (3) original samples from commercial lots are not always cut down to laboratory size, cleaned of foreign ma-

terial, ground, and otherwise prepared for testing, by uniform methods, and (4) uniform apparatus, chemicals, and methods are not used by all laboratories in making the protein determination.

At present (1931) the protein-testing laboratories are not giving definite consideration to moisture content in their certification of protein content. The protein content of wheat varies inversely with the moisture content, that is to say, as the moisture content increases the protein content decreases and vice versa. "For each per cent change in the moisture content of the sample there will be a corresponding change, equivalent to 1 per cent of the protein content originally present" (*4, p. 21*). Thus, if a sample of wheat contains 13 per cent protein at a moisture content of 14 per cent, and the sample is dried to 12 per cent moisture, the protein content on the new moisture basis will be 13.26 per cent.

A practical illustration of the effect of moisture content on protein content is shown by the protein tests made in 1928 on six portions of the same sample of wheat, sent to a Minneapolis commission firm from Havre, Mont., in different containers, under conditions as follows (*1, p. 20*):

	Protein	Moisture
	Per cent	*Per cent*
Sample in tin container	12.25	13.70
Sample in cloth sack	12.60	11.76
Sample held overnight at Havre office	12.80	10.80
Sample held 48 hours in Havre office	12.80	10.90
Sample held 48 hours in cool place	12.56	11.75
Sample held 72 hours in warm place	13.00	9.55

The relation between protein content and moisture content is well known in the grain trade. Samples are sometimes submitted for testing which have been artificially or naturally dried so as to have a lower moisture content than the lots from which they were taken, thus causing a false and slightly increased protein reading for the commercial lot of grain. Many buyers of grain are aware of the protein variations caused by drying of samples and refuse to recognize retests made on the same sample used for the original test, or even on a new sample from a lot of grain that has had time to dry out since the original test was made.

Variations are bound to occur in the commercial use of protein tests so long as the protein determination is made without giving consideration to the moisture content of the sample. The practical solution of this problem is to test all samples for moisture as well as for protein and then either to (1) compute the protein content on a uniform moisture base, and certify protein content accordingly or (2) certify both the protein and the moisture content on the same certificate, thus to provide complete information for the use of the grain trade in the determination of protein premiums.

Variable samples, caused by the use of different methods in obtaining samples from commercial lots, are probably responsible for more variations in the protein tests on given lots of wheat than any other single factor. The samples used by the various protein laboratories are not all taken from the commercial lots of wheat by systematic and thorough methods of probing, blending, and cutting down

the original sample to a small-sized sample for laboratory use. Some of the laboratories undoubtedly use representative samples obtained by careful, systematic methods of probing and handling, but others make and certify tests that are based on samples obtained from careless or unsystematic probing or on submitted samples which are not known to be representative.

Variations between tests made from officially drawn, representative samples and from either carelessly drawn or submitted samples, are to be expected. The protein analyst may not be at fault, but the method of sampling may be, and often is, under existing procedure. The submitted sample may be, and often is, entirely unrepresentative of the commercial lot of grain. It may have been taken from the mixture of a small number of probes, or from the top of the load, and thus be nonrepresentative, or it may have been dried out to have a percentage of moisture lower than that of the commercial lot, thus causing a false test of the commercial lot.

The importance of systematic and thorough sampling to obtain representative samples and thereby to minimize interlaboratory variations in tests of the same lot of wheat, is well illustrated by an experiment in sampling and testing a car of Montana wheat, conducted by the Minnesota State Grain Inspection Department in the spring of 1929. Prior to this experiment the car had been tested by three different laboratories, with the following results: 14.40, 13.65, and 13.90 per cent protein, respectively. Thereafter 10 probes were made in the car, and a test was made of the sample from each probe. The highest test so made was 14.6 per cent, the lowest 13.2 per cent, with other tests falling between these extremes; the average of the 10 tests was 13.81 per cent protein (*17*, *p. 33*). This experiment illustrates the wide variations in protein tests which may result from the use of samples that are not representative of a large lot of wheat because they were not prepared by systematic methods of probing, blending the grain from the various probes, and cutting down the original sample to laboratory size.

Studies made by the United States Bureau of Agricultural Economics in 1926 of protein-testing methods used by the State, grain-exchange, and private laboratories (*4*), showed that samples ranging from 6 to 60 grams in size were being used and that in the grinding of the small samples a loss of moisture occurs that affects the protein determination materially. Standard methods require the use of laboratory samples of at least 30 grams. Other variations were observed that were due to grinding the samples in overheated laboratory mills, thus causing a loss of moisture in the sample, or to neglect in cleaning the mills thoroughly between the grinding of each sample, thus causing a partial mixture of the samples.

Some laboratories, it was observed, were more careful than others with respect to the removal of foreign material from the samples before they were ground. The investigations showed, further, that finely ground samples assure a more representative sample for the test than unground or coarsely ground samples, and that this detail in laboratory procedure was not standardized among the protein laboratories.

Most important of all, these studies showed that three different methods were in common use among the laboratories for making the chemical protein test, although the Kjeldahl method is recommended as being the most practicable and accurate by the Association of Official Agricultural Chemists and the Bureau of Agricultural Economics of the United States Department of Agriculture. Although there has been some improvement in laboratory procedure since the investigations and published findings of the Bureau of Agricultural Economics in 1926, much nonuniformity in protein-testing procedure still prevails (1931), especially with reference to sampling, computing the protein content on a uniform moisture basis, and certification.

CERTIFICATION OF PROTEIN AND GRADE INFORMATION

Both protein and grade contract specifications are used in the merchandising of a large part of the hard red spring and hard red winter wheat crops and of a small part of the durum, soft red winter, and white wheat crops. Under the provisions of the United States grain standards act, the grade of wheat is certified only on official certificates issued by either licensees or employees of the United States Department of Agriculture. Under the conditions now prevailing (1931), however, in commercial protein testing, the protein content of wheat is not certified on the official certificates of grade but separately and on various forms of certificates issued by State and commercial laboratories which are not a part of the Federally supervised grain-inspection service.

Where wheat is merchandised according to both grade and protein specifications, the grain trade has expressed a preference for one official certificate that will evidence the protein content as well as the grade, issued by one inspection agency.

STANDARDIZATION OF SAMPLING, TESTING, AND CERTIFICATION

The existing lack of uniformity in the methods of sampling, testing, and certification of wheat for its protein content, followed by the numerous State, exchange, and private laboratories, indicates the desirability of adopting a standardized method in making protein tests for commercial use. The adoption of a standardized method of protein testing as a requirement for official certification would not interfere with the use of the standard method by colleges, mills, and commercial analysts, for any purpose other than official certification. Maximum intermarket uniformity and efficiency can not be obtained without such standardization. Should the number of protein-testing laboratories increase, the necessity for standardization would become increasingly important to prevent intermarket variations.

Some improvement in the intermarket uniformity of protein tests has been made since 1926 as a result of experience gained by the leading protein-testing laboratories, the recommendations of the American Association of Cereal Chemists, and the investigations and recommendations of the Bureau of Agricultural Economics. The data given in Table 12, from an interlaboratory experiment on the uniformity of protein tests conducted by the American Association of

Cereal Chemists in 1930, are indicative of this progress. From these data it may be noted that 90 per cent of the protein tests made by 71 laboratories on portions of the same sample of wheat were within a 0.25 per cent variation from the average protein content for the 71 tests, and that the greatest variation from the average was 0.57 per cent. Average protein content for the 71 tests was 12.92 per cent; greatest single variation from the average was 0.57 per cent, and seven variations from the average were greater than 0.25 per cent. Such variations as did occur in this interlaboratory check were caused, in all probability, by variations in the individual methods employed in grinding and otherwise preparing the sample for testing and in the chemical reagents used. The often important variations caused by sampling and moisture content were not present in this interlaboratory experiment.

TABLE 12.—*Protein tests on same sample of wheat as made by 71 members of the American Association of Cereal Chemists in 1930*[1][2]

Collaborator No.	Crude protein	Variation from average	Collaborator No.	Crude protein	Variation from average	Collaborator No.	Crude protein	Variation from average
	Per cent	*Per cent*		*Per cent*	*Per cent*		*Per cent*	*Per cent*
1	13.15	0.23	25	12.91	0.01	49	12.84	0.08
2	13.00	.08	26	13.25	.33	50	12.58	.34
3	12.94	.02	27	12.85	.07	51	13.10	.18
4	13.10	.18	28	12.89	.03	52	12.71	.21
5	13.10	.18	29	13.15	.23	53	13.03	.11
6	13.23	.31	30	12.89	.03	54	13.19	.27
7	12.89	.03	31	13.05	.13	55	12.94	.02
8	12.97	.05	32	13.07	.15	56	12.74	.18
9	13.08	.16	33	13.09	.17	57	12.98	.06
10	12.94	.02	34	12.87	.05	58	12.80	.12
11	12.92	.00	35	12.95	.03	59	12.81	.11
12	13.13	.21	36	12.89	.03	60	13.00	.08
13	13.13	.21	37	12.83	.09	61	12.68	.24
14	12.81	.11	38	12.85	.07	62	12.79	.13
15	12.82	.10	39	13.08	.16	63	12.72	.20
16	12.61	.31	40	13.03	.11	64	12.97	.05
17	12.88	.04	41	12.96	.04	65	12.86	.06
18	12.79	.13	42	13.08	.16	66	12.79	.13
19	13.07	.15	43	12.82	.10	67	13.09	.17
20	12.85	.07	44	12.99	.07	68	12.52	.40
21	13.03	.11	45	12.97	.05	69	13.07	.15
22	12.77	.15	46	12.79	.13	70	12.74	.18
23	12.91	.01	47	12.86	.06	71	12.35	.57
24	13.05	.13	48	12.89	.03			

[1] J. T. Flohil (*5*).

[2] These tests were made on carefully prepared subdivisions of 1 sample of wheat; the protein content, in each case, was calculated to a uniform moisture base of 13.5 per cent from a moisture analysis made coincident with the protein analysis. Thus, no variations in these protein determinations were caused by either sampling or moisture content. All the collaborators used the Kjeldahl method for the determination of protein content but did not use standard methods in preparing the sample for testing nor identical chemical reagents.

The possibilities in effecting a high degree of intermarket uniformity in protein determinations are demonstrated better, however, by the data given in Table 13 than by those in Table 12. The data in Table 13 were developed from protein tests made on 241 car lots of wheat at Minneapolis by the Bureau of Agricultural Economics, for the purpose of demonstrating the fact that protein determinations made on duplicate samplings from the same car lot of wheat may be made practically uniform for commercial purposes, providing the sampling and protein testing are done by uniform, standard methods. Table 13 shows that 91.7 per cent of the tests varied by less than 0.2 per cent, and that 95.9 per cent varied by less than 0.25 per cent.

This high degree of uniformity, as compared with that obtained in the tests shown in Table 12, was obtained moreover, with the added variable of sampling included as a part of the test.

TABLE 13.—*Protein tests on duplicate samples from 241 car lots of wheat at Minneapolis*

[Basis 13.5 per cent moisture]

Number of cars sampled	141	194	221	231
Percentage variation in duplicate tests	0 to 0.09	0 to 0.14	0 to 0.19	0 to 0.24
Percentage of total car samplings	58.5	80.5	91.7	95.9

Certain explanations of and deductions from the data given in Table 13 are quoted herewith from the investigational work of the Bureau of Agricultural Economics (*4, p. 15–16*).

It is absolutely essential that a car or lot of wheat be correctly sampled before proceeding with any test. Questions as to how close duplicate samplings of bulk loadings will agree in protein content have been frequently raised. For the purpose of obtaining some data on these points, duplicate samplings were made of 241 cars of wheat as they arrived at the Minneapolis market. Some of these cars contained as high as 15 per cent of dockage and represented receipts loaded both evenly and unevenly. Each car was sampled twice in five different areas by means of the usual grain probe * * *. The contents of probes 1 to 5 and 6 to 10, inclusive, were composited separately, thoroughly cleaned, mixed, and reduced to 75 grams in size to be ground for making protein tests * * *. Moisture determinations were made at the time the protein determinations were made, so that the results reported are on a uniform moisture basis.

* * * This value [less than 0.25 per cent], moreover, is the variation permitted by the American Association of Cereal Chemists in the matter of making protein tests. It is evident then that carlots of wheat can be sampled a number of times with a reasonable degree of accuracy, providing, of course, that other conditions affecting the protein tests be controlled.

The data given in Table 13 demonstrate conclusively that when sampling, preparation of the sample for testing, chemical reagents, equipment, testing procedure, and consideration of the moisture content in computing the protein content, are standardized, and when the work throughout is done expertly, a very high degree of intermarket uniformity is possible. The United States Department of Agriculture has recommended standard methods of sampling, protein testing, and computing the protein content on a uniform moisture base. The department, however, has not had specific authority to establish standardized methods in the laboratories that make protein tests for commercial use, although it has had authority to establish official standards for the inspection and certification of grain for grade.

ADVANTAGES OF COORDINATING COMMERCIAL PROTEIN TESTING WITH INSPECTION FOR GRADE

Effective coordination of protein testing with the inspection of grain for grade would be desirable. Such coordination would be particularly beneficial in the matter of sampling in the terminal markets. Organized and supervised sampling facilities are now available for grain-grading purposes at all the important grain markets of the United States where inspection for grade is conducted under the United States grain standards act. Thus, if coordination between

protein testing and inspection for grade were effected in these markets, the samples taken by standard, approved methods for grain-inspection purposes could be divided to make one part available for protein testing. The same sampling force established for the grain-inspection service would be available to obtain samples desired for use only in protein testing. Such coordination between the protein-testing and grain-inspection services should result not only in greater sampling efficiency in protein testing but also in operating economies and the avoidance of needless duplication.

Coordination would be advantageous, also, in the certification of protein content. There is a preference in many commercial transactions for an official certificate showing both protein content and grade. Without close coordination, it is difficult and sometimes impracticable to assemble protein-test information from one agency and grade information from another agency, and to combine the desired information on a single certificate. Such certificates covering both grade and protein content, or certificates of protein content only, if issued by licensed analysts or employees of the Federal Government in a manner similar to the issuance of official grade certificates, should enjoy a higher commercial rating than certificates issued under a system which does not require the use of standard methods of sampling and testing, nor provide for uniform supervision and final determination in case of dispute.

If protein testing were to be closely coordinated with grain inspection for grade, and if official certification of protein content were to be limited to licensed analysts, as in the case of certificates of grade, the principal functions of such licensed analysts would be (1) to make original protein tests for commercial use and to certify protein content, (2) to make protein tests on submitted samples of individual commercial lots of grain for the use of producers, country shippers, and others desiring tests prior to marketing; and (3) to make protein tests of part of the samples collected annually in connection with the protein surveys and estimates.

INTERDEPENDENCE OF PROTEIN-TESTING AND PROTEIN-SURVEY SERVICE

Protein-testing service for commercial use and protein survey and educational work are mutually necessary in the development and improvement of the marketing of wheat according to protein content.

An adequate, nationally unified wheat protein-testing service for commercial use in terminal markets and for the use of producers and country shippers who desire premarketing tests on individual lot samples, would be facilitated by annual protein surveys, market-news service on protein premiums, and organized educational work on the marketing of wheat by its protein content. The surveys and educational work would expand the use of protein specifications in wheat marketing and stimulate the demand for protein tests for all classes of wheat. Thus the operations of the laboratories would be expanded and stabilized, and the increased revenues would make possible the installation of the best equipment, the steady employment of a competent personnel, and the adoption of the most thorough procedure possible in sampling and testing, all of which would assist in providing the grain industry with accurate, uniform tests.

On the other hand, the ultimate benefits to be derived from protein surveys, market-news service, and educational work, would be contingent on an efficient, national protein-testing service for commercial use. The very completion annually of a comprehensive and thorough protein survey is dependent on a well-organized system of protein-testing laboratories to make tests of premarketing survey samples and to provide current data throughout the entire marketing season. Moreover, an efficient national protein-testing service is essential to meet the increased demand for tests that would doubtless result from the surveys, market-news service, and educational work.

OIL TESTS AND SURVEYS FOR FLAXSEED AND SOYBEANS

OIL CONTENT OF FLAXSEED

Flax is grown in the United States chiefly for the oil content of its seeds. Linseed oil, expressed from flaxseed, is used chiefly in the manufacture of paints. The by-product, linseed cake, is rich in protein and has high commercial value for use as a livestock feed. Investigations of northwestern-grown flaxseed conducted by the Bureau of Agricultural Economics (*3*) have shown that the average oil content of flaxseed is about 40 per cent, that there is a common range of oil content in commercial lots from 37 to 44 per cent, and an extreme range from 30 to 45 per cent.

OIL CONTENT OF SOYBEANS

Soybeans are another oil-bearing seed crop of importance in United States commerce. The oil expressed from soybeans is used chiefly in the manufacture of soaps, paints, and varnishes. The by-product of the crushing plants, soybean cake or meal, is also rich in protein and has high commercial value as a livestock feed. The average oil content of commercial lots of soybeans is approximately 18 per cent, and a common range of 15 to 20 per cent is found. An extreme range of 12 to 22 per cent has been observed. The variations in oil content between different varities of soybeans are material. Investigations by the Bureau of Plant Industry of the United States Department of Agriculture have recorded variety variation in oil content from 12.7 to 19.9 per cent in the same season (*12*), and similar investigations by the Illinois Agricultural Experiment Station have recorded variations of 16 to 22 per cent (*6*). Wide variations in oil content exist within any given variety, and are caused by variations in climatic and soil environment, and by variations in the time of planting and harvesting.

PROCESSING VALUE OF FLAXSEED MEASURED BY OIL CONTENT

The oil content of flaxseed is of greater significance in the determination of the value of flaxseed for processing, year in and year out, than is the protein content of wheat in the determination of its milling value. The significance of oil content as a measure of the use value of flax may be illustrated as follows: The average oil content of northwestern-grown flaxseed is approximately 40 per cent. The average market price of No. 1 flaxseed at Minneapolis for the period 1925 to 1929, inclusive, was approximately $2.40 per bushel.

At this market price for flaxseed, each per cent of oil above or below the average of 40 per cent represents a use value of about 6 cents per bushel. For a car lot of 1,200 bushels each such variation of 1 per cent in oil content represents a variation in use value of $72. With common ranges in oil content of 37 to 44 per cent, car lots of flaxseed may vary, therefore, from $200 to $400 in processing value. Extrame variations may amount to as much as $700 to $1,000 per car lot.

EXISTING MARKET PRACTICES FOR FLAXSEED

Existing marketing practices in regard to flaxseed are such that the variations in processing value, as determined by oil content, are not definitely reflected in market prices. Some "map buying" is done by the flaxseed processors as the result of their premarketing and early-marketing-period studies of the oil content of flaxseed in the various producing areas. From such trade information the prices for the various shipping stations in some years are scaled up or down from the average price, thus reflecting prices in some cases that are partly established as a result of the oil content of the crop. By and large, however, and specifically within any given shipping area, the producer or country shipper of high-oil-content flaxseed receives no better price than does the producer or shipper of low-oil-content seed. Most of the oil-content tests of flaxseed are made at present (1931) for the confidential use of the processors and are not definitely employed in the markets as a measure for the determination of the market value of individual lots of seed.

The domestic crop of flaxseed is sold commonly under standards of the States of Minnesota, Montana, Oregon, Washington, and Wisconsin, of boards of trade in Chicago, Ill., and Sioux City, Iowa, and of the chamber of commerce in St. Louis, Mo. All these standards are based on various requirements for such physical characters as test weight, moisture, damaged kernels, plump kernels, foreign material, and color. None of them use oil content as a measure of quality. No official Federal standards for flaxseed have been promulgated.

OIL CONTENT NOT MEASURABLE BY PHYSICAL CHARACTERS

Investigational work of the Bureau of Agricultural Economics (*3*) on northwestern flaxseed of the crops of 1918 to 1924, inclusive, has shown conclusively that no consistent relationship exists between the oil content of flaxseed and any of the commercial grades. Within the same grade a spread of as much as 18 per cent in oil content was found. Studies were made to ascertain the correlations, if any, between oil content and each of such individual physical characters as test weight, plumpness, color, and damaged kernels, but in no instance were correlations found of sufficient reliability to make any one of these factors useful as a commercial measure of the processing value.

OIL-TESTING SERVICE AND SURVEYS IN RELATION TO MARKET PRACTICES

Market prices for flaxseed should be based primarily on the factor of oil content, because oil content reveals the chief value in the seed for processing. Some of the physical tests now used for grading flaxseed have value in the determination of relative quality, in that

they reveal the condition and purity of the commodity, but these tests alone do not reveal the full commercial value. The testing and certification of flaxseed for its oil content would (1) provide information of value to the processors in making their purchases, (2) establish market premiums for flaxseed of relatively high oil content, (3) reflect more equitable market prices to producers and shippers than do the prices paid under the present grading system, and (4) provide an incentive to growers to raise and ship a high-grade product.

The oil content of flaxseed and other oil-bearing seeds can be determined accurately and rapidly by the so-called Wesson (refractometer) test. A competent analyst can make 10 to 12 tests per hour, and can make a greater number under conditions in which a large volume of tests is being handled and a division of labor can be arranged. It is entirely practicable to install the test in the State or commercial-exchange inspection departments of the important flaxseed markets, although the cost of the necessary equipment (about $600) might preclude its installation at small country shipping points.

The adoption of oil tests in the inspection and marketing of soybeans would function in much the same manner as that described above for flaxseed. The common ranges in the oil content of commercial lots of soybeans are not so great as in the case of flaxseed; nevertheless market prices would be on a more equitable basis if the oil test were included in the inspection and market procedure.

Oil tests of flaxseed and soybeans for commercial use are desirable as a part of the national grain-inspection service. Such tests may be effected best by coordination with the inspection of grain for grade under the United States grain standards act for reasons identical with those applicable to protein testing.

Official Federal standards for soybeans are now in effect, and the United States Department of Agriculture contemplates promulgating official standards for flaxseed as soon as certain standardization studies have been completed. Oil tests are necessary, however, to supplement standards based on physical characters in order to indicate accurately the commercial values in these commodities.

Premarketing oil-content surveys, market-news service, and educational work relative to the marketing of flaxseed and soybeans would be as useful to the producers, handlers, and processors of these crops, as similar information with respect to the protein content of wheat would be for the wheat industry.

PROTEIN TESTS FOR BARLEY AND ALFALFA MEAL

Numerous European tests of the malting value of barley have shown a close correlation between low nitrogen content (protein) and high malting value in barley. It is reported that German maltsters and brewers have specified nitrogen content in their barley contracts for 20 to 30 years and that the English brewers are becoming interested in it as a criterion of malting quality (*15, p. 138*).

Protein tests are now used in the domestic commerce in alfalfa meal. Prices are governed in large degree by the protein content, and transactions are governed commonly by contracts which include protein specifications. Most of the testing is done by private, com-

mercial laboratories and by the laboratories of the mixed-feed manufacturers who are the chief users of this commodity.

A national service that provides protein tests for wheat should provide also for those kindred technical laboratory tests to measure the quality of other grains and oil-bearing seeds that are useful to supplement grade determinations. The commercial use of these technical laboratory tests has increased materially since 1920 and may be expected to increase further. The inspection services for grain, oil-bearing seeds, and feedstuffs, in order to keep pace with commercial requirements, should adopt these technical tests as rapidly as they are made practical for commercial-inspection purposes, if trade conditions warrant.

PERMISSIVE PRINCIPLES FOR PROTEIN AND OIL-TESTING SERVICE

The use of the protein test in grain commerce as a commercial measure of quality has been established by the voluntary action of the grain trade. Such protein-testing services as are now in operation are on a permissive basis, and it is likely that the commercial use of the protein test will expand further in accordance with the requirements and voluntary action of the grain industry.

In several respects a chemical laboratory testing service for the purpose of determining the protein content of grain is not analagous to the inspection of grain for grade as now conducted under the United States grain standards act. The necessity for grain inspection for grade is national and is constant in character. The facts about the condition and the physical characters of grain are necessary constantly to producers, elevator superintendents, merchants, processors, carriers, bankers, and others, in their handling, transportation, storage, mixing, financing, merchandising, and utilization of grain. At present (1931), however, the use of protein tests is largely regional, and is confined principally to the Hard Red Spring and Hard Red Winter wheat classes. The demand, also, is intermittent, and varies, from time to time, according to the seasonal supplies of high and low protein wheat.

Up to the present time the oil test for flaxseed and soybeans has not been adopted by the oil-seed industry as a whole in connection with the marketing of these crops; yet it has a significance that is comparable to or even greater than that of the protein test for wheat as a commercial measure of quality.

For these reasons a national service for determining the protein or oil content of commercial lots of grain at both terminal and country points may well be founded on permissive principles. So much importance is attached to these measures of quality in the present-day grain business that a wide commercial use of such service might be expected. An effective protein and oil-testing service, accompanied by comprehensive protein surveys of the wheat crops and oil surveys of the flaxseed and soybean crops and by a market-news service pertaining to protein and oil premiums, supplies, and market requirements, should be of distinct benefit to the grain industry, especially to producers and country shippers.

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U. S. GOVERNMENT PRINTING OFFICE: 1932